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# THE CARBONIFEROUS AMMONOIDS OF AMERICA



BY

JAMES PERRIN SMITH

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# LETTER OF TRANSMITTAL.

STANFORD UNIVERSITY, CAL., *May 17, 1901.*

SIR: I have the honor to transmit herewith the manuscript and drawings for a paper entitled The Carboniferous Ammonoids of America, in which all the Carboniferous ammonoid genera and species known in America are listed, described, and, where possible, figured.

A phylogenic classification of the Paleozoic ammonoids is attempted, which, it is hoped, will prove useful to students of systematic paleontology.

Very respectfully,

JAMES PERRIN SMITH.

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# PREFACE.

A number of years ago the writer began his studies of American Carboniferous ammonoids with the preparation of a report on Marine Fossils from the Coal Measures of Arkansas for the geological survey of Arkansas, under the directorship of Prof. John C. Branner, State geologist. This work has been continued uninterruptedly since then in connection with the writer's studies in the cephalopods of the Trias.

In the prosecution of these studies the writer has spent much time in the field in Arkansas and Texas, and has had access to the material collected by the geological surveys of those two States.

The writer desires to make acknowledgment to the gentlemen named below for courtesies in the loan of specimens and for assistance in the prosecution of this work:

Dr. John C. Branner, of Leland Stanford Junior University, formerly State geologist of Arkansas, for the opportunity of studying the collections of Carboniferous cephalopods made by the geological survey of Arkansas.

Dr. Stuart Weller, of the University of Chicago, for the opportunity of studying the Gurley collection (the richest in the United States in Carboniferous ammonoids), for the loan of specimens and drawings, and for much valuable assistance.

Prof. Alpheus Hyatt, for the loan of specimens and for valuable advice and suggestions

Prof. Robert T. Jackson, of Harvard University, for the loan of specimens.

Mr. Charles Schuchert, of the U. S. National Museum, for the use of specimens.

Messrs. E. T. Dumble and W. F. Cummins, of the geological survey of Texas, and Prof. F. W. Simonds, of the University of Texas, for the opportunity of studying the collections of the geological survey and of the university.

Mr. G. A. Graham and Dr. Gant, of Graham, Tex., for the gift of valuable specimens.

# THE CARBONIFEROUS AMMONOIDS OF AMERICA.

By James Perrin Smith.

## STRATIGRAPHY OF THE AMERICAN CARBONIFEROUS.

### LOWER CARBONIFEROUS.

*Kinderhook.*—The oldest Carboniferous fauna of America is typically developed in the northern part of the Mississippi Valley, where the formations in which it is found have been called Kinderhook, Chouteau, Marshall, and Waverly. Ammonoids of this epoch are best known from the goniatite beds of Rockford, Ind., where the following species have been found: *Prolecanites lyoni* Meek and Worthen, *Aganides rotatorius* de Koninck, *Muensteroceras oweni* Hall, *M. parallelum* Hall, *Prodromites gorbyi* Miller, *P. præmaturus* Smith and Weller. In addition to these, the Kinderhook stage of other parts of the State has furnished *Prolecanites greenii* Miller and *Muensteroceras indianense* Miller. The Chouteau limestone near Sedalia and Louisiana, Mo., has also furnished a number of ammonoids: *Prolecanites louisianensis* Rowley, *P. gurleyi* Smith, *Aganides jessieæ* Miller and Gurley, *A. discoidalis* Smith, *Prodromites gorbyi* Miller, *P. ornatus* Smith, *Pericyclus blairi* Miller and Gurley, *Muensteroceras? holmesi* Swallow, *M.? morganense* Swallow, and *M.? osagense* Swallow.

The Marshall group of Michigan has furnished *Prolecanites houghtoni* Winchell, *P. marshallensis* Winchell, *Muensteroceras oweni* Hall, *M. parallelum* Hall, *M. holmesi* Swallow, *Prionoceras? andrewsi* Winchell, *Aganides? propinquus* Winchell, *A. romingeri* Winchell, *A. shumardianus* Winchell, *Glyphioceras? pygmæum* Winchell.

The Lower Waverly, or Kinderhook, of Ohio has furnished *Prolecanites lyoni* Meek and Worthen, *P. marshallensis* Winchell, *Prionoceras? andrewsi* Winchell, *P.? ohiocnse* Winchell, *Aganides? shumardianus* Winchell.

The Kinderhook stage of Iowa has furnished *Prodromites gorbyi* Miller, *Agoniatites opimus* White and Whitfield.

Cephalopod faunas of the Tournaisian formation, the European equivalent of the Kinderhook, are known at Tournai in Belgium, Erdbach in Germany, and in Ireland, where the most characteristic genera are *Aganides*, *Prolecanites*, *Pericyclus*, and *Muensteroceras*, some of the species probably being identical with American forms.

Cephalopod faunas of Tournaisian age are not yet known elsewhere in the world.

*Osage.*—While marine deposits of Osage or Burlington-Keokuk age are widely distributed in America, ammonoids are cited from but two places—from the Burlington limestone of Louisiana, Mo. (*Muensteroceras? osagense* Swallow), and from the Upper Waverly formation of Ohio (*Aganides? sciotoensis* Miller and Faber).

*St. Louis-Chester.*—The St. Louis-Chester, or Ste. Genevieve, stage of Indiana and Kentucky has furnished the following species: *Glyphioceras leviculum* Miller and Faber, *Goniolobоceras? limatum* Miller and Faber, *Goniatites kentuckiensis* Miller, *G. greencastlensis* Miller and Gurley, *G. subcircularis* Miller.

The only goniatite found in Illinois in this formation is *Nomismoceras? monroense* Worthen.

The lower part of the St. Louis-Chester stage in Arkansas, the so-called Fayetteville shale, has yielded *Bactrites carbonarius* Smith, *Glyphioceras calyx* Phillips, *Goniatites crenistria* Phillips, *G. newsomi* Smith, *G. sphæricus* Martin, *G. striatus* Sowerby, *G. subcircularis* Miller. The upper part of the St. Louis-Chester in Arkansas, the Boston group, has yielded *Pronorites cyclolobus* Phillips, var. *arkansasensis* Smith, and *Gastrioceras branneri* Smith.

The Bend formation of Texas, which has been assigned by the writer to the St. Louis-Chester, has yielded *Goniatites crenistria* Phillips, *G. striatus* Sowerby, *Gastrioceras compressum* Hyatt, *G. entogonum* Gabb, *Paralegoceras iowense* Meek and Worthen, and *P. texanum* Shumard.

Cephalopod faunas of St. Louis-Chester age are known in the Visé formation of Europe at Visé in Belgium, at Bolland in Yorkshire; in the Culm of the Hartz Mountains; in the upper Kohlenkalk of Silesia; and in the Carboniferous limestone of the Pyrenees in Spain. The most char-

acteristic forms of the Visé formation are *Goniatites crenistria* Phillips, *G. sphæricus* Martin, *G. striatus* Sowerby, *Glyphioceras calyx* Phillips, all of which occur in America in the same horizon.

### UPPER CARBONIFEROUS.

*Lower Coal Measures.*—Goniatites are known certainly in America from the Lower Coal Measures at but a single locality, near Morrillton, in Arkansas, where *Paralegoceras newsomi* Smith was found; this rarity of cephalopods from this horizon is due in part to the fact that the marine beds of the Lower Coal Measures have been deposited chiefly in the Southwest, and that most of this time is represented in Missouri, Illinois, Indiana, and adjacent States by an erosion interval.

*Middle Coal Measures.*—The Middle or Productive Coal Measures have furnished goniatites in but few places. The following fossils have been found in this formation: In Illinois, *Prolecanites? compactus* Meek and Worthen, *Glyphioceras hathawayanum* McChesney; in Iowa, *Paralegoceras iowense* Meek and Worthen; in Kentucky, *Gastrioceras occidentale* Miller and Faber, *G. nolinense* Cox, *Neoicoceras elkhornense* Miller and Gurley, *Goniatites lunatus* Miller and Gurley; in Arkansas, *Gastrioceras excelsum* Meek, *G. globulosum* Meek and Worthen, *G. carbonarium* Buch, *G. listeri* Martin, *Pronorites siebenthali* Smith; in Missouri, *Goniatites politus* Shumard, *Gastrioceras welleri* Smith; in Texas, *Popanoceras parkeri* Heilprin.

This formation has commonly been called Lower Coal Measures in the States within the Mississippi Valley, but it does not form the bottom of the series, and in Arkansas is separated from the limestones of the Mississippian by several thousand feet of shales and sandstones—the so-called Arkansan formation.

This fauna is represented in the zone of *Gastrioceras listeri* in western Europe, especially in Silesia, Belgium, and England.

*Upper Coal Measures.*—The Upper Coal Measures have furnished the following species: In Illinois, *Gastrioceras globulosum* Meek and Worthen, *G. montgomeryense* Miller and Gurley, *G. illinoisense* Miller and Gurley, *Goniolaboceras welleri* Smith, *Schistoceras fultonense* Miller and Gurley; in Ohio, *Schistoceras hildrethi* Morton, "*Goniatites*" *colubrellus* Morton; in Missouri, *Milleroceras parrishi* Miller and Gurley, *Gastrioceras excelsum* Meek, *G. kansasense* Miller and Gurley, *G. planorbiforme* Shumard, *G.*

*subcavum* Miller and Gurley, *Schistoceras missouriense* Miller and Faber; in Kansas, "*Goniatites*" *parvus* Shumard; in Texas, *Goniolobocerus welleri* Smith, *Dimorphoceras texanum* Smith, *Agathiceras ciscoense* Smith, *Popanoceras ganti* Smith, *Shumardites simondsi* Smith, *Schistoceras hildrethi* Morton, *S. hyatti* Smith, *Gastrioceras globulosum* Meek and Worthen, *G. subcavum* Miller and Gurley, *Schuchertites grahami* Smith. All these Texas species came from Graham, in the Cisco formation, associated with a typical Upper Coal Measures fauna. Many of the other species are identical with forms in the Uralian formation, but the numerous ammonites are more highly developed than any known in the European Upper Coal Measures; the nautiloids found in the Graham beds are mostly identical with forms that also occur in the overlying Wichita Permian, as are also most of the other invertebrates. But the stratigraphic position is about 1,000 feet below the Wichita beds, in a region where the structure is exceedingly simple, the strata being nearly horizontal, thus precluding the possibility of a mistake in the stratigraphy.

*Permian.*—Ammonoids are at present known in the American Permian only in Texas, in Wichita, Baylor, Archer, and Kent counties. The geological survey of Texas recognized two divisions of this group: (1) The Wichita and Clear Fork beds, from which Dr. C. A. White[a] described the following forms: *Paralegoceras baylorense* White, *Popanoceras walcotti* White, *Waagenoceras cumminsi* White, *Medlicottia copei* White; (2) the Double Mountain beds, from which only a single ammonite is known, *Waagenoceras hilli* Smith, described in this paper.

The Wichita beds are generally correlated with the Artinsk stage of Russia, the Fusulina limestone of Sosio in Sicily, and the Middle Productus limestone of India, some of the ammonite species being very nearly related in all these localities.

The Double Mountain beds are probably Upper Permian, and should be correlated with the Hungarites beds of Djulfa in Armenia and the Upper Productus limestone of India; but this is purely stratigraphic, the known fauna of the Upper Permian of Texas being too scanty to warrant paleontologic correlation.

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[a] Bull. U. S. Geol. Survey No. 77, 1891.

*Correlation table of the Carboniferous.*

| Series. | Stage. | Mississippi Valley. | Texas. | Pacific coast. | |
|---|---|---|---|---|---|
| Permian. | Wichita. | | Double Mountain. | | |
| | | | Wichita and Albany formations of Wichita, Baylor, and Archer counties. | McCloud shales. | Zone of *Fusulina longissima*. |
| Coal Measures or Pennsylvanian. | Missourian. | Upper Coal Measures. | Cisco formation of northern Texas. | | Zone of *Schwagerina robusta*. |
| | Des Moines. | Middle Coal Measures. | Canyon formation. | McCloud limestone of northern California. | Zone of *Fusulina cylindrica*. |
| | Arkansan. | Lower Coal Measures. | Strawn formation. | | |
| Lower Carboniferous or Mississippian. | Ste. Genevieve. | St. Louis-Chester. | Bend formation. | | |
| | Osage. | Burlington-Keokuk. | Wanting. | Baird shales of northern California. | Zone of *Productus giganteus*. |
| | Kinderhook. | Kinderhook or Chouteau. | | | |

*Correlation table of the Carboniferous*—Continued.

| Western Europe. | | | | Russia. | | | Asia. | | Inter-regional Cephalopod zone. |
|---|---|---|---|---|---|---|---|---|---|
| Permian. | Dyas. | Zechstein. | | Permian. | Kostroma. | | *Hungarites* beds of Djulfa in Armenia. Upper *Productus* limestone. | | |
| | | Rothliegendes. | | | Artinsk. | | Middle *Productus* limestone of Salt Range. Lower *Productus* limestone of Salt range. | | *Medlicottia.* |
| Upper Coal Measures. | Stephanian. | Coal Measures of Belgium, Germany, and England. | | Uralian, CIII. | Upper Carboniferous limestone of the Urals. | Zone of *Gastrioceras marianum.* | Lo Ping marine beds in Upper Coal Measures of China. *Fusulina* beds of Padang in Sumatra. | | *Gastrioceras marianum.* |
| Lower Coal Measures. | Westphalian. | | | Moscovian, CII. | Middle Carboniferous limestone of Moscow. | Zone of *Fusulina cylindrica.* | *Spirifer mosquensis* beds of China. | | *Gastrioceras listeri.* |
| Millstone grit. | | Beds of Chockier in Belgium. | Culm formation of Nassau and Hartz. | | | Zone of *Spirifer mosquensis.* | *Posidonomya becheri* beds of the Altai Mountains. | | *Glyphioceras diadema.* |
| Mountain limestone. | Dinantian. | Visé formation. | Limestones of Visé in Belgium; Bolland in Yorkshire; and the Pyrenees. | | | | *Productus longispinus* beds of the Altai Mountains. *Productus semireticulatus* beds of Djulfa in Armenia. | | *Goniatites striatus.* |
| | | | | CI. | Lower Carboniferous limestone. | Zone of *Productus giganteus.* | *Productus giganteus* beds of Asia Minor, central and eastern China. | Limestone of central Siberia with *Productus giganteus* and *Spirifer tornacensis.* | |
| | Tournaisian. | Beds of Tournai and Erdbach. | | Zone of *Spirifer tornacensis.* | | | | | *Aganides rotatorius.* |

### CLASSIFICATION OF PALEOZOIC AMMONOIDS.

Formerly all Paleozoic ammonoids were classified as *Goniatites*, with the exception of *Clymenia*, which was at first supposed to be a nautiloid. As more forms became known, the unwieldiness of the genus *Goniatites* was recognized by Beyrich,[a] who subdivided it as follows: 1, *Nautilini* [*Anarcestes* and *Mimoceras*]; 2, *Simplices* [*Tornoceras*, *Aganides*, and *Prionoceras*]; 3, *Aequales* [*Sporadoceras* and *Prolecanites*]; 4, *Irregulares* [*Beloceras*]; 5, *Primordiales* [*Gephyroceras*]; 6, *Carbonarii* [*Glyphioceras*, *Goniatites* s. str., and *Gastrioceras*].

Afterwards another classification was attempted by G. and F. Sandberger,[b] who established the following subdivisions: 1, *Linguati* [*Sandbergeroceras*]; 2, *Lanceolati*=[*Aequales* p. p. Beyrich]; 3, *Genufracti*=[*Carbonarii* Beyrich]; 4, *Serrati*=[*Irregulares* Beyrich]; 5, *Crenati*=[*Primordiales* Beyrich]; 6, *Acutolaterales* [*Maeneceras*]; 7, *Magnosellares*=[*Simplices* Beyrich]; 8, *Nautilini*=[*Nautilini* Beyrich].

The divisions of Beyrich and those of the Sandbergers were not intended to represent genera, and they mostly contain heterogeneous elements. At that time even the old genus *Ammonites*, comprising several times as many species as *Goniatites* and species much more various in form, was still considered a unit.

*Goniatites* was supposed to differ fundamentally from *Ammonites*, although it was known to L. von Buch and Quenstedt that the ammonites in their youth went through a goniatite stage of growth; but since these forms were all supposed to be special creations, this phenomenon was not connected with the idea of evolution, and had no effect on classification.

The first attempt to distinguish genera among the goniatites was made by Dr. E. von Mojsisovics[c] in 1882, who named *Anarcestes*, *Pinacites*, *Pronorites*, *Prolecanites*, and *Pericyclus*, bringing them into rather fanciful relationships to his genera of Triassic ammonites.

The first systematic attempt to group all goniatites in families and genera was by Hyatt in his Genera of Fossil Cephalopods, where they were classified as follows:[d] Family 1, Nautilinidæ, including *Mimoceras* Hyatt,

[a] Beitr. z Kennt. Rhein. Uebergangsgeb.
[b] Verstein. Rheinischen Schichtensystems in Nassau.
[c] Cephalop. Mediterranen Triasprovinz.
[d] Proc. Boston Soc. Nat. Hist., Vol. XXII.

*Anarcestes* Mojsisovics, *Agoniatites* Meek, *Pinacites* Mojsisovics, *Celæceras* Hyatt; family 2, Primordialidæ, including *Gephyroceras* Hyatt, *Manticoceras* Hyatt; family 3, Magnosellaridæ, including *Parodoceras* Hyatt, *Tornoceras* Hyatt, *Mæneceras* Hyatt, *Sporadoceras* Hyatt; family 4, Glyphioceratidæ, including *Brancoceras* [*Aganides*] Hyatt, *Muensteroceras* Hyatt, *Gastrioceras* Hyatt, *Paralegoceras* Hyatt, *Prionoceras* Hyatt, *Glyphioceras* Hyatt [with *Goniatites* de Haan], *Dimeroceras* Hyatt, *Pericyclus* Mojsisovics, *Homoceras* Hyatt [no longer recognized], *Nomismoceras* Hyatt [now grouped with the Gephyroceratidæ], *Dimorphoceras* Hyatt; family 5, Prolecanitidæ, including *Sandbergeroceras* Hyatt, *Beloceras* Hyatt, *Prolecanites* Mojsisovics, *Pharciceras* Hyatt, *Schistoceras* Hyatt [now included with the Glyphioceratidæ], *Triænoceras* Hyatt, *Pronorites* Mojsisovics, *Popanoceras* Hyatt.

*Medlicottia* Waagen, *Sageceras* Mojsisovics, and *Lobites* Mojsisovics were also included by Hyatt in the Prolecanitidæ, although only *Medlicottia* seems to show any relationship to *Prolecanites*, and that only remotely.

Hyatt's families do not represent genetic series, but are polyphyletic groups of morphological equivalents—independent parallel developments from kindred stocks.

Before this publication of Hyatt, genera of Paleozoic ammonoids had already been recognized by Waagen[a] in the Permian of India and Russia as follows: *Xenodiscus* Waagen, *Medlicottia* Waagen (as subgenus of *Sageceras* Mojsisovics), *Cyclolobus* Waagen. These were classed with the ammonites on account of their resemblance to Triassic genera.

Gemmellaro's[b] monograph on the Permian cephalopod fauna of Sicily revealed hitherto unsuspected riches in Paleozoic ammonites of the families Glyphioceratidæ, Arcestidæ, Pinacoceratidæ, Noritidæ, and Tropitidæ.

A somewhat similar fauna was described by Dr. C. A. White[c] from the Permian of Texas, with *Paralegoceras*, *Popanoceras*, *Waagenoceras*, and *Medlicottia*.

The classic Permian fauna of the Ural Mountains was redescribed and revised by Karpinsky,[d] who showed the gradual transition from the Carboniferous goniatites into the Permian ammonites in the Glyphioceratidæ, Arcestidæ, and Prolecanitidæ.

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[a] Pal. Indica, Ser. XIII, Salt Range Fossils, Vol. I.
[b] Fauna calc. Fusulina.
[c] Bull. U. S. Geol. Survey No. 77.
[d] Die Ammoneen der Artinsk-Stufe.

Quite recently G. von Arthaber[a] has redescribed the Permian fauna of Djulfa in Armenia, making known the presence in the same beds of *Productus*, *Gastrioceras*, *Otoceras*, and *Hungarites*; the two latter ammonite genera are known elsewhere only in the Trias, and the beds containing them are considered as uppermost Permian, later even than the Upper Productus limestone of the Salt Range.

When these new discoveries began to be known, it became evident that a new classification of the Paleozoic ammonoids was necessary, since there was no place in the old scheme for the new forms. The first attempt to give a phylogenetic classification of ammonoids, showing the relationship of the goniatites and the ammonites was made by Steinmann,[b] but this was largely speculative, not based on the ontogeny of any species, and hence fails to express the true relationships of the groups.

The most satisfactory attempt at a phylogenetic classification of the Paleozoic ammonoids is that of E. Haug,[c] in which all known genera are grouped in five phyla, or superfamilies: (I) ANARCESTIDÆ, including *Anarcestes*, *Parodoceras*, *Prionoceras*, *Prolobites*, *Mæneceras*, *Sporadoceras*, *Dimeroceras*, *Pharciceras*, *? Sandbergeroceras*, *? Triænoceras;* (II) GLYPHIOCERATIDÆ, including *Pericyclus*, *Muensteroceras*, *Glyphioceras*, *Goniatites* s. str., *Gastrioceras*, *Paralegoceras*, *Agathiceras*, *Adrianites*, *Stacheoceras;* (III) AGONIATITIDÆ, including *Gyroceras* = [*Mimoceras*], *Agoniatites*, *Tornoceras*, *Pinacites*, *Aganides* = [*Brancoceras* Hyatt], *? Pronannites*, *Dimorphoceras*, *Thalassoceras*, *Popanoceras;* (IV) GEPHYROCERATIDÆ, including *Gephyroceras*, *Timanites*, *Nomismoceras*, *Beloceras;* (V) IBERGICERATIDÆ = [*Prolecanitidæ*, in part of Hyatt], including *Ibergiceras*, *Paraprolecanites*, *Pronorites*, *Parapronorites*, *Propinacoceras*, *Medlicottia*, *Daraelites*, *Prolecanites*.

On Table II, page 113, of Haug's work, is an attempt to show graphically the relations of the Paleozoic ammonoids to each other and to their successors of the Mesozoic. This classification is a distinct improvement over that of Steinmann, but also makes the mistake of grouping together heterogeneous elements and separating forms that are manifestly of near kinship. It also seems to the writer that there are too

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[a] F. Frech and G. von Arthaber, Ueber das Palaeozoicum in Hocharmenien und Persien (No. 4, G. von Arthaber, Das Jüngere Palaeozoicum aus der Araxes-Enge bei Djulfa): Beitr. Palaeont. und Geologie Oesterreich-Ungarns und des Orients, Vol. XII, No. IV, 1900.

[b] Elemente der Paläont.

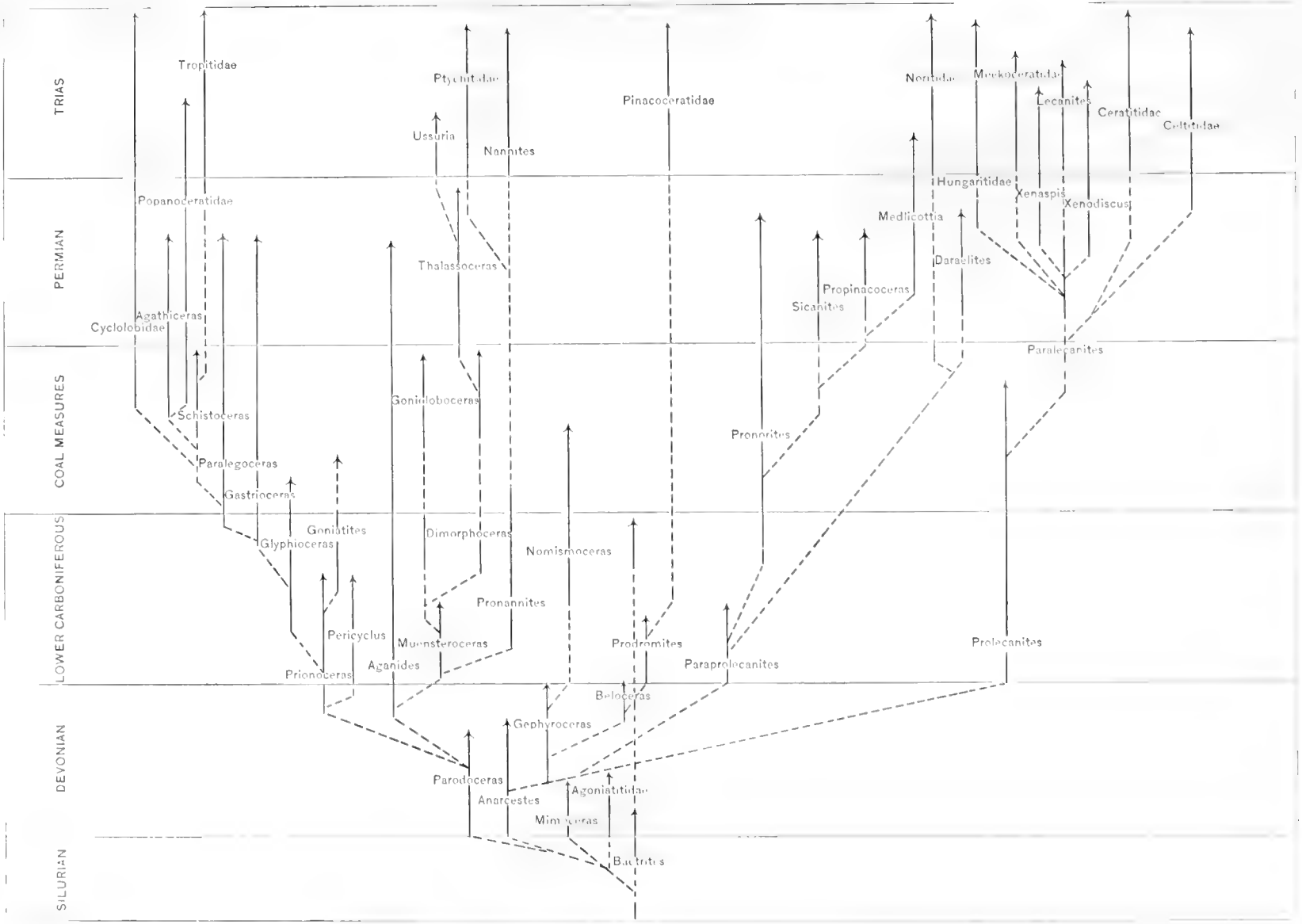
[c] Études sur les Goniatites.

few phyla recognized. Since most of the ammonoid genera of the Devonian and Carboniferous were progressive, and probably gave rise to descendants in the Permian and Mesozoic, there ought to be nearly as many phyla, or genetic series, as there are primitive genera. But since some of these are nearer of kin than others, for the sake of convenience we group them together, in spite of the fact that this does not express the true filiation of the genera. Thus, even at the best, many of the so-called families will not be a true genetic series, but a group of nearly related morphological equivalents. It is doubtful whether the ideal of strictly monophyletic families and genera can ever be realized, even if the geologic record should turn out to be less broken than we now suppose it to be. Of the great majority of Paleozoic ammonoids we do not now know, and probably shall never know, the ontogeny, and until we are able to compare in every case the individual ontogeny with the supposed genetic succession as preserved in the rocks we can never hope to establish a classification that will not be overthrown by each discovery of new faunas.

One great difficulty in classification is that we do not yet know what characters are of fundamental importance in taxonomy. One systematist selects the length of the body chamber as the criterion, another the septa, another the sculpture. A rigid adherence to any one of these systems leads to absurdities, for it becomes clear that any one of these characters may appear at different times in different stocks; and a dependence on any one character would cause the grouping together of forms that have no real kinship. The only safe way is to take into consideration all these characters, where it is possible, and to compare in every case the individual ontogeny with the biologic sequence as preserved in the successive geologic formations. The writer has endeavored to do this in the classification adopted in this work.

### TABLE OF PALEOZOIC AMMONOID GENERA.

For convenience of reference there is given below a table showing the genera and families now known from the Paleozoic, and their geologic range. This is based on the works of Hyatt, Gemmellaro, Karpinsky, Frech, Waagen, von Mojsisovics, von Arthaber, Haug, and Diener, and on the writer's own studies in the ammonoids of the Carboniferous and Lower Trias. This classification is only tentative; it represents merely the present state of knowledge, or rather of opinion, concerning the deri-




PHYLOGENIC TABLE OF THE PALEOZOIC AMMONOIDS

vation and relationship of the various groups. It is subject to revision or modification by any new discovery of forms, or any studies in the ontogeny of groups of which the ontogeny is at present unknown. It is not claimed that it is an absolute phylogenic classification; it is merely an attempt at such a classification. The writer has followed strictly the classifications of other investigators where he had no new observations of his own to offer; he has departed from the accepted classification in the construction of the phylogenic table of the Paleozoic ammonoids only where ontogenic study of the various groups makes such changes necessary.

*Table of Paleozoic ammonoid genera.*

| | Devonian. | Lower Carboniferous. | Coal Measures. | Permian. | Trias. |
|---|---|---|---|---|---|
| 1. Family BACTRITIDÆ: | | | | | |
| Bactrites Sandberger | × | × | | | |
| 2. Family CLYMENIDÆ: | | | | | |
| Clymenia Guembel | × | | | | |
| 3. Family ANARCESTIDÆ: | | | | | |
| Anarcestes Mojsisovics | × | | | | |
| Mimoceras Hyatt | × | | | | |
| Parodoceras Hyatt | × | | | | |
| Prolobites Karpinsky | × | | | | |
| Mæneceras Hyatt | × | | | | |
| Sporadoceras Hyatt | × | | | | |
| Dimeroceras Hyatt | × | | | | |
| 4. Family AGONIATITIDÆ: | | | | | |
| Agoniatites Meek | × | × | | | |
| Aphyllites Mojsisovics | × | | | | |
| Tornoceras Hyatt | × | | | | |
| Pinacites Mojsisovics | × | | | | |
| 5. Family GEPHYROCERATIDÆ: | | | | | |
| Gephyroceras Hyatt | × | | | | |
| Manticoceras Hyatt | × | | | | |
| Timanites Mojsisovics | × | | | | |
| Nomismoceras Hyatt | | × | | × ? | |
| Pseudonomismoceras Frech | | | × | | |
| Superfamily PROLECANITIDÆ— | | | | | |
| 6. Family LECANITIDÆ: | | | | | |
| Xenaspis Waagen | | | | × | × |
| Xenodiscus Waagen | | | | × | × |
| Paralecanites Diener | | | | × | |
| ? Lecanites Mojsisovics | | | | (?) | × |

*Table of Paleozoic ammonoid genera*—Continued.

| | Devonian. | Lower Carboniferous. | Coal Measures. | Permian. | Trias. |
|---|---|---|---|---|---|
| Superfamily PROLECANITIDÆ—Continued. | | | | | |
| 7. Family BELOCERATIDÆ: | | | | | |
| Probeloceras Clarke | × | | | | |
| Beloceras Hyatt | × | | | | |
| Prodromites Smith and Weller | | × | | | |
| 8. Family PRONORITIDÆ: | | | | | |
| Pronorites Mojsisovics | | × | × | × | |
| Paraprolecanites Karpinsky | | × | | | |
| Sicanites Gemmellaro | | | | × | |
| Propinacoceras Gemmellaro | | | | × | |
| Medlicottia Waagen | | | | × | × |
| 9. Family NORITIDÆ: | | | | | |
| Darælites Gemmellaro | | | | × | |
| Schuchertites Smith | | | × | | |
| 10. Family PROLECANITIDÆ: | | | | | |
| Prolecanites Mojsisovics | × | × | ×? | | |
| ? Paraceltites Gemmellaro | | | | × | |
| ? Sandbergeroceras Hyatt | × | | | | |
| ? Triænoceras Hyatt | × | | | | |
| ? Pseudarietites Frech | × | | | | |
| ? Phenacoceras Frech | × | | | | |
| Pharciceras Hyatt | × | | | | |
| 11. Family HUNGARITIDÆ: | | | | | |
| Hungarites Mojsisovics | | | | × | × |
| Otoceras Griesbach | | | | × | × |
| Superfamily GLYPHIOCERATIDÆ— | | | | | |
| 12. Family GLYPHIOCERATIDÆ s. str.: | | | | | |
| Prionoceras Hyatt | ×? | ×? | ×? | | |
| Pericyclus Mojsisovics | | × | | | |
| Glyphioceras Hyatt | | × | × | ×? | |
| Goniatites de Haan | | × | ×? | | |
| Gastrioceras Hyatt | | × | × | × | |
| Paralegoceras Hyatt | | × | × | × | |
| Schistoceras Hyatt | | | × | | |
| 13. Family AGANIDIDÆ: | | | | | |
| Aganides de Montfort | × | × | | × | |
| Muensteroceras Hyatt | | × | | | |
| ? Pronannites Haug | | × | | | |
| Goniolobоceras Hyatt | | | × | | |
| Dimorphoceras Hyatt | | × | × | | |

*Table of Paleozoic ammonoid genera*—Continued.

| | Devonian. | Lower Carboniferous. | Coal Measures. | Permian. | Trias. |
|---|---|---|---|---|---|
| Superfamily GLYPHIOCERATIDÆ—Continued. | | | | | |
| 13. Family AGANIDIDÆ—Continued. | | | | | |
| Thalassoceras Gemmellaro | | | ×? | × | |
| ? Milleroceras Hyatt | | | × | | |
| Superfamily ARCESTIDÆ— | | | | | |
| 14. Family POPANOCERATIDÆ: | | | | | |
| Agathiceras Gemmellaro | | | × | × | |
| Adrianites Gemmellaro | | | | × | |
| Popanoceras Hyatt | | | × | × | × |
| Stacheoceras Gemmellaro | | | | × | |
| ? Doryceras Gemmellaro | | | | × | |
| ? Clinolobus Gemmellaro | | | | × | |
| 15. Family CYCLOLOBIDÆ: | | | | | |
| Cyclolobus Waagen | | | | × | |
| Hyattoceras Gemmellaro | | | | × | |
| Shumardites Smith | | | × | | |
| Waagenoceras Gemmellaro | | | | × | |

## AMMONOIDS OF THE AMERICAN CARBONIFEROUS.

### GENERA REPRESENTED.

The writer has made no distinction between goniatites and ammonites, because there is none that will hold. Certain families, or genetic series, contain some genera that, on account of simplicity of the septa, would be called goniatites, and others that might appropriately be termed ammonites. There are other forms that, while having simple or goniatitic septa, have forward-pointing siphonal collars and would thus fall under the definition of ammonites. The form of the aperture has been frequently used as a mark of distinction between these two groups, but this is so commonly unknown as to have little value in systematic work.

There are at present known in the American Carboniferous eleven families, twenty-four genera, and eighty-nine species of ammonoids, besides two apocryphal species (not ammonoids). Their stratigraphic occurrence is as follows:

KINDERHOOK: *Prolecanites, Prodromites, Aganides, Prionoceras?, Muensteroceras, Goniolobocerasʔ, Pericyclus, Agoniatites.*

OSAGE: *Aganides?, Muensteroceras?.*

St. Louis-Chester: *Goniolobocerας, Glyphioceras, Goniatites* s. str., *Gastrioceras, Paralegoceras, Pronorites, Nomismoceras?*.

Lower Coal Measures: *Glyphioceras, Gastrioceras, Paralegoceras.*

Middle Coal Measures: *Popanoceras, Neoicoceras, Prolecanites?, Glyphioceras, Goniatites* s. str., *Gastrioceras, Paralegoceras.*

Upper Coal Measures: *Milleroceras, Glyphioceras?, Gastrioceras, Schistoceras, Shumardites, Paralegoceras, Agathiceras, Popanoceras, Schuchertites, Goniolobocerας, Dimorphoceras.*

Permian: *Paralegoceras, Popanoceras, Waagenoceras, Medlicottia.*

The association and range of the genera of the Upper Coal Measures are approximately the same as in the Uralian of Europe, except that in Europe the true ammonites are not known below the Permian.

*Popanoceras, Shumardites,* and *Schuchertites* would be classed by anyone among the ammonites, on account of their complex septa, while *Schistoceras* might justly be placed under the same group, on account of the large number of lobes and the forward-pointing siphonal collars.

While nearly all the characteristic European genera are present, some are extremely rare, represented by a single species, as *Agathiceras, Dimorphoceras, Nomismoceras,* and *Pericyclus;* others have a different range in America from that in Europe. *Dimorphoceras* appears first in Europe in the Visé horizon, but in America is unknown until the Upper Coal Measures, or Uralian. *Popanoceras* is known in Europe only in the Permian, but in America it occurs in the Middle and Upper Coal Measures. *Gastrioceras* and *Paralegoceras* do not appear in Europe before the middle of the Coal Measures, but in America they are known in the St. Louis-Chester. *Prodromites, Goniolobocerας, Schistoceras, Shumardites,* and *Schuchertites* are not yet known in the European region.

These differences of range and association give us hints as to the region where some of these forms originated, but the information is too indefinite to allow any positive statements as to the faunal geography of that time. This much is certain: At least periodically there was easy intermigration between the American and the European waters, for the community of genera, and even of species, is too great to be explained by any other hypothesis.

*Table of occurrence of ammonoid genera in the American Carboniferous.*

[The genera marked ××× are common; those marked ×× are rare; those marked × are very rare.]

| | Lower Carboniferous. | | | Coal Measures or Pennsylvanian. | | | Permian. |
|---|---|---|---|---|---|---|---|
| | Kinderhook. | Osage or Burlington-Keokuk. | St. Louis-Chester. | Des Moines. | | Missourian. | Wichita. |
| | Zone of *Aganides rotatorius.* | | Zone of *Goniatites striatus.* | Zone of *Glyphioceras diadema.* | Zone of *Gastrioceras listeri.* | Zone of *Gastrioceras marianum.* | Zone of *Medlicottia.* |
| BACTRITIDÆ: | | | | | | | |
| Bactrites | | | × | | | | |
| AGONIATITIDÆ: | | | | | | | |
| Agoniatites | × | | | | | | |
| GEPHYROCERATIDÆ: | | | | | | | |
| Nomismoceras | | | ×? | | | | |
| Superfamily PROLECANITIDÆ. | | | | | | | |
| BELOCERATIDÆ: | | | | | | | |
| Prodromites | × | | | | | | |
| PRONORITIDÆ: | | | | | | | |
| Pronorites | | | × | | × | | |
| Medlicottia | | | | | | | · |
| NORITIDÆ: | | | | | | | |
| Schuchertites | | | | | | × | |
| PROLECANITIDÆ: | | | | | | | |
| Prolecanites | ××× | | | | ×? | | |
| Superfamily GLYPHIOCERATIDÆ. | | | | | | | |
| GLYPHIOCERATIDÆ s. str.: | | | | | | | |
| Prionoceras | ×? | | | | | | |
| Pericyclus | × | | | | | | |
| Glyphioceras | | | × | ×? | × | ×? | |
| Goniatites s. str | | | ××× | | ×? | | |
| Gastrioceras | | | × | × | ××× | ××× | |
| Paralegoceras | | | × | × | × | | × |
| Schistoceras | | | | | | ×× | |
| AGANIDIDÆ: | | | | | | | |
| Aganides | ×× | | | | | | |
| Muensteroceras | ×× | | | | | | |
| Goniolobоceras | | | × | | | × | |
| Dimorphoceras | | | | | | × | |
| ? Milleroceras | | | | | | × | |

*Table of occurrence of ammonoid genera in the American Carboniferous*—Continued.

| | Lower Carboniferous. | | | Coal Measures or Pennsylvanian. | | | Permian. |
|---|---|---|---|---|---|---|---|
| | Kinderhook. | Osage or Burlington-Keokuk. | St. Louis-Chester. | Des Moines. | | Missourian. | Wichita. |
| | Zone of *Aganides rotatorius.* | | Zone of *Goniatites striatus.* | Zone of *Glyphioceras diadema.* | Zone of *Gastrioceras listeri.* | Zone of *Gastrioceras marianum.* | Zone of *Medlicottia.* |
| Superfamily ARCESTIDÆ. | | | | | | | |
| POPANOCERATIDÆ: | | | | | | | |
| Agathiceras | | | | | | × | |
| Popanoceras | | | | | × | × | × |
| CYCLOLOBIDÆ: | | | | | | | |
| Shumardites | | | | | | × | |
| Waagenoceras | | | | | | | × |
| Family indet. | | | | | | | |
| Neoicoceras | | | | | × | | |

## TABLE OF SPECIES DESCRIBED.

## DESCRIPTIONS OF THE SPECIES.

### Family BACTRITIDÆ.

#### Genus Bactrites Sandberger.

Shell straight or slightly curved, gently tapering, cross section circular or elliptical. Surface smooth except for the cross striæ of growth. Siphuncle marginal, with long backward-pointing extensions of the septum, as in *Spirula*. Septa simple, running nearly straight around the shell, but with a funnel-shaped siphonal lobe.

*Bactrites* was formerly regarded as a nautiloid, but its siphonal lobe and the calcareous protoconch that has been found on a few specimens cause it to be classed usually under the ammonoids. The genus has been usually considered as typical of the Devonian, and the species described below is the only authentic species known to occur in Carboniferous strata.

#### Bactrites carbonarius Smith, sp. nov.

Pl. VI, figs. 9–11.

Shell straight, gently tapering, slender, angle of the increase 5° 30′. Cross section of whorl circular. Chambers convex backward, deep, septa close together. The septum runs nearly straight around the shell, but has a slender tongue-shaped siphonal lobe, and short backward pointing siphonal collar. Siphuncle slender, with long backward extension of the septum, as in *Spirula;* when this extension reaches the extremity of the siphonal lobe it swells out into a knob-like expansion, supposed to represent a periodic repetition of the siphonal cæcum. From this contact with the septum a short siphonal collar extends backward into the next chamber. This septum is much more specialized than that of any other species of *Bactrites* yet described, but this is not remarkable if we consider the fact that the genus has not before been found above Devonian beds. Surface smooth except for fine sinuous imbricating cross striæ of growth.

*Bactrites* was probably the ancestor of the entire ammonoid stock, and thus in it we have a survival of a primitive type occurring along with the

more specialized descendants of that type This occurrence, however, is of even greater interest, not as an anachronism, but rather as a forerunner of other forms. Morphologists look to a straight orthoceran ammonoid as the ancestor of the Belemnoidea, but the gap from the Devonian to the Trias has been a rather severe tax on the faith of the geologist. Here, then, we have this gap at least partly filled out by the finding of *Bactrites* near the top of the Lower Carboniferous.

*Occurrence.*—St. Louis-Chester stage, so-called "Fayetteville shale" of the Arkansas geological survey, on farm of O. P. Goodwin, near Moorefield, Ark. The type was collected by the writer, and is deposited in his paleontologic collection at Leland Stanford Junior University, California.

## Family AGONIATITIDÆ.

### Genus AGONIATITES Meek.

The name *Agoniatites* was proposed by F. B. Meek[a] for compressed shells with flattened sides, narrow abdomens, narrow umbilici, with high and narrow aperture; septa consisting of a short abdominal lobe, and a lateral lobe consisting merely of a broad curve. The type chosen was *Goniatites expansus* Vanuxem.

### AGONIATITES OPIMUS White and Whitfield.

Pl. VII.

1862. *Goniatites opimus*, White and Whitfield, Proc. Boston Soc. Nat. Hist., Vol. VIII, p. 305.

1900. *Agoniatites opimus*, S. Weller, Kinderhook Faunal Studies, II, p. 121, Pl. VII, fig. 8; Pl. VIII, fig. 1; Pl. IX, fig. 1.

The following description is copied from Dr. Weller's paper:

Shell large, discoid, gently convex on the sides, rather sharply rounded on the periphery. Number of volutions not known, the inner ones embraced by the next outer one to a depth of one-half the diameter of the latter; the umbilicus rather small, but somewhat variable in size, being relatively larger in the larger individuals, its sides rounded. Aperture compressed crescentic in outline, the proportion of height to width about as 7 to 5, the ventral margin sinuate as indicated by the lines of growth. The size of the living chamber not known. Septa deeply concave, rather distant, being about 20 mm. apart in the outer volution of a large individual;

[a] U. S. Geol. Expl. Fortieth Parallel, Vol. IV, Pt. I, p. 99.

the sutures forming a low saddle upon the umbilical angle, then gently curving backward and forming on each lateral face a single broad lobe which occupies the entire width of the volution; the direction of the suture upon the periphery can not be certainly determined, but there seems to be a low saddle on either side, with a shallow ventral lobe between. Position of the siphuncle unknown. Surface marked by faint lines of growth which are sinuate on the periphery of the shell.

*Remarks.*—In the original description of *Goniatites opimus*, specimens of two entirely different species were apparently used, the general form of the shell being described from one specimen and the suture from another. The specimen here illustrated on Pl. VII, fig. 8 [in Weller's Kinderhook Faunal Studies, II, The Fauna of the Chonopectus Sandstone at Burlington, Iowa], is the type of the species in the University of Michigan collection, and corresponds with original description of the general form and proportions of the shell. This specimen, however, does not preserve the suture, and the original from which the suture was described has not been seen. The latter specimen was probably a fragmentary one, not preserving the form of the shell, which was believed to belong to the same species as the type which has been preserved. In the collection received from Prof. Calvin there is a goniatite much larger than the type of *G. opimus*, but agreeing closely with it in its general form and proportions in all respects save in its relatively larger umbilicus. This specimen is illustrated on Pls. VIII and IX [in Weller's paper cited above], and it is believed to be an individual of the same species as the type of *G. opimus;* but, unlike the type specimen, several of the sutures are fairly well preserved, and are entirely different from the sutures of *G. opimus* as indicated in the original description. It is therefore probable that the suture originally described as that of *G. opimus* is really that of some shell which is not only specifically but generically distinct from *G. opimus*. The true suture of the species is in all respects that of the genus *Agoniatites*, and therefore the species is placed in that genus. Heretofore this genus has been recognized only in the Devonian, and in America, at least, at no higher horizon than the Middle Devonian.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Chonopectus sandstone, Burlington, Iowa.

## Family GEPHYROCERATIDÆ.

### Genus NOMISMOCERAS Hyatt.

This genus was established by Hyatt,[a] with *Goniatites spirorbis* Phillips as the type, to include evolute shells with wide umbilicus and glyphioceran septa; it was regarded as belonging to the Glyphioceratidæ, section Dimorphoceræ. Haug[b] classes *Nomismoceras* under the Gephyroceratidæ, and regards it as the radical of the Meekoceratidæ of the Trias, the series being *Nomismoceras*, *Paralecanites*, *Lecanites*, *Meekoceras*.

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 330. [b] Études sur les Goniatites, p. 46.

It is possible that *Nomismoceras* may be the connecting link between this family and *Prolecanites*, although it may be a degenerate form of the Glyphioceratidæ, to which opinion E. Holzapfel[a] seems to incline.

### Nomismoceras ? monroense Worthen.

Pl. V, fig. 11.

1890. *Goniatites monroensis*, A. H. Worthen, Geol. Surv. Illinois, Vol. VIII, p. 150, Pl. XXVI, fig. 5.

Shell discoidal, evolute, compressed, sides slightly rounded, abdomen narrow and sharply rounded. Height of whorl a little greater than width; umbilicus comparatively wide, being about once and a half as wide as the height of the whorl. Umbilical shoulders rather angular and abrupt. Surface of shell smooth, septa consisting of a pair of short rounded lobes on each side, with obtuse saddles.

The generic reference is very doubtful; the species certainly does not agree with the type of the genus, but probably is as nearly related to it as are several other species that are generally classed under *Nomismoceras*.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Monroe, Illinois. Deposited in the Illinois State Museum.

## Superfamily PROLECANITIDÆ.

### Family BELOCERATIDÆ.

### Genus Prodromites Smith and Weller.

The type of this genus is *P.* (*Goniatites*) *gorbyi* Miller.[b] The type species was originally described as "*Goniatites*," but a most liberal interpretation of that group could not include this form, which was assigned to that division simply because of its occurrence in Carboniferous rocks.

The genus *Prodromites* is characterized by its laterally compressed, discoidal, involute deeply embracing whorls, narrow umbilicus, high, hollow abdominal keel, and complex ceratitic septa. Where the keel is broken off,

[a] Die Cephalopoden des Domanik im südlichen Timan, p. 21: Mém. Com. géol. Russie, XII, No. 3.

[b] Advance sheets Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 90, Pl. XV, fig. 1; and Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 700, Pl. XV, fig. 1.

as is usually the case, the abdomen is flattened and angular. The surface, as far as known, is smooth, destitute of ribs, constrictions, or other ornamentation. The septation is the most distinctive feature of this genus, on account of the large number of serrated lobes, and extensive auxiliary series of lobes and saddles. The ventral lobe is rather long and undivided, the saddles all rounded and entire; the first four or five lateral lobes are serrated, and in addition to these there is a series of six or more pointed and more or less irregular auxiliary lobes.

The only Paleozoic genus to which *Prodromites* may be likened is *Beloceras* Hyatt, which it resembles only in its compressed involute form and in the multiplication of the elements of the septa The resemblance is not great, but the agreement is fundamental, and the two genera may safely be placed in the same family or phylum. A much greater resemblance and probable kinship connects this form with *Hedenstræmia* Waagen, of the Lower Trias of the Oriental region. The best known species of that genus is *H. mojsisovicsi* Diener.[a] In *Hedenstræmia*, as defined by Waagen,[b] the ventral lobe is divided, the external saddle is divided by adventitious lobes; the first four lateral lobes are serrated, and there is a series of about six pointed auxiliary lobes. The form is flattened, involute, with narrow and angular abdomen. No keel is known, and the shell is smooth. In *Prodromites*, on the other hand, the ventral lobe is undivided, and the external saddle is entire and rounded; but in the serration of the first four or five lateral lobes, and in the auxiliary series it is almost identical with *Hedenstræmia*, as also in the form, with the exception of the keel, which may not have been preserved in the few specimens known. There can be no doubt that the two genera belong to the same phylum and even family, in spite of the long time that intervened between the Kinderhook formation of the Lower Carboniferous and the Lower Trias. *Hedenstræmia* (Pl. XXV, fig. 5), according to Waagen,[c] belongs to the family Pinacoceratidæ, subfamily Hedenstræminæ, which also contains *Clypites* Waagen, and *Carnites* Mojsisovics of the Trias. The family Pinacoceratidæ in the broader sense, as defined by Waagen, contains all forms with compressed involute whorls, an adventitious series of lobes, many lateral lobes and saddles, and an

[a] Pal. Indica, Ser. XV, Himalayan fossils, Vol. II, Pt. I, Cephalopoda of the Lower Trias, p. 63, Pl. XX, fig. 1a–c.

[b] Pal. Indica, Ser. XIII, Salt Range Fossils, Vol II, Fossils from the Ceratite formation, p. 140.

[c] Ibid.

auxiliary series of lobes outside of the umbilicus. In this family Waagen groups the following subfamilies: 1, Medlicottinæ; 2, Beloceratinæ; 3, Beneckeinæ; 4, Hedenstrœminæ; all of which have representatives in American Paleozoic or Triassic strata.

It is not likely that *Prodromites* is a descendant of *Beloceras*, since the septation is quite different in the two genera; and unless *Hedenstrœmia* should be found to have a keel, it is not probable that it has descended from *Prodromites*. *Beloceras* is commonly placed in the family Prolecanitidæ, although it antedates any typical species of *Prolecanites*. On the other hand, *Medlicottia*, which appears to be closely related to *Prodromites*, seems certainly to have been a descendant of the typical Prolecantidæ. No solution of these questions is possible until the ontogeny of several of these genera is known, which is prevented, at present, by a scarcity of specimens. Until other evidence is forthcoming *Prodromites* is placed under the Beloceratidæ, as an ancestral group of the family Pinacoceratidæ.

The genus is not founded solely on Miller's figure, which is not accurate, nor even on his type specimens, but also on three other specimens of this species and one of another species, bringing out certain characters that did not show on Miller's type. The writer has had at his disposal for study four specimens of *Prodromites gorbyi* Miller, and one of *P. præmaturus* Smith and Weller, all of which, except one, belong to the paleontologic collection of the Walker Museum, University of Chicago, to the authorities of which the writer's thanks are due for the use of the specimens. The first specimen, No. 6208,[a] is Miller's type of *Goniatites gorbyi*, and came from the Chouteau limestone, Pin Hook Bridge, Pettis County, Mo. A second specimen, No. 6474, was obtained from Prof. G. C. Broadhead; it is better preserved than the type, but is in the same sort of limestone, and while it is merely labeled "Chouteau limestone, Pettis County, Mo.," it probably came from the same locality as the type. A third specimen, No. 6722, is recorded merely from the Kinderhook stage of Burlington, Iowa. The material in which it is preserved is a buff or yellowish, rather finely crystalline limestone, the position of which in the Kinderhook section at Burlington is probably near the top, between the oolitic limestone and the buff magnesian bed, which lies immediately below the Burlington limestone,

[a] The numbers refer to the Walker Museum collection.

of Osage age. This horizon may then be correlated with the Chouteau limestone of central Missouri.

A fourth specimen of *Prodromites gorbyi* was studied in the collection of Fred. Braun, of Brooklyn, N. Y.; it came from the goniatite beds of the Kinderhook of Rockford, Ind., associated with *Prolecanites lyoni* Meek and Worthen, *Aganides rotatorius* de Koninck, *Muensteroceras oweni* Hall, *M. parallelum* Hall; thus it is certainly in the zone of *Aganides rotatorius* of the Tournaisian horizon of the Lower Carboniferous (Mississippian or Dinantian).

A fifth specimen of the genus, No. 6223, belongs to a new species, (*P. præmaturus* Smith and Weller); it came from the goniatite beds of the Kinderhook of Rockford, Ind.

*Occurrence.*—Since this genus occurs in the same horizon, in rocks of different lithologic character, and in three localities, separated by hundreds of miles, it may be considered as characteristic of the Kinderhook or Chouteau horizon of the Lower Carboniferous, equivalent to the lower part of the Tournaisian division of the European Dinantian formation. At present, *Prodromites* is not known outside of America, and but three species are known, in the Mississippi Valley region, from the three localities mentioned.

### Prodromites gorbyi Miller.

Pl. XXIII; Pl. XXV, figs. 1, 2.

1891. *Goniatites gorbyi*, S. A. Miller, Advance sheets Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 90, Pl. XV, fig. 1.

1892. *Goniatites gorbyi*, S. A. Miller, Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 700; Pl. XV, fig. 1.

1901. *Prodromites gorbyi*, Smith and Weller, Jour. Geol., Vol. IX, No. 3, p. 259, Pl. VI, fig. 1; Pl. VII, fig. 1; Pl. VIII, figs. 1 and 2.

Neither the description nor the figure of this type given by Miller is accurate, the drawings of the septa being much too generalized. The form is laterally compressed, involute, discoidal, with very narrow umbilicus. The abdomen is narrow and surmounted by a high hollow keel, which, however, is not usually preserved. Where the keel is broken away the abdomen is narrow, less than a millimeter wide, with angular edges. The sides are smooth, devoid of constrictions, ribs, or other ornamentation, so far as could be determined from the casts.

The septa are complex, ceratitic, with many lobes and saddles. The

ventral lobe is long and undivided. The external saddle is rounded, entire, and shorter than the laterals. The first lateral lobe is serrated, four-pointed; the second four-pointed; the third, three-pointed; the fourth, irregularly three-pointed; the fifth, irregularly bifid. With the sixth lateral lobe begins the auxiliary series of goniatitic lobes, which are of irregular size, and eight in number at maturity, growing smaller toward the umbilicus. These characters could not be made out distinctly on Miller's type, but the details were clearly seen on No. 6474, from the same locality. The differences between the two specimens might seem, at a casual glance, to be specific, but closer study shows them to be due to difference of preservation, and to different sizes at which the septa are seen. The type specimen shows the keel at only a few places on the periphery, and so indistinctly that Miller overlooked it, while No. 6474 shows the keel, 3½ mm. high, entirely around the periphery. On both specimens the body chamber is incomplete and occupies a little over a fourth of the last revolution. It is not known what was the shape of the aperture, how long the body chamber was when the keel began, nor what the internal lobes were like, since none of the specimens available sufficed to answer these questions.

A smaller specimen, No. 6222, from the Kinderhook beds, of Burlington, Iowa, showed much simpler septa and the narrow angular abdomen with the keel broken off. It is undoubtedly in the beginning of the mature stage of growth, and is of value in showing the shape of the cross section, since the sides were free from the matrix.

*Occurrence.*—At present there are known only five specimens of *Prodromites gorbyi*, all from the same horizon, Kinderhook or Chouteau stage zone of *Aganides rotatorius* of the Lower Carboniferous, equivalent to the Tournaisian horizon of the Dinantian formation of Europe, viz:

1. Miller's type, from the Chouteau limestone of Pin Hook Bridge, Pettis County, Mo. No. 6208, paleontologic collection, Walker Museum, University of Chicago (Gurley collection). This specimen is the type of the genus *Prodromites* Smith and Weller (Pl. XXIII, fig. 1).

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 114 |
| Height of last coil | 64 |
| Height of last coil from the preceding | 35 |
| Width of last coil | -- |
| Involution | 29 |
| Width of umbilicus | 4 |

2. Specimen obtained from Prof. G. C. Broadhead, Chouteau limestone, Pettis County, Mo., probably from the same locality as the last, No. 6474, paleontologic collection, Walker Museum, University of Chicago (Pl. XXIII, fig. 2).

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 117 |
| Height of last whorl | 68 |
| Height of last whorl from the preceding | 38 |
| Involution | 30 |
| Width of umbilicus | 5? |

3. Specimen from the Kinderhook limestone of Burlington, Iowa, between the oolitic limestone and the buff magnesian bed that lies immediately below the Burlington beds of the Osage stage. No. 6222, paleontologic collection, Walker Museum, University of Chicago (Pl. XXV, figs. 1 and 2).

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 75 |
| Height of last whorl | 42 |
| Height of last whorl from the preceding | 25 |
| Width of last whorl | 10 |
| Involution | 17 |
| Width of umbilicus, about | 4 |

4. Specimen from the goniatite beds of the Kinderhook of Rockford, Ind.; in the paleontologic collection of Fred. Braun, of Brooklyn, N. Y., where it was examined by the writer. Its dimensions are about the same as of the two specimens from Missouri.

5. A specimen from this species is said to be in the U. S. National Museum, but it has not been seen by the writer.

### Prodromites ornatus Smith, sp. nov.

Plate XXV, figs. 6–8.

Form discoidal, involute, laterally compressed. Whorls deeply embracing, and deeply indented by the inner volutions. Cross section of the whorl high and narrow, with flattened sides and acute venter, surmounted by a sharp, narrow keel. The umbilicus is almost entirely closed, and without umbilical shoulders. The height of the whorl is somewhat more than one-half of the total diameter of the shell, and the breadth is one-fourth of the height; it is indented by the inner volution to one-half of

its height. The surface of the cast is ornamented with sigmoidal ribs, which bend backward toward the venter. These ribs are fine and sinuous, showing with unusual distinctness on the cast. The outer shell is unknown, but they should be even more distinct on it.

Septa ceratitic, lanceolate. The ventral lobe seems to be undivided, the first lateral is indistinctly tripartite, the second lateral distinctly serrated, and the third is bifid; these are followed by a series of six unserrated auxiliary lobes, growing smaller and shorter toward the umbilicus.

From its small size, its shape, and the primitiveness of its septa, this specimen might be considered as the young of *Prodromites gorbyi*, but in all known specimens of that species the surface of the cast is perfectly smooth. It undoubtedly belongs to that genus, and is perhaps the young of some unknown form, but probably not that of *Prodromites gorbyi*, nor of *P. præmaturus;* a name is therefore given to it by which the mature form may be known when it is discovered.

Only a single specimen is known, No. 7682, paleontologic collection, Walker Museum, University of Chicago. The writer's thanks are due Dr. Stuart Weller for the use of the type. Diameter of the type, 28 mm.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pettis County, Mo.

### Prodromites præmaturus Smith and Weller.

Pl. XXV, figs. 3 and 4.

1901. *Prodromites præmaturus*, Smith and Weller, Jour. Geol., Vol. IX, No. 3, p. 261, Pl. VIII, figs. 3 and 4.

Type of species is specimen No. 6223, paleontologic collection, Walker Museum, University of Chicago (Gurley collection). Form laterally compressed, discoidal, involute, deeply embracing, with narrow umbilicus, narrow, slightly flattened abdomen surmounted by a hollow keel 3 mm. high. Whorl indented by the preceding whorl to a little over one-third of its height. Surface smooth, so far as known.

The septa are complex, ceratitic, with rounded, entire saddles, serrated lateral lobes, and a series of auxiliaries above the umbilicus. The ventral lobe is narrow and undivided; the first lateral is longer and three-pointed; the second lateral, four-pointed; the third lateral, bifid; the fourth lateral, bifid; then begins a series of auxiliary lobes, undivided and pointed, seven in number.

The only species with which *Prodromites præmaturus* might be compared is *P. gorbyi*, from the same horizon, but in *P. præmaturus* the abdomen is slightly broader, the shell rather thicker, the septa rather more complex, and the umbilicus slightly wider than on *P. gorbyi* at the same diameter. In the figures and descriptions of the septa a difference between the two species may easily be seen.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 62 |
| Height of last whorl | 34 |
| Height of last whorl from the preceding | 21 |
| Width of last whorl | 9.5 |
| Involution | 13 |
| Width of umbilicus | 6.5 |

This specimen was septate throughout, and when complete must have been much larger.

*Occurrence.*—Only a single specimen is known, No. 6223 of the paleontologic collection, Walker Museum, University of Chicago, from the Lower Carboniferous, Kinderhook limestone, goniatite beds of Rockford, Ind., near the base of the Mississippian series.

## Family PRONORITIDÆ.

As it is now generally admitted that *Pronorites* and its allies can not be classed under the family Prolecanitidæ in the strictest sense, some new designation for this group ought to be given. E. Haug[a] proposed the name Ibergiceratidæ for this phylum, but the genus on which the family was founded, *Ibergiceras*, has since been shown to be merely an immature form of *Pronorites cyclolobus*. Since *Pronorites* is the principal genus of this group, and is the ancestor of a large number of genera that occur in the Permian and Trias, the writer proposes to call the family Pronoritidæ, including *Pronorites*, *Sicanites*, *Propinacoceras*, and *Medlicottia*. These all seem to have been derived from *Paraprolecanites*, which may then be considered as the family radicle. F. Frech[b] has used the term Pronoritinæ for this group, regarding it as a subfamily.

### Genus PRONORITES Mojsisovics.

In the adult stage *Pronorites* is discoidal, has high, narrow whorl, with nearly parallel sides, is very involute, and has narrow umbilicus.

The siphonal lobe is three-pointed, the first lateral lobe divided into

[a] Études sur les Goniatites, p. 50. [b] Die Dyas, p. 481.

two or three parts by secondary sinuses. In addition to these there are several auxiliary lateral lobes, three to six, all slightly pointed, while all the saddles are rounded. No constrictions or other surface ornamentations are known, except that on the adult body chamber faint ribs have been observed.

The first septum of *Pronorites* is latisellate, and the broad sinus is soon divided by a siphonal lobe into two lateral sinuses (Pl. XII, fig. 1). This is the end of the embryonic stage, in which the shell is seen to belong to an ammonoid cephalopod, but the family is not yet indicated.

In the next stage the lateral sinuses are subdivided by broad, rounded lobes; the sutures then resemble those of *Goniatites* (*Ibergiceras*)[a] *tetragonus* Roemer, and the shell is in the beginning of the larval or nepionic stage; a little further on the sutures are like those of a *Prolecanites* (*P. serpentinus* Phillips), and the larval stage is approaching its end.

In the following or neanic stage the siphonal lobe becomes three-pointed, and the shell corresponds to *Paraprolecanites* Karpinsky, and its family affinities are beyond doubt (Pl. XIII, fig. 5).

With the adult or ephebic stage the first lateral lobe becomes divided into two or three parts (Pl. XIII, fig. 5c–f). With this stage the genus *Pronorites* stops; but Gemmellaro has described from the Permian of Sicily a further development of this series in the genus *Parapronorites*, in which the double lateral lobe and some of the simple ones become serrated.

Another line of development of *Pronorites* has been described by Gemmellaro as *Sicanites*, in which all the lateral lobes become double like the first one. The next higher stages are given by *Medlicottia* Waagen, in which the siphonal saddles become indented and ammonitic. Karpinsky[b] shows that *Medlicottia* in its development goes through the *Ibergiceras*, *Prolecanites*, *Paraprolecanites*, *Pronorites*, *Sicanites* and *Promedlicottia* stages.

*Pronorites* is represented in America by two species, one in the upper part of the St. Louis-Chester stage, and one in the Middle Coal Measures, both in Arkansas. The finding of *Pronorites* in Arkansas is of great importance, since it is the ancestor of *Medlicottia*, which, though unknown in Arkansas, has been found at no great distance away in the Texas Permian. *Pronorites*, on the other hand, has not yet been found in Texas.

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[a] Holzapfel has recently shown in Die Cephalopoden des Domanik im südlichen Timan, p. 45, that *Ibergiceras tetragonus* Roemer is merely a young stage of *Pronorites cyclolobus* Phillips, and came from the Carboniferous limestone instead of from the Devonian strata of the Hartz.

[b] Ammoneen der Artinsk-Stufe, p. 41.

These occurrences help to prove the continuity of life from the Carboniferous into the Permian, and to show that the same conditions existed here as in the Artinsk region of the Ural Mountains, where the Carboniferous beds contain the goniatites out of which most of the Permian ammonites were developed.

PRONORITES CYCLOLOBUS Phillips, variety ARKANSASENSIS Smith.

Pl. XII, figs. 12–15.

1836. *Goniatites cyclolobus*, J. Phillips, Geol. Yorkshire, Pt. II, p. 237, Pl. XX, figs. 40–42.
1845. *Goniatites cyclolobus*, Murchison, Verneuil, and Keyserling, Géol. Russie d'Europe, etc., Vol. II, p. 370, Pl. XXVII, fig. 4.
1855. *Goniatites cyclolobus*, F. A. Roemer, Palæontographica, Vol. V, p. 167, Pl. XXVII, fig. 1 (not Pt. II, p. 95, Pl. XIII, fig. 34).
1860. *Goniatites cyclolobus*, F. A. Roemer, Palæontographica, Vol. IX, p. 11, Pl. IV, figs. 1, a, b, c.
1880. *Goniatites cyclolobus*, L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 273, Pl. L, figs. 5, 6.
1882. *Pronorites cyclolobus*, E. von Mojsisovics, Cephalop. Mediterranen Triasprovinz, p. 201.
1884. *Pronorites cyclolobus*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 337.
1884. *Pronorites cyclolobus*, K. A. von Zittel, Handbuch der Palæont., Vol. II, p. 421, fig. 580.
1888. *Goniatites cyclolobus*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 311.
1889. *Pronorites cyclolobus* var. *uralensis*, A. Karpinsky, Ammoneen der Artinsk-Stufe, p. 8, Pl. I, fig. 4.
1890. *Pronorites cyclolobus*, Steinmann and Döderlein, Elemente der Paläont., p. 395, fig. 475.
1895. *Pronorites cyclolobus*, K. A. von Zittel, Grundzüge der Palæont., p. 400, fig. 1089.
1896. *Pronorites cyclolobus* var. *arkansasensis*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 267, Pl. XXIV, figs. 1–4.
1897. *Pronorites cyclolobus*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 264, fig. 125.
1900. *Pronorites cyclolobus*, A. Hyatt, Cephalopoda, p. 562, fig. 1156. (Not *Goniatites cyclolobus* Barrois, Mém. Soc. Géol. du Nord., Vol. II, p. 295, Pl. XIV, fig. 2, a–c=*Pronorites barroisi* Karpinsky.)

Phillips's original description of *Goniatites cyclolobus* is as follows:

Discoid, sides flat, back broad, inner whorls half concealed, septa with four round lateral lobes, a small double dorsal lobe, and small acute dorsal sinuses, the first lateral sinus double, the others simple, all round.

This description is too meager to be of more than generic value, and also the term "dorsal" is used where now "abdominal" is in common use.

The shell is smooth, discoidal, very involute. The sides are nearly

parallel and the breadth increases very slowly; the abdominal shoulders are nearly square, and the abdomen flat. The whorls are deeply embracing and increase rapidly in height. The umbilical shouders are square, the umbilicus narrow and deep, and increases slowly in diameter.

*Dimensions.*—The specimen, which was septate throughout, gave the following dimensions:

| | Millimeters. |
|---|---|
| Diameter | 34.0 |
| Height of last whorl from umbilical shoulders | 17.5 |
| Breadth | 10.0 |
| Width of umbilicus | 7.0 |

This gives the proportions: 1 : 0.5 : 0.29 : 0.20 : which agree almost exactly with Karpinsky's figures, 1 : 0.5 : 0.30 : 0.20. On the Arkansas specimen the involution is shown by the height of the last whorl from the top of the next inner one, 12.5 mm. as compared with the total height of the whorl, which is 17.5 mm. No measurements of this relation were shown on the Russian specimen.

This description applies only to the adult shell, the relative measurements of the nepionic and neanic shells being very different. The Arkansas specimen showed only the last whorl, but the young stages have been worked out by Karpinsky,[a] from whose work the following description is translated:

> Around the cylindrical embryonic chamber [Pl. XIII, fig. 2] are coiled very evolute whorls, whose involution increases gradually, but at first only in slight measure [Pl. XIII, fig. 4]. So, for example, the fourth whorl embraces at the beginning only about one-fourth of the preceding; thus the height of the evolute portion of this fourth whorl is six or seven times as great as that of its own involute portion.
>
> With later stages of growth the involution increases so that the whorls become finally completely embracing, and probably conceal a portion of the umbilicus. Because of this mode of growth the umbilicus appears at first broad, and increasing rapidly, then only gradually, and finally not at all, while the whorl continues to grow in height with great rapidity. Thus, at a diameter of the whorl of 4 or 5 millimeters, the umbilicus is about one-half of the total diameter, and at 30 millimeters only about one-fifth. The first and second whorls have a broad elliptical cross section [Pl. XIII, fig. 3], while that of the succeeding whorls becomes higher, with the long elliptical axis vertical [Pl. XIII, fig. 2], and then finally the flanks are bounded by almost parallel lines and the siphonal side is only slightly arched.

*Ontogeny.*—According to Karpinsky the first or typembryonic stage is latisellate—that is, the suture consists of a broad abdominal saddle; this saddle is next divided by a broad siphonal lobe (Pl. XII, fig. 1).

[a] Ammoneen der Artinsk-Stufe, p. 8.

The next stage corresponds to the supposed genus *Ibergiceras* Karpinsky, of which *Gon. tetragonus* Roemer is the type; in this the whorls are broad, low, and only slightly embracing, the umbilicus wide and shallow. The sutures consist of a long rather narrow siphonal lobe and two broadly rounded lateral lobes. This is the nepionic or larval stage (Pl. XIII, fig. 5*a*). In the continuation of this stage the whorls become higher and the lobes more complicated, corresponding to the genus *Prolecanites*, of which *Gon. henslowi* Phillips and *Gon. serpentinus* Phillips are typical forms.

In the next stage the shape of shell does not change materially, but the siphonal lobe becomes three-pointed (Pl. XIII, fig. 5); this is the neanic or youthful stage, and corresponds to the genus *Paraprolecanites* Karpinsky, of which the type is *Gon. mixolobus* Sandberger (not Phillips).[a]

The further development consists in the division of the first lateral lobe by a secondary saddle; the shell is then in the ephebic or adult stage, and in *Pronorites* gets no higher in its development.

The sutures are then constant in shape, and consist of a three-pointed siphonal lobe, a first lateral lobe deeply divided by a secondary saddle and five secondary lateral lobes outside the umbilical border, and one on the umbilical shoulder. All the lobes are pointed, and the saddles rounded. The inner lobes, covered by the involution, are unknown.

The sutures, as figured on Pl. XII, fig. 15, show some differences from those figured by Phillips, Pl. XII, fig. 3, and by Karpinsky, Pl. XIII, fig. 5. On the Arkansas specimens the three-pointed siphonal lobe is longer than on the type of Phillips, or the form *P. cyclolobus* variety *uralensis* Karpinsky, the secondary sinus on the first lateral lobe is deeper, and the second lateral lobe is proportionally longer. In this the Arkansas specimen does not depart further from the type than the variety *uralensis*. This difference was thought to be of sufficient importance to characterize a new variety, and the name *P. cyclolobus* Phillips, variety *arkansasensis* was proposed in 1896.

*Surface markings.*—The shell is smooth and devoid of constrictions or other ornamentation, but on the body chamber of the adult Karpinsky observed weak ribs that are stronger on the abdomen and grow weaker toward the umbilicus.

[a] Verstein. Rhein. Schichtensystems in Nassau, p. 67, Pl. III, fig. 13?; Pl. IX, fig. 6.

*Affinities.*—This species is certainly a variety of *Pronorites cyclolobus* Phillips,[a] but is more involute at the corresponding diameter, and has a narrower umbilicus and a greater number of lateral lobes. Specimens described by de Koninck[b] from Belgium, and by Roemer[c] from the Hartz Mountains in Germany, agree perfectly with the type of *Pronorites cyclolobus;* the English, Belgian, and German beds, in which the species was found, are all in about the same horizon as the bed in which it was found in Arkansas, and are considerably older than the Upper Carboniferous limestone in which it was found in the Ural Mountains. From this Karpinsky[d] thinks the variety *uralensis* represents a mutation from the type of the species.

The form from the Pyrenees described by Barrois[e] as *Goniatites cyclolobus* Phillips has been shown by Karpinsky to be a new species, *P. barroisi* Karpinsky. This form is more evolute than even the type of *P. cyclolobus*, and its lobes and saddles are broader and also less numerous.

*Occurrence.*—*Pronorites cyclolobus* Phillips, variety *arkansasensis* Smith was found with *Gastrioceras branneri* Smith in Arkansas, on Pilot Mountain, Carroll County, 3½ miles southwest of Valley Springs, in T. 17 N., R. 19 W., sec. 18, northeast corner, near the junction of the Chester limestone of the Lower Carboniferous with the Lower Coal Measures or "Millstone grit," but probably in the Chester stage, judging from the occurrence of *Productus cestriensis* Meek and Worthen in the same beds with the goniatite. The beds are called A 10 in Prof. H. S. Williams's section; below them lie 55 feet of micaceous sandstones and shales (A 9 of the section), and below that coarse, reddish-brown fossiliferous limestone, belonging to the Chester stage of the Lower Carboniferous.

The type figured on Pl. XII, figs. 12–15, is the property of the U. S. Geological Survey (National Museum), locality number 1275.

*Pronorites cyclolobus* has been found in England in the upper part of the Mountain limestone; in Belgium in the limestone of Visé; in Germany in the Kohlenkalk of the Hartz; and the variety *uralensis* has been found in Russia in the Upper Carboniferous limestone of the Ural Mountains in C 2 of the section.

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[a] Geol. Yorkshire, Pt. II, p. 237, Pl. XX, figs. 40–42.
[b] Faune calc. carbon. de la Belgique, Vol. I, p. 273, Pl. L, figs. 5 and 6.
[c] Palæontographica, Vol. IX, p. 167, Pl. XXVII, fig. 1.
[d] Ammoneen der. Artinsk-Stufe, p. 10.
[e] Mém. Soc. Géol. du Nord, Vol. II, No. 1, p. 295, Pl. XIV, fig. 2.

PRONORITES SIEBENTHALI Smith, sp. nov.

Pl. XI, figs. 5–7.

1896. *Pronorites* sp. indet., J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 270, Pl. XX, figs. 2a–c.

In the Middle Coal Measures of Scott County, Ark., T. 1 N., R. 28 W., sec. 4, SE ¼ of SE. ¼, was found a single fragment that seems to belong to *Prodromites*. It is septate, and must have belonged to an individual about 2½ inches in diameter. The sides are smooth and little embracing and almost parallel; the coil is thin and discoidal, and the ventral or external portion seems to be only slightly arched. From the umbilicus toward the ventral portion are seen five lateral lobes that are long and pointed, the saddles being somewhat rounded. The siphonal lobe and part of the first lateral lobe are not seen, that part of the shell being worn so that they can not be made out, but enough of the first lateral lobe is visible to show the secondary saddle that divides it. The septa are very close together, as seems to be the case on all species of this genus.

The nearest known relative is *Pronorites cyclolobus* Phillips, var. *uralensis* Karpinsky.[a] The lobes figured on Pl. I, fig. 4, of Karpinsky's monograph are very like those of the specimen from Scott County, and the general shape of the coil, the height, and the amount of the involution are about the same on both.

*Occurrence.*—Middle Coal Measures, Scott County, Ark., T. 1 N., R. 28 W., sec. 4.

Genus MEDLICOTTIA Waagen.

It was once thought that ammonites were not found below the Mesozoic, and that all the Paleozoic ammonoids were goniatites. A survival of this idea is seen in Dr. C. A. White's description of the Permian ammonites of Texas as "Mesozoic types." But to-day it is recognized that ammonites are quite as characteristic of the Permian as of any later formation.

*Medlicottia* was one of the first Paleozoic ammonites to be described, a species of this genus having been published by Murchison, Verneuil, and Keyserling[b] under the name *Goniatites orbignyanus*, from the Artinsk formation, Lower Permian, of eastern Russia.

[a] Ammoneen der Artinsk-Stufe, p. 8, Pl. I, fig. 4.
[b] Géol. Russie d'Europe etc., Vol. II, p. 375, Pl. XXVI, fig. 6.

Since that time species of this genus have been found in the Permian of India, Sicily, and Texas, and one species has recently been described by Diener[a] from the Lower Trias, so that it is no longer to be regarded as exclusively Paleozoic.

As to the systematic position of this genus there is no doubt, for Karpinsky[b] settled that question by his researches in the ontogeny of *Medlicottia*, *Pronorites*, and kindred forms. The only question now is whether *Medlicottia* is to be placed in a separate subfamily, Medlicottinæ, or whether the larger group, Prolecanitidæ, shall be retained. Waagen regards the latter group as a suborder.

### Medlicottia copei White.

Pl. XXII, figs. 1–3.

1889. *Medlicottia copei*, C. A. White, Am. Nat., Vol. XXIII, p. 117, Pl. I, figs. 1, 3.
1891. *Medlicottia copei*, C. A. White, Bull. U. S. Geol. Survey No. 77, p. 21, Pl. I, figs. 1, 3.
1901. *Medlicottia copei*, F. Frech, Die Dyas, p. 512, figs. 1 and 2.

Shell discoidal, compressed laterally, sides almost flat, narrow umbilicus; narrow flattened venter, with moderately deep ventral furrow bounded by angular and slightly beaded keels. Whorls involute and deeply embracing, becoming more so as age advances. Surface almost smooth, ornamented with fine curving cross ribs; the spiral ribs or striæ that are found on some species of *Medlicottia* have not been observed on the Texas specimens. The septa are complex, as is always the case with this genus. The siphonal lobe is long and narrow, with a number of small denticulations on the sides. The external saddle is deeply digitate and rather broad. The lateral saddles are long and tongue-shaped, but entire. The four principal lateral lobes are narrow and deeply bifid. There are also about eight auxiliary lateral lobes, of which the two highest upon the sides are bifid, and those nearer the umbilicus undivided, thus exemplifying Jackson's law of localized stages of development.

*Occurrence.*—In the Permian of Baylor County, Tex., at the military crossing on the Big Wichita River; also near San Angelo, Tom Green County, Tex.

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[a] Pal. Indica, Ser. XV, Himalayan fossils, Vol. II, Pt. I, p. 58.
[b] Ammoneen der Artinsk-Stufe.

Since this genus is so widely spread and so characteristic of the Permian, this horizon has been called the zone of *Medlicottia*. Closely related species have been found in the same horizon and in approximately the same association in the Artinsk formation of the Ural Mountains; in the Productus limestone of the Salt Range of India; in the Fusulina limestone of Sicily; and in the Wichita formation of northern Texas. Haug[a] has attempted to subdivide the Permian into zones, based on species of *Medlicottia*, but this is impracticable, since these species are not interregional in distribution and since the exact stratigraphic relations of these beds in various parts of the world are not yet known.

## Family NORITIDÆ.

### Genus SCHUCHERTITES gen. nov.

Form discoidal, laterally compressed; sides flattened; abdomen narrow, angular, and channeled. Close coiled, involute, with narrow umbilicus. Surface devoid of ribs, constrictions, and other ornamentation, except curved cross striæ of growth, forming gentle undulations on the shell.

Septa ammonitic and complex, with numerous lobes and saddles. Siphonal lobe divided into two short lobes by a secondary siphonal saddle. First lateral saddle divided by a short rounded indentation or adventitious lobe; all the other saddles rounded and entire. Lobes somewhat digitate and club-shaped, constricted at the upper portion. The septa, instead of running straight across the sides, are arranged in a backward-pointing curve, parallel with the striæ of growth.

No similar Paleozoic genus has been described, so its systematic position is somewhat doubtful, especially since the young stages of the shell are unknown. But the compressed, involute, discoidal form and the complication of the septa suggest a relationship to *Medlicottia*, hence it is grouped near that genus under the superfamily Prolecanitidæ, and doubtfully referred to the Noritidæ. The shape of the whorl, the character of the septa, and the surface of the shell remind one strongly of *Hauerites* Mojsisovics, of the Upper Trias, but *Schuchertites* is much too complex to have been the ancestor of that genus; it is probably only a case of parallelism, in accelerated development from a kindred stock.

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[a] Études sur les Goniatites, p. 70.

No Permian forms are known that could have developed out of this genus, so probably it is the end of a series which itself is at present unknown, for *Pronorites* could not have been the ancestor, and this is the only involute discoidal member of the Prolecanitidæ known from the Carboniferous. This genus is the most highly specialized form known in the Carboniferous, and is as complex as any yet described from the Permian. The occurrence of such forms suggests the great gaps that exist in our knowledge of the Paleozoic ammonoids, and inspires the hope that eventually these gaps will be filled out.

*Occurrence.*—*Schuchertites* is at present known only from the Upper Coal Measures, the type of the genus, *Schuchertites grahami* sp. nov., being known from only a single locality, Graham, Tex. Named in honor of Mr. Charles Schuchert, of the U. S. National Museum.

SCHUCHERTITES GRAHAMI Smith, sp. nov.

Pl. XXI, figs. 20–22.

This species, represented by only a single imperfect specimen, U. S. Nat. Mus. No. 27206, is laterally compressed, discoidal, involute, with flattened sides, narrow umbilicus, and narrow channeled abdomen. Surface so far as known is devoid of ribs and constrictions, but has fine curved cross striæ of growth, forming gentle undulations on the shell.

The septa are complex and ammonitic, divided into eight lobes and saddles. The siphonal lobe is divided by a short angular secondary saddle; the first five lateral lobes are undivided and digitate, and there are three simple auxiliary lobes, not digitate, but club-shaped. The first lateral saddle is divided by a short rounded secondary lobe, the other lateral saddles are undivided, and rounded at the extremities. The lobes are sharply constricted at the upper portion, giving a club shape to the lobes and a phylliform appearance to the saddles. The septa, instead of running in a straight line across the sides, are arranged in a backward-pointing curve, parallel to the striæ of growth. Internal septa unknown.

*Occurrence.*—Upper Coal Measures, Graham, Young County, Tex., about a thousand feet below the Permian, associated with a typical Upper Coal Measures fauna. Collected by A. B. Gant.

*Dimensions of the type specimen.*

| | Millimeters. |
|---|---|
| Diameter | 27 |
| Height of last whorl | 14.5 |
| Height of last whorl from the preceding | 9.5 |
| Width of last whorl | 6 |
| Involution | 5 |
| Width of umbilicus, about | 3 |

The specimen was septate throughout, and must, if complete, have reached at least twice this size.

## Family PROLECANITIDÆ s. str.

In this paper the superfamily Prolecanitidæ is used in the broad sense, as it was by Karpinsky, and is thus equivalent to Hyatt's superfamily *Prolecanitida*. The family name Prolecanitidæ is applied only to the immediate allies of *Prolecanites*. E. Haug[a] has recently proposed to substitute for this group the name Ibergiceratidæ, based on a supposed genus *Ibergiceras* Karpinsky, thought to represent the radicle of the stock, from which *Prolecanites*, *Paraprolecanites*, and *Pronorites* came. But Holzapfel[b] has shown that the genus *Ibergiceras*, (*Gon. tetragonus* Roemer) was based merely on a young specimen of *Pronorites cyclolobus*, and came, not from the Devonian, but from the Lower Carboniferous limestone of the Iberg in the Hartz.

### Genus Prolecanites Mojsisovics.

The genus *Prolecanites* was named by Mojsisovics[c] to include evolute, compressed forms, with wide umbilicus, slightly embracing whorls, and goniatitic, lanceolate septa. The external lobe is undivided, the two or three lateral lobes pointed and tongue-shaped. The saddles are spatulate and rounded. The antisiphonal lobe is long and pointed, flanked by a pair of short, rounded lobes.

As restricted by Haug,[d] *Prolecanites* is confined to the uppermost Devonian and the Carboniferous. The type of the genus is *Goniatites mixolobus* Sandberger of the Lower Carboniferous. One American species is found in the Middle Coal Measures.

[a] Études sur les Goniatites, p. 50.
[b] Die Cephalopoden des Domanik im südlichen Timan, p. 45.
[c] Cephalop. der Mediterranen Triasprovinz, p. 199.
[d] Études sur les Goniatites, p. 52.

### Prolecanites ? compactus Meek and Worthen.

Plate V, figs. 5–7.

1865. *Goniatites compactus*, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1865, p. 154.
1873. *Goniatites compactus*, Meek and Worthen, Geol. Surv. Illinois, Vol. V, p. 611, Pl. XXXI, fig. 2a–c.
1897. *Prionoceras compactum*, J. P. Smith, Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I, No. 3, p. 118.

The systematic position of this species is somewhat doubtful; the septa are of the *Prolecanites* type, while the cross section of the whorl retains the *Anarcestes* shape, approaching that of *Gastrioceras*. It is evolute, with broad, slightly arched whorls, wide umbilicus, and rounded umbilical shoulder. It may be that this species should be made the type for a new genus of the Prolecanitidæ, for the septa are lanceolate, consisting of a long tongue-shaped ventral lobe, flanked by two similar laterals, while the saddles are broadly rounded; but the writer has not seen the original, and is of the opinion that no one has a right to found genera or species on illustrations alone, of the accuracy of which he has no knowledge. It is barely possible, but not at all likely, that in this case, as in that of *Goniatites greencastlensis*, the impressions of the internal septa on the ventral of the next inner whorl give the lanceolate character to the lobes.

*Occurrence and locality.*—Middle Coal Measures, Menard and Macoupin counties, Ill.

### Prolecanites greenii Miller.

Pl. VIII, figs. 4, 5a, 5b.

1892. *Goniatites greenii*, S. A. Miller, Advance sheets Eighteenth Ann. Rept. Geol. Surv. Indiana, p. 76, Pl. X, figs. 5, 6.
1894. *Goniatites greenii*, S. A. Miller, Eighteenth Ann. Rept. Geol. Surv. Indiana, p. 330, Pl. X, figs. 5, 6.

Shell minute, discoidal, evolute, volutions more than four in number, narrow, and little embracing. Abdomen narrow and rounded. Cross section of the whorl elliptical. Umbilicus wide and shallow. Septa close and lanceolate, consisting of a short, pointed, tongue-shaped ventral lobe, flanked by two similar laterals. The saddles are rounded and club-shaped. The shape and the septa resemble *Prolecanites lyoni* Meek and Worthen,

but in *P. greenii*, the ventral lobe is broader and dart-shaped, while in *P. lyoni* it is simply a blunt point.

*Occurrence.*—Lower Carboniferous, Kinderhook, New Albany, Ind.

PROLECANITES GURLEYI Smith, sp. nov.

Pl. XXIV, figs. 1–4.

Shell extremely evolute, laterally compressed, widely umbilicate. Whorls low, and increasing very slowly in height, little embracing, and scarcely indented by the inner volutions. The umbilicus is wide and shallow. The cross section of the whorl is quadrate oval, the curve being interrupted by the rounded abdominal shoulders. The height of the whorl is one-fourth of the total diameter, and the breadth is slightly greater than the height. The width of the umbilicus is one-fourth of the total diameter of the shell. Six volutions are seen at the diameter of 16 mm.

The surface of the cast is entirely smooth, none of the outer shell being preserved. The length of the body chamber is unknown, as the only specimen seen is septate to the end. The septa are spatulate, the ventral lobe is undivided and tongue-shaped; the first lateral lobe is similar, and of the same size; the second lateral is two-thirds of the length of the first, and similar in shape. There is a short auxiliary lobe on the umbilical slope.

This species is most nearly related to *Prolecanites greenii* Miller, but differs from it in the greater evolution, wider umbilicus, less compressed whorls, and slower increase in size.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Cedar Gap, Wright County, Mo. The type specimen, No. 8600, paleontologic collection, Walker Museum, University of Chicago, was loaned to the writer by Dr. Stuart Weller. The specific name is given in honor of Prof. W. F. E. Gurley.

PROLECANITES HOUGHTONI Winchell.

1862. *Goniatites houghtoni*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 363.

Shell discoidal, evolute; whorls but slightly embracing, with flattened venters and sides, and cross section elongate-oval. Umbilicus wide and shallow. Surface smooth. Septa lanceolate, with pointed tongue-shaped lobes and rounded saddles; an undivided ventral lobe, two principal and an auxiliary lateral lobe.

This species differs (according to Winchell) from *P. lyoni* in the greater relative length of the second lateral lobe and the auxiliary saddle, and also in the greater compression of the cross section of the whorl; from *P. henslowi* Sowerby in the more acute lateral lobes and greater length of the saddles.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Marshall, Mich.

### Prolecanites ? louisianensis Rowley.

Pl. VI, figs. 6–8.

1895. *Goniatites louisianensis*, R. R. Rowley, Am. Geologist, Vol. XVI, p. 221, Pl. XXXI, figs. 15–18.

This minute species is of somewhat doubtful systematic position. It is hardly possible to determine it from Rowley's figures, but the writer is indebted to Dr. Stuart Weller, of the University of Chicago, for the loan of several well-preserved specimens from the Gurley collection. On these the lanceolate type of lobes can be clearly seen, resembling the young stages of *Pronorites cyclolobus*, the so-called "*Ibergiceras*" stage.

The whorls are evolute, depressed, little embracing. The shell has one or two constrictions to a revolution. The general shape reminds one strongly of *Anarcestes*, but the septa show that the transition to the stock of the Prolecanitidæ has already been made. The ventral lobe is long, tongue-shaped, and undivided; the lateral lobe is lanceolate, and the second lateral or auxiliary lobe is shallow, broad, and lies just outside of the umbilicus. The internal septa consist of a pointed antisiphonal lobe, flanked by a pair of shallow laterals. All the saddles are rounded.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Louisiana, Mo.

The figured specimen is deposited in the paleontologic collection, Walker Museum, University of Chicago (Gurley collection).

### Prolecanites lyoni Meek and Worthen.

Pl. XVI, fig. 18; Pl. XIX, figs. 9–11.

1860. *Goniatites lyoni*, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1860, p. 471.
1860. *Goniatites hyas*, J. Hall, Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 102, figs. 17, 18.
1866. *Goniatites lyoni*, Meek and Worthen, Geol. Surv. Illinois, Vol. II, p. 165, Pl. XIV, figs. 11a–c.

1879. *Goniatites lyoni*, J. Hall, Pal. N. Y., Vol. V, Pt. II, p. 476, Pl. LXXII, fig. 12; Pl. LXXIII, figs. 9–11; Pl, LXXIV, fig. 7.
1882. *Prolecanites lyoni*, E. von Mojsisovics, Cephalop. Mediterranen Triasprovinz, p. 199.
1888. *Goniatites lyoni*, C. L. Herrick, Bull. Denison Univ., Vol. IV, Pl. VII, fig. 2.
1895. *Goniatites lyoni*, C. L. Herrick, Geol. Surv. Ohio, Vol. VII, Pl. XVIII, fig. 2.
1899. *Prolecanites lyoni*, F. Frech, Die Steinkohlenformation, Pl. XLVI, *A*, fig. 11.
1901. *Prolecanites lyoni*, F. Frech, Ueber devonische Ammoneen, p. 64, fig. 21 c.

Shell discoidal, compressed, evolute; whorls but little embracing, only about one-fifth of the inner volutions being covered by the outer ones. Whorls six or more in number, the inner ones being semielliptical in cross section and the outer ones trapezoidal, with flattened sides and abdomen and rounded shoulders. Breadth of the whorl is two-thirds of the height. The whorls enlarge very slowly, giving a large number of whorls for a small diameter.

Length of body chamber unknown, but fragments indicate that specimens have attained a diameter of 80 or 90 mm., exclusive of body chamber.

Surface of the shell unknown, but the cast is smooth and devoid of constrictions and all other surface ornamentation.

Septa lanceolate, with pointed and slightly mucronate lobes and rounded saddles. Ventral lobe undivided and shorter than the laterals, which are two in number; the dorsal (internal) lobes consist of an undivided tongue-shaped antisiphonal, with a short, blunt lobe on the umbilical margin. The total number of lobes is therefore one pair less than on most species of *Prolecanites*, but this difference has not been considered by any writers to be of generic value, since so many otherwise typical species of *Prolecanites* possess this number of lobes, and several even have one more pair than the normal.

*Occurrence.*—*Prolecanites lyoni* occurs in the Lower Carboniferous, Kinderhook stage, at Rockford, Ind., along with *Aganides rotatorius* de Koninck, *Muensteroceras oweni* Hall, *M. parallelum* Hall, *Prodromites præmaturus* Smith and Weller, and *P. gorbyi* Miller. It has also been found in the same horizon in the Waverly group of Granville, Ohio.

### Prolecanites marshallensis Winchell.

1862. *Goniatites marshallensis*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 362.
1865. *Goniatites marshallensis*, A. Winchell, Proc. Acad. Nat. Sci. Phila., 1865, p. 133.
1870. *Goniatites marshallensis*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 258.

Shell evolute, discoidal, little embracing; cross section elliptical; impression moderate. Whorls at least four in number, with slow increase of growth. Umbilicus wide. Surface smooth. Length of body chamber unknown.

Septa lanceolate and close together. Ventral lobe long, pointed, and narrow; first and second lateral lobes not so large as the ventral and not sharply terminated. Auxiliary lobe outside of the umbilical border short and blunt. Antisiphonal lobe deep.

The nearest American species is *P. lyoni* Meek and Worthen, from which *P. marshallensis* differs in the additional pair of lobes outside of the umbilical border and in the greater length of the ventral lobe. It is also somewhat more involute than *P. lyoni*. Winchell thought this species to be nearest akin to *P. mixolobus* Phillips, which was chosen by Mojsisovics as the type of *Prolecanites*, but the lobes of *P. mixolobus* are not mucronate but rather club-shaped, and the auxiliary lobe is nearly as large as the principal laterals, and the ventral lobe seems to be very small.

*Occurrence.*—*P. marshallensis* was found in the Lower Carboniferous Kinderhook stage, Marshall group, at Marshall, Moscow, Battle Creek, Napoleon Cut, Mich., and in the Waverly group at Weymouth and Newark, Ohio.

## Superfamily GLYPHIOCERATIDÆ.

This group was established by Hyatt[a] to include a number of species from the Upper Devonian, Carboniferous, and Permian. The oldest genera are *Aganides* (*Brancoceras*) and *Prionoceras*, which began in the Upper Devonian and attained their acme in the Lower Carboniferous. Both genera are smooth-shelled, and both have a pointed, undivided, ventral lobe and two pairs of lateral lobes, of which the first is angular; the saddles of most species of both genera are broadly rounded, although on *Prionoceras* (*Goniatites*) *belvalianum* de Koninck the first lateral saddles are angular. The only difference between the two genera is that *Aganides* is compressed, high-whorled, almost discoidal, and very involute; while *Prionoceras* is broad, low-whorled, and evolute. Hyatt considered *Brancoceras* as the radicle of the Glyphioceratidæ, and traced the group from *Anarcestes* of the Lower Devonian, through *Tornoceras* (*Parodoceras*) of the

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 322.

Middle Devonian. He admitted the near relationship between the two genera, but considered *Prionoceras* as the link between the supposed radicle *Brancoceras* and *Glyphioceras*. The genealogy of the Glyphioceratidæ, according to Hyatt, is as follows:

$$\text{Anarcestes} \rightarrow \text{Tornoceras} \rightarrow \text{Brancoceras} \begin{cases} \text{Prionoceras} \rightarrow \text{Glyphioceras}. \\ \text{Muensteroceras} \rightarrow \text{Gastrioceras} \rightarrow \text{Paralegoceras}. \\ \text{Dimeroceras} \rightarrow \text{Pericyclus}. \end{cases}$$

Prof. K. A. von Zittel[a] has recently merged *Prionoceras* in *Brancoceras*, not even giving subgeneric rank to the former. But even though they may be nearly related, their phylogeny justifies the separation. Both genera probably branched off about the same time from *Parodoceras* or from *Sporadoceras* in the Upper Devonian, but *Aganides* (*Brancoceras*) is not the radicle, at least of the main branch of the Glyphioceratidæ. While it is possible, although not known, that *Muensteroceras* may go through a *Brancoceras* stage, *Prionoceras* does not, neither does *Glyphioceras*, nor *Goniatites* s. str. *Prionoceras* seems to have come directly from *Parodoceras*, and in turn gave rise to *Glyphioceras*. It seems likely, too, that some species of *Gastrioceras* descended directly from *Prionoceras* by division of the ventral lobe, while others may have come from *Glyphioceras*. In any case, whether it came off from the radicle, or through *Glyphioceras*, *Gastrioceras* is a later branch than *Glyphioceras*, having its maximum in the Upper Coal Measures; it therefore deserves to rank as an independent genus. It also seems proper to retain *Prionoceras?*, *Aganides* (*Brancoceras*), and *Muensteroceras*, with full generic rank.

Frech[b] derives the Glyphioceratidæ from *Sporadoceras*, but this hypothesis is not in harmony with the ontogeny of *Goniatites* and *Glyphioceras*. However, too little is known of the development of these forms to warrant any positive statement.

Some members, at least, of this group are prosiphonate, and deserve the designation "ammonite" as much as *Lobites* of the Trias, for simplicity of the septa is no longer considered as a distinctive mark of the goniatites.

Hyatt considered the Glyphioceratidæ as a family, but E. Haug[c] is of the opinion that it is rather a group of morphological equivalents than a genetic series. Haug even places *Aganides* and its descendants in a different

[a] Grundzüge der Palæont., p. 398. [b] Ueber devonische Ammoneen, p. 84.
[c] Études sur les Goniatites, p. 39.

phylum or superfamily, and derives them from a different Devonian genus, *Tornoceras*. This seems to the writer to be going further than the facts warrant. But it is beyond doubt that the Glyphioceratidæ, as Hyatt used the term, can be divided into two series. The writer prefers to retain the two under the same phylum or superfamily, Glyphioceratidæ, and to name each of the component series or families after the most characteristic genus.

Under the Glyphioceratidæ s. str. would fall *Prionoceras ?*, *Pericyclus*, *Glyphioceras*, *Goniatites*, *Gastrioceras*, *Paralegoceras*, *Schistoceras*.

Under the Aganididæ would fall *Aganides*, *Muensteroceras*, *Goniolobo-ceras*, *Dimorphoceras*, *Milleroceras*.

From the Glyphioceratidæ it appears that the Arcestidæ and the Tropitidæ have been derived. The Ptychitidæ seem to have sprung from the Aganididæ.

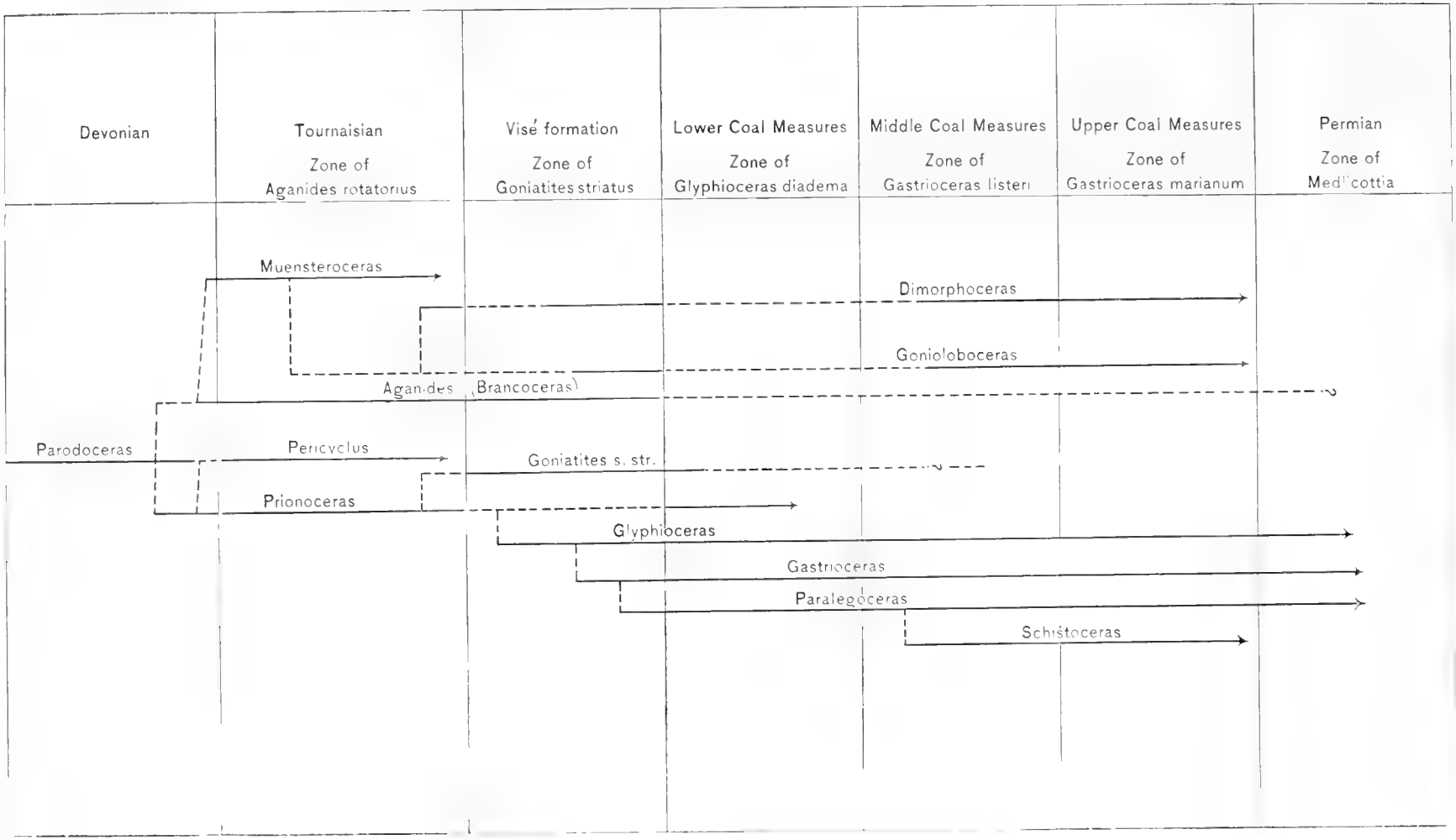
## Family GLYPHIOCERATIDÆ s. str.

### Genus Prionoceras ? Hyatt.

This genus was established by Hyatt[a] to include rather evolute, low-whorled forms, with undivided external lobes, and angular lobes and saddles. The type chosen was *Goniatites divisus* Muenster of the Devonian. Another species assigned to the genus is *Goniatites belvalianus* de Koninck from the Lower Carboniferous. It is very doubtful if either species fits the description. Certainly neither has angular saddles, and even the external lobe of *Goniatites belvalianus* is divided at maturity.

As a consequence of this the genus has been either abandoned entirely or merged by most authors with *Aganides* (*Brancoceras*). Whether this be correct or not, the ontogeny of later forms teaches that such a genus was the radicle of the greater part of the Glyphioceratidæ. It is very doubtful whether *Prionoceras* is represented in America at all, but three species are doubtfully assigned to it. Frech[b] has shown that *Goniatites divisus*, the type of *Prionoceras*, is identical with *Goniatites sulcatus* Muenster and *G. linearis* Muenster, both listed by Hyatt as most characteristic members of *Brancoceras* (*Aganides*). A strict ruling would thus throw this genus out entirely, although Haug proposes to retain it on account of its supposedly longer body chamber.

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 328. [b] Ueber devonische Ammoneen, p. 74.




PHYLOGENIC TABLE OF THE GLYPHIOCERATIDÆ.

### PRIONOCERAS? ANDREWSI Winchell.

1870. *Goniatites andrewsi*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 259.

Shell subglobose, evolute; whorls broader than high, low-arched, helmet-shaped, greatest width close to umbilical shoulder. Umbilicus deep and wide, umbilical shoulders abrupt and bearing faint ribs. Surface ornamented with four constrictions to a revolution.

Septa consisting of a long, undivided, tongue-shaped, pointed ventral lobe, a similar but shorter and broader lateral lobe, a rather narrow club-shaped external saddle, and a broad oblique lateral.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Lower Waverly group, Newark, Ohio.

### PRIONOCERAS? BROWNENSE Miller.

Pl. V, figs. 1 and 2.

1891. *Goniatites brownensis*, S. A. Miller, Advance sheets Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 90, Pl. XVIII, figs. 3, 4.

1892. *Goniatites brownensis*, S. A. Miller, Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 700, Pl. XVIII, figs. 3, 4.

Shell globose, evolute, broadly rounded on the venter, and rather deeply embracing the outer whorls, covering about three-fifths of the inner ones. Umbilicus rather wide, being about two-fifths of the total diameter of the shell, and exposing all the inner whorls. Surface of the shell apparently smooth.

Septa not distinctly made out, but consisting of a pointed ventral lobe, with a pair of angular laterals, and probably also with a pair of auxiliary lobes on the umbilical shoulders. The dorsal lobes correspond to the external, as well as could be seen on the broken face of the whorl.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Knobstone group, Brown County, Ind.

### PRIONOCERAS? OHIOENSE Winchell.

1870. *Goniatites ohioensis*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 259.

Shell subglobose, umbilicated; whorl depressed, helmet-shaped, abdomen broadly arched, sides sloping steeply to the abrupt umbilicus, which has diameter of more than one-half of the diameter of the shell.

Septa consisting of a slender ventral lobe with rounded end, a first

lateral lobe, twice as long as the ventral, clavate and pointed, and a short triangular auxiliary lobe on the umbilical shoulder. The external saddle is long and broadly rounded, the lateral saddle is narrower and shorter.

This species is said to be most nearly related to "*Goniatites*" *allei* Winchell, but differs in its shorter and rounded ventral lobe, its longer lateral, and in possessing the auxiliary lobe; also its sides are less convex, and the umbilicus less abrupt than in *G. allei*.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Lower Waverly group, Newark, Ohio.

## Genus Pericyclus Mojsisovics.

*Goniatites princeps* de Koninck was chosen by E. von Mojsisovics as the type of the genus *Pericyclus*, characterized by its angular lobes, spatulate saddles, and coarse ribs crossing the abdomen. Hyatt[a] included this under his family Glyphioceratidæ, on account of a supposed transition from *Brancoceras* to *Pericyclus*. In a later paper Hyatt[b] places *Pericyclus* in a new family, Pericyclidæ, supposed to differ from the Glyphioceratidæ in the possession of two internal lateral lobes instead of one on each side. This was based on Haug's mistaken copy of the septa of *Pericyclus kochi* Holzapfel,[c] in which there seem to be two internal laterals. A figure of the septa of this species is given by Holzapfel,[d] showing but one internal lateral lobe on each side. There can, therefore, be no reason for separating this genus from the Glyphioceratidæ.

### Pericyclus blairi Miller and Gurley.

Pl. XVI, figs. 4, 5.

1896. *Goniatites blairi*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 35, Pl. IV, figs. 4, 5.

Shell discoidal, moderately evolute, becoming more so with age; whorls compressed, with rounded venter and flattened sides, with subanguiar umbilical shoulders. Umbilicus narrow in youth, but widening rapidly with age as the spiral opens out, on account of the fact that the whorl increases very slowly in height. Height of whorl slightly greater than its

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 330.
[b] Cephalopoda, p. 551, in Eastman's Transl. Zittel's Elements of Palæontology, 1900.
[c] Études sur les Goniatites, p. 27, fig. 6c.
[d] Pal. Abhandl., Vol. V, Pl. III, fig. 6.

greatest breadth, which is just above the umbilical shoulders. The surface is ornamented by rounded furrows and angular ridges that curve from the umbilicus gently backward toward the periphery, and then on the abdomen bend sharply backward in a sinus. This ornamentation is characteristic of *Pericyclus*, to which genus the species is assigned, although the septa have not been seen. It is more evolute and less robust than *P. princeps*, but is more nearly related to that than to any other known species. The strong transverse ribs crossing the abdomen without interruption are not known on any other genus of goniatites, and much reliance is placed in this character, even in the absence of knowledge of the septa.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Sedalia, Mo.

PERICYCLUS ? PRINCEPS de Koninck.

1843. *Goniatites princeps*, L. G. de Koninck, in d'Omalius, Précis élém. géol., p. 515.
1842–1844. *Ammonites princeps*, L. G. de Koninck, Descr. anim. foss., p. 579, Pl. LI, figs. 2, 3.
1850. *Aganides princeps*, A. d'Orbigny, Prod. de paléont. stratigr., Vol. I, p. 116.
1852. *Ammonites princeps*, C. G. Giebel, Fauna der Vorwelt, Vol. III, p. 644.
1880. *Goniatites princeps*, L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 268, Pl. XLIX, figs. 1, 2.
1882. *Pericyclus princeps*, E. von Mojsisovics, Cephalop. Mediterranen Triasprovinz, p. 141.
1884. *Pericyclus princeps*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 330.
1888. *Goniatites princeps*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 312.
1890. *Glyphioceras princeps*. Steinmann and Döderlein, Elemente der Paläont., p. 393.
1897. *Pericyclus princeps*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 145, figs. 68a and b.

J. J. Bigsby[a] cites *Goniatites princeps* from the Goniatite limestone of Rockford, Ind., but no American collection is known to have an authentic specimen of this, nor is it cited in any list of American species. In the paleontologic collection of the Walker Museum, University of Chicago, is a specimen wrongly labeled "*Goniatites princeps*," and this may have been the cause of the mistaken reference. Bigsby's citation is, therefore, probably a mistake. But it is by no means improbable that *P. princeps* may be found in the Kinderhook of America, since *P. blairi*, a closely related form, shows that the genus *Pericyclus* is represented in America, and since the rest of the Kinderhook fauna so closely resembles that of Ireland and Belgium.

[a] Thesaurus Devonico-Carboniferus, p. 336.

## Genus Glyphioceras Hyatt (emend. Haug).

In establishing his genus *Glyphioceras* Hyatt took for the type *Goniatites sphæricus* Martin, already chosen by de Haan as the type of *Goniatites*, so that the group of *G. sphæricus* and *G. striatus* can not properly come under this genus. But Hyatt divided his genus into two divisions, the second of which is characterized by open umbilici, less involution, broader and lower whorls, semilunular or trapezoidal cross section, fine lateral or umbilical ribs. Of the species mentioned by Hyatt under this section *Goniatites diadema* Goldfuss is the best known. E. Haug[a] has accordingly proposed to retain Hyatt's name for this section, and has selected *G. diadema* as the type, although the first species mentioned by Hyatt is *G. obtusus* Phillips, which belongs to the group of *G. striatus*.

This division seems quite satisfactory from the stratigraphic standpoint, for *Goniatites* s. str. is almost confined to the Visé horizon of the Lower Carboniferous, while *Glyphioceras* as thus restricted is more common in the Lower Coal Measures.

### Glyphioceras calyx Phillips.

Pl. XVIII.

1836. *Goniatites calyx*, J. Phillips, Geol. Yorkshire, Pt. II, p. 236, Pl. XX, figs. 22, 23.
1836. *Goniatites mutabilis* (pars), J. Phillips, Geol. Yorkshire, Pt. II, p. 236, Pl. XX, figs. 24, 25 (not 26).
1852. *Ammonites vesica* (pars), C. G. Giebel, Fauna der Vorwelt, Vol. III, p. 470.
1880. *Goniatites calyx*, L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 265, Pl. L, fig. 18.
1884. *Homoceras calyx*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 330.
1888. *Goniatites calyx*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 311.
1889. *Glyphioceras mutabile* (pars), E. Holzapfel, Pal. Abhandl., Vol. V, p. 30.
1897. *Glyphioceras calyx*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 206.
1898. *Glyphioceras calyx*, E. Haug, Études sur les Goniatites, p. 101.

This species was selected by Hyatt as the type of a new genus *Homoceras*, but its characters are common to the young of all members of *Glyphioceras* when they have just made the transition from the *Prionoceras* stage of growth. Holzapfel thought this was the young of *G. mutabile* Phillips, as, indeed, it may be, but the connection has not yet been demonstrated.

The shell is much smaller than is usual with the Glyphioceratidæ, not

[a] Études sur les Goniatites, p. 26.

reaching a greater diameter than 6 mm.; it is evolute, has wide open umbilicus, low flattened whorls with trapezoidal cross section, faint umbilical ribs which reach almost to the abdomen. There are about three rather faint constrictions to a revolution. The surface is ornamented only with fine smooth cross striæ. The septa are like those figured by de Koninck; the differentiation into two external lobes has not taken place, as in the rest of the section *Glyphioceras*, but it is indicated by the incipient ventral saddle. These are certainly persistent larval characters, and the so-called species may be merely a case of arrested development such as is seen in the young of *Glyphioceras diadema*, but whether it is really the young of some other species, or whether it is a separate form, can hardly be determined as yet. At any rate the adult of *Glyphioceras mutabile* has not been found in America, and the American form can hardly be the young of that species. Nor in the beds where it occurred have any other species with similar young been found; in fact no other species of *Glyphioceras* has been found there at all. To the writer it seems quite possible that *G. calyx* is only the male of some species of the group of *Goniatites striatus*, since in England, Belgium, and America it is associated with this group, and more especially because the young stages are exactly alike in these. A demonstration of this is at present impossible, for we know nothing of sexual variations in the ammonoids.

*Occurrence.*—The specimens figured here are deposited in the geologic collection of Leland Stanford Junior University, California, and were found in the Lower Carboniferous, St. Louis-Chester stage, Fayetteville shale, at Moorefield, Ark., associated with *Goniatites crenistria* Phillips, and many other species of invertebrates characteristic of this horizon. In Europe the species is found in the Visé horizon, in England, Belgium, and Germany.

### ? Glyphioceras diadema Goldfuss.

Pl. XII, fig. 10.

1837. *Ammonites diadema* (Goldfuss), H. E. Beyrich, De Goniatitis, p. 15, Pl. II, figs. 8–10.

1837. *Ammonites listeri*, H. E. Beyrich, Beitr. z. Kennt. Rhein. Uebergangsgeb., p. 14, Pl. II, figs. 6a–b, and 11.

1842–44. *Ammonites diadema*, L. G. de Koninck, Descr. anim. foss., p. 574, Pl. L, figs. 1a–f, 2a–b.

1845. *Goniatites diadema*, Murchison, Verneuil and Keyserling, Géol. Russie d'Europe, etc., Vol. II, p. 367, Pl. XXVII, figs. 1a–d.

1851. *Goniatites diadema*, G. Sandberger, Jahrbuch. Nassau Ver. Nat., Vol. VII, 2 and 3, p. 304, Pl. III, fig. 33.
1855. *Aganides diadema*, F. McCoy, Brit. Pal. Fossils, p. 563.
?1863. *Goniatites diadema*, F. Roemer, Zeitschr. Deutsch. Geol. Gesell., Vol. XV, p. 578, Pl. XV, figs. 1, *a*, *b*, *c*.
1880. *Goniatites diadema*, W. Branco, Palæontographica, Vol. XXVII, Pl. IV, fig. 1.
1884. *Glyphioceras diadema*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 329.
1888. *Ammonites diadema*, E. Beyrich, Zeitschr. Deutsch. Geol. Gesell., Vol. XXXVI, p. 213.
1888. *Goniatites diadema*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 311.
1889. *Gastrioceras diadema*, E. Holzapfel, Pal. Abhandl., Vol. V, Pt. I, p. 26.
1897. *Glyphioceras diadema*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 202, fig. 98.
1898. *Glyphioceras striolatum* (pars), E. Haug, Études sur les Goniatites, p. 92.

In England, Belgium, and Germany this species is characteristic of the Lower Coal Measures; in Arctic America it has been found on Berg Island,[a] brought in by the Nares expedition.

It is quite likely that Phillips's name, *G. striolatum*, will take precedence over *G. diadema*, which Goldfuss left in manuscript, and which Beyrich afterwards published.

A similar species has been described by F. Roemer[b] under the name *Goniatites listeri* Martin, from Carboniferous limestone of Sumatra, although this latter may be *Goniatites beyrichianum* de Koninck. At any rate this type of *Glyphioceras* is widespread, characteristic of Lower Coal Measures, and may be chosen as a zone fossil. It has not yet been found within the United States, but may well be expected there on account of general similarity of faunas of this horizon.

### Glyphioceras ? hathawayanum McChesney.

1860. *Goniatites hathawayana*, J. H. McChesney, Descr. New Pal. Foss., p. 66.
1865. *Goniatites hathawayana*, J. H. McChesney, Illustrations of new sp. Pal. Foss., Pl. III, fig. 3.
1868. *Goniatites hathawayanus*, J. H. McChesney, Trans. Chicago Acad. Sci., Vol. I, p. 53, Pl. III, fig. 3.

The following description is quoted from McChesney's last paper:

Shell moderately small, discoidal, much compressed. Volutions two to three, strongly embracing, and concealing about two-thirds of the inner volutions; umbilicus comparatively wide and shallow. Dorsum [venter] extremely narrow, having a linear depression along its center; sides of the volutions very slightly and regularly

[a] Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 205.
[b] Palæontographica, Vol. XXVII, Pl. III, fig. 6.

convex to the slope into the umbilicus, which is more sharply curved. Aperture very narrow and much elongated. Septa on the sides of the volutions strongly sigmoidal, with the curves or lobes which stand back toward the apex much more sharply turned than those pointing in the opposite direction. Outer shell entirely wanting in the specimen.

McChesney's drawing and description do not permit a certain determination as to whether this species is a *Glyphioceras* or a *Gastrioceras*.

*Occurrence.*—Middle Coal Measures, Lasalle, Ill.

### Glyphioceras ? leviculum Miller and Faber.

Pl. VIII, figs. 10, 11.

1892. *Goniatites levieulus*, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, p. 167, Pl. VI, figs. 10, 11.

Shell discoidal, whorl highly arched with gently rounded sides and highly arched narrow abdomen. Umbilical shoulders abrupt. Whorls deeply embracing, the outer whorl being indented to about one-third of its height by the next inner volution. Width of whorl is more than three-fourths of its height. Umbilicus wide and deep, width is one-third of the total diameter. On the inner whorls the umbilicus is proportionally narrower, and the breadth of the whorl greater than its height.

Surface of shell smooth, no constrictions or ribs having been seen. Specimens septate throughout, thus the body chamber and aperture are unknown.

Septa close together and sinuous, as is usual in the Glyphioceratidæ. The ventral lobe is divided by a small pointed siphonal saddle; the lateral lobe is funnel-shaped and pointed; the external and the lateral saddles are broadly rounded. There are three internal lobes as in all typical Glyphioceratidæ, but their shape could not be ascertained.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Crab Orchard, Ky. The type is deposited in the paleontologic collection, Walker Museum, University of Chicago.

### Glyphioceras pygmæum Winchell.

1862. *Goniatites pygmæus*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 366.

Shell globose, involute, umbilicus small. Whorl broad, depressed, breadth equal to one-half of the total diameter. Surface with four constrictions to a revolution.

Septa consisting of a broad, obtusely rounded ventral lobe, with a very small siphonal indentation; lateral lobe shallow, acute, funnel-shaped; ventral and lateral saddles broad, shallow, with circular ends.

Winchell compares this species with *Glyphioceras striolatum* Phillips, from which it differs in the smaller umbilicus, larger ventral lobe, and ventral saddles. The description, however, would make it appear that this species in nearer to *Glyphioceras mutabile* Phillips.

*Occurrence.*—Supposed to have come from the Lower Carboniferous (?), Kinderhook stage, Marshall group, Battle Creek (?), Mich.

## Genus Goniatites de Haan.

When Hyatt undertook a revision of the goniatites in his Genera of Fossil Cephalopods he did not include *Goniatites* itself in his list, but included the type of all this stock in his new genus *Glyphioceras*. Many years before this de Haan[a] had described and figured the genus *Goniatites*, using *G. sphæricus* Martin as the type; in so doing, he complied with all the laws of nomenclature, and no genus stands on a firmer basis than this. Therefore when it has been found that de Haan included under this name many species of diverse orgin, it is quite proper to give separate generic titles to these; but the type of the original genus can not receive any new name, and must always stand for the original species and all like it.

Hyatt[b] first mentions *Goniatites sphæricus* under the description *Glyphioceras*, and therefore this species is to be regarded as the type of the genus, rather than *G. crenistria*, which authors usually cite as the type. Hyatt divides the genus *Glyphioceras* into two sections:

I. Involute globose shells, including such forms as *Goniatites sphæricus* Martin, *G. crenistria* Phillips, and *G. striatus* Sowerby.

II. Forms with compressed whorls, and open umbilici, including *Goniatites obtusus* Phillips as type of the section, *G. diadema* Goldfuss, *G. platylobus* Phillips, *G. barbotanus* M. V. K., and others. Of this second section, *G. diadema* can not be included in the same genus with *G. sphæricus*, and either a new name will have to be given it or else Hyatt's name will have to be restricted to this section. E. Haug[c] proposes to restrict the name *Goniatites*

[a] Mon. Ammon. et Gon., 1825, p. 159.
[b] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 328.
[c] Études sur les Goniatites, p. 26.

to species of the type of *G. sphæricus*, *G. crenistria*, and *G. striatus*; and to restrict *Glyphioceras* to the type of *G. diadema.*

As thus restricted, *Goniatites* is almost entirely confined to the Lower Carboniferous zone of *Goniatites striatus*, and is thus of great importance in stratigraphic paleontology. It has been shown by researches in the ontogeny of *Goniatites crenistria*[a] and *Glyphioceras diadema*[b] that these two genera have a common origin in *Prionoceras*, which is considered by most paleontologists as a synonym of *Brancoceras* Hyatt, or *Aganides* de Montfort.

F. Frech[c] thinks that *Goniatites* s. str. was derived from *Sporadoceras;* and certainly *S. mammilliferum* Sandberger and *S. subinvolutum* Muenster, as figured by Frech, do resemble closely what the writer has described as the *Prionoceras* stage of growth in *Goniatites.* It is, however, by no means certain that these species should be assigned to *Sporadoceras*, as Hyatt took *Goniatites mammillifer* as the type of his genus *Dimeroceras*, and regarded it as transitional from *Brancoceras* to *Pericyclus.* But if these species should be accepted as genuine members of *Sporadoceras*, the writer agrees with Frech in regarding this genus as the ancestral stock of the Glyphioceratidæ s. str.

### Goniatites choctawensis Shumard.

1868. *Goniatites choctawensis*, B. F. Shumard, Trans. St. Louis Acad. Sci., Vol. II, p. 109.

The following description is quoted from Shumard's paper:

Shell discoidal, broadly and strongly rounded on the dorsum [abdomen] and flattened laterally, inner volutions entirely concealed by the outer one; umbilicus small, its diameter scarcely equal to one-sixth the breadth of the volution; transverse diameter of volution about equal to the breadth from dorsal to ventral side; aperture lunate, much wider than high; surface marked with fine distinct revolving lines, less than the width of the intervals between, crossed by extremely fine, crowded, transverse striæ. *Septæ* having but one lateral lobe on either side; dorsal [ventral] lobe as wide as long, divided into two lanceolate branches by an accessory saddle, which is truncated and bifid at tip and extends almost to the middle of the lobe; dorsal [ventral] saddle of the same form, but wider and double the length of the branches of the dorsal [ventral] lobe; superior lateral lobe wider than the dorsal [ventral] saddle, and contracted at extremity to an acute point.

This shell resembles the *G. striatus* (Sowerby) both in the form and number of the lobes of the septæ and its surface markings, and for several years I have had

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[a] J. P. Smith, Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I, No. 3, pp. 105, 128.
[b] W. Branco, Palæontographica, Vol. XXVII, Pl. IV, figs. 1 a–o.
[c] Ueber devonische Ammoneen, p. 84.

it in my cabinet under the latter name. A closer examination, however, shows points of difference which appear to me to be of specific value. The striæ of our shell are finer and more crowded; the dorsum [abdomen] is more broadly rounded, and the umbilicus is proportionally smaller.

This description shows the species to belong to the group of *G. striatus*, and the differences noted are precisely those characteristic of *G. crenistria*, which has been found in both Arkansas and Texas, and of which *Goniatites choctawensis* may turn out to be a synonym.

*Occurrence.*—Lower Carboniferous, St. Louis-Chester stage (?), Bend formation, Choctaw Nation (?), Ind. T.

### Goniatites crenistria Phillips.

Pl. X, figs. 12–16; Pl. XIV; Pl. XV; Pl. XVI, figs. 1a–j; Pl. XXVI, figs. 1–5.

1836. *Goniatites crenistria*, J. Phillips, Geol. Yorkshire, Pt. II, p. 234, Pl. XIX, figs. 7–9.
1841. *Goniatites crenistria*, J. Phillips, Pal. Foss. Cornwall, Devon, and W. Somerset, p. 121, Pl. L, figs. 234a–g.
1843. *Goniatites crenistria*, F. A. Roemer, Verstein. Harzgeb., p. 33, Pl. IX, figs. 10a–b.
1850. *Goniatites crenistria*, F. A. Roemer, Palæontographica, Vol. III, p. 51, Pl. VIII, figs. 13a–c.
1852. *Goniatites crenistria*, F. A. Roemer, Palæontographica, Vol. III, p. 93, Pl. XIII, figs. 29a–c.
1852. *Aganides sphæricus* var. *crenistria*, F. McCoy, Brit. Pal. Fossils, p. 567.
1870. *Goniatites sphæricus* (not Martin), F. Roemer, Geol. Oberschlesien, p. 55, Pl. VI, figs. 2a–b.
1880. *Goniatites striatus* (pars), L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 253.
1882. *Goniatites crenistria*, C. Barrois, Mém. Soc. Géol. du Nord, Vol. II, No. 1, p. 292, Pl. XIV, fig. 1.
1884. *Glyphioceras crenistria*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 329.
1893. *Glyphioceras incisum*, A. Hyatt, Fourth Ann. Rept. Geol. Surv. Texas, p. 471, Pl. XLVII, figs. 44–48.
1897. *Glyphioceras crenistria*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 160, fig. 76.
1897. *Glyphioceras incisum*, J. P. Smith, Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I, No. 3, p. 111, Pls. XIII–XV.
1898. *Goniatites crenistria*, E. Haug, Études sur les Goniatites, p. 27.
1898. *Glyphioceras crenistria*, G. C. Crick, Trans. Linn. Soc. Zool., 2d series, Vol. VII, Pt. IV, p. 106, Pl. XX, figs. 15–18.

This species has been united by many paleontologists with *Goniatites sphæricus* and by still others with *G. striatus*, and in fact all three species

have so much in common that it is very hard to distinguish them; it is quite possible that they are only varieties of *G. sphæricus.*

The form is globose, broad, low-whorled, with semilunular cross section. The umbilicus is very narrow, about one-tenth of the diameter of the shell, so that the inner coils are concealed. There are four or five constrictions to a revolution, visible both on the shell and the cast. The whorl is exceedingly involute, each whorl being indented to about three-fifths of its height by the preceding. The shell is marked with distinct cross striæ with fine, sharp crenulations, which show only toward maturity. The elevations between the pits of the crenulations become in the adult indistinct spiral striations, giving a finely reticulate aspect to the surface. These are not visible on the cast. In the adult stage the cross striæ bundle near the umbilicus, forming weak incipient nodes.

From *G. sphæricus* this species is distinguished by being more compressed laterally, less globose, having narrower umbilicus, weaker spiral striæ, and coarser cross striæ. From *G. striatus* this species may be distinguished chiefly by its slightly narrower umbilicus, its finer spiral striæ, and coarser cross striæ. The table below, compiled from Foord and Crick's catalogue, shows the principal differences and agreements between the three species:

| | *G. crenistria.* | *G. striatus.* | *G. sphæricus.* |
|---|---|---|---|
| Breadth in proportion to diameter | B=$\frac{3}{5}$ D | B=$\frac{5}{8}$ D | B=$\frac{3}{4}$ D. |
| Height of whorl to width | A little wider than high. | Wider than high | $\frac{3}{5}$ W. |
| Height of whorl to diameter | A little over $\frac{1}{2}$ D | $\frac{3}{7}$ D | $\frac{4}{9}$ D. |
| Width of umbilicus to diameter | U=$\frac{1}{10}$ D | U=$\frac{1}{6}$ D | U=$\frac{1}{6}$ D. |
| Indentation of last whorl by preceding. | Indented more than $\frac{1}{3}$. | Nearly $\frac{2}{3}$ | More than $\frac{1}{2}$. |
| Constrictions to revolution | (4 in American specimens.) | 4 to 5 feeble | 4 or more faint. |
| Septa to revolution | 19–20 | 20 | 18. |
| Spiral striæ | (Fine in American specimens.) | Strong and sharp | Very fine. |
| Cross striæ | Finely crenulated | Sharply incised, sinuous. | Obscure. |

Not enough specimens have been studied to show that these characters are really constant; that they are not constant is shown by the fact that

McCoy grouped all three under *G. sphæricus*, and de Koninck united *G. crenistria* with *G. striatus*.

*Occurrence.*—*Goniatites crenistria* is common in the upper part of the Lower Carboniferous in Great Britain, Belgium, and Germany. It has been described under the name of *Glyphioceras incisum* Hyatt from the St. Louis–Chester stage, of Texas (see Pl. X, figs. 12–16) and Arkansas, associated with *Goniatites striatus* (=*Glyphioceras cumminsi* Hyatt (in the Bend formation of Texas, and the Spring Creek limestone, so-called Fayetteville shale, of Arkansas.

The specimens figured on Pl. XIV; Pl. XV; Pl. XVI, figs. 1a–j; and Pl. XXVI, figs. 1–3, came from Moorefield, Arkansas, from calcareous nodules in shales. They were associated with an undoubted St. Louis fauna. The specimen figured on Pl. XXVI, fig. 5, came from the same formation, near Boles, Ark.

On account of the great interest and importance of this species, there is given below the complete ontogeny of the American *Goniatites crenistria* Phillips, var. *incisa* Hyatt, based on specimens from the St. Louis stage of Moorefield, Ark., associated with an undoubted St. Louis fauna. The development of this species was first published by the writer in a paper in the Proceedings of the California Academy of Sciences,[a] from which paper the following description with some modifications is taken:

LARVAL STAGES.

In order to obtain the larval stages of *Goniatites crenistria*, a number of adults were selected, so as to make sure of the identity, and the outer coils were broken off until the desired size was obtained. This necessitated the destruction of several specimens, but was well worth while in view of reliability of the results. The specimens were studied in three different mountings, dry on cardboard, in a drop of water on cardboard, and in water in a watch glass over a strong condensing lens. In the first way the surface markings are seen best, in the second the sutures and form, in the third the internal structure when the specimen is translucent. The nomenclature used is that of Hyatt, published in Phylogeny of an Acquired Characteristic.

*Phylembryonic.*—The protoconch represents the first shell secreted by the shell gland, and must have been formed while the animal was in the egg. It is quite possible that some of the chambers were formed before the egg was hatched, but this can not be determined on fossils. The protoconch is taken for convenience to represent the phylembryonic stage of growth, the end of the embryonic, when the class or phylum can be determined and the animal is already a cephalopod. In shape

[a] Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I, No. 3.

the protoconch is a smooth, rather elongate, bobbin-shaped, oval body, of which the upper part projects forward in a lap, where the first chamber was joined to it. The protoconch was not the whole of the embryo chamber, for a part of the spiral tube must have furnished a lodging for the embryo; but after the formation of the first air chamber it is no longer possible to determine how long the primitive body chamber was. The protoconch corresponds to the primitive nautilian shell from which the ammonoids descended, but the parallelism is not exact, for the initial chamber of the nautiloids is not calcareous, while acceleration of development has pushed back to the embryo the calcareous shell of the ammonoids.

In the protoconch is seen the beginning of the syphon, or syphonal cæcum, a pear-shaped knob, projecting a short distance into the embryonic shell. It must have been present in the embryo, for it is older than the first suture, but its function is unknown. In some specimens what seemed to be a tube could be seen attached to the cæcum; this is probably the prosiphon described by Munier-Chalmas, but no specimens sufficiently definite to figure could be obtained.

On Pl. XIV, figs. 1 and 2,[a] is shown the protoconch from which all the chambers have been broken off.

*Dimensions.*

| | Millimeter. |
|---|---|
| Diameter | 0.46 |
| Height of whorl at attachment of first chamber | .24 |
| Height of first chamber from protoconch | .17 |
| Width | .66 |
| Involution | .07 |

The protoconch is constant in size and dimensions, for several specimens were obtained free from the air chambers. Also a number of others were broken back almost to the protoconch, and the dimensions agreed, as nearly as could be determined.

On Pl. XIV, figs. 3, 4, and 5, is shown the protoconch of a *Goniatites* from the Carboniferous of Scott County, Ark., 2 N., 29 W., sec. 36, near the center. This species was compared by the writer[b] to *G. sphæricus* Martin, and said to be identical with the species from Moorefield. But although the adults are nearly alike, the protoconchs are quite unlike, as may be seen by a comparison of the two figures.

*Dimensions of the Scott County form.*

| | Millimeter. |
|---|---|
| Diameter | 0.53 |
| Height of whorl at attachment to the protoconch | .26 |
| Height of whorl from the protoconch | .18 |
| Width | .80 |
| Involution | .08 |

These figures show it to be larger and proportionally broader than the typical *G. crenistria*. If the species are identical, then this is an unusual variation.

*Ananepionic.*—As soon as the first air chamber is formed the animal has left the embryonic and begun the larval stage, and then takes rank with the chambered nautiloids. The suture at this stage consists of a very broad ventral saddle, with a pair of narrow, lateral lobes. On Pl. XIV, fig. 1, is shown this suture; fig. 6

[a] The figures here referred to are those of this monograph.

[b] Proc. Am. Philos. Soc., Vol. XXXV, p.11.

shows this, and also the second chamber wall; figs. 9 and 10 show the ananepionic suture with half a coil attached. Pl. XVI, fig. 1, shows the initial suture along with the later ones. While this stage can not be compared to any particular genus, it corresponds to some nautilian form of the Silurian. The ananepionic siphon is about halfway between the dorsum and the venter; in this character, too, agreeing with the nautiloids. Where the siphon passes through the partition the wall is bent backward in a cone and has a siphonal collar around the tube. The surface is still smooth, no ornamentation of any sort ever having been seen on early stages of ammonoids.

*Metanepionic.*—With the second larval substage the shell becomes a true ammonoid. This begins with the second suture, which takes on the ventral lobe of the goniatites. The shell is smooth, as before, and the whorl changes little in shape, being still low, broad, and little embracing. The sutures and shape correspond exactly to *Anarcestes*, the primitive goniatite and radicle of the ammonoids. *Anarcestes* was named but not characterized by Mojsisovics,[a] and afterwards defined by Hyatt,[b] as containing forms with smooth, broad, and low whorls, with semilunular cross section, deep umbilicus, and rather broad abdomen. *Goniatites subnautilinus* Schlotheim, of the Middle Devonian, was chosen as type of the genus, but most of the species occur in the Lower Devonian, in the Hercynian beds, which were formerly assigned to the Upper Silurian.

*Goniatites crenistria* shows the *Anarcestes* stage at the second and third sutures, and resembles closely *A. lateseptatus* Beyrich of the Lower Devonian. On Pl. XIV, fig. 6, is seen the transition from the ana- to the meta-nepionic; figs. 9 and 10 show the transition from ananepionic (first suture) to metanepionic (second and third sutures); figs. 11 and 12 show the *Anarcestes* stage at the first and second sutures visible on the whorl. The metanepionic sutures, seen in projection on Pl. XVI, figs. 1b and c, consist of a deep, rounded, ventral lobe, and a pair of broad, shallow, lateral lobes. When the animal has progressed thus far in its development it is a true goniatite, and the siphon has already turned to the outside of the whorl, or abdomen.

*Paranepionic.*—When the broad lateral lobes become indented with a pair of lateral saddles, the sutures, the narrow umbilicus, and the broad, low whorl all correspond to *Parodoceras* Hyatt, of the Middle and Upper Devonian. *G. crenistria* reaches this stage at the fourth suture, at a diameter of about 0.68 mm., one-third of a whorl, and continues in it for the fourth, fifth, and sixth sutures, up to a diameter of 0.80 mm., and five-eighths of a whorl. Pl. XIV, figs. 9 and 10, shows the form at the *Parodoceras* stage, at one-half a whorl, with the following dimensions:

| | Millimeter. |
|---|---|
| Diameter | 0.74 |
| Height last coil | .38 |
| Height last coil from the protoconch | .13 |
| Width of last whorl | .77 |
| Involution | .26 |
| Width of umbilicus | .06 |

[a] Cephalop. Mediterranen Triasprovinz, p. 181.
[b] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 309.

On Pl. XIV, figs. 11 and 12, the *Parodoceras* stage shows at the fourth, fifth, and sixth sutures.

*Neanic.*—When the ammonoid in its growth no longer shows the characters of its distinct ancestors, but has already taken on those of its own family, it may be said to have left the larval stage proper and to have begun its youth. The ananeanic is then the beginning of the adolescent period. *G. crenistria* at the seventh suture, three-fourths of a whorl, and diameter of 0.85 mm., changes its form markedly; the two pairs of lateral lobes become more pronounced, and the ventral lobe becomes smaller in proportion; the coil leaves its close spiral and shows decided egression, the umbilicus becomes wider, while the chamber becomes actually narrower than in the *Parodoceras* stage, as seen from these figures: Width of chamber at diameter 0.74 mm. is 0.77 mm., at diameter 0.92 mm. it is 0.69 mm. The involution also becomes less. At diameter 0.90 mm. and end of the first whorl a decided constriction, marking a temporary mouth of the shell, makes its appearance. This stage corresponds to the Upper Devonian and Carboniferous genus *Prionoceras* Hyatt,[a] of which *P. divisum* Muenster, of the Upper Devonian, and *P. belvalianum* de Koninck, of the Lower Carboniferous, are the types. These species have broad, low, rather evolute whorls, with wide umbilici and smooth surfaces, ornamented only with periodic constrictions. The external sutures consist of an undivided, pointed, ventral lobe, one pair of angular lateral lobes, and a second pair of rounded lobes on the umbilical border. The external saddles are angular and the lateral saddles rounded and broad. If the genus *Prionoceras* is dropped, as now seems likely, it will be necessary to give some other name to this stage of growth. The beginning of the *Prionoceras* stage is shown on Pl. XIV, figs. 11 and 12, in the widening of the umbilicus, egression of the spiral, and narrowing of the chamber.

*Dimensions of the specimen.*

| | Millimeter. |
|---|---|
| Diameter | 0.92 |
| Height of last whorl | .33 |
| Height of last whorl from the preceding | .23 |
| Width of last whorl | .69 |
| Involution | .10 |
| Width of umbilicu | .30 |

This stage begins at 0.85 mm. diameter, three-fourths of a whorl from the protoconch, and lasts with little change except increase in size for two revolutions up to a diameter of 2.25 mm., when the transition to *Goniatites* begins.

Plate XV, figs. 1 and 2, shows a continuation of the *Prionoceras* stage, at $1\frac{3}{4}$ whorls.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 1.29 |
| Height of last coil | .45 |
| Height of last coil from the preceding | .29 |
| Width of last coil | .95 |
| Involution | .15 |
| Width of umbilicus | .50 |

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 328.

On this specimen are seen two constrictions about two-thirds of a revolution apart, thus making the resemblance to *Prionoceras* very striking. At this stage are first seen the cross striæ of growth. A continuation of the same generic stage is shown on Pl. XV, figs. 3 and 4, at $1\frac{7}{8}$ whorls.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 1.38 |
| Height of last coil | .52 |
| Height of last whorl from the preceding | .31 |
| Width of last whorl | 1.02 |
| Involution | .21 |
| Width of umbilicus | .51 |

The relative dimensions are nearly the same as at diameters 0.92 mm. and 1.29 mm., but the sutures differ slightly, the ventral lobe being slightly blunted, as shown on Pl. XVI, fig. 1. On this specimen only one constriction was visible at diameter of 0.85 mm.

On Pl. XV, figs. 5 and 6 show a larger specimen still in the *Prionoceras* stage, at $2\frac{1}{8}$ whorls.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 1.64 |
| Height of last whorl | .60 |
| Height of last whorl from the preceding | .40 |
| Width of last whorl | 1.38 |
| Involution | .20 |
| Width of umbilicus | .54 |

No constrictions were visible on this specimen; that one which occurs at end of the first whorl being concealed by the outer coil. The relative dimensions are nearly the same as on the preceding specimens, except that the last whorl is proportionally broader and the umbilicus narrower. The sutures are the same as on the last specimen. The end of the *Prionoceras* stage is shown on Pl. XV, figs. 7 and 8, at $2\frac{3}{4}$ of a whorl.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 2.25 |
| Height of last whorl | .87 |
| Height of last whorl from the preceding | .50 |
| Width of last whorl | 1.82 |
| Involution | .37 |
| Width of umbilicus | .58 |

No constrictions were visible on this specimen, the earlier ones being concealed by the outer whorl. The figures show that the relative dimensions remain nearly as before, but the umbilicus becomes considerably narrower. The sutures are like those of the smaller specimens, but on the last half whorl the ventral lobe becomes very much flattened, and at diameter of 2.2 mm. becomes slightly indented by the beginning of a ventral saddle, thus showing a transition to *Goniatites* and the end of the adolescent stage. No youthful stages larger than this were suc-

cessfully broken out in condition to figure, but the imperfect ones obtained showed a gradual narrowing of the umbilicus and increase in height of the whorl and involution.

ADULT STAGE.

The form of the adult *G. crenistria* has already been sufficiently described in this paper and in Hyatt's monograph. The sutures changed in increasing depth of the ventral sinus and sharpening of the lateral lobes, as shown on Pl. XVI, fig. 1, taken from a specimen of diameter of 15 mm. The early adult sutures have been figured by Hyatt,[a] and the figures are reproduced in this paper.

Pl. XV, fig. 9, shows a small specimen in the early adult stage; it agrees in all essentials with those of larger growth, only the ventral saddle is shorter and the lateral saddles more rounded.

*Table of stages of growth.*

| | Protoconch. | Protoconch and two chambers. | One-half whorl, *Anarcestes* to *Parodoceras*. | First whorl, *Parodoceras* to *Prionoceras*. | *Prionoceras* stage, 1¾ whorls. | *Prionoceras*, 1⅞ whorls. |
|---|---|---|---|---|---|---|
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| Diameter | 0.46=1.00 | 0.61=1.00 | 0.74=1.00 | 0.92=1.00 | 1.29=1.00 | 1.38=1.00 |
| Height of last whorl | .24= .52 | .31= .50 | .38= .52 | .33= .35 | .45= .34 | .52= .38 |
| Height of last whorl from the preceding | .17= .36 | .15= .24 | .13= .17 | .23= .25 | .29= .22 | .31= .22 |
| Width of last whorl | .66=1.56 | .66=1.08 | .77=1.04 | .69= .75 | .95= .73 | 1.02= .73 |
| Involution | .07= .15 | .16= .26 | .26= .35 | .10= .10 | .15= .11 | .21= .15 |
| Width of umbilicus | | | .06= .08 | .28= .30 | .50= .38 | .51= .37 |

| | *Prionoceras*, 2⅛ whorls. | *Prionoceras*, 2¾ whorls. | *Prionoceras* to *Goniatites*. | *Prionoceras* to *Goniatites*. End of neanic. | *Goniatites*. Anephebic. | *Goniatites*. |
|---|---|---|---|---|---|---|
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| Diameter | 1.64=1.00 | 2.25=1.00 | 2.60=1.00 | 3.00=1.00 | 6.00=1.00 | 11.00=1.00 |
| Height of last whorl | .60= .36 | .87= .38 | 1.24= .47 | 1.45= .48 | 3.50= .58 | 5.50= .50 |
| Height of last whorl from the preceding | .40= .23 | .50= .22 | .76= .29 | .83= .27 | 1.80= .30 | 3.00= .27 |
| Width of last whorl | 1.38= .84 | 1.82= .80 | 2.32= .88 | 2.82= .94 | 6.00=1.00 | 10.00= .90 |
| Involution | .20= .12 | .37= .16 | .48= .18 | .62= .20 | 1.65= .27 | 2.50= .22 |
| Width of umbilicus | .54= .32 | .58= .25 | .61= .23 | .66= .22 | .90= .15 | 1.00= .09 |

SUMMARY.

The ontogeny of *Goniatites* is of interest not only for its own sake, but also because it is the most important genus of the largest family of ammonoids of the Carboniferous, and because this family gave rise to a large part of the ammonites of the Trias. *Goniatites* in its ontogeny goes through the following stages: phylembryonic, protoconch, representing the primitive cephalopod; ananepionic, Silurian

[a] Fourth Ann. Rept. Geol. Surv. Texas, Pl. XLVII, figs. 44–45.

nautiloid; metanepionic, *Anarcestes* of Lower Devonian; paranepionic, *Parodoceras* of Middle Devonian; neanic, *Prionoceras* of Upper Devonian and Carboniferous, showing gradual transition through ana-, meta-, and paraneanic, and a gradual change from *Prionoceras* to *Goniatites* in the late adolescent and early adult stages. *Prionoceras* or some similar form seems to have been the family radicle, and *Aganides* is a side branch, since *Goniatites* does not go through any stage corresponding to the latter genus. *Gastrioceras* comes from *Prionoceras* (through *Glyphioceras*) by somewhat narrowing the whorl and division of the ventral lobe. *Glyphioceras* and *Goniatites* come directly from *Prionoceras* by narrowing the umbilicus so as to conceal most of the inner whorls, and by division of the ventral lobe.

The division of the family Glyphioceratidæ into *Aganides*, *Prionoceras*, *Goniolobоceras*, *Dimorphoceras*, *Pericyclus*, *Goniatites*, *Glyphioceras*, *Münsteroceras*, *Gastrioceras*, *Paralegoceras*, and *Schistoceras* is quite proper for phylogenetic reasons.

According to Steinmann the Ceratitidæ of the Trias are descended from *Gastrioceras*, and the Tropitidæ from *Pericyclus*, but neither of these groups goes through stages of growth corresponding to these genera. *Tropites* does, however, go through a *Prionoceras* stage, and later it resembles closely *Gastrioceras*, but it already has the *Tropites* keel before the ventral lobe is divided. But it is quite likely that some of the genera assigned to the Tropitidæ do descend directly from other members of the Glyphioceratidæ.

All specimens of *Goniatites crenistria* figured in this paper, except those on Pl. X, figs. 12–16, are deposited in the geologic collection of Leland Stanford Junior University, California, and came from the St. Louis-Chester stage (Fayetteville shale), of Moorefield, Ark. Those figured on Pl. X, figs. 12–16, are from the Lower Carboniferous, St. Louis-Chester, Bend formation, near Richland Springs, San Saba County, Tex.

### Goniatites greencastlensis Miller and Gurley.

Pl. XVII, figs. 12–14.

1896. *Goniatites greencastlensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 44, pl. 5, figs. 12–14.

This species has been referred by E. Haug[a] to *Goniatites* s. str., on the supposition that the pointed undivided abdominal lobe was merely the lobe of the internal part of the next outer coil pressed on the shell. Through the kindness of Dr. Stuart Weller the writer was allowed to examine the type of this species in the paleontologic collection, Walker Museum, University of Chicago, and found the facts to be as Haug suspected. This specimen is, therefore, a member of *Goniatites* s. str., and not of *Prionoceras*, as one would think from the drawing published.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Greencastle, Ind.

[a] Études sur les Goniatites, p. 64.

### Goniatites kentuckiensis Miller.

Pl. XVII, fig. 1.

1889. *Goniatites kentuckiensis*, S. A. Miller, North American Geol. and Pal., p. 440, fig. 740.

1896. *Goniatites kentuckiensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 40, Pl. V, fig. 1.

This species is probably identical with *G. striatus* Sowerby, and thus with *Glyphioceras cumminsi* Hyatt, for the globose rather flattened form, the size of the umbilicus, the septa and the spiral ridges all agree with that species. But Miller does not describe nor figure any constrictions on the shell, although it probably has them in the earlier stages.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Crab Orchard, Ky. The type is deposited in the paleontologic collection, Walker Museum, University of Chicago.

### Goniatites lunatus Miller and Gurley.

Pl. VI, figs. 2–5.

1896. *Goniatites lunatus*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 41, Pl. V, figs. 2–5.

Shell globose, volutions enlarging rapidly, and becoming more broadly rounded with increasing size. Cross section of the whorl semilunular. Greatest breadth of whorl about one-fourth larger than the height, and situated at a point about one-fifth of the height of the whorl above the umbilicus. Whorls deeply embracing, the last whorl being indented to one-half of its height by the preceding one. Umbilicus very narrow, being not more than one-eighth of the total diameter. Surface of the shell smooth, except for fine cross imbricating striæ of growth. No constrictions have been observed.

Septa consisting of a narrow divided ventral lobe and broad, shallow, bluntly pointed laterals. External saddles rather narrow, lateral saddles broad and shallow. Dorsal septa unknown.

In this species is seen the survival of a type that prevailed in the St. Louis-Chester stage of the Lower Carboniferous, but it has apparently lost the constrictions and tendency to surface ornamentation characteristic of the group at that time.

*Occurrence.*—Coal Measures (Middle?), Elkhorn Creek, Kentucky.

Deposited in the paleontologic collection in Walker Museum, University of Chicago. The writer's thanks are due Dr. Stuart Weller for the use of the drawings of this species, from Bull. No. 11, Illinois State Mus. Nat. Hist., Pl. V, figs. 2–5.

### Goniatites newsomi Smith, sp. nov.

Pl. XVII, figs. 2–5.

Whorl depressed, with broadly rounded abdomen, and angular umbilical shoulders. Whorl a little wider than high, greatest breadth a little above the middle, indented to half its height by the preceding whorl. Involute, umbilicus rather wide, about one-fourth of diameter of shell; narrower in young. Several sharply incised constrictions to a revolution showing on both shell and cast. These bend sharply forward on the abdomen, making a broad saddle, with a narrower lobe. Shell ornamented with strong spiral striæ or ridges, with broader interspaces coarser than on *G. striatus*. There are also fine cross striæ of growth, giving a slightly reticulated aspect to the shell and the cast. These show on both shell and cast. The ornamentation resembles *G. striatus*, but is coarser, and the form is somewhat more strongly compressed than that species, from which it also differs in the form of the constrictions and in its wider umbilicus. The nearest relative of this species is *G. subcircularis* Miller, but *G. newsomi* is much broader than *G. subcircularis*, has coarser spiral ridges, and wider umbilicus. The septa are more larval in character than those of *G. striatus*. Named in honor of the collector, J. F. Newsom. Deposited in the geologic collection of Leland Stanford Junior University, California.

*Occurrence.*—Lower Carboniferous, St. Louis stage, so-called Fayetteville shale, Batesville, Independence County, Ark.

### Goniatites sphæricus Martin.

1809. *Conchyliolithus Nautilites sphæricus*, W. Martin, Petrif. Derb., p. 15, Pl. VII, figs. 3, 4, 5.
1814. *Ammonites sphæricus*, J. Sowerby, Min. Conchol., Vol. I, p. 116, Pl. LIII, fig. 2.
1825. *Goniatites sphæricus*, G. de Haan, Mon. Ammon. et Gon., p. 159.
1828. *Orbulita sphærica*, J. Fleming, Hist. Brit. Anim., p. 248.
1832. *Ammonites carbonarius* (pars), L. von Buch., Phys. Abhandl. Berlin Akad. der Wissenschaften for 1830, p. 176, Pl. II, figs. 9, 9 I, 9 II, 9 III (not fig. 9 IV).
1836. *Goniatites sphæricus*, J. Phillips, Geol. Yorkshire, Pt. II, p. 234, Pl. XIX, figs. 4–6.

1837. *Ammonites sphæricus*, E. Beyrich, De Goniatitis in Mont. Rhen., p. 13.
1837. *Ammonites sphæricus*, E. Beyrich, Beitr. z. Kennt. Rhein. Uebergangsgeb., p. 38.
1842–4. *Ammonites sphæricus*, L. G. de Koninck, Descr. anim. foss., p. 570, Pl. XLIX, figs. 6; Pl. L, figs. 9, 10.
1844. *Goniatites sphæricus*, F. McCoy, Synop. Carb. Foss. Ireland, p. 15.
1846. *Goniatites sphæricus*, F. A. Quenstedt, Petrifact. Deutschl., Vol. I, Cephalopoden, p. 66, Pl. III, fig. 11 (not fig. 10 a–d).
1850. *Aganides sphæricus* (pars), A. d'Orbigny, Prod. de Paléont., Vol. I, p. 115.
1855. *Aganides sphæricus*, F. McCoy, Brit. Pal. Fossils, p. 566.
1867. *Goniatites sphæricus*, H. Trautschold, Bull. Soc. Impér. Nat. Moscou, Vol. XL, No. 3, p. 44, Pl. V, fig. 10.
1875. *Goniatites sphæricus*, W. H. Baily, Charact. Fossils, p. 117, Pl. XL, figs. 9a, b.
1880. *Goniatites sphæricus* (pars), L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 249, Pl. XLVII, figs. 3–5.
1884. *Glyphioceras sphæricum*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 329.
1888. *Goniatites sphæricus*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 312.
1897. *Glyphioceras sphæricum*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 157, fig. 73.
1897. *Glyphioceras sphæricum*, S. Weller, Trans. N. Y. Acad. Sci., Vol. XVI, p. 271, Pl. XXI, figs. 1, 2.
1898. *Goniatites sphæricus*, E. Haug, Études sur les Goniatites, p. 26.
1901. *Glyphioceras sphæricum*, F. Frech, Ueber devonische Ammoneen, p. 84, fig. 37 b and c.

This species was somewhat doubtfully identified by Weller from the so-called Batesville sandstone, St. Louis-Chester stage, Lower Carboniferous, of Batesville, Ark. Since the same group has furnished in that region *G. crenistria* and *G. striatus* the occurrence of *G. sphæricus* is not at all unlikely, but better specimens must be found before the identification will be certain. The European form was the one chosen by Hyatt as the type of his genus *Glyphioceras*.

For the distinctions between *Goniatites crenistria*, *G. sphæricus*, and *G. striatus* see the descriptions of *G. crenistria* and *G. striatus*, where the relations of all three are fully discussed and the comparative dimensions given. The three species have usually been confused, and indeed they are separated by very slight differences, which seem, however, to be fairly constant. But it is by no means impossible, nor even unlikely, that at least *G. crenistria* and *G. striatus* may be the same species, and both possibly only a variety of *G. sphæricus*.

*Occurrence.*—Lower Carboniferous, St. Louis-Chester stage, Batesville sandstone, Batesville, Ark.

### Goniatites striatus Sowerby.

Pl. X, figs. 1–11; Pl. XXVI, figs. 6–13.

1814. *Ammonites striatus*, J. Sowerby, Min. Conchol., Vol. I, p. 115, Pl. LIII, fig. 1.
1825. *Goniatites striatus*, G. de Haan, Mon. Ammon. et Gon., p. 159.
1836. *Goniatites striatus*, J. Phillips, Geol. Yorkshire, Pt. II, p. 233, Pl. XIX, figs. 1–3.
1842–1844. *Ammonites striatus* (pars), L. G. de Koninck, Descr. anim. foss., p. 568, Pl. XLIX, figs. 7, a, b, c, d; Pl. L, figs. 7, a, b. c.
1844. *Goniatites striatus*, F. McCoy, Synop. Carb. Foss. Ireland, p. 16.
1852–1854. *Goniatites sphæricus* (pars), F. Roemer, in Lethæa Geognostica, 3d ed., Vol. I, Pt. II. p. 517, Pl. I, figs. 17, a, b, c.
1855. *Aganides sphæricus*, var. *γ striatus*, F. McCoy, Brit. Pal. Fossils, p. 567.
1876. *Goniatites sphæricus*, F. Roemer, Lethæa Geognostica, Pt. II, Lethæa Palæozoica, Pl. XLVI, figs. 11, a, b, c.
1880. *Goniatites striatus* (pars), L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 253, Pl. XLVI, figs. 1, 1a, 2, 2a; Pl. XLVII, figs. 1, 1a, 2, 2a.
1884. *Glyphioceras striatum*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 329.
1893. *Glyphioceras cumminsi*, A. Hyatt, Fourth Ann. Rept. Geol. Surv. Texas, p. 467, Pl. XLVII, figs. 33–43.
1897. *Glyphioceras striatum*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 166, fig. 78.
1898. *Goniatites striatus*, E. Haug, Études sur les Goniatites, p. 28.
1899. *Glyphioceras striatum*, F. Frech, Die Steinkohlenformation, Pl. XLVI, figs. 1–2.

Shell globose, involute, with slightly flattened sides, and broadly rounded abdomen. Height of whorl about the same as the breadth, and a little more than one-half of the diameter. Whorl indented more than half its height by the preceding whorl. Umbilicus narrow, about one-eighth of the diameter, broader than in *G. crenistria*, and narrower than in *G. sphæricus*. Three to four distinct constrictions to a revolution; these form a broad, shallow saddle on the abdomen, showing on both shell and cast.

Surface ornamented with fine, sharp, spiral striæ, with slightly broader interspaces, and fine cross striæ, giving a reticulated aspect to the shell. The cross striæ are finely crenulated, as in *G. crenistria*, but the spiral ridges much stronger. *G. striatus* is most nearly allied to *G. crenistria*, from which it differs in being slightly more compressed, in its coarser spiral striæ and less distinct cross striæ, and somewhat wide umbilicus. From *G. sphæricus* this species differs in its more distinct spiral and cross striæ, the slight reticulation of the shell, the somewhat narrower umbilicus, and the greater lateral compression.

It will be seen from the foregoing description that *G. striatus* is directly intermediate in character between *G. crenistria* and *G. sphæricus*, and a large suite of specimens of all three would probably show transitions from one to the other.

There seem to be among the American specimens two rather well-marked varieties of this species, one with the spiral lines very sharp and the cross striæ very weak; this one occurs in the St. Louis-Chester stage of Batesville, Ark.; the other has the spiral lines and cross striæ of about equal strength, and very sharply defined crenulations; this occurs in the St. Louis-Chester stage, the Bend formation of central Texas (*Glyphioceras cumminsi* Hyatt, Pl. X, figs. 1–11), although it seems to the writer that Hyatt has included under this designation specimens of both *G. striatus* and *G. crenistria*. In youth these varieties can not be distinguished from each other, nor from *G. crenistria*, which is associated with them.

*Goniatites kentuckiensis* Miller is probably identical with this species, but until a specimen is found showing constrictions it is left under its present name.

*Occurrence.*—*Goniatites striatus* is characteristic of the upper part of the Lower Carboniferous in Great Britain, Belgium, and Germany, and is considered a typical zone fossil in that region. We may therefore extend the term zone of *Goniatites striatus* to the same horizon in America, the St. Louis-Chester stage, in which this species has been found near Batesville, Ark. (Pl. XXVI, figs. 6–13), and in the Bend formation near Lampasas, Tex. (Pl. X, figs. 1–11). The specimens figured on Pl. XXVI, figs. 6–13, in this paper are deposited in the geologic collection of Leland Stanford Junior University, and came from the St. Louis-Chester beds (Fayetteville shale) of Batesville, Ark. Those figures on Pl. X, figs. 1–11, came from the Bend formation near Lampasas, Tex., and are deposited in the Texas State Museum.

### Goniatites subcircularis Miller.

Pl. XXVI, figs. 14–18.

1889. *Goniatites subcircularis*, S. A. Miller, North American Geol. and Pal. p. 440, fig. 741.

This species resembles somewhat *G. striatus*, but has wider umbilicus, coarser spiral striæ, more compressed whorl, and lacks entirely the

crenulations seen on most other species of this group. Constrictions deeply incised, four to a revolution, bending sharply forward on the abdomen.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Crab Orchard, Ky., and the same horizon in the so-called Fayetteville shale of Batesville, Ark. The figured specimens came from the Arkansas locality, and are deposited in the geologic collection of Leland Stanford Junior University, California.

## Genus Gastrioceras Hyatt.

This genus was originally established by Hyatt[a] to include evolute species with open umbilicus, trapezoidal or semilunular cross section, and usually ribs or tubercles on the sides; the species included by Hyatt in this genus all have prominent siphonal saddles, first lateral saddle broadly rounded, second lateral saddle broad, but inclined to be pointed; the siphonal lobes are long, narrow, and pointed, and the lateral lobes broad and pointed. In all the species cited by Hyatt[b] as belonging to *Gastrioceras*, there is but a single pair of lateral lobes visible—that is, on the sides of the shell; and Hyatt[c] limits *Gastrioceras* to forms with a single pair of lateral lobes and with the second pair on the umbilical shoulders. Hyatt[d] refers *G. russiense* Tzwetaev to his genus *Paralegoceras*, because that species has the second pair of lateral lobes on the sides of the shell and not on the umbilical shoulders. But *Gastrioceras russiense* has just the same number of lobes as all other known species of *Gastrioceras*, namely, nine in all, and lacks the lobe on the umbilical border, which is characteristic of *Paralegoceras*. Dr. K. von Zittel[e] confines *Gastrioceras* to forms with a single pair of lateral lobes. But the relations of *Gastrioceras*, *Glyphioceras*, *Goniatites*, and *Paralegoceras* have been best worked out by Karpinsky, who shows that there is no marked distinction between *Goniatites* and *Gastrioceras;* that both have the same number of lobes and saddles—nine of each; that the second pair of lateral lobes may be on the umbilical shoulders or on the sides of the shell, thus differing from *Paralegoceras*, in which the third pair of lateral lobes is on the umbilical shoulders. *Gastrioceras* usually has a trapezoidal cross section and umbilical ribs; but some species lack the

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.
[b] Ibid.
[c] Second Ann. Rept. Geol. Surv. Texas, p. 355.
[d] Ibid.
[e] Grundzüge der Palæont., p. 399.

ribs, as *G. globulosum* Meek and Worthen, while some species of *Glyphioceras* have umbilical ribs and, in their youth, also the elliptical cross section, as *Glyphioceras diadema* Goldfuss. But the two extremes are widely separated from each other, as *Gastrioceras jossæ* Verneuil and *Goniatites sphæricus* Martin.

This genus has been looked upon by Steinmann as the ancestor of the trachyostracan families of the Trias, the Ceratitidæ and the Tropitidæ. Dr. K. von Zittel agrees with this opinion as to the origin of the Tropitidæ, but thinks the Ceratitidæ developed out of the Prolecanitidæ, which is in agreement with the writer's studies on the development of Ceratites of the Trias.

### Gastrioceras branneri Smith.

Pl. XI, figs. 8–13.

1896. *Gastrioceras branneri*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 257, Pl. XXIII, figs. 1–6.

The adult shell is discoidal, with low, narrow whorls of semilunular cross section; the adult whorl is very evolute, embracing not more than a third of the preceding one, and the increase in height and breadth is extremely slow. The young whorls are proportionally broader and more involute, so that the umbilicus of the younger part of the shell is deeper, but widens rapidly with age, as the involution decreases. *G. branneri* is the most evolute species of *Gastrioceras* known in the Carboniferous, and approaches the narrow evolute Permian type, described by Gemmellaro from Sicily; but the Sicilian form still retains the strong constrictions, and has also acquired the spiral striæ that are characteristic of Permian *Gastrioceras*.

*Dimensions.*

| | Millimeters. |
|---|---|
| Diameter | 39.5 |
| Height of last whorl | 10.5 |
| Width of umbilicus | 19.0 |
| Breadth | 15.0 |
| Height of last whorl from top of preceding | 8.0 |

The specimen shows nine whorls at the diameter of 39.5 mm.

*Sutures.*—The sutures consists of three external lobes and as many saddles. The siphonal lobes are long, narrow, and pointed; the first lateral broadly pointed, and on the umbilical shoulder is another shallow lobe, broad and pointed. The siphonal saddle is narrow, with the usual indentation at the end; the first lateral saddle is broadly rounded and deep, the second lateral saddle shallow and inclined to be pointed. The inner lobes

are three in number, a long, narrow, pointed antisiphonal lobe, and a pair of shorter, pointed lateral lobes; the four internal saddles are rounded. The figures on Pl. XI, figs. 12 and 13, show the sutures to be characteristic of *Gastrioceras;* but the second lateral lobe, while on the umbilical shoulders, is plainly visible from the outside. Thus the species might be referred to the genus *Paralegoceras* of Hyatt; but it has only nine lobes and nine saddles, while *Paralegoceras* has eleven of each.

*Surface characters.*—The shell is preserved on only a small portion of the specimen, but the cast shows the generic and specific characters quite as well. Obscure and somewhat doubtful constrictions were observed, but the preservation is such that their interval could not be ascertained. The umbilical shoulders are marked with rather weak nodes or ribs, which on the outer whorls reach up nearly to the abdominal shoulders; on the young shell they are relatively much stronger.

*Affinities.*—*Gastrioceras branneri* belongs to the group of *G. listeri* Martin, *G. jossæ* Verneuil, and *G. marianum*, all characterized by trapezoidal cross section, umbilical ribs, pointed lobes and rounded saddles, and evolute whorls. From the above-mentioned species *G. branneri* differs in the narrowness of its whorls, and wide, shallow umbilicus; it seems to depart further from the *Glyphioceras* stock than any other Carboniferous species of the genus *Gastrioceras.*

*Occurrence.*—*Gastrioceras branneri* was found along with *Pronorites cyclolobus* Phillips, var. *arkansasensis* Smith, and *Productus cestriensis* Meek and Worthen, in Arkansas, on Pilot Mountain, Carroll County, 3½ miles southwest of Valley Springs, in T. 17 N., R. 19 W., sec. 18, northeast corner, in Lower Carboniferous, Chester group (A10 of Prof. H. S. Williams's section).

The type, for the use of which the writer is indebted to Prof. H. S. Williams, is the property of the U. S. Geological Survey (U. S. National Museum), locality number 1275.

### Gastrioceras carbonarium von Buch.

Plate XI, figs. 1–4.

1832. *Ammonites carbonarius* (pars), L. von Buch, Phys. Abhandl. Berlin Akad. der Wissenschaften for 1830, p. 176, Pl. II, fig. 9 IV, (not 9, 9 I–III).

1842. *Goniatites carbonarius* (pars), d'Archiac and Verneuil, Trans. Geol. Soc. London, 2d series, Vol. VI, p. 382.

1842–44. *Ammonites listeri*, L. G. de Koninck, Descr. anim. foss., p. 577, Pl. LI, figs. 4, a–b.
1861. *Goniatites listeri*, J. W. Salter, Mem. Geol. Survey, Iron Ores of Great Britain, Pt. III, p. 221, Pl. I, figs. 35, 36.
1863. *Goniatites listeri* (pars), F. Roemer, Zeitschr. Deutsch. Geol. Gesell., Vol. XXXVI, p. 213.
1884. *Glyphioceras carbonarium* (pars), A. Hyatt, Proc. Boston, Soc. Nat. Hist., Vol. XXII, p. 329.
1890. *Goniatites listeri*, J. Ward, Trans. N. Staffs. Inst. Min. and Mech. Eng., Vol. X, Pl. I, figs. 4, 5.
1892. *Goniatites listeri*, G. Wild, Trans. Manchester Geol. Soc., Vol. XXI, p. 396, Pl. II, figs. 9, 10.
1896. *Gastrioceras*, sp. indet., J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 262, Pl. XX, figs. 1, a, b, c, d.
1896. *Goniatites carbonarius*, H. Bolton, Trans. Manchester Micros. Soc., 1895, p. 130, Pl. II, fig. 20.
1897. *Gastrioceras carbonarium*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 229, figs. 110, a–d.
1898. *Gastrioceras listeri* (pars), E. Haug, Études sur les Goniatites, p. 103.
1899. *Glyphioceras subcrenatum*, F. Frech, Die Steinkohlenformation, Pl. XLVI, *B*, figs. 3 and 5.
[Not 1840. *Goniatites carbonarius*, J. de C. Sowerby, Trans. Geol. Soc. London, 2d series, Vol. V, p. 703, Pl. LII, figs. 8, 9.]

Form somewhat compressed laterally; whorls helmet-shaped, wider than high, highly arched, and indented to nearly one-half the height by the preceding whorl. Greatest breadth at the umbilical margin. Umbilicus wide and deep, inner area steep. In the adolescent stage the whorls are broad, low, and flattened, with angular sides exactly like those of *G. listeri*.

The sides are ornamented with strong tubercles, which on the young stages are like those of *G. listeri*, but at maturity form ribs that reach halfway up to the abdomen.

Three or four constrictions are seen on each revolution. Outer shell with fine cross striæ of growth, visible on the cast. The ventral lobes are sharp and narrow, the lateral lobe narrower than is usual with *Gastrioceras*, and not tongue-shaped.

The inner whorls are flattened and angular, with much stronger tubercles than those on the mature shell.

E. Haug[a] has included not only this species, but also *G. coronatum*

[a] Études sur les Goniatites, p. 103.

Foord and Crick, in *G. listeri*, but these three differ in septa, in involution, and shape of the whorl, *G. listeri* being intermediate between the others, and no transitions from one to the other being known.

*Occurrence.*—*Gastrioceras carbonarium* is characteristic of the middle division of the Coal Measures in England, Belgium, and Germany. In America it has been found at the same horizon in western Arkansas—Scott County, near Boles—associated with *G. listeri*. The identification is not beyond question, on account of the nature of the preservation of the specimens. It is therefore referred with some doubt to *G. carbonarium*. Figured specimen deposited in the geologic collection of Leland Stanford Junior University.

### Gastrioceras compressum Hyatt.

Pl. IX, figs. 1–3.

1891. *Gastrioceras compressum*, A. Hyatt, Second Ann. Rept. Geol. Surv. Texas, p. 355, figs. 57, 58.

The following description is quoted from Hyatt's paper:

The form of the whorl is helmet-shaped, and at the diameter of 109 mm. in a cast the greatest transverse diameter was 42 mm.; the distance in a straight line from umbilical shoulder to center of abdomen, 38–39 mm.; the abdomino-dorsal diameter, 23 mm. The increase by growth in both diameters is slow and the umbilici consequently shallow. The involution covers more than two-thirds of next internal whorl at the diameter of 109 mm., and in another specimen at diameter of 68 mm. it is just two-thirds. The still younger whorls are numerous and visible from the sides at the centers of the umbilici, and doubtless the amount of involution is correspondingly less. Constrictions appear in the smaller specimen measured and in the younger stages of another flattened example.

The ventral lobe is divided by a large bottle-shaped siphonal saddle divided by a siphonal lobe at the extremity; the lateral branches of the ventral lobes are very long and acutely pointed, as are also the first lateral lobes, which are of the same length as these branches of the ventral. The first lateral saddles are hastate and acutely pointed, and second lateral saddles are, as is usual in this genus, subhastate. The inner outlines of these last are concave near the points, then suddenly convex internally where the lobe of the umbilical shoulder begins. These last-mentioned lobes are also acutely pointed, but much more abbreviated than the other two pairs. The shell is strongly striated, but it is not pilated or otherwise marked, except when constrictions occur.

*Occurrence.*—Lower Carboniferous, St. Louis-Chester stage, Bend formation, San Saba County, near Bend, Tex. The type is deposited in the U. S. National Museum.

### Gastrioceras entogonum Gabb.

Plate X, figs. 17–19.

1861. *Goniatites entogonus*, W. M. Gabb, Proc. Acad. Nat. Sci. Phila., 1861, p. 372.
1893. *Gastrioceras entogonum*, A. Hyatt, Fourth Ann. Rept. Geol. Surv. Texas, p. 472, Pl. XLVII, figs. 49–51.

The following description is quoted from Hyatt's paper:

This species is similar to others of the genus in its open umbilici and the arcuate trapezoidal outline of the whorl in section. The cast is marked by deep constrictions, confined to the abdomen, and somewhat less than one-third of a volution apart, or about three and five-tenths to one volution. These bend forward on either side and then back, forming two crests and a median sinus on the abdomen. The sides are divergent, narrow, and smooth. The abdomen is strongly furrowed and ridged on the shell, and these markings are repeated on the cast. The longitudinal ridges are crossed by strong lines and narrow laminæ of growth, which are to a greater or less extent impressed upon the surface of the cast, as shown in fig. 51 [in Hyatt's paper]. The lines of growth and the constrictions are exactly parallel on the abdomen, and the apertures were probably similar in outline.

The shell was seen only in small fragments, but there is sufficient of these to show that it was not very thick, and ornamented by continuous ridges much sharper than those on the cast. These were crossed and slightly serrated by fine transverse lines, occurring as the edges of narrow laminæ of growth. The sides are smooth except for the presence of the edges of these same laminæ. But there is one patch near the line of involution having a ridge with the usual crenulations. The ridges on the venter cross the constriction of the cast below without any inflection, the constriction being caused entirely by the internal thickening of inner layer of the shell.

This species differs from *Gast. listeri* of Europe in the smoothness of the shell on the sides and the extent of the involution, which is here coextensive with the abdomen of the whorls, and also in the strong ridges on the abdomen.

The sutures were also visible on the specimen and are of the usual gastrioceran type.

*Occurrence.*—Lower Carboniferous, St. Louis-Chester stage, Bend formation, 5 miles west of Lampasas, Texas. A similar species, thought to be identical with *G. entogonum*, was found by the geological survey of Arkansas in the Lower Carboniferous, Fayetteville shale, near Boles, Ark. In both Arkansas and Texas this species was associated with *Goniatites cumminsi* of Hyatt, or *Goniatites striatus*, according to the writer.

### Gastrioceras excelsum Meek.

Pl. XVI, fig. 2; Pl. XXVIII; Pl. XXIX.

1866. *Goniatites globulosus* (pars), Meek and Worthen, Geol. Surv. Illinois, Vol. II, p. 390, fig. 38 (not Pl. XXX, figs. 2 a–c).
1876. *Goniatites globulosus* var. *excelsus*, F. B. Meek, Bull. U. S. Geol. and Geog. Surv. Terr., Vol. I, No. 6, p. 445.
1896. *Gastrioceras excelsum*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 260, Pl. XVII, figs. 1 a, b, c.

This is the largest known species of Carboniferous ammonoids. A specimen from Osage, Kans., now deposited in the United States National Museum, has a diameter of 11 inches, and is entirely septate, so that the full size, with the complete body chamber, must have been several inches more. Shell globose, with depressed helmet-shaped whorls, and abruptly rounded umbilical shoulders. Width of whorl nearly equal to the total diameter of the shell, and more than twice the height of the whorl. Each whorl indented to one-third of its height by the inner volution.

Surface apparently smooth except for obscure traces of nodes on the umbilical shoulder.

Umbilicus deep and wide, being more than one-third of the total diameter in width. Septa of the usual gastrioceran type, ventral lobes long, narrow, and pointed, divided by a broader siphonal saddle. Lateral lobes longer than the ventral, and very little wider. First and second lateral saddles broadly rounded. A third lateral lobe, short and funnel shaped, is seen below on the umbilical slope of the umbilical shoulder. This is not shown in the sketch on Pl. XXVIII, fig. 2, which stops at the umbilical shoulder, but can be seen on fig. 1, from a photograph of the shell. Internal septa unknown.

*Occurrence.*—A specimen doubtfully compared by Meek with this species was found at an unknown locality in the Upper Coal Measures of Kansas, and figured in geological survey of Illinois, Vol. II, p. 390, fig. 38.

This type was found in the Upper Coal Measures of eastern Kansas at Osage. This is the specimen now deposited in the United States National Museum. In the paleontologic collection of the Walker Museum, University of Chicago, is a specimen, No. 6226, from the Upper Coal Measures of Osage, Kans.; this is better preserved than the type, and has therefore been figured on Pls. XXVIII and XXIX. The writer's thanks are due Dr. Stuart Weller, of

the University of Chicago, for the opportunity of studying the specimen, and for the photographs of it. On Pl. XVI, figs. 2a and 2b, is figured a specimen from the Middle Coal Measures of Pope County, Ark., T. 10 N., R. 20 W., sec. 8, collected by the geological survey of Arkansas, and now deposited at Leland Stanford Junior University.

### Gastrioceras globulosum Meek and Worthen.

Pl. VI, fig. 1; Pl. XXI, figs. 7–9.

1860. *Goniatites globulosus*, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1860, p. 471.
1866. *Goniatites globulosus*, Meek and Worthen, Geol. Surv. Illinois, Vol. II, p. 390. Pl. XXX, fig. 2.
1884. *Gastrioceras globulosum*, A. Hyatt, Proc. Boston Soc. Nat. Hist. Vol., XXII, p. 327.
1896. *Gastrioceras globulosum*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 258, Pl. XVIII, figs. 1–6.
1898. *Glyphioceras globulosum*, E. Haug, Études sur les Goniatites, p. 26.

This species has some slight resemblance to *Paralegoceras baylorense* of the Texas Permian, but the lobes of the latter are alone sufficient to separate the species, exceeding by one the number on the sides of *G. globulosum*. The Texas species also has the umbilicus much wider and more open, and is not so globose.

The angle of the umbilicus is 45°, which remains constant notwithstanding the fact that the shell grows more involute with age, being in its youth a comparatively open coil. In youth the whorls are flattened, but with age they become more rounded, until the shell reaches almost the form of *Goniatites sphæricus* Martin. As many as six whorls are known.

The deeply marked constrictions, that are so common in the family of the Glyphioceratidæ, are seen on the casts, about four to a whorl.

*Sutures.*—The sutures show nine lobes and nine saddles; the siphonal lobes are narrow and pointed, the first lateral lobe is broad, but pointed, and on the umbilical shoulder is a small, pointed "suspensive" lobe. There are three pointed, internal (concealed by the involution) lobes, of which the antisiphonal (dorsal) is the longer.

The siphonal saddle is rather deeply notched, long and narrow; the two lateral saddles are broad and rounded. The two internal saddles are rather pointed and long, as is the case with most species of this genus. The internal lobes and saddles have never been seen before in this species.

The septa are exactly like those figured by Meek and Worthen, so that no further description of them is necessary; they are typical of the genus *Gastrioceras*, as characterized by Hyatt, although as Karpinsky[a] remarks, the sutures alone are not sufficient to separate the genera *Glyphioceras* and *Gastrioceras*, since a comparison of the sutures of *Gastrioceras jossæ* Verneuil and *Glyphioceras diadema* Verneuil (not Goldfuss) shows the almost perfect similarity of the two.

The surface of the shell was unknown to Meek and Worthen, but some of the Arkansas specimens have the shell partially preserved. It is marked with fine, sharp, doubly arcuate, sickle-shaped striæ or ribs, with the sinus on the ventral portion pointing backward. The surface ornamentation resembles that of *Glyphioceras obtusum* Phillips,[b] but the form is much more globose, and the lobes unlike those of Phillips's species.

*Dimensions.*—One of the fragments shows a diameter of over 2 inches; on this only the body whorl was seen, it being at least one coil in length.

*Dimensions of the largest figured specimen.*

| | Millimeters. |
|---|---|
| Diameter | 36 |
| Breadth | 27 |
| Height of last whorl | 14 |
| Height of last whorl from center of umbilicus | 19 |
| Height of last whorl from top of the inner one | 8 |
| Width of umbilicus | 9 |

These measurements show the adult shell to be very globose.

*Occurrence.*—Several specimens of this species were found in the Middle Coal Measures of Scott County, Ark., T. 1 N., R. 28 W., sec. 4, SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$. This species is also found in the Cisco formation of the Texas Upper Coal Measures, and in the Upper Coal Measures of Springfield, Ill. The specimen figured on Pl. XXI, figs. 7–9, came from the Upper Coal Measures, Cisco formation, of Graham, Tex., and has been deposited by the writer in the U. S. National Museum.

[a] Ammoneen der Artinsk-Stufe, p. 46.

[b] Geol. Yorkshire, Pt. II, p. 235, Pl. XIX, figs. 10–13.

GASTRIOCERAS ILLINOISENSE Miller and Gurley.

Pl. XVII, figs. 6–8.

1896. *Goniatites illinoisensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 42, Pl. V, figs. 6–8.
1898. *Paralegoceras illinoisense*, E. Haug, Études sur les Goniatites, p. 31.

The following description is quoted from the paper by Miller and Gurley:

Species medium size, subglobose, volutions moderately enlarging, and periphery broadly rounded. One specimen exposes part of three volutions, leaving the impression that a complete shell contained not less than six volutions. A transverse of a volution is suberescentiform, the horns being short and obtuse. The last volution incloses all the inner ones, but leaves a rather large open umbilicus. The air chambers are short and complicated. The outer shell is not preserved in our specimen.

The septa are gastrioceran in character, consisting of a pair of ventral lobes divided by a blunt siphonal saddle, a principal lateral lobe, and a broad, shallow, pointed, funnel-shaped auxiliary. The saddles are club-shaped, and the ventral and first lateral lobes mucronate.

This species certainly belongs in the same genus with *Gastrioceras kansasense* Miller and Gurley, of which the writer has satisfied himself by an examination of the types of the two. Haug referred this species to *Paralegoceras*, but in the drawing of the septa (the internal part was added to the original drawing from a sketch of the type by Dr. Stuart Weller) it is seen to lack the fourth external lobe that is characteristic of *Paralegoceras*, and to have the normal number of lobes, external and internal, characteristic of *Gastrioceras*.

*Occurrence.*—Upper Coal Measures, Montgomery County, Ill. Type specimen is deposited in the paleontologic collection, Walker Museum, University of Chicago.

GASTRIOCERAS KANSASENSE Miller and Gurley.

Pl. XVII, figs. 9–11.

1896. *Goniatites kansasensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 43, Pl. V, figs. 9–11.

Shell small, subglobose; whorls slowly increasing in size, depressed helmet-shaped and deeply embracing, indented to half their height by the

preceding whorls. Breadth of whorl about two-thirds of the total diameter of the shell and nearly twice as great as the height of the whorl. Umbilicus wide, its width being more than a third of the total diameter of the shell. Surface of the shell smooth, not marked by ribs.

According to Miller and Gurley, this species differs from *G. illinoisense* in its larger umbilicus, more depressed whorls, less gibbous shape of the whorls, greater abruptness of the umbilical shoulders, and greater simplicity of the septa, which are decidedly mucronate in *G. illinoisense* and merely tongue-shaped in *G. kansasense*. Also in *G. kansasense* the auxiliary lobe is on the umbilical border, while on *G. illinoisense* it is on the umbilical slope, just below the shoulder. Both species belong to the group of *G. globulosum*, characterized by globose whorls and absence of umbilical nodes or ribs, thus differing from the species that have been considered typical of *Gastrioceras*. This seems to be a rather specialized group that has lost the nodes entirely, and retains the constrictions only in the young.

*Occurrence.*—Upper Coal Measures, Missourian stage, Kansas City, Mo. The type is in the paleontologic collection, Walker Museum, University of Chicago.

### Gastrioceras kingi Hall and Whitfield.

Pl. IV, figs. 4–8.

1877. *Goniatites kingi*, Hall and Whitfield, U. S. Geol. Expl. Fortieth Parallel, Vol. IV, Pt. II, p. 299, Pl. VI, figs. 9–14.

1884. *Gastrioceras kingi*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.

Shell subglobose, the breadth of the whorls being about two-thirds of the total diameter of the shell and about twice as great as the height of the whorl. Whorls with flattened broad venter, depressed helmet-shaped outline, abrupt angular umbilical shoulders, the umbilical border having an inclination of 45° with the axis of the shell. Umbilicus wide, being about one-half of the diameter of the shell. Whorls deeply embracing, each one covering the inner whorl to near the umbilical shoulder, and being indented by this to one-half its height.

Surface ornamented by obscure nodes on the umbilical shoulders, sometimes forming faint undulations across the abdomen. The whole surface is covered by fine lines of growth, the crowding together of which causes the undulations. Surface of the cast marked by constrictions, about two to a revolution.

Septa of the usual gastrioceran type; ventral lobes narrow and long, separated by a deeply notched siphonal saddle. Lateral lobe rather broad and funnel-shaped. External and lateral saddles broadly rounded. The second lateral lobe is not above the umbilicus. Body chamber at least two revolutions in length.

*Occurrence.*—In black shale of the Coal Measures, presumably the upper part, near Eberhardt Mill, White Pine, Nev. The type is deposited in the U. S. National Museum.

### Gastrioceras listeri Martin.

Pl. XIII, figs. 6–15.

1809. *Conchyliolithus Nautilites Ammonites* (*listeri*), W. Martin, Petrif. Derb., Pl. XXXV, fig. 3, and p. 16.
1825. *Ammonites listeri*, J. Sowerby, Min. Conchol., Vol. V, p. 163, Pl. DI, fig. 1 (right and left hand figures).
1832. *Ammonites listeri*, L. von Buch, Phys. Abhandl. Berlin Akad. der Wissenschaften for 1830, p. 175.
?1833. *Ammonites listeri*, C. J. Davreux, Mém. Cour. Acad. Roy. Bruxelles, Vol. IX, p. 270, Pl. III, figs. 1, 2.
1836. *Goniatites listeri*, J. Phillips, Geol. Yorkshire, Pt. II, p. 235, Pl. XX, figs. 1, 1a.
1842. *Goniatites listeri*, F. McCoy, Synop. Carb. Foss. Ireland, p. 14.
1842–44. *Ammonites listeri* (pars), L. G. de Koninck, Descr. anim. foss., p. 577 (excluding figures).
?1855–57. *Goniatites listeri*, J. Kelly, Jour. Geol. Soc. Dublin, Vol. VII, p. 7.
1863. *Goniatites listeri*, F. Roemer, Zeitschr. Deutsch. Geol. Gesell., Vol. XV, p. 580 (excluding figures).
1884. *Gastrioceras listeri*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.
1884. "*Ammonites listeri*," E. Beyrich, Zeitschr. Deutsch. Geol. Gesell., Vol. XXXVI, p. 213.
1888. *Goniatites listeri*, R. Etheridge, British Fossils, Vol. I, Palæozoic, p. 312.
1892. *Goniatites striatus*, G. Wild, Trans. Manchester Geol. Soc., Vol. XXI, p. 396, Pl. II, fig. 11.
1896. *Goniatites listeri*, H. Bolton, Trans. Manchester Micros. Soc., 1895, pp. 130, 134, Pl. II, fig. 21.
1896. *Gastrioceras marianum*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 260, Pl. XVI, figs. 1–5.
1897. *Gastrioceras listeri*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 233, fig. 111.
1898. *Gastrioceras listeri* (pars), E. Haug, Études sur les Goniatites, p. 103, Pl. I, figs. 28–31.
1899. *Glyphioceras listeri*, F. Frech, Die Steinkohlenformation, Pl. XLVI, *B*, figs. 2 a–b.

The whorl is low, broad, with trapezoidal cross section, very evolute, broader than high; indented about one-half the height by the preceding whorl. Greatest breadth at the umbilical margin, about three-fourths the diameter; height of the whorl about two-sevenths the diameter and less than half the breadth. Umbilicus broad and deep, width about one-half the diameter. Strong umbilical tubercles, which are continued across the abdomen by fine undulations. About three constrictions to a revolution. Outer shell with fine cross striæ, and obscure spiral striæ on the inner whorls. Septa consisting of a pair of tongue-shaped narrow ventral lobes, and a somewhat shorter and broader lateral lobe. On the umbilical shoulders is a small shallow "suspensive" lobe. The saddles are all broadly rounded.

This species has been united by many writers with *Gastrioceras carbonarium*, but is always broader and more depressed, has stronger umbilical tubercles and broader lateral lobes than that species. Some have confused it with *G. marianum* M. V. K., and the American representative has been referred by the writer[a] to that species. But the figures and descriptions of Foord and Crick enable these two species to be distinguished quite easily. *G. listeri* is not quite so involute as *G. marianum*, is always broader and coarser in sculpture. The breadth of the whorl in *G. listeri* is more than three-fourths of the diameter, in *G. marianum* it is only two-thirds of the diameter. Also in *G. listeri* the lobes are proportionally longer and narrower.

*Occurrence.*—In England, Belgium, and Germany *Gastrioceras listeri* is characteristic of the middle division of the Coal Measures. In America it has been found in the same horizon near Boles, Scott County, Ark., accompanied by *G. carbonarium*. It may thus be taken as diagnostic for this zone in these two regions.

The figured specimens came from near Boles, Scott County, Ark., and are deposited in the geologic collection of Leland Stanford Junior University, California.

[a] Proc. Am. Philos. Soc., Vol. XXXV, p. 260.

### Gastrioceras montgomeryense Miller and Gurley.

Pl. XVI, figs. 12–14.

1896. *Goniatites montgomeryensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 38, Pl. IV, figs. 12–14.

Shell robust, breadth nearly as great as the diameter; whorls slowly expanding, three times as broad as high, deeply embracing, the outer whorl being indented to one-half its height by the inner one, but the umbilical shoulders of the inner whorls are exposed in the deep funnel-shaped umbilicus. Cross section of whorls depressed, trapezoidal, broader than is usual in *Gastrioceras*. Ventral portion flattened and broad; umbilical shoulders angular and abrupt, descending steeply to the umbilicus, and ornamented with sharply incised ribs or nodes. Umbilicus wide and deep, being one-half of the total diameter of the shell.

There are six constrictions to a revolution, beginning at the umbilical border, curving abruptly forward on the sides and then backward on the abdomen in a broad, gentle series.

Septa consisting of a pair of narrow tongue-shaped ventral lobes, separated by a short siphonal saddle, deeply incised by a secondary notch or lobe; a broad, short, lateral lobe on the sides halfway between the siphon and the umbilical shoulders.

This species is most nearly related to *Gastrioceras listeri*, but is broader in proportion, and also has a greater number of constrictions to a revolution. The lateral sculpture is slightly coarser than on *G. listeri*.

*Occurrence.*—Upper Coal Measures, Montgomery County, Ill. Type in the paleontologic collection, Walker Museum, University of Chicago.

### Gastrioceras nolinense Cox.

Pl. V, figs. 8–10.

1857. *Goniatites nolinensis*, E. T. Cox, Geol. Surv. Kentucky, Vol. III, p. 574, Pl. X, figs. 1, 1a, 1b.

1891. *Goniatites nolinensis*, C. R. Keyes, Proc. Acad. Nat. Sci. Phila., 1891, p. 264.

Form subglobose, somewhat compressed laterally. Whorls highly arched, with broadly rounded abdomen and slightly flattened sides, deeply embracing, and covering most of the inner volutions. Umbilical shoulders abruptly rounded, umbilicus narrow, being not over one-fifth of the total

diameter. Surface smooth, but ribs and constrictions might possibly not be preserved by the iron ore by which the shell is replaced. Septa consisting of hastate lobes and tongue-shaped saddles; siphonal saddle long, mucronate, ventral saddles long and tongue-shaped, lateral saddle broadly rounded; ventral lobes narrow and hastate, lateral lobes broader and pointed, second lateral or auxiliary lobe on the umbilical border. The antisiphonal lobe is long, narrow, and pointed, flanked by a pair of shorter hastate lobes and narrow tongue-shaped saddles. The internal lateral saddles are very broad and shallow.

This species seems to be nearest akin to *Gastrioceras carbonarium*, with which its form and septa agree, but the smoothness of the shell of *G. nolinense* would serve to distinguish them, if it should be proved that the specimens are always devoid of ornamentation.

*Occurrence.*—Middle Coal Measures, Nolin, Edmonson County, Ky., and Des Moines formation, Middle Coal Measures, of Des Moines, Iowa.

### Gastrioceras occidentale Miller and Faber.

Pl. VIII, figs. 6 and 7.

1892. *Goniatites occidentalis*, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, p. 166, Pl. VI, figs. 6 and 7.

Shell subglobose, abdomen broadly rounded, sides sloping with a gentle curve to the abrupt umbilical shoulders. Whorls highly arched, deeply embracing, indented to about one-half of their height by the inner whorls. Umbilicus deep and wide, being about one-third of the total diameter. Umbilical shoulder crenulated or subnodose. Surface marked by four broad, shallow constrictions which run nearly straight across the abdomen. Between these furrows are fine transverse lines of growth, parallel to the constrictions. The septa, as shown by Miller and Faber, do not resemble those of any known goniatite genus, but are remarkably like the impressions of the internal muscle-scars, as seen on many ammonoids. This is probably what was seen by Miller and Faber and reproduced in the drawing. The septa when seen will probably be like those of other species of *Gastrioceras*.

*Occurrence.*—Middle Coal Measures, Elkhorn Creek, Kentucky.

### Gastrioceras planorbiforme Shumard.

1855. *Goniatites planorbiformis*, B. F. Shumard, Geol. Surv. Missouri, Vol. II, p. 208, Pl. C, figs. 11-a-b.

1894. *Goniatites planorbiformis*, C. R. Keyes, Geol. Surv. Missouri, Vol. V. Pt. II, p. 221.

Shell evolute; whorls depressed, rounded, little embracing, elliptical rather than trapezoidal in cross section. Sides rounding gently to the abrupt umbilical shoulders, which, however, are not angular. Umbilicus very wide, exposing all the inner whorls, being more than a third of the total diameter.

Surface ornamented with fine imbricating bands of growth, bearing very minute striæ, which are flexuous on the abdomen; one constriction has been observed at about the end of the fifth revolution. Septa gastrioceran in character, with lobes inclined to be pointed, and broadly rounded saddles. Shumard's type was very small, and these septa are larval in character, so this probably does not represent a mature form, but might be the young of any one of several species of *Gastrioceras*.

*Occurrence.*—Upper Coal Measures, Kansas City, Dovers Landing, Mo.

### Gastrioceras subcavum Miller and Gurley.

Pl. XVII, figs. 15–17.

1896. *Goniatites subcavus*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 45, Pl. V, figs. 15–17.

This species was first described by Miller and Gurley from the Upper Coal Measures of Montgomery County, Ill. The writer has a specimen collected by Dr. N. F. Drake in the Upper Coal Measures, Cisco formation, of Graham, Young County, Tex., about 1,000 feet below the Permian.

The species resembles *Gastrioceras globulosum*, but the whorls are narrower, more depressed, more angular on the umbilical shoulders, and less rounded than on that species. The two agree in the septa and in the absence of umbilical ribs.

The figured specimen is in the paleontologic collection, Walker Museum, University of Chicago (Gurley collection).

*Occurrence.*—Upper Coal Measures, Montgomery County, Ill., and Graham, Young County, Tex.

GASTRIOCERAS WELLERI Smith, sp. nov.

Pl. XXIV, figs. 13–20.

Form evolute, widely umbilicate; whorls low and broad, increasing slowly in size. Cross section trapezoidal, ventral arch low. Umbilicus deep, funnel-shaped, with abruptly angular umbilical shoulders. The height of the whorl is one-third of the total diameter, and the width is twice the height. The width of the umbilicus is slightly more than one-third of the diameter of the shell. The impressed zone is about one-sixth of the height of the whorl. The greatest breadth of the whorl is at one-half the height.

The surface is ornamented with both cross striæ of growth and periodic constrictions. These are seen on both shell and cast. The cross striæ are sinuous and show only imbrication of the shell. There are no crenulations nor spiral lines visible. The constrictions on the last whorl are five in number, deeply incised, and slightly sinuous, bending forward in a broad sinus. The cross striæ also form incipient undulations on the shell and cast. The length of the body chamber is at least one revolution.

The septa are typically gastrioceran; the ventral lobe is divided by a narrow siphonal saddle into two short, narrow branches; the principal lateral lobe is deeper, broad and pointed; the second lateral lobe is on the umbilical slope, just outside of the suture.

This species is most nearly related to *Gastrioceras kingi* Hall and Whitfield, but differs from that species in its weaker sculpture, fewer constrictions, less highly arched whorls, and more angular shoulders. The relative dimensions and the septa of the two species are exceedingly similar. The species belongs to the group of *Gastrioceras globulosum* Meek and Worthen, characterized by rather globose shape and absence of umbilical ribs. But *G. welleri* is proportionally narrower and has a wider umbilicus than *G. globulosum*.

*Occurrence.*—In the Middle Coal Measures, Des Moines formation, of Carroll County, Mo., exact locality unknown. The figured specimens are deposited in the paleontologic collection of the Walker Museum, University of Chicago (No. 1313). The specific name is given in honor of Dr. Stuart Weller, to whom the writer's thanks are due for the loan of the specimens.

## Genus Paralegoceras Hyatt.

This genus was described by Hyatt[a] to include forms similar in many respects to *Gastrioceras*, but with more highly arched whorls, helmet-shaped rather than trapezoidal in outline, narrower umbilici, and less pronounced sculpture. The septa are of the lanceolate type, both lobes and saddles being narrow and long, the saddles being rounded and club-shaped, while the lobes are pointed and tongue-shaped, or mucronate. The lobes on each side are four in number—an external or ventral two laterals, and an auxiliary lobe just on the umbilical border. There are three internal or dorsal lobes—a long, pointed antisiphonal flanked by two similar laterals. This gives for *Paralegoceras* eleven lobes in all, one pair more than *Gastrioceras* posesses.

The type chosen was *P. iowense* Meek and Worthen.

### Paralegoceras baylorense White.

Pl. IV, figs. 9–11.

1891. *Goniatites baylorensis*, C. A. White, Bull. U. S. Geol. Survey No. 77, p. 19, Pl. II, figs. 1–3.

The following description is quoted from White's paper:

Shell apparently reaching a moderately large size; its transverse diameter less than that of the plane of its coil; volutions moderately embracing; the peripheral and lateral portions regularly rounded from the border of one umbilicus to that of the other; umbilici deep and somewhat narrow, but showing a portion of each of the inner volutions, their borders abruptly rounded inward from the sides; the transverse diameter of the volutions nearly three times as great as the dorso-ventral diameter, a transverse section of them showing a lunate outline. Living chamber and aperture unknown. Septa moderately distant from one another; dorsal [ventral] lobe longer than wide, deeply divided into two narrow, lanceolate, slightly diverging branches; dorsal [ventral] and superior lateral saddles linguiform and nearly equal in size; the two saddles separated by the superior lateral lobe, which is simple, slightly constricted in the middle, and acutely pointed; the inferior lateral lobe similar in shape to the superior, but a little shorter and less distinctly constricted; inferior lateral saddle a little shorter than the others, somewhat irregular in shape, and occupying the margin of the umbilicus. Surface apparently unornamented.

The only specimen in the collection, when perfect, probably reached a diameter of coil of about 55 millimeters.

This species bears considerable resemblance to the *G. globulosus* of Meek and

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.

Worthen, but the septa of the Texan form have each one more lobe and saddle between the periphery and the margin of the umbilicus than have those of the other form.

There can be little doubt that this species is correctly referred to *Paralegoceras*, because the auxiliary lobe appears to be on the umbilical border giving the right number of lobes, although it is not shown in the drawing.

*Occurrence.*—Permian, Wichita formation, military crossing of the Big Wichita River, Baylor County, Tex.

Deposited in U. S. National Museum.

### Paralegoceras iowense Meek and Worthen.

Pl. IV, figs. 12–14; Pl. IX, figs. 4–7.

1860. *Goniatites iowensis*, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1860, p. 471.

1866. *Goniatites iowensis*, Meek and Worthen, Geol. Surv. Illinois, Vol. II, p. 392, Pl. XXX, figs. 3 a–c.

1884. *Paralegoceras iowense*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.

1893. *Paralegoceras iowense*, A. Hyatt, Fourth Ann. Rept. Geol. Surv. Texas, p. 474, figs. 52–54.

Not 1896. *Paralegoceras iowense*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 263, Pl. XIX, figs. 1–3.

The following description is quoted from Meek and Worthen, in Geological Survey of Illinois, Vol. II, p. 392:

> Shell attaining a rather large size, discoidal or nearly flat on the sides, and narrowly rounded on the dorsum [abdomen]. Umbilical rather shallow, about one-half as wide as the breadth of the outer whorl from the ventral to the dorsal side, showing apparently about one-third of each inner whorl. Volutions increasing gradually in size, but gently convex on the sides, nearly twice as broad from the ventral to the dorsal side as the transverse diameter, and profoundly grooved within for the reception of the inner whorls; aperture, as near as can be determined from a section of the whorls, narrow-subovate, deeply sinuous on the ventral side. (Surface unknown.)

The septa are lanceolate, lobes and saddles all long, narrow, and crowded. Saddles rounded and tongue-shaped, lobes lanceolate and sharply pointed. The ventral lobe is divided by a siphonal saddle; the first and second lateral lobes are smaller than the ventral; a fourth lobe lies just on the umbilical border. There are therefore eight lobes visible on the outside,

one pair more than possessed by *Gastrioceras*, with which this genus has sometimes been united.

There is no other species with which this may be compared; the writer[a] erroneously identified a species from the Lower Coal Measures of Arkansas with *P. iowense*, but further study of the specimen has shown it to be specifically distinct, and it is described in this paper under the name of *P. newsomi*. Hyatt has described,[b] under the name of *Paralegoceras iowense* Meek and Worthen, a goniatite from the Bend formation of Texas. But the lobes are not exactly like those of the Iowa Coal Measures species, the third lateral saddle is on the umbilical shoulders, and the young shell is marked with ribs which form well-defined tubercles, even on the older shell. These differences were explained by the supposition that the Texas specimen was the young of *Paralegoceras iowense*, and might thus naturally show them. The Bend formation is called Coal Measures by the geological survey of Texas, but its fauna seems to be identical with that of the Fayetteville shale of Arkansas, which belongs to the Lower Carboniferous, and probably to St. Louis-Chester stage. Species that are almost certainly identical with *Glyphioceras incisum* Hyatt and *G. cumminsi* Hyatt have been collected in the Fayetteville shale of Arkansas.

*Occurrence.*—*Paralegoceras iowense* was first described from the Middle Coal Measures of Alpine, Iowa, and since then has been described from the Bend formation (St. Louis-Chester) of Texas, near Bend, San Saba County.

PARALEGOCERAS NEWSOMI Smith, sp. nov.

Pl. XII, figs. 4–9.

1896. *Paralegoceras iowense*, J. P. Smith, Proc. Am. Philos. Soc., Vol. XXXV, p. 263, Pl. XIX, figs. 1–3.

Not 1860. *Goniatites iowensis*, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1860, p. 471. Not 1866. *Goniatites iowensis*, Meek and Worthen, Geol. Surv. Illinois, Vol. II, p. 392, Pl. XXX, figs. 3a–c.

Shell somewhat discoidal, with flattened sides and rounded abdomen. Greatest breadth somewhat above the umbilical border. Umbilical shoulders rounded. Whorl indented to about two-fifths of its height by the preceding whorl. Height of whorl equal to the breadth, and nearly

[a] Proc. Am. Philos. Soc., Vol. XXXV, p. 263.

[b] Fourth Ann. Rept. Geol. Surv. Texas, p. 474.

one-half the diameter. Umbilicus broad and shallow, one-fourth the diameter, and a little over half the height of the last whorl.

Septa consisting of an external lobe, two lateral, and a "suspensive" lobe on the umbilical shoulders; the internal lobes are three in number, long, narrow, and pointed; this gives eleven lobes in all for *Paralegoceras*, while *Gastrioceras* has only nine, and *Schistoceras* has thirteen or more; that is, four external lobes on each side, one on each umbilical shoulder, and three internal. *Schistoceras* is the only Carboniferous member of the Glyphioceratidæ that is known to have more than three internal lobes.

The type specimen is a septate cast that when complete must have been at least 4 inches in diameter. The whorls are broader and rounder than on *P. iowense*. They are quite involute, and the umbilicus is narrow on the young shell, becoming wider as the shell grows older. The surface of the cast is smooth, no constrictions or other ornamentations appearing on the older shell. On the younger shell the umbilical shoulders show faint ribs, that shade off into fine undulations on the sides. Hyatt has shown the same thing on *P. iowense*.[a] But in the Texas specimen the ribs persist to a much later stage than on that from Arkansas.

*Dimensions.*—Although the specimen was not well preserved, the measurements of the entire form could be taken. They were as follows:

| | Millimeters. |
|---|---|
| Diameter | 55.5 |
| Height of last whorl from umbilicus | 25.5 |
| Height of last whorl from top of inner whorl | 17.0 |
| Width of umbilicus | 13.5 |

An inner coil taken out of the same specimen gave the following measurements:

| | Millimeters. |
|---|---|
| Diameter | 28.5 |
| Height of last whorl from umbilicus | 12.0 |
| Height of last whorl from top of inner whorl | 7.5 |
| Width of umbilicus | 6.0 |

These show the inner coils to be much lower, less highly arched, and less embracing than the outer ones.

*Surface markings.*—On the inner whorls a trace of the shell is preserved, and is like that figured by Hyatt. The undulating striæ are like those common on the Glyphioceratidæ.

*Sutures.*—The sutures are like those of *P. iowense* figured by Meek and

[a] Second Ann. Rept. Geol. Surv. Texas, p. 355.

Worthen, but the siphonal saddle is notched by a small siphonal lobe, and all the lobes are somewhat constricted in the middle. The three external lateral saddles are broadly rounded, while the lobes are sharply pointed. The lobes are eleven in number, three on each side, one on each umbilical shoulder (suspensive lobe) and three internal, that is, covered by the involution. The interior lateral lobes and the antisiphonal lobe (dorsal) are very sharp and long. The sutures approach very closely to those of *Gastrioceras russiense* Tzwetaev, but *Paralegoceras* has one more pair of lobes than the Russian species and has also a suspensive lobe on the umbilical shoulders. In the latter characteristic *Paralegoceras newsomi* resembles *P. tschernyschewi* Karpinsky.[a] Karpinsky[b] has emended Hyatt's genus to embrace those forms with two lateral lobes and a "suspensive" lobe on the umbilical shoulders. Hyatt[c] emended the genus *Paralegoceras* to include those forms with the second lateral lobe on the umbilical shoulders, and he included in it *Gastrioceras russiense* Tzwetaev. But the Russian species has the suspensive lobe on the side and has only nine lobes in all, and thus ought to remain in the group characterized as *Gastrioceras*.

This species was first assigned by the writer[d] to *Paralegoceras iowense* Meek and Worthen, although differences were noted. A reexamination of the type and careful comparison with all figures and descriptions of *Paralegoceras* shows that this form, while nearest to *P. iowense*, can not correctly be placed under that species. The umbilicus on *P. iowense* and on *P. newsomi* is one-fourth of the total diameter. The whorl of *P. iowense* has a breadth about three-fourths of its height, while on *P. newsomi* the breadth is nearly equal to the height. The Arkansas species is therefore more globose, with highly arched, helmet-shaped rather than laterally compressed whorls, has a much more rapid increase of size of the whorls, and is more involute and less discoidal than *P. iowense*.

Shumard's description of *P. texanum* suggests a near kinship with *P. newsomi*, but this form seems to be more compressed laterally, more discoidal, and more involute than *P. newsomi*. *Schistoceras missouriense* Miller and Faber also resembles this species externally, but has one more pair of lobes and saddles, and thus can not be assigned to *Paralegoceras*.

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[a] Ammoneen der Artinsk-Stufe, p. 62, Pl. III, fig. 1.
[b] Ibid.
[c] Second Ann. Rept. Geol. Surv. Texas, p. 355.
[d] Proc. Am. Philos. Soc., Vol. XXXV, p. 263.

*Occurrence.—Paralegoceras newsomi* was found in the Lower Coal Measures near Morrillton, Conway County, Ark., T. 5 N., R. 16 W., sec. 14, on the Arkansas River. Specific name in honor of the discoverer, J. F. Newsom. The type specimen is deposited in the geologic collection of the Leland Stanford Junior University.

### Paralegoceras texanum Shumard.

1863. *Goniatites texanus*, B. F. Shumard, Trans. St. Louis Acad. Sci., Vol. II, p. 109.

The following description is quoted from Shumard's paper:

Shell large, discoidal, strongly rounded on the dorsum [abdomen], gently convex on the sides, umbilicus deeply excavated, exhibiting the inner volutions, and having a diameter equal to two-thirds the greatest width of the last volution; margin subangulated; transverse section of last volution semielliptical; its dorso-ventral diameter about equal to, or a little greater than, the width from side to side.

A small fragment only of the shell is preserved in one of the specimens in the Texas State collection. It is extremely thin, and the surface is marked with numerous parallel revolving lines, crossed with flexuous transverse lines, presenting a neat cancellated appearance. There are also faint indications of transverse costæ perceptible near the margin of the umbilicus. *Septæ* deeply sinuous; dorsal [ventral] lobe cleft by a profound linguæform sinus with a broad base, into two narrow, elongated branches, which are not so wide as the sinus between, and which are gently expanded in the middle and narrowed to an acute point at their extremities by an oblique truncature of their inner margins; dorsal [ventral] saddle linguæform, longer than wide and larger than the branches of the dorsal [ventral] lobe; superior lateral lobe having nearly the same form as the branches of the lateral lobe, but larger.

This description places it beyond doubt that the species is a *Paralegoceras*, but as it was never figured, and the type is lost, it is difficult to say whether *P. texanum* is equivalent to any of the other species of this genus. It may be the same as *P. iowense* Meek and Worthen.

*Occurrence.*—Lower Carboniferous, St. Louis-Chester stage, Bend formation, Wallace Creek, San Saba County, Tex.

## Genus Schistoceras Hyatt.

Type of genus, *Schistoceras hyatti* Smith.

The genus *Schistoceras* was established by Hyatt[a] to include—

a single species which is not figured or described, but can be readily distinguished by its large bottle-shaped, siphonal saddle. This is the only characteristic by which

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 336.

it differs from *Prolecanites*. The two arms of the ventral lobe are widely separated, and there are only three pairs of lateral lobes and a small umbilical lobe with two pairs of dorsal lobes. The lobes are hastate, and the saddles more rounded and club shaped, as in *Prolecanites*. The first pair of saddles have dorsal correspondents, and the annular lobe is deep and acute.

Professor Hyatt's type was never figured, and the existence of any other species belonging to this genus was unknown to him, so it was afterwards either ignored or the species of this group were included in other genera. Foord and Crick[a] recognized the affinity of this group with *Agathiceras*, which was established by Gemmellaro,[b] based on the type *A. suessi* Gemmellaro, to include Carboniferous ammonoids with rather helmet-shaped whorls, somewhat compressed laterally, with spiral ornamentation, with four external tongue-shaped goniatitic lobes. Karpinsky[c] subsequently included in this genus *Adrianites* Gemmellaro, which differed only in having a longer body chamber and a greater number of lobes. But such a character as this has a much greater significance in the simpler goniatites than in the specialized ammonites. Thus a difference in number of lobes may always be taken as indicating generic progress. It therefore seems better to leave the genera as Gemmellaro defined them, except as to their systematic position.

Haug[d] has recently included in *Agathiceras* two species of *Schistoceras*, *S. fultonense* Miller and Gurley, and *S. hildrethi* Morton, which he assigned to the Glyphioceratidæ. On page 105 of the same work Haug redescribes *S. hildrethi*, and calls attention to the fact that it has one pair of lobes and saddles more than the type of *Agathiceras*, and therefore might represent a new genus descended from *Gastrioceras* through *Paralegoceras*. In this he is in perfect accord with the writer, except that it was unknown to Haug that the genus *Schistoceras* met all these requirements. This genus undoubtedly resembles *Agathiceras*, but appears to differ in the constant number of lobes and saddles; one external lobe divided deeply by a bottle-shaped siphonal saddle, three lateral lobes decreasing in length toward the umbilicus, a short pointed lobe on the umbilical shoulder; and the internal lobes consisting of a long tongue-shaped undivided dorsal or antisiphonal lobe and two pairs of lateral lobes. There are, then, in all ten external and

[a] Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 269.
[b] Fauna calc. Fusulina, p. 77.
[c] Ammoneen der Artinsk-Stufe, p. 64.
[d] Études sur les Goniatites, p. 33.

five internal lobes, four more than are possessed by *Paralegoceras*, and two more than *Agathiceras*.

Professor Hyatt has kindly turned over to the writer the type specimen of *Schistoceras*, and through the kindness of Dr. Stuart Weller the type of *Schistoceras* (*Gon.*) *fultonense* Miller and Gurley was open to his inspection. Haug has also refigured *Schistoceras hildrethi* Morton, so that all the known species of this genus were available for study. The type species has never been named until now, but the laws of priority demand a recognition of Hyatt's genus.

The ontogeny of *S. hyatti* shows unmistakably that the genus is derived from *Gastrioceras* through *Paralegoceras*, and is thus not a member of the Prolecanitidæ. It may possibly be an ancestor of the Arcestidæ, but that question can be settled only by a study of the ontogeny of the primitive Permian members of this group.

*Occurrence.*—At present the genus *Schistoceras* is known only from America, in the Upper Coal Measures.

### Schistoceras fultonense Miller and Gurley.

Pl. XVI, figs. 15–17.

1896. *Goniatites fultonensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 39, Pl. IV, figs. 15–17.

The following description is quoted from Miller and Gurley's paper:

Species medium size, subglobose, periphery regularly rounded; volutions rather rapidly expanding. Transverse section of a volution semielliptical, the transverse diameter being a little more than the dorso-ventral. Number of volutions not known. The last volution embraces all the inner ones. Umbilicus small, open but not disclosing the inner volutions. The sides of the volutions are slightly flattened and inclined toward the regularly rounded periphery. The sides of the umbilicus are abrupt, and the greatest transverse diameter of a volution is near the abrupt descent to the umbilical cavity. The external shell of our specimen is not preserved.

The septa are lanceolate, the saddles all rounded and tongue-shaped, the lobes all pointed and slightly constricted at the middle. The external lobe is long, rather broad, and divided by a siphonal saddle of equal breadth. The superior lateral lobe is of equal length and similar to the external; the second lateral lobe is about two-thirds of the length of the superior lateral; the third lateral lobe is very small and stands well above the umbilical shoulder; on the umbilical border is a fourth lobe similar to

the third. The internal or dorsal lobes consist of a narrow and pointed antisiphonal lobe, flanked on either side by a pair of similar laterals, making five internal lobes.

Miller and Gurley did not attempt to assign this species to its proper genus, and E. Haug[a] ascribed it to *Agathiceras*. The writer has, through the kindness of Dr. Stuart Weller, examined the type specimen in the paleontologic collection of the Walker Museum, University of Chicago, and has been able to determine it unquestionably as a *Schistoceras*, since in the number and character of both external and internal lobes, fifteen in all, it agrees with Hyatt's type specimen.

It is most nearly related to *Schistoceras missouriense* Miller and Faber, but is more globose than that species and has a slightly narrower umbilicus, which is only one-fifth of the total diameter of the shell, while in *S. missouriense* it is nearly one-fourth. It also resembles *S. hyatti* in the narrow umbilicus, but is more robust than that species and apparently lacks the umbilical nodes. It agrees with *S. hildrethi* in its robust form, but differs in its narrower umbilicus. It is quite possible that all these species, *S. fultonense*, *S. hyatti*, and *S. hildrethi*, may be only local varieties of the same thing, in which case they would all fall under the synonymy of the latter species. But not enough material is known at present to demonstrate a gradation between them, and they are accordingly kept separated until the discovery of sufficient material should warrant a union of all or part of them in one species.

*Occurrence.*—Upper Coal Measures, Fulton County, Ill. Type in the paleontologic collection, Walker Museum, University of Chicago.

### Schistoceras hildrethi Morton.

Pl. III, figs. 1 and 2.

1836. *Ammonites hildrethi*, S. G. Morton, Am. Jour. Sci., 1st series, Vol. XXIX, p. 149, Pl. I, fig. 24; Pl. XXVIII, figs. 48, 50, 53, 54.

1898. *Agathiceras hildrethi*, E. Haug, Études sur les Goniatites, p. 105, Pl. I, fig. 40.

Shell subglobose, involute; whorls highly arched, height being four-fifths of their breadth; helmet-shaped, deeply embracing, concealing all but the umbilical shoulder of the inner whorls, and indented by them to one-third of its height. Umbilicus wide and deep, being nearly one-third of

[a] Études sur les Goniatites, pp. 33 and 105.

the total diameter. Umbilical shoulder abruptly rounded and ornamented with fine nodes or ribs.

Septa lanceolate, lobes pointed and linguæform, saddles rounded. Ventral saddle long, narrow, and bottle-shaped; ventral lobes long, tongue-shaped; three lateral lobes, similiar in shape, but decreasing in size toward the umbilicus.

This species is most nearly related to *S. hyatti* Smith, but has a wider umbilicus, more globose whorls, and retains the umbilical ribs to a greater size. It is quite possible that *S. hyatti* may be only a variety of *S. hildrethi*, but they will be kept separate until enough specimens are found to show the intergradation.

Haug[a] redescribed *S. hildrethi* and assigned to it the genus *Agathiceras*, at the same time stating that it did not agree entirely with the type of *Agathiceras;* but Hyatt's genus *Schistoceras* was unknown to him, since it had not been figured and the type species had not been named.

*Occurrence.*—Upper Coal Measures ("Lower Barren"), near Cambridge, Guernsey County, Ohio, and Cisco formation, Graham, Young County, Tex.

Specimens are in the U. S. National Museum from Graham, and Haug has rediscovered one in the Verneuil collection of the École des Mines, Paris, presented by Hildreth, from Cambridge, Ohio.

### Schistoceras hyatti Smith, sp. nov.

Pl. XX, figs. 1–8; Pl. XXI, figs. 10–13.

1884. *Schistoceras*, sp. indet., A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 336.

Form somewhat compressed laterally, with high helmet-shaped whorl, sloping sides, rounded venter, rounded umbilical shoulders, and deep, open umbilicus, showing the inner whorls. The last whorl is indented to two-fifths of its height by the preceding whorl. No ribs or constriction occur on the mature shell, but the surface is ornamented with fine spiral striæ and fine sinuous cross striæ, giving a beautifully reticulated appearance to the shell. In the adolescent stages there are strong umbilical ribs, which become obsolete at a diameter of about 15 mm. The septa are goniatitic, but complex, divided into a large number of lobes and saddles. The siphonal saddle is long, notched, and bottle-shaped; the three lateral

[a] Études sur les Goniatites, p. 105.

saddles are long, narrow, and spatulate; the external lobe and the three lateral lobes are long, narrow, pointed, and tongue-shaped. On the umbilical shoulder is a fifth lobe, short and pointed, and on the dorsal side is a long, narrow, and pointed antisiphonal lobe, flanked on each side by a pair of lobes, of which the one nearest the dorsum is long and the second short, like that on the umbilical shoulder. There are thus fifteen lobes and fifteen saddles in all—one pair more than those of *Agathiceras* and two pairs more than those of *Paralegoceras*. It is prosiphonate, but it could not be ascertained at what stage the siphonal collars began to point forward.

The largest specimen seen had the following dimensions:

| | Millimeters. |
|---|---|
| Diameter | 69 |
| Height of last whorl | 35 |
| Height of last whorl from the preceding | 23 |
| Width of last whorl | 35 |
| Width of umbilicus | 14 |
| Involution | 12 |

This specimen was septate throughout, and the outer shell showed the impressions of the septa of nearly one-half a revolution in addition to this. The body chamber would have added at least three-quarters of a revolution more, so that the full diameter of this shell could not have been less than 175 mm.

The type of this species served Professor Hyatt as the type of his genus *Schistoceras*, and to his kindness the writer owes the use of the specimens. Since a specific name was never given to this form, the designation *Schistoceras hyatti* is appropriate.

This species is nearest to *S. hildrethi* Morton, but differs from it in being more compressed laterally, in the greater height of the whorl, in the slightly narrower umbilicus, and in the fainter umbilical ribs, which persist to a later stage in *S. hildrethi*.

*Occurrence.*—This species is at present known only from the Upper Coal Measures, Cisco formation, of Graham, Tex. Specimens of it, including the type (Pl. XX, figs. 5 and 6), are in the private collection of the late Prof. Alpheus Hyatt, of Cambridge, Mass.; in the Museum of Comparative Zoology; and in the U. S. National Museum.

*Ontogeny.*—Since the individual development of this species shows its phylogeny in the plainest terms, it is given below, so far as could be ascertained.

The smallest specimen seen (Pl. XXI, figs. 10a and 10b) had a diameter of 5.5 mm., was evolute, broad and low-whorled, with caronate form, strong umbilical ribs, and periodic constrictions. This unmistakably corresponded to *Gastrioceras*. At one-half revolution in addition to the above the dimensions were:

| | Millimeters. |
|---|---|
| Diameter | 7.75 |
| Height of last whorl | 3.00 |
| Height of last whorl from the preceding | 2.25 |
| Width of last whorl | 5.00 |
| Width of umbilicus | 2.75 |
| Involution | 0.75 |

The gastrioceran ribs still persisted, but the whorl had become more highly arched, and the septa were transitional from *Gastrioceras* to *Paralegoceras*, while the form was still typical of *Gastrioceras*. The addition of another half coil showed no change in the shell, except that the ribs were seen only on the umbilicus. At this stage the dimensions were:

| | Millimeters. |
|---|---|
| Diameter | 10.5 |
| Height of last whorl | 3.5 |
| Height of last whorl from the preceding | 2.5 |
| Width of last whorl | 6.0 |
| Width of umbilicus | 4.0 |
| Involution | 1.0 |

This is shown on Pl. XXI, figs. 11a, 11b, and 11c.

Another revolution showed the whorl highly arched and helmet-shaped, and the ribs had disappeared; the resemblance to *Paralegoceras* was now plain, but the septa showed an extra pair of lateral lobes just within the umbilical border. No species of *Paralegoceras* has yet been observed with this extra pair of lobes, but such may yet be found, since only a few specimens of that genus are known. This stage (shown on Pl. XX, figs. 1 and 2, and Pl. XXI, fig. 12) gave the following dimensions:

| | Millimeters. |
|---|---|
| Diameter | 21 |
| Height of last whorl | 10 |
| Height of last whorl from the preceding | 7 |
| Width of last whorl | 12.5 |
| Width of umbilicus | 6 |
| Involution | 3 |

At diameter of 30 mm., one-half revolution more than the preceding, the shell had taken on mature characters, the septa were typical of *Schistoceras*, and after this only an increase in size took place. This early mature stage is shown on Pl. XX, fig. 3.

A still larger specimen (one of Hyatt's types) is shown on Pl. XX, figs. 5 and 6, giving the following dimensions:

| | Millimeters. |
|---|---|
| Diameter | 42 |
| Height of last whorl | 20.5 |
| Height of last whorl from the preceding | 14 |
| Width of last whorl | 21 |
| Width of umbilicus | 9.5 |
| Involution | 6.5 |

The largest specimen figured, diameter 69 mm., showed about two-thirds of a revolution more than the last, but no change in septa, shape, or surface characters (Pl. XX, figs. 7 and 8; Pl. XXI, fig. 13). Thus *Schistoceras* clearly is derived from *Gastrioceras*, through *Paralegoceras*, and undoubtedly belongs to the Glyphioceratidæ, being the most complex member of that group.

### Schistoceras missouriense Miller and Faber.

Pl. VIII, fig. 1.

1892. *Goniatites missouriensis*, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, p. 164, Pl. VI, fig. 1.

Shell subglobose, involute, whorls highly arched, helmet-shaped, sides somewhat flattened, about twice as high as broad, deeply embracing, showing but little of the inner whorls, and deeply indented by them. Umbilical shoulders abrupt and the umbilicus is deep and rather narrow, being hardly one-fourth of the total diameter. Surface apparently smooth, no constrictions being visible. The preservation of the cast does not permit the determination of the presence or absence of umbilical ribs.

Septa consisting of four lateral lanceolate lobes on each side, and probably a fifth on the umbilical border. The saddles are also like the lobes, but more constricted and club-shaped. The form and septa are unmistakably those of *Schistoceras*, and the species may very likely be identical with either *S. hyatti* or *S. hildrethi*, but the figures and description of *S. missouriense* do not permit this determination. It seems to be more compressed and to have a narrower umbilicus than either of the other species.

*Occurrence.*—Upper Coal Measures, Missourian stage, Brush Creek, near Kansas City, Mo. Type in paleontologic collection, Walker Museum, University of Chicago.

## Family AGANIDIDÆ.

### Genus AGANIDES de Montfort.

1884. *Brancoceras*, A. Hyatt (not *Brancoceras* Steinmann, 1881).
1898. *Aganides*, E. Haug, Études sur les Goniatites, p. 39.
1901. *Aganides*, F. Frech, Ueber devonische Ammoneen, p. 74.

### AGANIDES ROTATORIUS de Koninck.

Pl. XVI, fig. 19; Pl. XIX, figs. 12–14.

1842–1844. *Ammonites rotatorius*, L. G. de Koninck, Descr. anim. foss., p. 565, Pl. LI, fig. 1.
1852–1854. *Goniatites rotatorius*, F. Roemer, Lethæa Geognostica, 3d ed., Vol. I, Pt. II, p. 51, Pl. I, fig. 16.
1860. *Goniatites rotatorius ?*, James Hall, Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 101, figs. 15 and 16.
1860. *Goniatites ixion*, James Hall, Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 125, figs. 1–3.
1876. *Goniatites rotatorius*, James Hall, Illustr. Devonian Foss. Cephal., Pl. LXXIII, figs. 12–14.
1876. *Goniatites rotatorius*, F. Roemer, Lethæa Geognostica, Pt. I, Lethæa Paleozoica, Pl. XLVI, figs. 12a, b.
1879. *Goniatites ixion*, James Hall, Pal. N. Y., Vol. V., Pt. II, p. 474, Pl. LXXIII, figs. 12–14; Pl. LXXIV, fig. 12.
1880. *Goniatites rotatorius*, L. G. de Koninck, Faune calc. carbon. de la Belgique, Vol. I, p. 246, Pl. XLVII, fig. 12.
1884. *Brancoceras ixion*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.
1886. *Brancoceras ixion*, James Hall, Fifth Ann. Rept. N. Y. State Geologist, Pl. XIII, fig. 3.
1888. *Brancoceras ixion*, C. E. Beecher, Pal. N. Y., Vol. V, Pt. II, Supplement, p. 40, Pl. CXXVIII, fig. 3.
1897. *Brancoceras ixion*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 141, fig. 62.
1898. ? *Brancoceras rotatorium*, M. Tzwetaev, Mém. Com. Géol., Vol. VIII, No. 4, p. 28, Pl. V, 19.
1898. *Aganides rotatorius*, E. Haug, Études sur les Goniatites, p. 39, fig. 9e.
1901. *Aganides ixion*, F. Frech, Ueber devonische Ammoneen, p. 74, fig. 32c.

This species, which is very common at Rockford, Ind., but unknown anywhere else in America, is quite easily recognizable. The following description is based on a number of specimens from Rockford.

Discoidal, compressed laterally, with sides sloping gently to the

rounded abdomen; umbilical shoulders broadly rounded, abdominal shoulders more abruptly. Greatest width of whorl at about one-fifth of height of whorl. Involution almost one-half of height of whorl. Umbilicus very narrow, almost closed, and not showing the inner coils. Surface smooth, no constrictions, ribs, or other ornamentation at maturity; but the writer has observed constrictions on a specimen of diameter 13 mm. Septa composed of a tongue-shaped ventral lobe, with a narrow, long, pointed lateral lobe on each side, narrow external saddle and broad lateral saddle. On the umbilicus there is a short broad lobe, and concealed by the involution there is a pointed spatulate antisiphonal lobe, resembling the external one, and on each side a narrow pointed lateral lobe. The septa figured here are from actual drawings from a specimen broken open to expose the interior. Number of septa to a revolution from 17 to 20.

James Hall at first considered *Goniatites rotatorius* and *G. ixion* to be identical, but afterwards changed his opinion. The differences on which he based the specific discrimination were the greater number of septa to a revolution in *G. ixion* and the greater lateral compression. But these very characters are not constant in the specimens from Rockford, the number of septa to a revolution varying from 17 to 20, and some shells are more compressed than others. The variation between individual specimens from Rockford is at least as great as the differences between de Koninck's and Hall's types, and most paleontologists have always believed in the identity of the species.

The following are the dimensions of a Rockford specimen:

| | Millimeter. |
|---|---|
| Diameter | 68.0=1.00 |
| Height of last whorl | 39.0= .56 |
| Height of last whorl from the preceding | 21.0= .30 |
| Width of the last whorl | 27.0= .40 |
| Involution | 18.0= .26 |
| Width of umbilicus | 2.5= .03 |

Compared with Hall's figures and those of de Koninck this specimen might belong to either. In fact, instead of being more compressed than the Belgian form, it is rather broader.

Hyatt[a] chose *Goniatites ixion* Hall as the type of his genus *Brancoceras*, but this name had been preoccupied three years before by G. Steinmann for a genus of Cretaceous ammonites. It has, however, been demonstrated

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.

that de Montfort[a] used as the type of his genus *Aganides* the same species afterwards described by de Koninck as *Goniatites rotatorius*. Since this genus was described and figured by de Montfort, the laws of priority demand a recognition of it, in spite of the confusion made by later writers, for which he was not responsible.

*Occurrence.*—*Aganides rotatorius* occurs in America only in the goniatite beds of Rockford, Ind., in the Kinderhook stage. In Europe it is known only in the calcareous shales of Tournai, in Belgium, and in the same horizon in Ireland. Since the species occurs in the same horizon in two widely separated regions, it may be taken as a zone fossil and the horizon called the zone of *Aganides rotatorius*. Even if the species should not be absolutely identical, there are so many other identical forms in the two regions that the correlation is beyond doubt. The form described by M. Tzwetaev[b] as *Brancoceras rotatorium*, from the Moscow limestone of Russia, probably belongs to another species, although quite closely related to the one under discussion.

### Aganides discoidalis Smith, sp. nov.

Pl. XXIV, figs. 5–7.

Shell discoidal, involute, laterally compressed, whorls deeply embracing, and deeply impressed by the inner volution. The height of the whorl is slightly more than one-half of the total diameter, and it is indented to nearly one-third of its height by the inner whorl. The width of the last whorl is nearly one-third of the total diameter of the shell and four-sevenths of the height. The umbilicus is almost entirely closed. The sides of the whorl are flattened convex, curving gently to the narrow and rounded venter.

The surface (of the cast) is ornamented only with obscure sigmoidal striæ of growth, with a broad, backward-pointing sinus.

The septa are of the usual *Aganides* type, with a tongue-shaped ventral lobe, deep and rather narrow, pointed lateral lobe, narrow external saddle, and broadly rounded lateral saddle.

This species is more compressed and discoidal than any other known species of this genus.

[a] Conchyliologie Systématique, Vol. I, p. 30. [b] Mém. Com. Géol., Vol. VIII, p. 28.

*Occurrence.*—In the Lower Carboniferous, Kinderhook stage, Chouteau limestone, of Pettis County, Mo. The type is deposited in the paleontologic collection of the Walker Museum, University of Chicago, No. 8601. The writer's thanks are due to Dr. Stuart Weller for the use of the specimen, which is the only one known.

### AGANIDES JESSIEÆ Miller and Gurley.

Pl. XVII, figs. 18–20.

1896. *Goniatites jessieæ*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 46, Pl. V, figs. 18–20.

Shell discoidal, laterally compressed, involute. Whorls high, indented to one-half of the height by the preceding whorl; abdomen narrowly rounded, sides flattened. Volutions rapidly expanding, concealing all the inner whorls. Umbilical shoulders abruptly rounding; umbilicus closed. Breadth of whorl is equal to three-fourths of the height and nearly one-half of the total diameter

Septa composed of a long, tongue-shaped, undivided, ventral lobe and a shorter and more rounded lateral. First lateral saddle long and narrowly rounded; second lateral short and broadly rounded. Internal septa unknown.

Surface smooth, so far as known.

This species is closely related to *Aganides rotatorius*, but has somewhat simpler septa, with longer ventral lobe, and rounded instead of angular laterals. The form is also slightly more robust than that of *Aganides rotatorius*.

Dr. J. M. Clarke[a] cites *Aganides jessieæ* as a member of the genus *Tornoceras*, but its characters agree better with *Aganides*.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Sedalia, Mo.

### AGANIDES PROPINQUUS Winchell.

1862. *Goniatites propinquus*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 365.

1870. *Goniatites propinquus*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 259.

Shell robust, whorl highly arched, with broadly rounded abdomen and moderately convex sides. Umbilicus closed, not showing the interior

[a] Naples Fauna (Fauna with *Manticoceras intumescens*) of New York, p. 110.

whorls. Septa with short funnel-shaped ventral lobe, and longer, broader, and rounded lateral lobe. Ventral saddles parabolic, lateral saddles rounded.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Marshall group, Point aux Barques, Mich.

### Aganides romingeri Winchell.

1862. *Goniatites romingeri*, A. Winchell, Proc. Acad. Nat. Sci. Phila., 1862, p. 427.

Shell subglobose, whorl highly arched with regularly rounded venter and gently convex sides, and but slight umbilical depression. Umbilicus closed. Breadth of whorl equal to one-half of the total diameter of the shell.

Ventral lobe long, linguiform; clarate acute; lateral lobe long as ventral, narrow and sublinguiform. Ventral saddle obtuse, linguiform, unsymmetric; lateral saddle deep, broad, extending nearly as far forward as the ventral.

This species resembles *Aganides rotatorius* de Koninck, but has narrower lateral lobe and is more robust on subglobose; the breadth of the whorl is one-half of the diameter, instead of only one-third, as in *A. rotatorius*.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Marshall, Mich.

### Aganides sciotoensis Miller and Faber.

Pl. VIII, figs. 2 and 3.

1892. *Goniatites sciotoensis*, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, p. 165, Pl. VI, figs. 2, 3.

The following description is quoted from the paper by Miller and Faber:

Shell medium, or rather above medium size; somewhat lenticular in form, obtusely rounded on the dorsum [abdomen]. Umbilicus consisting of a shallow, funnel-shaped fossette, without exposing any of the volutions. Volutions few, rapidly enlarging, the outer ones profoundly grooved for the reception of the inner ones, and depressed convex on the sides. The greatest transverse diameter is at the margin of the umbilical fossette, and it is about two-thirds the dorso-ventral diameter. Seven furrows radiate from the margin of the umbilicus on each side, curve gently forward at the superior lateral sides and then curve more abruptly backward across the dorsum [abdomen], as is shown in one specimen. Probably, if the specimen was

perfectly preserved, it would show eight of these radiating furrows. Surface between the furrows showing traces of finer similarly sinuous lines. Body chamber and aperture unknown.

The sinuosities of the septa, as near as they can be determined from our specimen, may be described as follows: Dorsal [ventral] lobe lanceolate and pointed, superior lateral lobes longer than the dorsal, and pointed at the extremities; dorsal [ventral] saddle sublinguiform, gradually narrowing and rounded at the extremity, lateral saddles similar in outline, the three inferior lobes short, with corresponding saddles.

*Occurrence.*—Lower Carboniferous, Osage stage, Upper Waverly, Sciotoville, Ohio.

### Aganides ? shumardianus Winchell.

1862. *Goniatites shumardianus*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 364.

1870. *Goniatites shumardianus*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 258.

Shell discoidal, involute, laterally compressed. Whorl highly arched, narrow, deeply embracing, but showing a portion of the inner whorls. Umbilicus open, width nearly one-fourth of the total diameter. Height of whorl nearly one-half of the total diameter and once and a half times the height.

Septa of the usual *Aganides* type. Ventral lobe simple, tongue-shaped, pointed; lateral lobe wider and longer, also pointed; internal septa consisting of a long, slender antisiphonal lobe, with a pair of shorter laterals.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Lower Waverly group, Newark, Ohio.

## Genus Muensteroceras Hyatt.

The genus *Muensteroceras* was established by Hyatt,[a] with *Goniatites parallelus* Hall as the type, to include evolute, compressed, discoidal forms, with highly arched whorls and moderately wide umbilicus. The septa are glyphioceran, and the most distinctive feature is the presence of an acute second lateral lobe outside of the umbilicus.

The genus has usually been abandoned by later writers, being considered as a synonym of *Goniatites* de Haan or *Glyphioceras* Hyatt; indeed, it is impossible to draw any line between these three groups, but the extremes may be differentiated.

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.

E. Haug[a] proposes to retain the name, but as a subgenus under *Pericyclus* Mojsisovics, on account of the sharp umbilical lobe. But in reality all the Glyphioceratidæ have just such a lobe, only it is usually on the umbilicus, and the presence of such a lobe is hardly sufficient justification for classing the smooth-shelled *Muensteroceras* under the roughly sculptured *Pericyclus*.

The compressed form of this genus seems to indicate its origin in *Aganides*, by dividing the ventral lobe and widening the umbilicus.

### Muensteroceras? holmesi Swallow.

1860. *Goniatites? holmesi*, G. C. Swallow, Trans. St. Louis Acad. Sci., Vol. I, p. 659.

Discoidal, involute, whorls high, abdomen sharply rounded, sides flattened. Whorls deeply embracing, increasing rapidly in height. Umbilicus narrow, funnel-shaped. Surface smooth, so far as known. Septa unknown.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Cooper County, Mo.

### Muensteroceras? indianense Miller.

Pl. V, figs. 3 and 4.

1891. *Goniatites indianensis*, S. A. Miller, Advance sheets Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 90, Pl. XIX, figs. 2 and 3.

1892. *Goniatites indianensis*, S. A. Miller, Seventeenth Ann. Rept. Geol. Surv. Indiana, p. 700, Pl. XIX, figs. 2 and 3.

Shell discoidal, involute, deeply embracing, the inside whorl being entirely concealed by the outer. Whorl highly arched, laterally compressed, and indented to one-half of its height by the preceding; sides flattened; abdomen rounded and rather broad. Umbilicus very narrow, not showing the inner whorls. Surface marked by four constrictions that run from the umbilicus nearly straight across the abdomen. Septa unknown.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Knobstone formation, Clark County, Ind. Type in the State Museum at Indianapolis.

[a] Études sur les Goniatites, p. 29.

### Muensteroceras? morganense Swallow.

1860. *Goniatites morganensis*, G. C. Swallow, Trans. St. Louis Acad. Sci., Vol. I, p. 659.

Shell subglobose, whorl deeply embracing, with abdomen and sides regularly rounded. Height of the whorl is one-half of the width and a little over one-fourth of the total diameter. Umbilicus narrow and deep, funnel-shaped. Surface ornamented with three or four deep and broad constrictions to a revolution.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Chouteau limestone, Missouri.

### Muensteroceras osagense Swallow.

Pl. XXIV, figs. 8–12.

1860. *Goniatites osagensis*, G. C. Swallow, Trans. St. Louis Acad. Sci., Vol. I, p. 659.

Shell discoidal, moderately convex, with broadly rounded abdomen and somewhat flattened sides. Whorls deeply embracing and deeply indented by the inner volutions. The umbilicus is narrow and funnel-shaped, exposing only the umbilical shoulders of the inner whorls. The height of the whorl is one-half of the total diameter of the shell, and the width is equal to the height. The last whorl is indented to one-half its height by the preceding volution. The umbilicus is one-sixth of the total diameter.

The surface of the cast is marked, on the last revolution, with six deeply incised, sinuous constrictions, showing a narrow backward-pointing sinus.

The septa have a divided ventral lobe and a moderately deep lateral. The lobes are all pointed, and the saddles are rounded. Swallow compared this species with *Glyphioceras micronotum* Phillips, but the relationship is not close.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Cooper, Moniteau, and Pettis counties, Mo. The specimen figured in this paper is deposited in the paleontologic collection of the Walker Museum, University of Chicago (No. 8602); it was found in the Chouteau limestone of Pettis County, Mo., the more exact locality being unknown. The writer's thanks are due Dr. Stuart Weller for the use of the specimen.

### Muensteroceras oweni Hall.

Pl. XIX, figs. 3–8.

1860. *Goniatites oweni*, J. Hall, Thirteenth Rept. New York State Cab. Nat. Hist., p. 100, figs. 11, 12.
1862. *Goniatites oweni*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 364.
1879. *Goniatites oweni*, J. Hall, Pal. N. Y., Vol. V, Pt. II, p. 47[illegible], Pl. LXXIII, figs. 3–8, Pl. LXXIV, fig. 9.
1881. *Goniatites oweni*, C. A. White, Second Ann. Rept. Geol. Surv. Indiana, p. 514, Pl. VII, figs. 3 and 4.
1884. *Muensteroceras oweni*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.
1884. *Muensteroceras whitei*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.
1886. *Goniatites oweni*, J. Hall, Fifth Ann. Rept. N. Y. State Geologist, Pl. XIII, figs. 4, 7.
1888. *Goniatites oweni*, C. E. Beecher, Pal. N. Y., Vol. V, Pt. II, Supplement, p. 40, Pl. CXXVIII, figs. 4–7.
1897. *Glyphioceras oweni*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 188, fig. 89.
1898. *Pericyclus* (*Muensteroceras*) *oweni*, E. Haug, Études sur les Goniatites, p. 102, Pl. I, fig. 43.
1901. *Glyphioceras oweni*, F. Frech, Ueber devonische Ammoneen, p. 84, fig. 37a.

Shell discoidal, laterally compressed, abdomen rounded, sides somewhat flattened. Whorl about as high as broad, deeply embracing, covering four-fifths of the inner whorl, and indented by it to one-half of the height. Cross section of the whorl helmet-shaped; height less than one-half of the total diameter; greatest breadth a short distance above the umbilical shoulders, which are abrupt and angular. Umbilicus moderately wide, varying in width from one-fourth to more than one-third of the total diameter, and exposing the angular shoulders of all the inner whorls. The inner whorls are very globose, the breadth at diameter of 10 mm. being nearly equal to the diameter, and the umbilicus is proportionally narrower. Surface of the shell, which is rarely seen, marked by fine transverse striæ. Surface of cast marked by three or four wide and shallow constrictions, beginning on the umbilical shoulders and bending backward over the abdomen in a broad curve. These constrictions are variable in interval and become much more frequent on old shells.

Septa close together, consisting of a long, narrow siphonal lobe, divided by a short, notched siphonal saddle; a sharply pointed, shallow

lateral saddle, and a short, pointed auxiliary lobe on the umbilical shoulder; the superior lateral saddle is deep, and the second is broad and shallow. The internal septa consist of a short, pointed antisiphonal lobe and a pair of similar laterals; the antisiphonal saddle is narrow, and the interior lateral is broadly rounded.

This species is most nearly related to *Muensteroceras* (*Glyphioceras*) *barroisi* Holzapfel,[a] of the Lower Carboniferous of Germany, but differs in the backward-pointing curve of the constrictions, greater width of the umbilicus, more depressed whorls, and greater approximation of the septa.

The species is exceedingly variable in width of umbilicus, breadth of whorls, and involution, so that it is possible that there are several distinct but nearly related species included in this one. Prof. A. Hyatt[b] proposed the name *Muensteroceras whitei* for a specimen figured by Dr. C. A. White[c] under the name of *Goniatites oweni* Hall. But since White's figure seems to be merely a copy of Hall's illustration of the type specimen, this name becomes merely a synonym. In a large number of specimens examined by the writer there was no constancy of characters that might justify a separation into species or even varieties.

*Occurrence.*—*Muensteroceras oweni* is common in the Lower Carboniferous, Kinderhook stage, goniatite limestone of Rockford, Ind., associated with *M. parallelum* Hall, *Prolecanites lyoni* Meek and Worthen, *Aganides rotatorius* de Koninck, *Prodromites gorbyi* Miller, *P. prœmaturus* Smith and Weller. All these are of distinctly European type, except *Prodromites*, which is of unknown antecedents. *M. oweni* has also been cited by Winchell from the Kinderhook stage, Marshall group, of Michigan, and in somewhat the same association as at Rockford, Ind. The illustrations on Pl. XIX, figs. 3–8, are copied from Hall's Paleontology of New York, Vol. V, Pt. II, Pl. LXXIII, figs. 3–8.

### Muensteroceras parallelum Hall.

Pl. XVI, fig. 3; Pl. XIX, figs. 1, 2.

1860. *Goniatites oweni* var. *parallela*, J. Hall, Thirteenth Rept. New York State Cab. Nat. Hist., p. 100, figs. 13, 14.

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[a] Pal. Abhandl., Vol. V, p. 30, pl. 1, figs. 10, 10a–b.
[b] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 326.
[c] Second Ann. Rept. Geol. Surv. Indiana, Pl. VII, figs. 3 and 4.

1862. *Goniatites oweni* var. *parallela*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 364.

1879. *Goniatites oweni* var. *parallela*, J. Hall, Pal. N. Y., Vol. V, Pt. II, p. 473, Pl. LXXIII, figs. 1 and 2; Pl. LXXIV, fig. 10.

1884. *Muensteroceras parallelum*, A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 327.

1897. *Glyphioceras parallelum*, Foord and Crick, Catal. Foss. Ceph. Brit. Mus., Pt. III, p. 189, fig. 90.

Shell discoidal involute, laterally compressed, deeply embracing, concealing nearly all of the inner whorls. Abdomen highly arched, sides flattened. Whorl high, helmet-shaped, indented to three-fifths of its height by the inner volution, width four-fifths of its height, which is more than one-half of the total diameter. Greatest breadth at a point even with the top of the inner volution. Umbilicus narrow, less than one-fifth of the total diameter; umbilical shoulders abrupt and angular.

Surface marked by about four backward-curving constrictions.

Septa similar to those of *M. oweni*, but closer together.

This species is most nearly related to *M. oweni*, but differs from it in the greater lateral compression, the higher whorls, the narrower umbilicus, greater involution, and greater approximation of the septa. In the young shell the form is more globose, as the writer has seen on a specimen 10 mm. in diameter, broken out of a large shell. In this small specimen the umbilicus was still narrow, and the sides still somewhat compressed, so that even at this stage it could be distinguished from the young of *Muensteroceras oweni*.

This young specimen had the following dimensions as compared with the young of *Muensteroceras oweni:*

| | *M. parallelum.* | *M. oweni.* |
|---|---|---|
| | *Millimeters.* | *Millimeters.* |
| Diameter | 10 | 10 |
| Height of last whorl | 5.5 | 4 |
| Height of last whorl from the preceding | 3 | 2 |
| Width of last whorl | 7 | 8.25 |
| Involution | 2.5 | 2 |
| Width of umbilicus | 2 | 3.5 |

The septa at this young stage are still of the glyphioceran type, and very similar to those of the adult except that they are less approximate, and the ventral lobe is less deeply divided by the siphonal saddle. A

smaller specimen would doubtless show the *Aganides* stage of development with undivided ventral lobe, but the writer did not succeed in breaking out any smaller shell than diameter of 10 mm.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, goniatite beds of Rockford, Indiana. Winchell has also cited this species from the Kinderhook, Marshall group, of Michigan.

The septa shown on Pl. XVI, fig. 3, are drawn from a specimen in the writer's collection. The illustration on Pl. XIX, figs. 1 and 2, are copied from Hall's Palæontology of New York, Vol. V, Pt. II, Pl. LXXIII, figs. 1 and 2.

### Genus GONIOLOBOCERAS Hyatt.

### GONIOLOBOCERAS? ALLEI Winchell.

1862. *Goniatites allei*, A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 363.
1870. *Goniatites allei*, A. Winchell, Proc. Am. Philos. Soc., Vol. XI, p. 258.
1870. *Goniatites allei*, A. Winchell, Sketches of Creation, p. 116, fig. 50.

Shell discoidal, laterally compressed, involute. Abdomen highly arched and narrowly rounded, sides flattened. Umbilicus closed, not showing any of the inner whorls. Whorl increasing rapidly in height and indented to one-half of its height by the preceding volution. Surface ornamented with fine spiral lines, and with four constrictions to a revolution. Septa consisting of a shallow, broad, pointed external lobe, divided by a broad ventral saddle, which is probably notched; a broader and pointed lateral lobe. The first and second lateral saddles are somewhat similar to the lateral lobe, but rather rounded; internal septa consisting of a pointed dorsal, and pair of similar laterals. This form is doubtfully referred to *Goniolobocerας*, but Winchell's description is inadequate, and his figure in Sketches of Creation is hardly more than a sketch.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Marshall group, Marshall, Mich.

### GONIOLOBOCERAS GONIOLOBUM Meek.

Pl. IV, figs. 1–3.

1877. *Goniatites goniolobus*, F. B. Meek, U. S. Geol. Expl. Fortieth Parallel, Vol. IV, Pt. I, p. 98, Pl. IX, figs. 5, 5a, 5b.

Meek's *Goniatites goniolobus* was taken by Hyatt[a] as the type of the new genus *Goniolobocerας*, of the family Magnosellaridæ, characterized by

[a] Cephalopoda, 1900, p. 551.

the flattened sides, narrow abdomen, and the extremely angular lobes. The specimen came from an unknown horizon and locality of the Carboniferous of New Mexico, presumably from the Coal Measures. The writer, however, considers this genus as a member of the Glyphioceratidæ, from observations made on the young of another species. It probably came from *Aganides* though *Muensteroceras*, and in turn gave rise to *Dimorphoceras* by a further division of the external lobes. It seems, however, quite possible that the *Dimorphoceras* of the Upper Coal Measures, while similar to that of the Lower Carboniferous, may not necessarily be of common origin with it.

*Occurrence.*—Carboniferous, Coal Measures.? New Mexico, locality unknown.

GONIOLOBOCERAS ? LIMATUM Miller and Faber.

Pl. VIII, figs. 8 and 9.

1892. *Goniatites limatus*, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, p. 166, Pl. VI, figs. 8 and 9.

The following description is quoted from Miller and Faber's paper:

Shell small, elegant, thin, discoidal, rapidly expanding in circumference, with very slight increase in thickness; sides flat, and dorsum [abdomen] narrowly rounded. Umbilicus small, abrupt, exposing very little of the inner whorls. Volutions expanding dorso-ventrally with very little increase transversely; the outer ones fully embracing the inner ones, flattened on the sides from the umbilicus to the middle of the superior lateral saddles, from which a flat depression extends to the margin of the rounded dorsum [abdomen].

The septa are of the *Aganides* type; ventral lobe linguiform, narrow, twice as long as wide; lateral lobe broad, shallow, and pointed; ventral saddle broader than the ventral lobe and of the same length; superior lateral saddle broader than the ventral saddle, narrow, and rounded at the extremity; second lateral saddle broadly rounded. Internal septa consisting of an antisiphonal lobe and a pair of similar laterals.

This form is evidently transitional from *Aganides* to *Goniolobocerasi* it is a typical *Aganides* on the younger part of the shell, but the ventral lobe seems to be divided on the last whorl.

*Occurrence.*—Lower Carboniferous, St. Louis stage, Crab Orchard, Ky. Type in the paleontologic collection, Walker Museum, University of Chicago.

GONIOLOBOCERAS WELLERI Smith, sp. nov.

Pl. XX, figs. 9–11; Pl. XXI, figs. 1–6.

This species was at first thought by the writer to be identical with *G. goniolobum* Meek, but it has the sides somewhat more flattened, is more compressed laterally, and at maturity has the venter narrow, angular, and slightly furrowed; also the ventral saddle is not notched, but has a tongue-shaped forward extension. In *G. goniolobum* the siphonal saddle is narrow, in *G. welleri* it is broad and rounded. These differences may be due to individual variation or to incorrect drawing of Meek's type; but none of the specimens before the writer varied in these respects.

The adolescent stage (figured on Pl. XX, figs. 9–11) of a young shell, broken out of a mature specimen from Graham, Tex., shows the characters of *Muensteroceras*, and proves that the genus is derived from a typical member of the Glyphioceratidæ, for the shape of the shell, the wide umbilicus, flattened sides, broadly rounded abdomen, constrictions, and the septa all agree with that genus.

The shell is smooth, compressed, with flattened sides and narrow rounded venter at early maturity; angular and slightly furrowed at a later stage. The umbilicus is very narrow, showing none of the inner whorls; the whorl is involute, deeply embracing, indented to more than one-third of its height by the preceding whorl. Surface smooth, devoid of constrictions, ribs, or other ornaments. The septa are angular and sinuous, showing the general character of the Glyphioceratidæ. Internal septa show the characteristic sharp antisiphonal lobe and the tongue-shaped internal lateral on each side, as do all typical members of the Glyphioceratidæ.

*Occurrence.*—The first specimen of this species was seen by the writer in the paleontologic collection of the Walker Museum, University of Chicago, from the Upper Coal Measures of Montgomery County, Ill. The only other specimens known are from the Upper Coal Measures, Cisco formation, of Graham, Young County, Tex., where they were collected by A. B. Gant. Other specimens are in the private collection of the late Prof. Alpheus Hyatt, in the U. S. National Museum, and in the private collection of the writer, obtained on a recent visit to Graham. The genus *Milleroceras* of Hyatt is probably only the young of *Goniolobocerας*, but not enough specimens are known at present to determine this.

The specific name is given in honor of Dr. Stuart Weller, of the University of Chicago.

The type is figured on Pl. XXI, figs. 1 and 2. It was presented to the writer by Dr. Gant, and was collected from the Cisco formation, Upper Coal Measures, of Graham, Tex. It is in the writer's collection in the Leland Stanford Junior University, California.

### Genus Dimorphoceras Hyatt.

The type of this genus[a] was *Goniatites gilbertsoni* Phillips. All the species are rather compressed, involute, smooth shells, with narrow umbilicus. The surface is ornamented only by the curved cross striæ of growth. The ventral lobe is divided by a deep, notched, siphonal saddle, and the two lobes thus formed are divided a second time, giving a pair of short, narrow ventral lobes on each side of the abdomen. On the middle of the flank there is a deeper, pointed lateral lobe, and another on the umbilical shoulder. Inside, concealed by the involution, is a tongue-shaped antisiphonal lobe, flanked on each side by a pointed lateral. Thus there are three internal lobes, six external, and a pair on the umbilical shoulders, eleven in all. This is the same number as in *Paralegoceras*, but of different character. In *Paralegoceras* the multiplication of lobes takes place within the umbilical border, but in *Dimorphoceras* the internal number is normal and the extra pair of lobes is formed by division of the ventral lobes. This genus probably comes from *Goniolobоceras*, by secondary division of the external lobes.

*Occurrence.—Dimorphoceras* occurs in Europe in the Lower Carboniferous and the Coal Measures; in America it is known only from the Upper Coal Measures, Cisco formation, near Graham, Young County, Tex., the specimen described in this paper being the only one known to be in any collection.

### Dimorphoceras texanum Smith, sp. nov.

Pl. XX, figs. 12–15.

Shell discoidal, compressed, involute, with narrow umbilicus, flattened sides, and greatest breadth at the umbilical shoulders. Venter narrow, flattened, angular, and slightly furrowed at maturity, but rounded in

[a] A. Hyatt, Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 331.

youth. The surface is free from sculpture and ornamented only with lines of growth.

The septa consist of a ventral lobe, divided by a broad, notched siphonal saddle, and the pair of external lobes thus formed are divided a second time by a narrow, spatulate saddle; a broad, pointed lateral lobe, and another somewhat similar on the umbilical shoulder. Inside the involution there is a long, narrow, tongue-shaped antisiphonal lobe, flanked by a pair of shorter laterals. There are thus six external lobes, a pair on the umbilical shoulders, and three internal, eleven in all. This is the number possessed by *Paralegoceras*, but in that genus the division of lobes takes place on the dorsal side, inside the umbilicus, while in *Dimorphoceras* it takes place on the ventral side.

*Dimensions of specimen figured.*

| | Millimeters. |
|---|---|
| Diameter | 54 |
| Height of last whorl | 32 |
| Height of last whorl from the preceding | 22 |
| Width of last whorl | 13 |
| Involution | 10 |
| Width of umbilicus | 3 |

This specimen was septate throughout, and if the body chamber added three-fourths of a volution, the complete diameter must have been not less than 100 mm.

*Occurrence.*—Upper Coal Measures, Cisco formation, west of Mars Hill, near Graham, Young County, Tex., collected by A. B. Gant. The type is in the private collection of the late Prof. Alpheus Hyatt, of Cambridge, Mass., to whose kindness the writer owes the use of the specimen.

### Genus Milleroceras ? Hyatt.

### Milleroceras parrishi Miller and Gurley.

Pl. XVI, figs. 6–8.

1894. *Goniatites* sp. indet., C. R. Keyes, Geol. Survey Missouri, Vol. V, Pt. VII, Pl. LV, fig. 1.

1896. *Goniatites parrishi*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 36, Pl. IV, figs. 6–8.

1900. *Milleroceras parrishi*, A. Hyatt, Cephalopoda, 1900, p. 550.

This species is the type of Hyatt's supposedly new genus *Milleroceras*, which he assigned to the Primordialidæ. The writer has examined the type, in the paleontologic collection of the University of Chicago, and is con-

vinced that it is merely the young of some member of the Glyphioceratidæ, probably either *Goniolobоceras* or *Dimorphoceras*. At any rate, the occurrence of the Primordialidæ in the Upper Coal Measures is extremely unlikely, since that family is not known above the Devonian.

*Occurrence.*—Upper Coal Measures, Kansas City, Mo.

## Superfamily ARCESTIDÆ.

The ontogeny of but few of the Paleozoic forms assigned to the Arcestidæ has been investigated, but Triassic species show in their adolescent stages strong resemblances to some of these, and enable us to piece out their history.

The genera thought to represent the Arcestidæ in the American Carboniferous are *Agathiceras*, *Popanoceras*, *Shumardites*, and *Waagenoceras*. Haug[a] has placed the first with the Glyphioceratidæ, and the second with the Agoniatitidæ, leaving only *Waagenoceras* as an undoubted representative of the Arcestidæ. This classification, however, is based purely on resemblances of adults, hence the writer has preferred to follow Karpinsky, whose classification seems to agree more closely with the facts brought out by the writer's investigation of the ontogeny of *Shumardites*, *Arcestes*, and *Parapopanoceras* Also the supposed species of *Agathiceras*, on which Haug's opinion was based, is shown in the present paper to be a *Schistoceras*, and to belong to the Glyphioceratidæ. Hyatt[b] classed *Popanoceras* under the Prolecanitidæ, with which group, as now understood, it has manifestly no kinship. In his most recent work Hyatt[c] classed *Popanoceras* in the family Popanoceratidæ along with *Waagenoceras* under the superfamily Arcestida.

In the Paleozoic Arcestidæ may be found at least two families with characteristics in common that point to a common origin in the gastrioceran branch of the Glyphioceratidæ, but with sufficient differences to make probable their derivation from different genera. *Agathiceras*, *Adrianites*, *Popanoceras*, *Stacheoceras*, and possibly *Doryceras* and *Clinolobus* all seem to be nearly related, and form a transition from the goniatitic *Paralegoceras*, through *Agathiceras*, into genuine ammonites characterized by a triænidian development of the lobes. Hyatt has classed some of these genera under the group Popanoceratidæ, which term is here used for this branch of the *Arcestes*-like forms.

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[a] Études sur les Goniatites. [b] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 337. [c] Cephalopoda, p. 564.

*Shumardites*, *Waagenoceras*, *Cyclolobus*, and *Hyattoceras* have phylloid development of the septa, and are unlike the Popanoceratidæ in general characters. K. A. von Zittel has classed some of these under the group Cyclolobidæ, which term is here retained as a family name for the Paleozoic Arcestidæ with phylloid septa. The writer has observed in *Shumardites* a transition from *Schistoceras;* and in *Schistoceras* a development from *Gastrioceras*, through *Paralegoceras*. This family is, therefore, undoubtedly derived from the gastrioceran branch of the Glyphioceratidæ.

It is not possible, at present, to determine which of these families gave rise to the typical Arcestidæ of the Trias, but the writer is inclined to the opinion that they came from the Cyclolobidæ. The young stages of some *Arcestes*, however, show a strong resemblance to *Adrianites*, and both branches may be represented among them. *Popanoceras*, at any rate, still persisted until the middle Trias, with its characters little changed, and may very well have given rise to a number of the genera commonly assigned to *Arcestes*; this genus then would prove to be polyphyletic, and the sub genera into which it is divided would be given full generic rank.

The oldest of the Arcestidæ, *Popanoceras*, has been found in the Middle Coal Measures, while *Agathiceras*, from which it is supposed to have been derived, is not known below the Upper Coal Measures. *Agathiceras* probably came from either *Paralegoceras* or *Schistoceras*, although the latter genus is not known at present to antedate it. But in *Gastrioceras*, *Paralegoceras*, *Schistoceras*, *Shumardites*, *Waagenoceras* we have a line of descent in which the geologic sequence, the transitions of the adult forms, and the individual ontogeny are all in perfect accord.

Since these Arcestidæ are so well represented in the American Coal Measures, and are unknown elsewhere in the world below the Permian, they may be considered as having originated in the American region, and to have reached the rest of the world afterwards by migration.

Suess[a] years ago formulated the hypothesis that the appearance of ammonites in the Mediterranean region at the beginning of Permian time marked an invasion of tropical forms from a supposed southern region. But the evidence brought forward in this paper shows clearly that the Arcestidæ need not have come from this supposed southern region, especially as we do not know anywhere in southern Paleozoic deposits members

[a] Antlitz der Erde, Vol. II. p. 316.

of the Arcestidæ older than the Permian. Karpinsky[a] has shown that *Medlicottia* came directly from *Pronorites*, which is known in the Lower Carboniferous in both Europe and America. Thus the whole argument for a Permian migration from the Southern to the Northern Hemisphere falls to the ground.

The Paleozoic Cyclolobidæ are known at present only in Texas, the Mediterranean region, and in India. The Paleozoic Popanoceratidæ are known in these regions (with the exception of India), in the Ural Mountains in Russia, and one form, *Agathiceras ? micromphalum* Morris, has been described from the Permian of Australia. But since both stocks appear in the Coal Measures of America, and since their ancestor, *Paralegoceras*, is known, in America, even in the Lower Carboniferous, both Cyclolobidæ and Popanoceratidæ probably originated in the American waters and reached the rest of the world by migration at a later date. Their differences of distribution do not, therefore, argue for climatic differences, but rather for greater hardihood of the Popanoceratidæ, which is borne out by the fact not only that they migrated as far from their point of origin as Russia on the one side and Australia on the other, but also that they persisted with but little change as late as the Middle Trias.

## Family POPANOCERATIDÆ.

### Genus AGATHICERAS Gemmellaro.

To the writer it seems wiser to keep *Agathiceras* separate from *Adrianites*, because the former is a more primitive type, even though there should be a perfect gradation between the two groups. Two American species of *Schistoceras* have been placed under *Agathiceras;* but those species differ from the type in having an extra pair of lateral lobes, and in not possessing the unusually strong development of the spiral lines, so characteristic of all species of *Agathiceras*. Another characteristic worth noting is that in *Schistoceras* the lobes and saddles are long, pointed, and tongue-shaped, while in *Agathiceras* they are short and spatulate.

[a] Ammoneen der Artinsk-Stufe, p. 86.

AGATHICERAS CISCOENSE Smith, sp. nov.

Pl. XXI, figs. 17–19.

In the U. S. National Museum is deposited a specimen that meets all the requirements of the genus *Agathiceras*, the type of *A. ciscoense* sp. nov.

This species is rather high-whorled, with rounded venter and flattened sides. The umbilicus is closed, and thus narrower than in *Paralegoceras* and *Schistoceras*. The surface has constrictions, and is ornamented with very strong spiral lines or ridges narrower than the intermediate furrows, as in European species of this genus. It, however, lacks the network of fine cross lines of growth seen on *Schistoceras*, and this difference may turn out to be one of the criteria for the separation of the two genera.

The septa resemble those of *Schistoceras* in number and general shape, but the lobes are rounded and not pointed. The siphonal saddle is notched. The four lateral saddles are rounded and entire, spatulate in shape, while the four external lobes are constricted and tongue shaped.

This species resembles *A. suessi* Gemmellaro, of the Permian Fusulina limestone of Sicily, but is slightly more compressed. This difference might not be more than individual if the association and range of the two were the same, but in view of the great separation and differences in faunal association it must be specific. *A. uralicum* occurs in the Upper Carboniferous limestone of the Ural Mountains, but does not resemble *A. ciscoense* except in a general way.

*Occurrence.*—In the Upper Coal Measures, Cisco formation, of Graham, Young County, Tex., associated with a typical Missourian fauna. Only a single specimen is known, deposited in the U. S. National Museum (No. 27199), collected by A. B. Gant.

Dimensions of the specimen figured:

| | Millimeters. |
|---|---|
| Diameter | 35 |
| Height of last whorl | 19 |
| Height of last whorl from the preceding | 12 |
| Width of last whorl | 14 |
| Involution | 7 |
| Width of umbilicus | (closed) |

## Genus Popanoceras Hyatt.

This genus was established by Hyatt[a] to include involute, slightly compressed forms, with almost closed umbilicus and little sculpture. The saddles are rounded and entire; the external lobes, four or more in number on each side, are serrated, either bifid or trifid.

The type is *Goniatites kingianus* M. V. K., from the Artinsk beds of the Permian of the Ural Mountains. Several Triassic species have usually been classed under this group, but they are now placed under *Parapopanoceras* Haug, which differs from *Popanoceras* in having the lobes distinctly serrated, with the denticulations encroaching on the saddles.

### Popanoceras ganti Smith, sp. nov.

Pl. XXI, figs. 14–16.

This species is involute, with broadly rounded venter and slightly flattened sides, very involute and close-coiled, with umbilicus almost closed. The shell has fine cross lines of growth, slightly curved forward, and five sharply defined, backward-curving constrictions on the last whorl, parallel to the cross striæ. The septa are typical of *Popanoceras*, and are divided into numerous lobes and saddles. The external lobes are five in number on each side, and the internal are five on each side, with an undivided antisiphonal. The saddles are all rounded and entire, the lobes all denticulate. The external lobe is short and bifid, the lateral lobes all trifid. The siphonal saddle is notched by a shallow indentation. The shape and number of the internal lobes could be seen, but it could not be ascertained whether or not they are denticulate.

*Affinities.*—*Popanoceras ganti* resembles slightly *P. parkeri* Heilprin, but differs from it in being somewhat more compressed laterally in the shorter lobes and saddles, and in having the first lateral lobe trifid instead of bifid. It is thus a more specialized form than *P. parkeri*, but simpler than *P. walcotti* White of the Permian, from which form it differs in the smaller number and greater simplicity of its lobes. It may possibly be an intermediate form in the genetic series of *P. parkeri* and *P. walcotti*. This

[a] Proc. Boston Soc. Nat. Hist., Vol. XXII, p. 337.

species has only a generic resemblance to the forms from the Ural Mountains and the Fusulina limestone of Sicily, all of which belong to the Permian, and are therefore usually more complex in development.

Dimensions of the figured specimen:

| | Millimeters. |
|---|---|
| Diameter | 25 |
| Height of last whorl | 14.5 |
| Height of last whorl from the preceding | 6.5 |
| Width of last whorl | 16 |
| Involution | 8 |
| Width of umbilicus | 1.5 |

This form is more globose and primitive than most of the described species of this genus, and it is next to the oldest known member of *Popanoceras*, the oldest being *P. parkeri* of the Middle Coal Measures.

*Occurrence.*—Upper Coal Measures, Cisco formation, Graham, Young County, Tex., collected by A. B. Gant. Type No. 27202 in the U. S. National Museum.

### Popanoceras parkeri Heilprin.

Pl. XVI, fig. 21.

1884. *Ammonites parkeri*, A. Heilprin, Proc. Acad. Nat. Sci. Phila., 1884, p. 53, figs. 1 and 2.

1889. *Popanoceras parkeri*, A. Karpinsky, Ammoneen der Artinsk-Stufe, p. 75.

Shell subglobose involute, abdomen rounded, sides somewhat flattened, whorls high and deeply embracing.

Septa divided into numerous lobes and saddles; the lobes are all digitate, the saddles entire and rounded, except the siphonal saddle, which is notched. Ventral lobe long and bifid; first lateral lobe like the ventral, but shorter and broader; second lateral tripartite, and broader than the first; third lateral on the umbilical shoulders.

*Occurrence.*—Middle Coal Measures, Strawn formation, Wise County, Tex. F. Frech[a] refers to these beds as Permian, but they are some distance below the Cisco formation, and associated not with a Permian fauna, but with undoubted Coal Measures species. The Strawn formation lies several thousand feet below the Wichita Permian.

[a] Die Dyas, p. 510.

### Popanoceras walcotti White.

Pl. XXII, figs. 9–11.

1889. *Popanoceras walcotti*, C. A. White, Am. Nat., Vol. XXIII, p. 117, Pl. I, figs. 9–11.

1891. *Popanoceras walcotti*, C. A. White, Bull. U. S. Geol. Survey No. 77, p. 21, Pl. I, figs. 9–11.

The following description is quoted from Dr. White's paper:

Shell discoid, periphery rounded; sides gently convex, the inner volutions almost wholly embraced by the next preceding one, and umbilici are consequently minute. Surface marked with numerous slightly raised and slightly sinuous radiating ridges, apparently indicating stages of growth, which extend continuously from one umbilicus to the other across the periphery; septa showing numerous short lobes and saddles, the former [the saddles] being simple and regularly rounded at the ends and the latter [the lobes] more or less notched or pointed at the extremity. Those near the periphery have sometimes three digitations, and those near the umbilicus are simple and more or less pointed.

The specimen had diameter of about 26 mm. and was entirely septate, hence the body chamber and aperture are unknown.

*Occurrence.*—Permian, military crossing of the Big Wichita River, Baylor County, Tex.

## Family CYCLOLOBIDÆ.

### Genus Shumardites Smith, gen. nov.

The type is *Shumardites simondsi*, sp. nov. Form subglobose, rather evolute, whorls highly arched, helmet-shaped, deeply embracing. Abdomen broadly rounded, sloping in a gentle curve to the abrupt umbilical shoulders. Umbilicus broad and deep, exposing the shoulders of the inner whorls. Surface nearly smooth, except for a few obscure constrictions and traces of ribs on the umbilical border.

Septa complex, divided into numerous lobes and saddles; saddles all rounded and constricted, lobes partly bifid, and becoming slightly ammonitic. Ventral lobe divided by a bottle-shaped siphonal saddle, the two lobes thus formed being unsymmetrically divided by a rather deep cleft; first lateral lobe similarly divided; second lateral lobe mucronate and tending to become trifid; third lateral lobe slightly divided; fourth lateral lobe on the umbilical shoulder, narrow and pointed; a fifth lobe stands on the umbilical border. Internal septa complex, consisting of a trifid

antisiphonal lobe, bifid first lateral lobe, and undivided second lateral lobe. Internal saddles rounded like the external.

In youth the form of the whorls is gastrioceran, like *Gastrioceras globulosum* Meek and Worthen, and *G. subcavum* Miller and Gurley; the constrictions, form of the whorls, and the obscure traces of umbilical nodes all point to a gastrioceran ancestor, but the septa show a transition to the primitive Arcestidæ. A small specimen showed gastrioceran characters at diameter of 7 mm., and those of *Schistoceras* at diameter of about 10 mm., but the transition to *Shumardites* takes place very quickly toward maturity.

In form this genus is a goniatite, but the septa have already made the transition to the ammonite stage of development; it might be placed with the Glyphioceratidæ, because of the gradation through *Gastrioceras*, *Paralegoceras*, and *Schistoceras;* but it is the most primitive of the *Arcestes*-like forms, and might with equal propriety be classed with the Arcestidæ. The nearest known genus is *Hyattoceras* Gemmellaro, of the Sicilian Permian, but *Shumardites* has simpler septa than that genus, and may very possibly be the ancestor of it. The arrangement and shape of the lobes in *Waagenoceras* and other similar genera show that they have developed out of some genus like *Shumardites*. Now, since *Cyclolobus*, *Waagenoceras*, and *Hyattoceras* all show a common ancestry in *Shumardites* or in some similar form, it is proper to group them all under the family Cyclolobidæ of Zittel, but excluding from this family the genera *Lobites*, *Stacheoceras*, *Popanoceras*, *Procladiscites*, *Megaphyllites*, and *Monophyllites*. Since *Adrianites*, *Popanoceras*, and *Stacheoceras* all seem to have been derived from *Agathiceras*, it is proper to class them under the family Popanoceratidæ of Hyatt. Both families together would make up the Paleozoic superfamily Arcestidæ. But a single species of *Shumardites* is known, *S. simondsi* sp. nov., of the Upper Coal Measures, Cisco formation, or Missourian stage, of Graham, Young County, Tex. The generic name is given in honor of Dr. B. F. Shumard, the first State geologist of Texas.

SHUMARIDITES SIMONDSI Smith, sp. nov.

Pl. III, figs. 3–13.

Shell subglobose, breadth equal to more than two-thirds of the diameter; evolute; whorls highly arched, helmet-shaped, twice as wide as high,

deeply embracing, covering two-thirds of the inner volution, and indented to one-half of its height by the inner whorl. Abdomen broadly rounded in a curve that extends almost unchanged to the angular and steep umbilical shoulders. Umbilicus about one-third of the total diameter, deep, and exposing the umbilical shoulders of the inner whorls.

Surface smooth, so far as could be observed on the cast, except that a few constrictions are visible, more common on the inner whorls.

Septa of the lanceolate type, saddles rounded and constricted, lobes also constricted, and pointed. Ventral lobe divided by a notched siphonal saddle not quite so broad as the two divisions of the lobe. The ventral lobe is unsymmetrically divided by a deep cleft or adventitious saddle; the first lateral lobe is smaller than the ventral and is divided in the same unsymmetric way; the second lateral lobe is slightly larger than the first, and is mucronate in shape, showing a tendency to become tripartite; the third lateral lobe is similar to the first, except that it is the reverse of it. A fifth lobe, or auxiliary, sharply pointed and rather long, stands on the umbilical shoulder.

The internal septa consist of a tripartite antisiphonal lobe, a bifid first lateral, and a simple second lateral, with a small auxiliary on the umbilical border.

The siphonal saddle is nearly as broad as the ventral lobes, the first lateral saddle is still broader, while the second and third laterals are narrow; the fourth lateral, just above the umbilical shoulder, is broad and short.

The lobes are not arranged in a straight line across the sides, but in a backward-pointing curve, which would suggest that the lateral lobes are secondary, and have developed out of a single primary lobe; this is borne out by the ontogeny of the species.

*Ontogeny.*—At the diameter of 7 mm. the whorl is depressed, trapezoidal, and scarcely arched. The cast is marked by frequent deep and curved constrictions, and the septa, as shown on Pl. III, fig. 7, are gastrioceran, although the lateral lobe is beginning to become tripartite. This is the gastrioceran stage.

At diameter of 12 mm. the ventral lobes have become much longer, and the lateral is divided into three nearly equal secondary lobes; at this stage the whorl is more highly arched, and the stage is transitional from *Paralegoceras* to *Schistoceras*. The septa of this are shown on Pl. III, fig. 8.

At diameter of 16 mm. (one-half revolution more than at 12 mm.) the three secondary lobes have ceased to show their origin, and are arranged in a gentle curve across the sides, no longer corresponding to the shape of the original lateral. The whorls begin to be more highly arched, and the stage corresponds to *Schistoceras*. The septa at this stage are shown on Pl. III, fig. 9.

At diameter of 22 mm. (one-half revolution more than at 16 mm.) the ventral lobe begins to be divided unsymmetrically by a secondary saddle or notch; the first lateral is affected in the same way; the second lateral becomes strongly mucronate; the third lateral tends to become notched, like the ventral and first lateral. The saddles are all still rounded at this stage; the form of the whorl is as before, and the shell is making the transition from goniatite to ammonite, from the Glyphioceratidæ to the Arcestidæ; or from a distinctly Paleozoic type to an harbinger of the Mesozoic era. The septa at this stage are shown on Pl. III, fig. 10, and the form of the whorl is shown on Pl. III, figs. 5 and 6, which may be considered as the end of the adolescent, or paraneanic, period.

At diameter of 38 mm. (one-half revolution more than at 22 mm.) the ventral lobe is deeply divided on the side toward the umbilicus; the first lateral similarly divided, but reversed; the second lateral slightly tripartite; the third lateral like the first, but reversed. The saddles are deeply constricted, and the general appearance of the lobes is phylloid, and suggestive of *Waagenoceras* and *Hyattoceras*, of which genera *Shumardites* is probably the ancestor. The septa of this, the adult, stage are shown on Pl. III, fig. 11, and the form on Pl. III, figs. 12 and 13.

The ancestry of *Shumardites* is clearly seen in its successive stages through *Gastrioceras*, *Paralegoceras*, *Schistoceras*, and its transition at maturity into the primitive *Arcestes* type. That it is primitive is shown by the fact that it makes this transition at such a large size (20 mm. in diameter), while all the Permian and Triassic forms make this transition shortly after their larval period, and at a very small size, thus illustrating the law of acceleration of development.

No other species is known with which *Shumardites simondsi* may be compared, for this type has not been found in the Paleozoic deposits of other regions.

*Occurrence.*—In the Upper Coal Measures, Cisco formation, Missourian

stage, of Graham, Young County, Tex., associated with *Gastrioceras globulosum* Meek and Worthen, *G. subcavum* Miller and Gurley, *Schistoceras hildrethi* Morton, *S. hyatti* Smith, *Goniolobocerus welleri* Smith, *Dimorphoceras texanum* Smith, *Agathiceras ciscoense* Smith, *Schuchertites grahami* Smith, *Popanoceras ganti* Smith, and a typical brachiopod and pelecypod Coal Measures fauna. The beds in which these fossils were obtained lie about a thousand feet below the Wichita Permian beds. This is a remarkable assemblage of ammonites to be found below the Permian, but it will be noted, by reference to the plates accompanying this paper, that they are all primitive or transitional forms, such as one would expect to find in the Upper Coal Measures.

The type figured on Pl. III, figs. 11–13, was collected by the writer in the Cisco beds on Salt Creek, in the outskirts of Graham, Tex. Dimensions of the type:

| | Milimeter. |
|---|---|
| Diameter, about | 38 |
| Height of last whorl | 14 |
| Height of last whorl from the preceding | 7 |
| Width of last whorl | 26 |
| Involution | 24 |
| Width of umbilicus | 14 |

The type is in the collection of the writer, deposited in the geologic collection of Leland Stanford Junior University, California.

In the U. S. National Museum are three specimens (two of 27203 and one of 27201), which were also used in preparing the diagnosis of the genus and species, and in illustrating the development of the septa.

The specific name is given in honor of Prof. F. W. Simonds, of Austin, Tex.

## Genus Waagenoceras Gemmellaro.

This is the most complex of American Paleozoic ammonoids, and the only one that in the strictest sense may be said to have developed entirely beyond the limits of the goniatites and to have become a true ammonite in all its characters.

All known species of this genus have a compact *Arcestes*-like shape, with rounded whorl and moderately narrow umbilicus. The septa are complex, ammonitic and phylloid, the lobes and saddles numerous, and all digitate. The internal divisions are almost as numerous as the external, in this respect strongly resembling *Arcestes*.

The shell is smooth, except for the transverse striæ of growth and the periodic constrictions on sulcations. This genus was first described by Gemmellaro[a] from the Permian of Sicily, and has been found elsewhere only in Texas; it seems to be lacking in the Productus limestone of the Salt Range of India, and in the Hungarites beds of the Upper Permian of Armenia. On this account some writers have been inclined to regard *Waagenoceras* as a southern genus. But the evidence brought forward in this paper shows that it probably developed in the American region from the gastrioceran stock of the Glyphioceratidæ, in the genetic series *Gastrioceras, Paralegoceras, Schistoceras, Shumardites, Waagenoceras.*

The phylliform septa, the globose whorls, and the constrictions all show that the genus could not have been derived from the Popanoceratidæ, in which the septa are never phylliform, and the whorls usually laterally compressed. *Shumardites*, described in this paper, shows an approach to *Waagenoceras*, in the form of the whorls, the constrictions, and the beginning of phylliform digitation of the septa, and through this genus the family history can readily be traced back to *Gastrioceras.*

### Waagenoceras cumminsi White.

Pl. XXII, figs. 4–8.

1889. *Ptychites cumminsi*, C. A. White, Am. Nat., Vol. XXIII, p. 117, Pl. I, figs. 4–8.

1891. *Waagenoceras cumminsi*, C. A. White, Bull. U. S. Geol. Survey No. 77, p. 20, Pl. I, figs. 4–8.

1901. *Popanoceras* (*Hyattites*) *cumminsi*, F. Frech, Die Dyas, p. 512, figs. 3 and 4.

Shell subglobose somewhat compressed laterally, with broadly rounded venter. Umbilicus rather deep and narrow, with small portion of the inner whorls showing. Cross section of whorl helmet-shaped, with greatest breadth at one-third of the height from the umbilical shoulders. Shell nearly smooth, with fine cross striæ, and fine spiral lines occasionally visible. Septa complex, the numerous lobes and saddles being all digitate; the siphonal lobe is deeply divided by a rather narrow siphonal saddle, the lateral lobes are three in number, and in addition to these there are three auxiliaries.

[a] Fauna calc. Fusulina, p. 9.

The species seems to have reached a diameter of at least 50 mm., but only fragments of the larger ones have been found. The nearest known relative is *Waagenoceras stachei* Gemmellaro, from the Permian Fusulina limestone of Sicily.

*Occurrence and locality*.—Permian, Wichita stage, military crossing of the Big Wichita River, Baylor County, Tex.

### Waagenoceras hilli Smith, sp. nov.

Pl. XXVII.

This species is more compressed laterally than *Waagenoceras cumminsi* White, has narrower umbilicus, and higher whorl, but the whorls are less deeply embracing, the involution being less than one-half of the height of the whorl. There are five sinuous constrictions on the last revolution, which bend sharply backward on the abdomen. The surface is otherwise smooth, so far as can be ascertained from the casts.

The septa are much more complex than on *W. cumminsi* at the same size, the lobes and saddles are all deeply divided; the saddles are phylliform, with three leaf-like divisions; the lobes are digitate, with three principal finger-like extensions, resembling the septa of *Phylloceras*, and being more complex than those of any other species yet known of *Waagenoceras*. There are seven lobes visible outside of the umbilicus, the ventral, five laterals, and one on the umbilical shoulder, being one less than is seen on the species described by Gemmellaro[a] from the Permian of Sicily. The agreement with that genus is not perfect, but the Texas species is nearer to that than to any other, and the differences are hardly sufficient for the discrimination even of a subgenus.

*Dimensions of the figured specimen.*

| | Millimeters. |
|---|---|
| Diameter | 98 |
| Height of last whorl | 53 |
| Height of last whorl from the preceding | 31 |
| Width of last whorl | 48 |
| Involution | 22 |
| Width of umbilicus | 10 |

This specimen was septate throughout, so the length of the body chamber, and the full size of the shell could not be determined; but in the

[a] Fauna calc. Fusulina, pp. 9–12.

Arcestidæ the length of the body chamber is at least a revolution, and this would almost double the size of the complete form.

None of the species described by Gemmellaro are comparable with this one; they are all more depressed and have less complicated digitation of the lobes and saddles. The septa bear a greater resemblance to *Hyattoceras* Gemmellaro,[a] but that genus has the umbilicus entirely closed and lacks the constrictions or varices; also its saddles, while phylliform, are distinctly bipartite and not tripartite as in *Waagenoceras hilli*.

*Occurrence.*—*Waagenoceras hilli* was collected by W. F. Cummins in the Double Mountain formation, Upper Permian, at the falls on Salt Croton Creek, Kent County, Tex., associated with *Popanoceras*, *Medlicottia*, and other forms possibly identical with those described by Dr. C. A. White[b] from the Wichita division. The type specimen was loaned the writer by the late Prof. Alpheus Hyatt.

The name is given in honor of Mr. R. T. Hill, of the U. S. Geological Survey, in recognition of his contributions to the geology of Texas.

## SPECIES NOT GENERICALLY IDENTIFIED.

### Goniatites? colubrellus Morton.

1836. *Ammonites colubrellus*, S. G. Morton, Am. Jour. Sci., 1st series, Vol. XXIX, p. 154, pl. 28, figs. 49 and 51.

Shell discoidal, evolute, numerous convex volutions, laterally compressed. Three or four constrictions to a revolution.

*Occurrence.*—Upper Coal Measures, Cambridge, Guernsey County, Ohio.

### Goniatites? minimus Shumard.

1860. *Goniatites minimus* Shumard, Trans. St. Louis Acad. Sci., Vol. I, p. 200.

Shell subglobose, involute, deeply embracing; breadth equal to three-fourths of diameter. Abdomen and sides strongly rounded. Umbilicus minute, not showing the inner whorls. Surface ornamented with exceedingly fine spiral lines; and obscure nodes, visible on the umbilical shoulders.

*Occurrence.*—Middle Coal Measures, near Dovers Landing, Missouri.

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[a] Fauna calc. Fusulina, p. 12.

[b] Bull. U. S. Geol. Survey No. 77.

### Goniatites? parvus Shumard.

1860. *Goniatites parvus*, B. F. Shumard, Trans. St. Louis Acad. Sci., Vol. I, p. 199.

Shell discoidal, moderately compressed, strongly embracing, the inner whorls being concealed by the outer. Umbilicus very small. Abdomen strongly arched, sides gently convex; whorl higher than wide. Surface marked with a few obscure folds, strongest near the aperture.

*Occurrence.*—Upper Coal Measures, Willow Spring, on Santa Fé road, Kansas.

### Goniatites ? politus Shumard.

1860. *Goniatites politus*, B. F. Shumard, Trans. St. Louis Acad. Sci., Vol. I, p. 199.

Shell very much compressed laterally, thin, discoidal, involute, deeply embracing, the inner whorls being concealed by the outer. Abdomen strongly rounded, smooth; sides evenly and gently convex, greatest thickness being about the middle of the whorl. Surface marked with obscure, sinuous folds and minute striæ of growth, crossed by fine spiral lines.

*Occurrence.*—Middle Coal Measures, Lexington, Mo.

## SPECIES NAMED BUT NOT DESCRIBED.

### Goniatites ? sulciferus Winchell.

1862. *Goniatites sulciferus* A. Winchell, Am. Jour. Sci., 2d series, Vol. XXXIII, p. 365.

No description given, but the suggestion is made that it may be a variety of "*Goniatites*" *propinquus* Winchell.

*Occurrence.*—Lower Carboniferous, Kinderhook stage, Marshall formation, Marshall, Mich.

## SPECIES NOT AMMONOIDS.

### "Ammonites" bellicosus Morton.

1836. *Ammonites bellicosus*, S. G. Morton, Am. Jour. Sci., 1st series, Vol. XXIX, p. 150, Pl. III, fig. 8.

This species is probably a nautiloid, but can not be determined.

*Occurrence.*—Upper Coal Measures, Cambridge, Guernsey County, Ohio.

SYSTEMATIC POSITION DOUBTFUL.

## Family NEOICOCERATIDÆ.

### Genus NEOICOCERAS Hyatt.

### NEOICOCERAS ELKHORNENSE Miller and Gurley.

Plate XVI, figs. 9–11.

1896. *Goniatites elkhornensis*, Miller and Gurley, Bull. Illinois State Mus. Nat. Hist. No. 11, p. 37, Pl. IV, figs. 9–11.
1900. *Neoicoceras elkhornense*, A. Hyatt, Cephalopoda, p. 550.

This species was taken by Hyatt as the type of a new genus and family of goniatites; the writer has examined the type specimen in the paleontologic collection of the Walker Museum, University of Chicago, and is of the opinion that it is not an ammonoid at all, but a nautiloid.

*Occurrence.*—Middle Coal Measures, Elkhorn Creek, Kentucky.

*Table of the species.*

| Species. | Lower Carboniferous. | | | Coal Measures. | | | Permian |
|---|---|---|---|---|---|---|---|
| | Kinderhook. | Osage. | St. Louis–Chester. | Lower Coal Measures. | Middle Coal Measures. | Upper Coal Measures. | Wichita. |
| *Bactrites carbonarius* Smith, sp. nov | | | × | | | | |
| *Agoniatites opimus* White and Whitfield | × | | | | | | |
| *Nomismoceras? monroense* Worthen | | | × | | | | |
| *Prodromites gorbyi* Miller | × | | | | | | |
| *Prodromites ornatus* Smith, sp. nov | × | | | | | | |
| *Prodromites praematurus* Smith and Weller | × | | | | | | |
| *Pronorites cyclolobus* Phillips, var. *arkansasensis* Smith | | | × | | | | |
| *Pronorites siebenthali* Smith, sp. nov | | | | | × | | |
| *Medlicottia copei* White | | | | | | | × |
| *Schuchertites grahami* Smith, sp. et gen. nov | | | | | | × | |
| *Prolecanites? compactus* Meek and Worthen | | | | | × | | |
| *Prolecanites greenii* Miller | × | | | | | | |
| *Prolecanites gurleyi* Smith, sp. nov | × | | | | | | |
| *Prolecanites houghtoni* Winchell | × | | | | | | |
| *Prolecanites? louisianensis* Rowley | × | | | | | | |
| *Prolecanites lyoni* Meek and Worthen | × | | | | | | |
| *Prolecanites marshallensis* Winchell | × | | | | | | |
| *Prionoceras? andrewsi* Winchell | × | | | | | | |
| *Prionoceras? brownense* Miller | × | | | | | | |
| *Prionoceras? ohioense* Winchell | × | | | | | | |
| *Pericyclus blairi* Miller and Gurley | × | | | | | | |
| *? Pericyclus princeps* De Koninck | × ? | | | | | | |
| *Glyphioceras calyx* Phillips | | | × | | | | |
| *? Glyphioceras diadema* Goldfuss | | | | × ? | | | |
| *Glyphioceras? hathawayanum* McChesney | | | | | × | | |
| *Glyphioceras leviculum* Miller and Faber | | | × | | | | |
| *Glyphioceras? pygmaeum* Winchell | × | | | | | | |
| *Goniatites choctawensis* Shumard | | | × | | | | |
| *Goniatites crenistria* Phillips | | | × | | | | |
| (*Goniatites cumminsi* Hyatt=*G. striatus* Sowerby) | | | × | | | | |
| *Goniatites greencastlensis* Miller and Gurley | | | × | | | | |
| (*Goniatites incisus* Hyatt=*G. crenistria* Phillips) | | | × | | | | |
| *Goniatites kentuckiensis* Miller | | | × | | | | |
| *Goniatites lunatus* Miller and Gurley | | | | | × | | |
| *Goniatites newsomi* Smith, sp. nov | | | × | | | | |
| *Goniatites sphaericus* Martin | | | × | | | | |
| *Goniatites striatus* Sowerby | | | × | | | | |
| *Goniatites subcircularis* Miller | | | × | | | | |

*Table of the species*—Continued.

| Species. | Lower Carboniferous. | | | Coal Measures. | | | Permian. |
|---|---|---|---|---|---|---|---|
| | Kinderhook. | Osage. | St. Louis–Chester. | Lower Coal Measures. | Middle Coal Measures. | Upper Coal Measures. | Wichita. |
| *Gastrioceras branneri* Smith | | | × | | | | |
| *Gastrioceras carbonarium* von Buch | | | | | × | | |
| *Gastrioceras compressum* Hyatt | | | × | | | | |
| *Gastrioceras entogonum* Gabb | | | × | | | | |
| *Gastrioceras excelsum* Meek | | | | | × | × | |
| *Gastrioceras globulosum* Meek and Worthen | | | | | × | × | |
| *Gastrioceras illinoisense* Miller and Gurley | | | | | | × | |
| *Gastrioceras kansasense* Miller and Gurley | | | | | | × | |
| *Gastrioceras kingi* Hall and Whitfield | | | | | | × ? | |
| *Gastrioceras listeri* Martin | | | | | × | | |
| *Gastrioceras montgomeryense* Miller and Gurley | | | | | | × | |
| *Gastrioceras nolinense* Cox | | | | | × | | |
| *Gastrioceras occidentale* Miller and Faber | | | | | × | | |
| *Gastrioceras planorbiforme* Shumard | | | | | | × | |
| *Gastrioceras subcarum* Miller and Gurley | | | | | | × | |
| *Gastrioceras welleri* Smith, sp. nov | | | | | × | | |
| *Paralegoceras baylorense* White | | | | | | | × |
| *Paralegoceras iowense* Meek and Worthen | | | × | | × | | |
| *Paralegoceras newsomi* Smith | | | | × | | | |
| *Paralegoceras texanum* Shumard | | | × | | | | |
| *Schistoceras fultonense* Miller and Gurley | | | | | | × | |
| *Schistoceras hildrethi* Morton | | | | | | × | |
| *Schistoceras hyatti* Smith | | | | | | × | |
| *Schistoceras missouriense* Miller and Faber | | | | | | × | |
| *Aganides discoidalis* Smith, sp. nov | × | | | | | | |
| *Aganides jessiæ* Miller and Gurley | × | | | | | | |
| *Aganides? propinquus* Winchell | × | | | | | | |
| *Aganides? römingeri* Winchell | × | | | | | | |
| *Aganides rotatorius* de Koninck | × | | | | | | |
| *Aganides? sciotoensis* Miller and Faber | | × | | | | | |
| *Aganides? shumardianus* Winchell | × | | | | | | |
| *Muensteroceras? holmesi* Swallow | × | | | | | | |
| *Muensteroceras? indianense* Miller | × | | | | | | |
| *Muensteroceras osagense* Swallow | × | × | | | | | |
| *Muensteroceras oweni* Hall | × | | | | | | |
| *Muensteroceras parallelum* Hall | × | | | | | | |
| (*Muensteroceras whitei* Hyatt=*M. oweni* Hall) | × | | | | | | |
| *Goniolobоceras? allei* Winchell | × | | | | | | |

*Table of the species*—Continued.

| Species. | Lower Carboniferous. | | | Coal Measures. | | | Permian. |
|---|---|---|---|---|---|---|---|
| | Kinderhook. | Osage. | St. Louis–Chester. | Lower Coal Measures. | Middle Coal Measures. | Upper Coal Measures. | Wichita. |
| *Goniolobocerας goniolobum* Meek | | | | | ×? | | |
| *Goniolobocerας? limatum* Miller and Faber | | | × | | | | |
| *Goniolobocerας welleri* Smith, sp. nov | | | | | | × | |
| *Dimorphocerας texanum* Smith, sp. nov | | | | | | × | |
| *? Milleroceras parrishi* Miller and Gurley | | | | | | × | |
| *Agathiceras ciscoense* Smith, sp. nov | | | | | | × | |
| *Popanocerας ganti* Smith, sp. nov | | | | | | | |
| *Popanocerας parkeri* Heilprin | | | | | | | |
| *Popanocerας walcotti* White | | | | | | | |
| *Shumardites simondsi* Smith, sp. et gen. nov | | | | | | × | |
| *Waagenocerας cumminsi* Hyatt | | | | | | | |
| *Waagenocerας hilli* Smith, sp. nov | | | | | | | × |
| SPECIES OF WHICH THE GENERA COULD NOT BE DETERMINED. | | | | | | | |
| *Goniatites colubrellus* Morton | | | | | | × | |
| *Goniatites parvus* Shumard | | | | | | × | |
| *Goniatites politus* Shumard | | | | | × | | |
| (*? Goniatites sulciferus* Winchell = *? G. propinquus* Winchell) | | | | | | | |
| PROBABLY NOT AMMONOIDS. | | | | | | | |
| *Neoicocerας elkhornense* Miller and Gurley | | | | | × | | |
| "*Ammonites*" *bellicosus* Morton | | | | | | × | |

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FIGS. 3–13. SHUMARDITES SIMONDSI Smith, gen. et sp. nov ..... 135
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Figs. 3 and 4. Views of young shell, at diameter of 22 mm., showing gastrioceran shape of whorl.

Figs. 5 and 6. Partial restoration of the above specimen.

Fig. 7. Septa showing gastrioceran character and beginning of division of lateral lobe, at diameter of 7 mm., 10 times enlarged.

Fig. 8. Septa at diameter of 12 mm., transitional from *Paralegoceras* to *Schistoceras;* 3.6 times enlarged.

Fig. 9. Septa at diameter of 16 mm. (one-half revolution more than fig. 8), 3.6 times enlarged. (Septa inverted.)

Fig. 10. Septa at diameter of 22 mm. (one-half revolution more than fig. 9), 4 times enlarged.

Fig. 11. Septa at 38 mm. (one-half revolution more than fig. 10), showing mature characters; drawn from specimen shown in figs. 12 and 13, 1.6 times enlarged.

Figs. 12 and 13. Type specimen, natural size.

NOTE.—Figs. 1 and 2 are figs. 40*a* and 40*b* of Pl. 1 of Étude sur les Goniatites.

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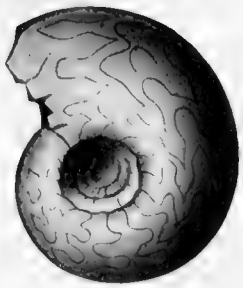

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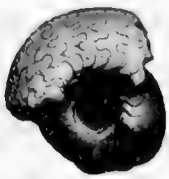

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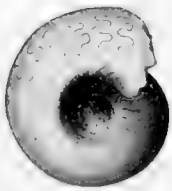

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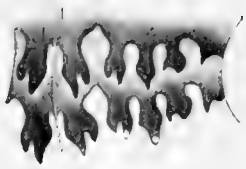

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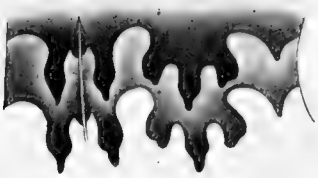

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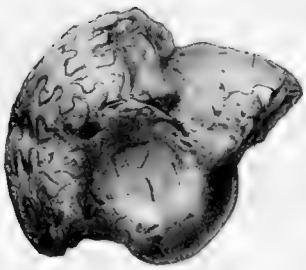

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FIGS. 9–11. PARALEGOCERAS BAYLORENSE White ..... 99
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FIGS. 12–14. PARALEGOCERAS IOWENSE Meek and Worthen ..... 100
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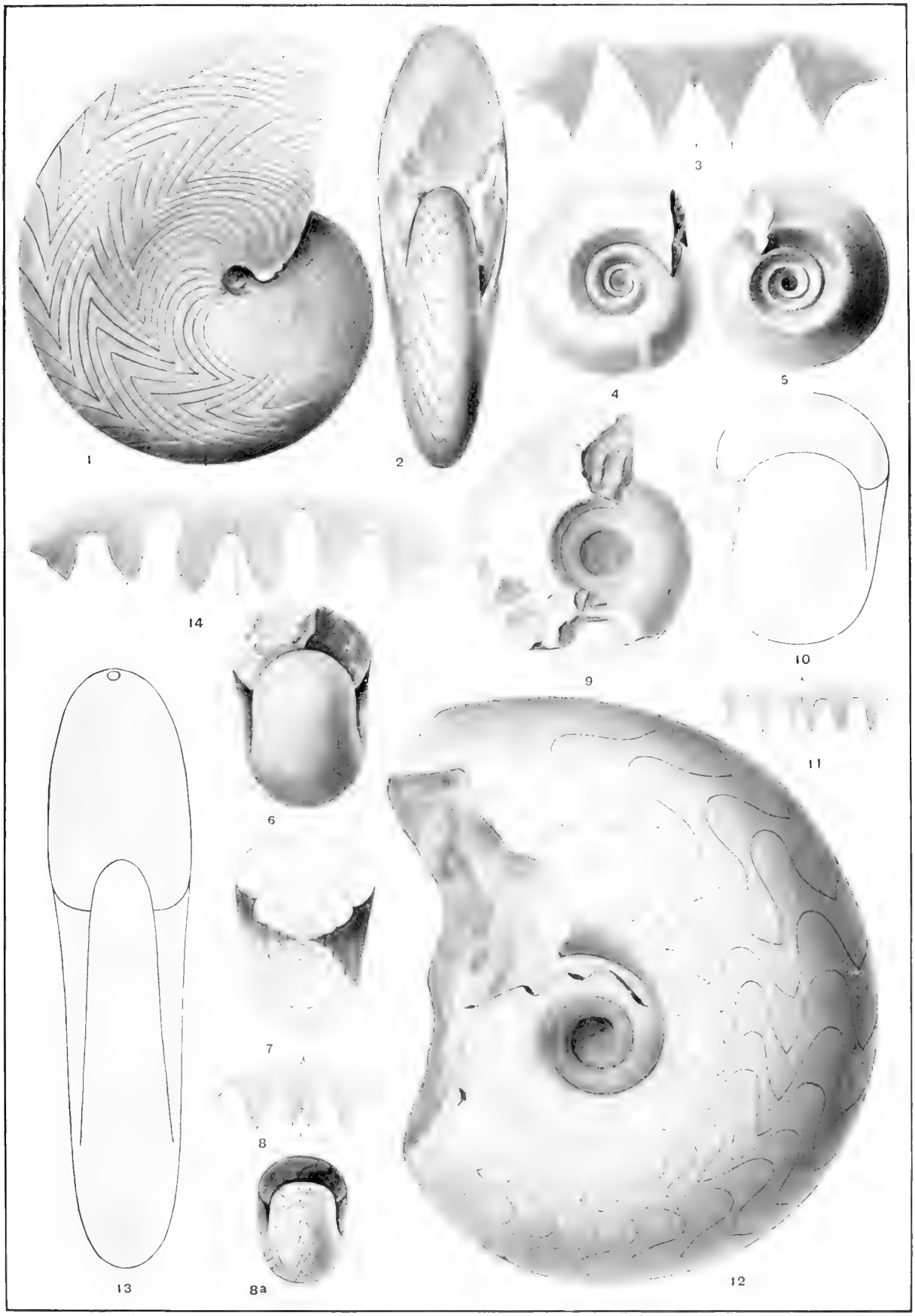
NOTE.—FIGS. 1–3 are from U. S. Geol. Expl. Fortieth Parallel, Vol. IV, Pt. I, Pl. IX, figs. 5, 5a, 5b.
FIGS. 4–8 are from U. S. Geol. Expl. Fortieth Parallel, Vol. IV, Pt. II, Pl. VI, figs. 9–14.
FIGS. 9–11 are from Bull. U. S. Geol. Survey No. 77, Pl. II, figs. 1–3.
FIGS. 12–14 are from Geol. Surv. Illinois, Vol. II, Pl. XXX, figs. 3a–c.

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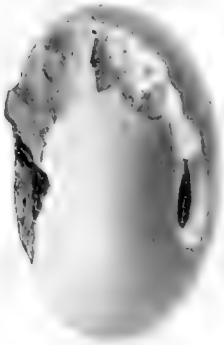
NOTE.—Figs. 1 and 2 are from Seventeenth Ann. Rept. Geol. Surv., Indiana, Pl. XVIII, figs. 3 and 4.

Figs. 3 and 4 are from Seventeenth Ann. Rept. Geol. Surv., Indiana, Pl. XIX, figs. 2 and 3.

Figs. 5–7 are from Geol. Surv. Illinois, Vol. V, Pl. XXXI, figs. 2 a–c.

Figs. 8–10 are from Geol. Surv. Kentucky, Vol. III, Pl. X, figs. 1, 1a, 1b.

Fig. 11 is from Geol. Surv. Illinois, Vol. VIII, Pl. XXVI, fig. 5.



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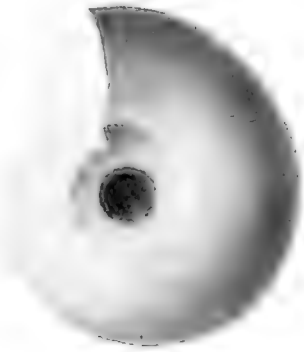

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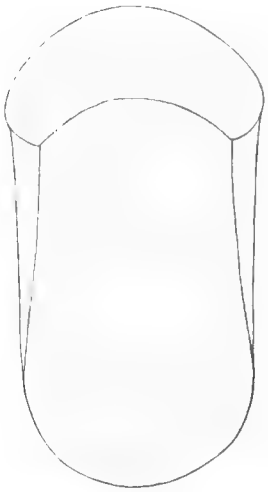

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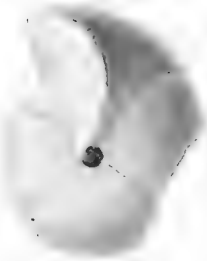

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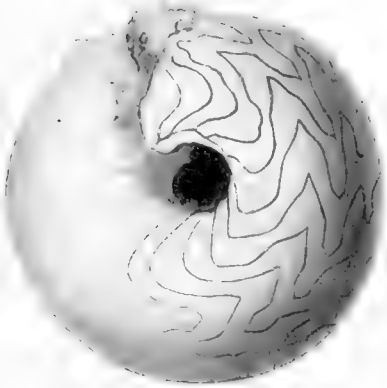

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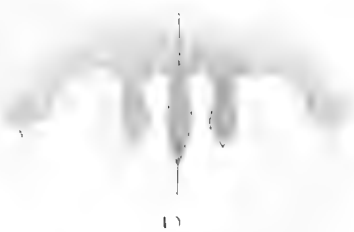

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NOTE.—Fig. 1 is from Proc. Am. Philos. Soc., Vol. XXXV, Pl. XVIII, fig. 4.
Figs. 2–5 are from Bull. Illinois State Mus. Nat. Hist. No. 11, Pl. V, figs. 2–5.
Figs. 6–8 are after a specimen loaned by the Walker Museum, University of Chicago.

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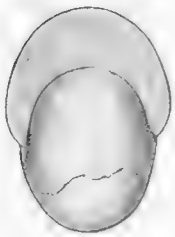

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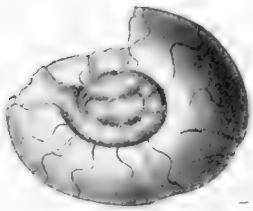

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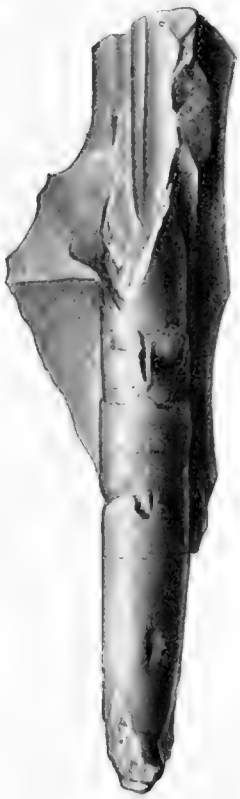

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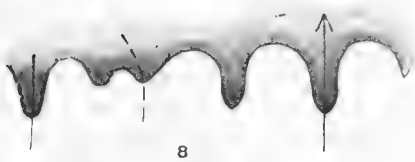

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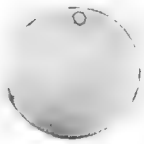

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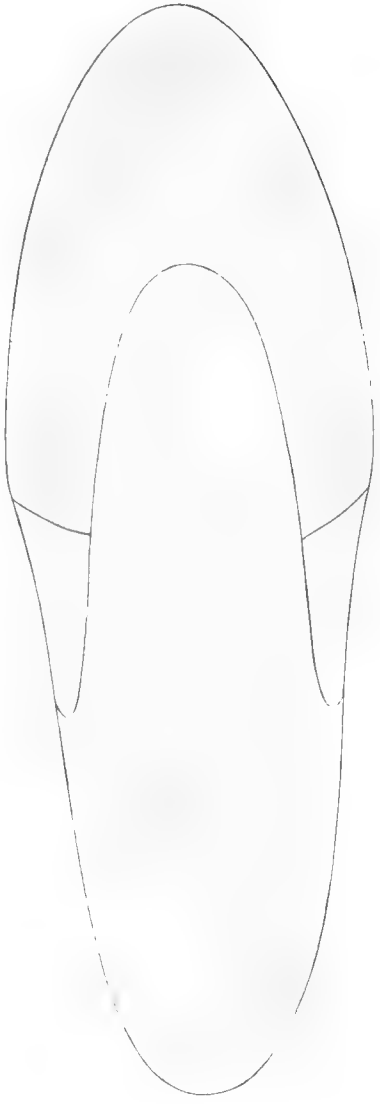
FIGS. 1 and 2. AGONIATITES OPIMUS White and Whitfield..... 32
Lower Carboniferous, Kinderhook stage, Burlington, Iowa.
Fig. 1, outline of the whorl.
Fig. 2, side view.

NOTE.—These drawings are copied from Dr. Stuart Weller's paper, Kinderhook Faunal Studies, II, The Fauna of the Chonopectus sandstone at Burlington, Iowa: Trans. St. Louis Acad. Sci., Vol. X, No. 3, Pl. VIII, fig. 1; and Pl. IX, fig. 1.



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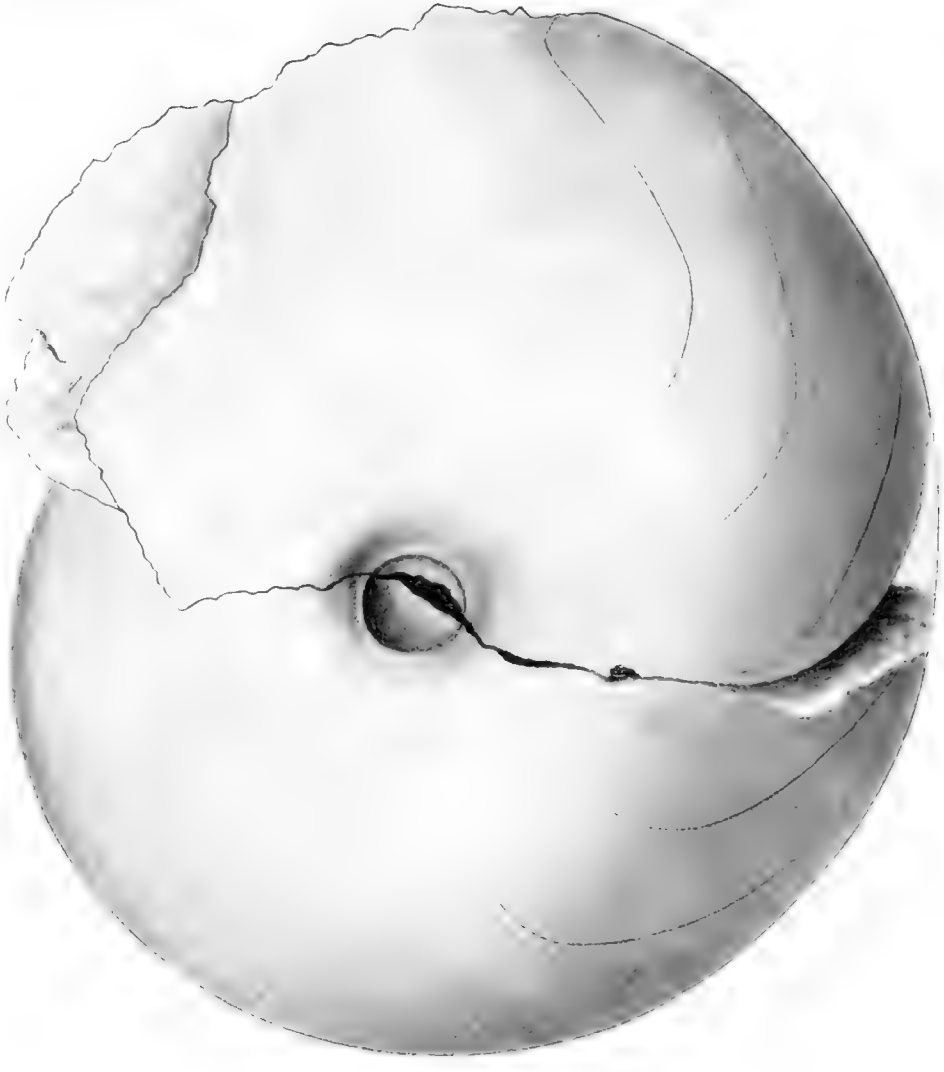

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NOTE.—Figs. 1–3 and 6–11 are taken from Jour. Cincinnati Soc. Nat. Hist., Vol. XIV, Pl. VI. Figs. 4, 5, and 5*a* are taken from Seventeenth Ann. Rept. Geol. Surv. Indiana, Pl. X, figs. 5 and 6.

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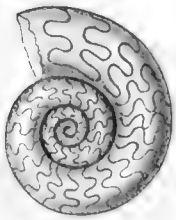

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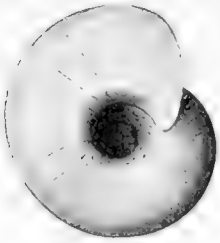

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CARBONIFEROUS AMMONOIDS

# PLATE IX.

# PLATE IX.

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FIGS. 1–3. GASTRIOCERAS COMPRESSUM Hyatt ..... 86

Lower Carboniferous, St. Louis-Chester stage, Bend formation, San Saba County, near Bend, Tex.

Specimen Nat. Museum.

FIGS. 4–7. PARALEGOCERAS IOWENSE Meek and Worthen ..... 100

Lower Carboniferous, St. Louis-Chester stage, Bend formation, near Bend, San Saba County, Tex.

Figs. 4 and 5. Immature shell.

Fig. 6. Septa at this stage.

Fig. 7. Enlarged view of the shell at this stage.

NOTE.—Figs. 1–3 are from Second Ann. Rept. Geol. Surv. Texas, figs. 57–59 (p. 355).
Figs. 4–7 are from Fourth Ann. Rept. Geol. Surv. Texas, figs. 52–55 (p. 474).

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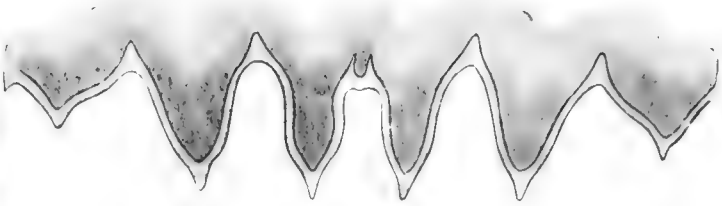

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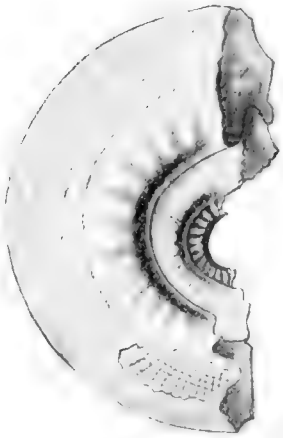

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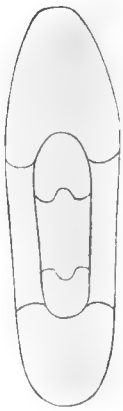

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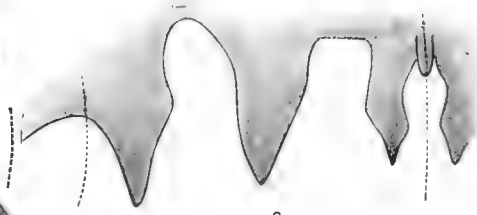

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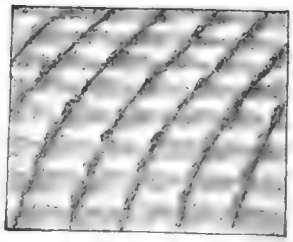

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CARBONIFEROUS AMMONOIDS.

# PLATE X.

# PLATE X.

Page.

FIGS. 1–11. GONIATITES STRIATUS Sowerby (=*Glyphioceras cumminsi* Hyatt) ..... 80
Lower Carboniferous, St. Louis-Chester stage, Bend formation, 5 miles west of Lampasas, Tex.
Figs. 1 and 2. Adolescent stage.
Fig. 3. Shell at this stage.
Figs. 4 and 5. Early adolescent stage.
Fig. 6. Shell at this stage.
Figs. 7 and 8. Early adolescent stage.
Figs. 9 and 10. Fully matured stage.
Fig. 11. Shell at this stage.

FIGS. 12–16. GONIATITES CRENISTRIA Phillips (=*Glyphioceras incisum* Hyatt) ..... 68
Lower Carboniferous, St. Louis-Chester stage, Bend formation, near Richland Springs, San Saba County, Tex.
Figs. 12 and 13. Early adult stage.
Figs. 14 and 15. Cross striæ on mature shell.
Fig. 16. Restoration of the form after fig. 15.

FIGS. 17–19. GASTRIOCERAS ENTOGONUM Gabb ..... 87
Lower Carboniferous, St. Louis-Chester stage, Bend formation, 5 miles west of Lampasas, Tex.
Figs. 17 and 18. Front and side view.
Fig. 19. Shell enlarged.

NOTE.—This plate is taken from Fourth Ann. Rept. Geol. Surv. Texas, Pl. XLVII.


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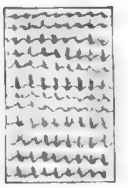
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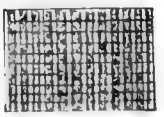
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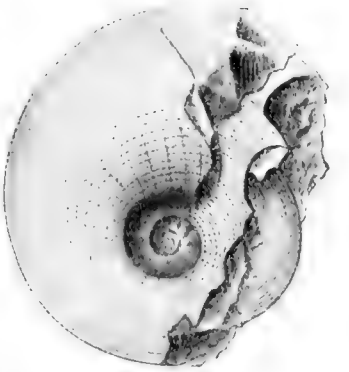
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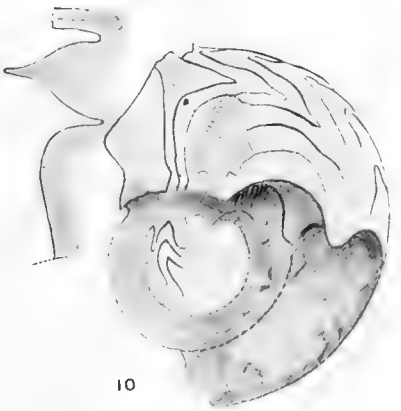
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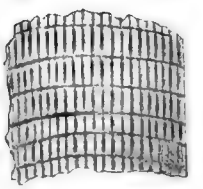
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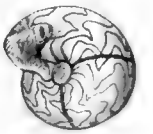
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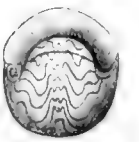
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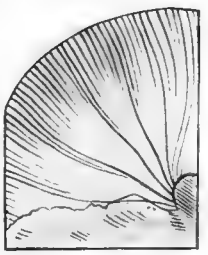
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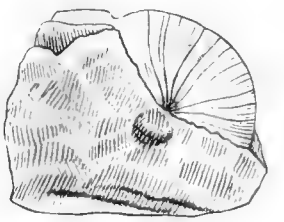
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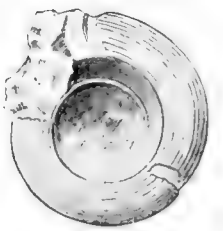
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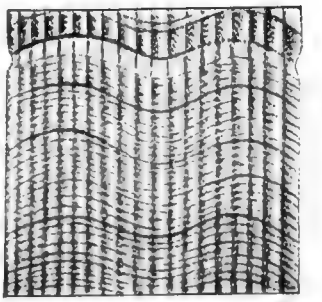
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CARBONIFEROUS AMMONOIDS.

# PLATE XI.

# PLATE XI.

Page.

FIGS. 1–4. GASTRIOCERAS CARBONARIUM von Buch ..... 84

Middle Coal Measures, near Boles, Scott County, Ark.

Fig. 1. Side view of a composite artificial cast, from three specimens.

Fig. 2. Side view of a septate fragment.

Fig. 3. Cross section of whorl.

Fig. 4. Sutures.

FIGS. 5–7. PRONORITES SIEBENTHALI Smith, sp. nov ..... 47

Middle Coal Measures, near Boles, Scott County, Ark.

Fig. 5. Side view of septate fragment.

Fig. 6. Cross section of whorl.

Fig. 7. Sutures.

FIGS. 8–13. GASTRIOCERAS BRANNERI Smith ..... 83

Lower Carboniferous, Chester stage, Pilot Mountain, Carroll County, Ark.

Fig. 8. Side view.

Fig. 9. Front view.

Fig. 10. Rear view.

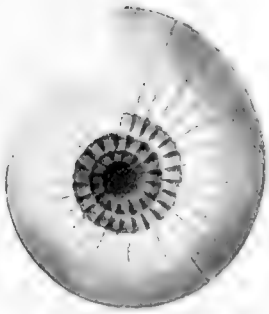
Fig. 11. Cross section.

Fig. 12. Sutures of adult, twice enlarged.

Fig. 13. Sutures at diameter 23 mm., twice enlarged.

Spec. Nat. Mus.

NOTE.—Figs. 1–7 formed Pl. XX, Proc. Am. Philos. Soc., Vol. XXXV.
Figs. 8–13 formed part of Pl. XXIII, Proc. Am. Philos. Soc., Vol. XXXV.



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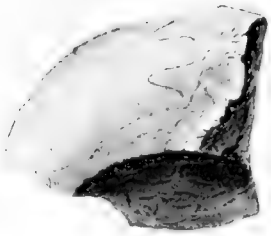

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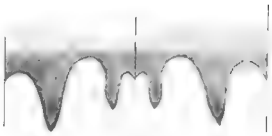

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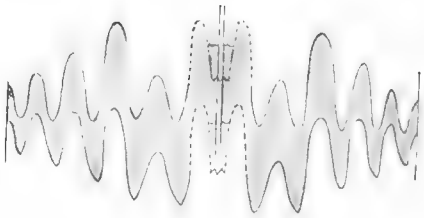

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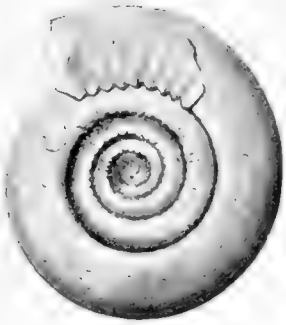

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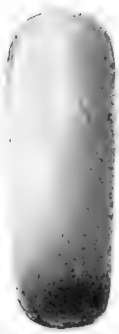

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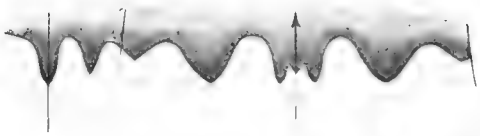

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CARBONIFEROUS AMMONOIDS.

# PLATE XII.

# PLATE XII.

Page

FIGS. 1, 2. PRONORITES PRÆPERMICUS Karpinsky (to show the young stages) ..... 44
Fig. 1. First two sutures.
Fig. 2. Embryo chamber.

FIG. 3. PRONORITES CYCLOLOBUS Phillips ..... 44
Fig. 3. Sutures, twice enlarged.

FIGS. 4–9. PARALEGOCERAS NEWSOMI Smith sp. nov ..... 101
Lower Coal Measures, Morrillton, Ark.
Fig. 4. Side view, partly restored.
Fig. 5. Front view.
Fig. 6. Side view of inner whorl taken out of the large specimen shown in fig. 1.
Fig. 7. Front view.
Fig. 8. Sutures taken from the inner whorl of 25 mm. diameter.
Fig. 9. Sutures on the outer whorl.

FIG. 10. GLYPHIOCERAS DIADEMA Goldfuss, showing development of the sutures ..... 63
*a*. First suture.
*b*. Second suture.
*c*. Third suture.
*d*. At 1.25 mm. diameter.
*e*. At 2.25 mm.
*f*. Adult.

FIG. 11. TORNOCERAS RETRORSUM von Buch ..... 73
*a*. First suture.
*b*. Second suture.
*c*. At 1.75 mm. diameter.
*d*. At 2.50 mm.
*e*. At 10 mm., adult.

FIGS. 12–15. PRONORITES CYCLOLOBUS Phillips variety ARKANSASENSIS Smith ..... 43
Lower Carboniferous, Chester stage, Pilot Mountain, Carroll County, Ark.
Fig. 12. Side view.
Fig. 13. Rear view.
Fig. 14. Front view.
Fig. 15. Sutures.
Spec. Nat. Mus.

NOTE.—Figs. 1–3 were part of Pl. XXIII, Proc. Am. Philos. Soc., Vol. XXXV; figs. 1 and 2 are after Karpinsky, Ammoneen der Artinsk-Stufe, Pl. I, fig. 2, e, f, g; fig. 3 is after Phillips, Geol. Yorkshire, Pt. II, Pl. XX, fig. 42.

Figs. 4–11 were part of Pl. XIX, Proc. Am. Philos. Soc., Vol. XXXV; fig. 10 is after Branco, Palæontographica, Vol. XXVII, Pl. IV, fig. 1; fig. 11 is after Branco, Palæontographica, Vol. XXVII, Pl. V, fig. 7.

Figs. 12–15 were part of Pl. XXIV, Proc. Am. Philos. Soc., Vol. XXXV.

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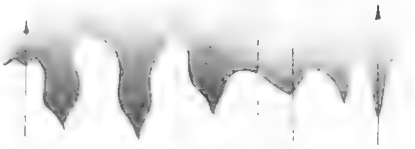

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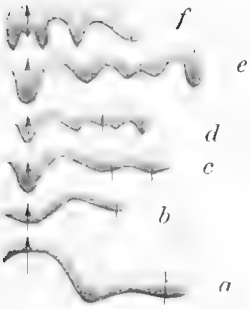


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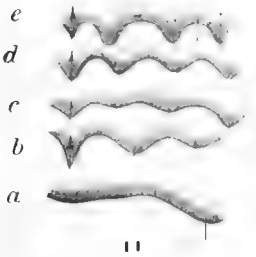


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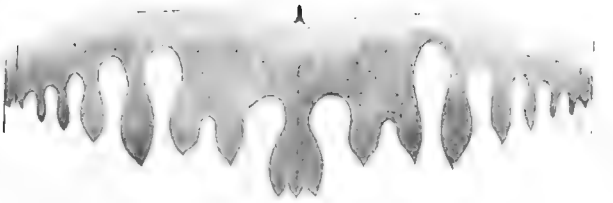

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# PLATE XIII.

# PLATE XIII.

Page.

FIGS. 1–5. PRONORITES CYCLOLOBUS Phillips ..... 43

Ural Mountains.

Fig. 1. Side view.

Fig. 2. "Cross section of a volution, *Ibergiceras* stage."—Karpinsky.

Fig. 3. "Cross section of a volution, *Paraprolecanites* stage."—Karpinsky.

Fig. 4, a, b. Natural size.

Fig. 5, a–f. Showing development of the sutures, from the *Ibergiceras* to the *Pronorites* stage.

FIGS. 6–15. GASTRIOCERAS LISTERI Martin ..... 93

Middle Coal Measures, Boles, Ark.

Fig. 6. Side view.

Fig. 7. Rear view.

Fig. 8. Front view. Artificial cast, magnified twice.

Fig. 9. Side view.

Fig. 10. Side view, largest specimen.

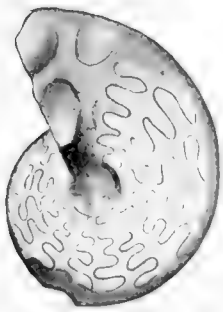
Fig. 11. Cross section of whorl.

Fig. 12. Artificial cast.

Figs. 13–15. Development of the sutures.

NOTE.—Figs. 1–5 formed part of Pl. XXIV, Proc. Am. Philos. Soc., Vol. XXXV, from Ammoneen der Artinsk-Stufe, Pl. I.

Figs. 6–15 formed Pl. XVI, Proc. Am. Philos. Soc., Vol. XXXV.



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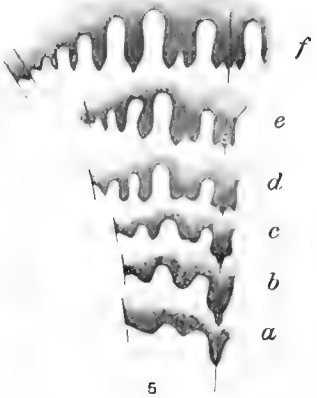


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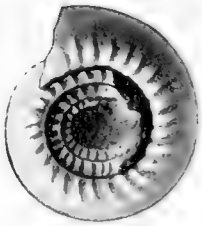

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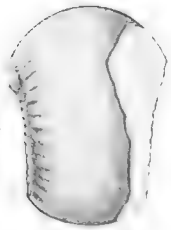

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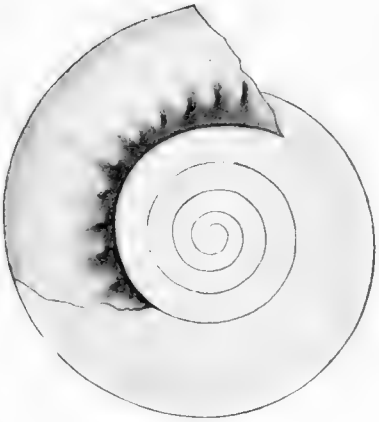

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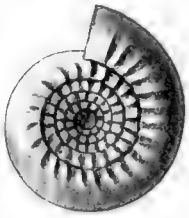

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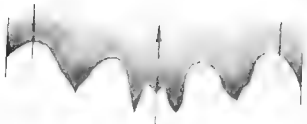

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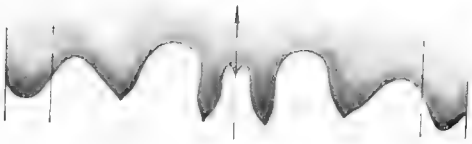

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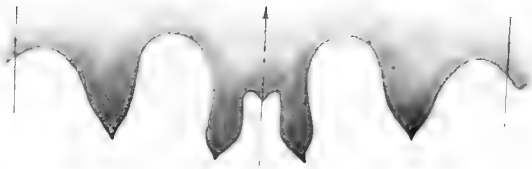

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# PLATE XIV.

# PLATE XIV.

(All figures on this plate are forty times enlarged.)

Page.

GONIATITES CRENISTRIA Phillips ..... 68

Figs. 1, 2. Protoconch.

Fig. 1. From above.

Fig. 2. From front; diameter 0.46 mm.

Figs. 3–5. Protoconch of same or a nearly related species from Scott County, Ark.

Fig. 3. From above.

Fig. 4. From front.

Fig. 5. From side.

Figs. 6–8. Protoconch with first two sutures.

Fig. 6. From above.

Fig. 7. From front.

Fig. 8. From side.

Figs. 9, 10. Larval stage, diameter of 0.74 mm., protoconch and one-half of first whorl, showing the first four sutures, from phylembryonic to the paranepionic substage.

Fig. 9. From side.

Fig. 10. From front.

Figs. 11, 12. Larval stage, diameter of 0.92 mm., first whorl, showing first eight sutures, and transitions from the metanepionic (*Anarcestes* stage), through paranepionic (*Parodoceras* stage) to ananeanic (*Prionoceras*) stage.

Fig. 11. From front.

Fig. 12. From side.

NOTE.—This was Plate XIII, Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I.

All specimens figured on this plate, except figs. 3, 4, 5, came from the Lower Carboniferous, St. Louis-Chester stage, Moorefield, Ark.

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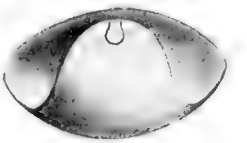

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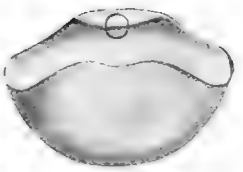

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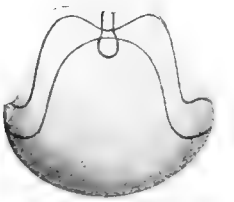

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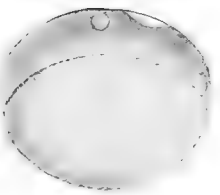

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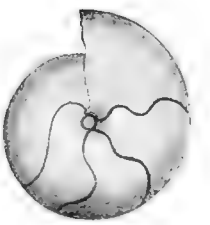

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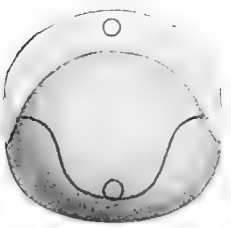

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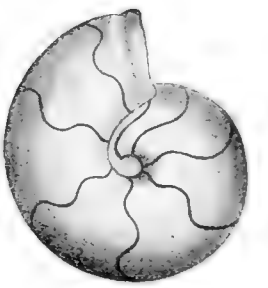

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# PLATE XV.



MON XLII—02——12

# PLATE XV.

(All figures on this plate are twenty times enlarged, except fig. 9, which is twice natural size.)

Page.

GONIATITES CRENISTRIA Phillips..... 68

Figs. 1, 2. Adolescent stage, $1\frac{3}{4}$ whorls, diameter of 1.29 mm., last whorl is ananeanic (*Prionoceras* stage) and shows transition from paranepionic.

Fig. 1. Front.

Fig. 2. Side.

Figs. 3, 4. Adolescent stage, diameter of 1.37 mm., $1\frac{7}{8}$ whorls, *Prionoceras* stage.

Fig. 3. From front.

Fig. 4. From side.

Figs 5, 6. Adolescent stage, diameter of 1.64 mm., $2\frac{1}{8}$ whorls, *Prionoceras* stage.

Fig. 5. From front.

Fig. 6. From side.

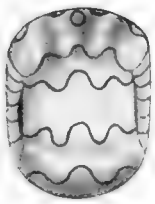
Figs. 7, 8. End of adolescent stage, diameter of 2.25 mm.; $2\frac{3}{4}$ whorls; transition from *Prionoceras* to *Goniatites* in the division of the ventral lobe, and beginning rounding of the whorl.

Fig. 7. From front.

Fig. 8. From side.

Fig. 9. Early adult stage, diameter of 15 mm.

NOTE.—This was Pl. XIV, Proc. Cal. Acad. Sci., 3d series, Geology, Vol. I. All specimens figured on this plate came from the Lower Carboniferous, St. Louis-Chester stage, Moorefield, Ark.



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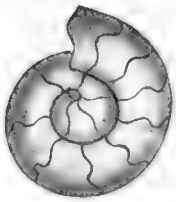

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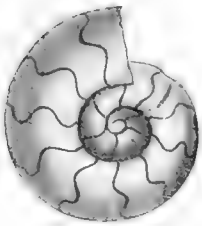

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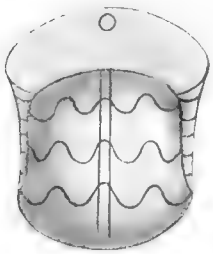

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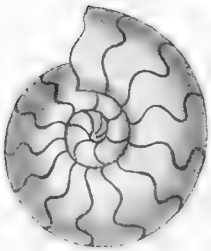

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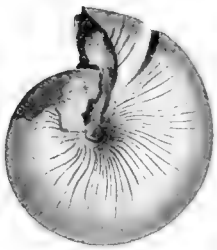

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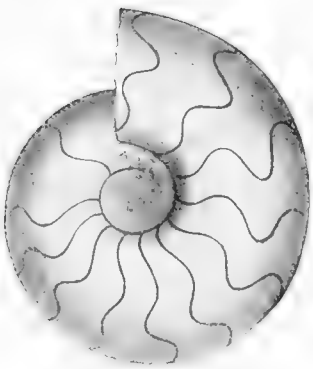

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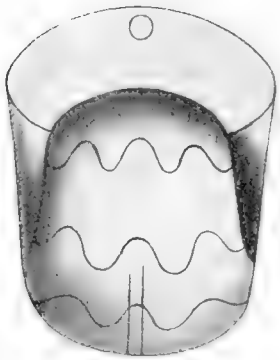

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CARBONIFEROUS AMMONOIDS

# PLATE XVI.

# PLATE XVI.

Page.

FIG. 1. GONIATITES CRENISTRIA Phillips, showing development of septa ..... 68
Lower Carboniferous, St. Louis-Chester stage, Moorefield, Ark.
*a*. First septum, ananepionic.
*b*. Second septum, metanepionic.
*c*. Third septum, metanepionic.
*d*. Fourth septum, paranepionic.
*e*. Fifth septum, one-half revolution, diameter 0.74 mm., paranepionic.
*f*. Eighth septum, one revolution, diameter 0.92 mm., ananeanic (*Prionoceras*).
*g*. Ananeanic septum, $1\frac{3}{4}$ revolutions, diameter 1.29 mm.
*h*. Septum at $1\frac{7}{8}$ whorls, diameter 1.37 mm..
*i*. Septum at 2.25 mm., $2\frac{3}{4}$ revolutions, transitional from *Prionoceras* to *Goniatites*.
*j*. Septum at 15 mm., early adult. All figures magnified 20 times, except *j*, which is twice enlarged.

FIG. 2. GASTRIOCERAS EXCELSUM Meek ..... 88
Middle Coal Measures, Pope County, Ark.
*a*. Septa.
*b*. Cross section of whorl.

FIG. 3. MUENSTEROCERAS PARALLELUM Hall ..... 121
Lower Carboniferous, Kinderhook stage, Rockford, Ind.; septa natural size.

FIGS. 4 and 5. PERICYCLUS BLAIRI Miller and Gurley ..... 60
Lower Carboniferous, Kinderhook stage, Sedalia, Mo.

FIGS. 6–8. MILLEROCERAS PARRISHI Miller and Gurley ..... 127
Upper Coal Measures, Kansas City, Mo.

FIGS. 9–11. NEOICOCERAS ELKHORNENSE Miller and Gurley ..... 143
Middle Coal Measures, Elkhorn Creek, Kentucky.

FIGS. 12–14. GASTRIOCERAS MONTGOMERYENSE Miller and Gurley ..... 95
Upper Coal Measures, Montgomery County, Ill.

FIGS. 15–17. SCHISTOCERAS FULTONENSE Miller and Gurley ..... 106
Upper Coal Measures, Fulton County, Ill.

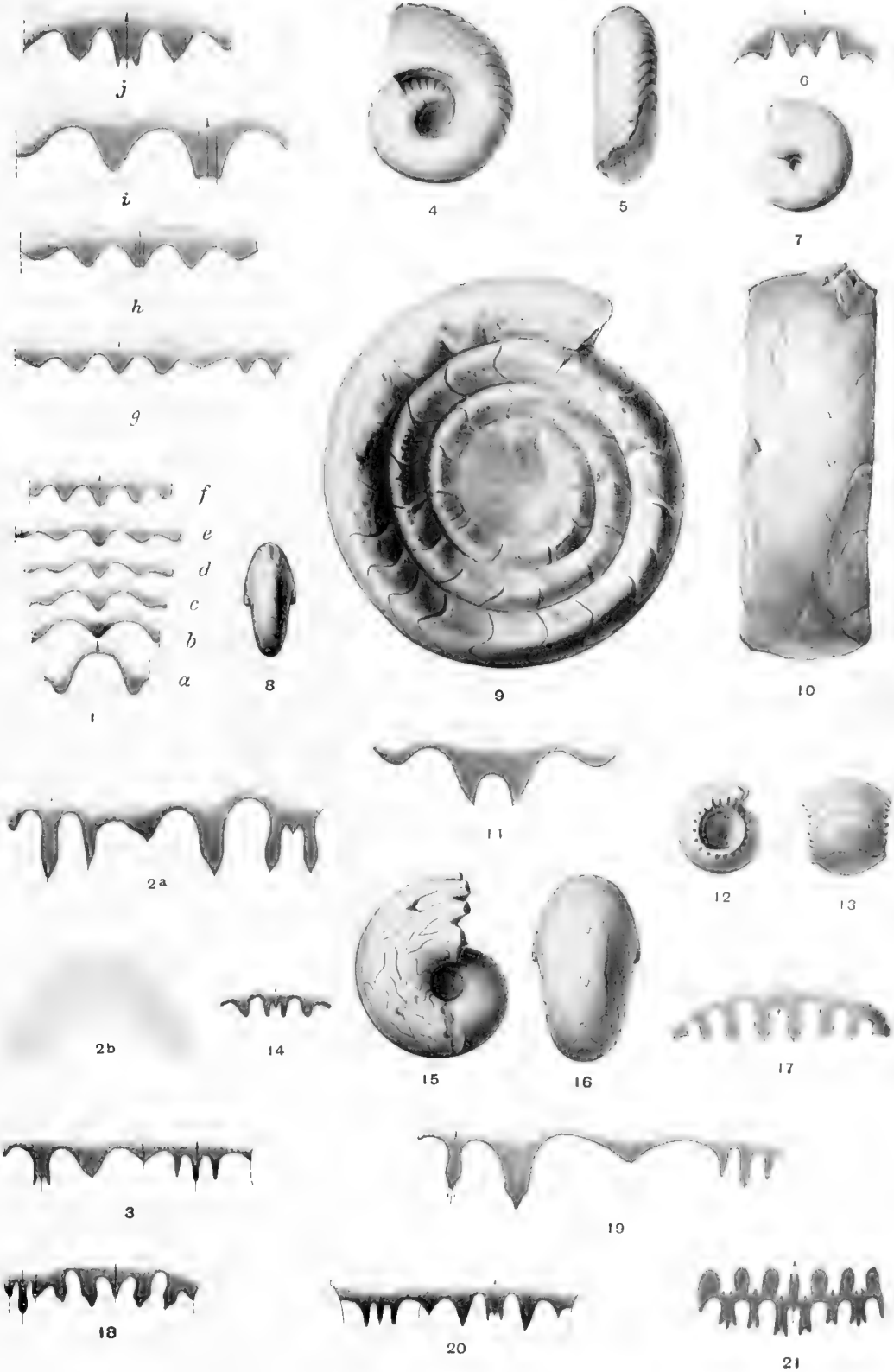
FIG. 18. Septa of PROLECANITES LYONI Meek and Worthen ..... 54
Lower Carboniferous, Kinderhook stage, Rockford, Ind.

FIG. 19. AGANIDES ROTATORIUS de Koninck ..... 112
Lower Carboniferous, Kinderhook stage, Rockford, Ind.

FIG. 20. Septa of PERICYCLUS KOCHI Holzapfel ..... 61
Lower Carboniferous, Tournaisian stage, Erdbach, Germany.

FIG. 21. Septa of POPANOCERAS PARKERI Heilprin ..... 133
Middle Coal Measures, Strawn formation, Wise County, Tex.

NOTE.—Figs 4–17 loaned by the University of Chicago, from Bull. Illinois State Mus. Nat. His., No. 11.
Fig. 18 is after Frech, Die Steinkohlenformation, Pl. XLVI, A, fig. 11.
Fig. 20 from Pal. Abhandl., Vol. V, Pl. III, fig. 6.
Fig. 21 is from Proc. Acad. Sci. Phila., 1884, p. 53.)




CARBONIFEROUS AMMONOIDS.

# PLATE XVII.

# PLATE XVII.

Page.

FIG. 1. GONIATITES KENTUCKIENSIS Miller ..... 77
Lower Carboniferous, Crab Orchard, Ky.

FIGS. 2–5. GONIATITES NEWSOMI Smith, sp. nov ..... 78
Lower Carboniferous, St. Louis-Chester stage, Batesville, Ark.
Figs. 2, 3. Natural size.
Fig. 4. Inner coil of specimen shown in fig. 3; diameter 9 mm., 3 times enlarged.
Fig. 5. Three times enlarged.

FIGS. 6–8. GASTRIOCERAS ILLINOISENSE Miller and Gurley ..... 91
Upper Coal Measures, Montgomery County, Ill.

FIGS. 9–11. GASTRIOCERAS KANSASENSE Miller and Gurley ..... 91
Upper Coal Measures, Kansas City, Mo.

FIGS. 12–14. GONIATITES GREENCASTLENSIS Miller and Gurley ..... 76
Lower Carboniferous, Greencastle, Ind.

FIGS. 15–17. GASTRIOCERAS SUBCAVUM Miller and Gurley ..... 97
Upper Coal Measures, Montgomery County, Ill.

FIGS. 18–20. AGANIDES JESSIEÆ Miller and Gurley ..... 115
Lower Carboniferous, Sedalia, Mo.

NOTE.—Figs. 1 and 6–20 loaned by the University of Chicago, from Bull. Illinois State Mus. Nat. Hist. No. 11.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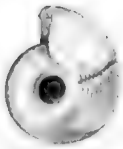
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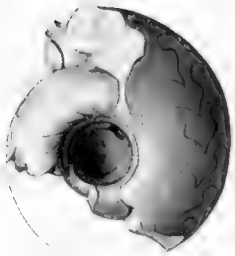
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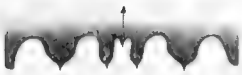
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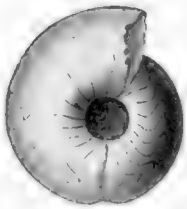
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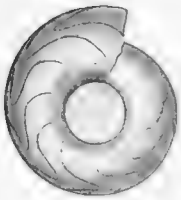
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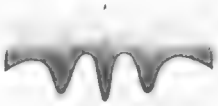
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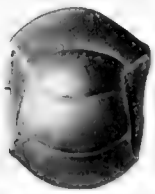
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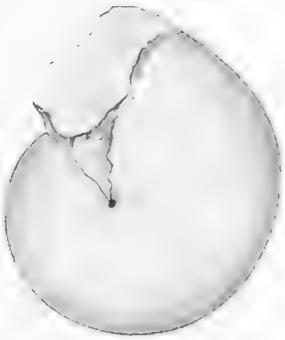
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CARBONIFEROUS AMMONOIDS.

# PLATE XVIII.

# PLATE XVIII.

Page.

GLYPHIOCERAS CALYX Phillips ..... 62

Lower Carboniferous St. Louis-Chester stage, Moorefield, Ark.

Figs. 1–3, Larval stage, diameter 0.98 mm., 20 times enlarged; corresponding to *Parodoceras*.

Figs. 4 and 5. Early adolescent stage, corresponding to *Prionoceras;* diameter 1.56 mm., $1\frac{2}{3}$ coils, 20 times enlarged.

Figs. 6–8. Later adolescent stage, transitional from *Prionoceras* to *Glyphioceras;* diameter 2.25 mm., $3\frac{1}{8}$ coils, 13 times enlarged.

Figs. 9–11. Mature stage, diameter 4.25 mm., $4\frac{1}{2}$ coils, 10 times enlarged.

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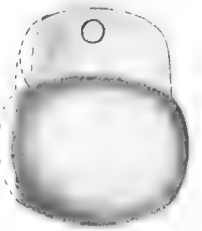

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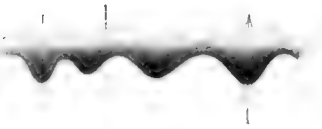

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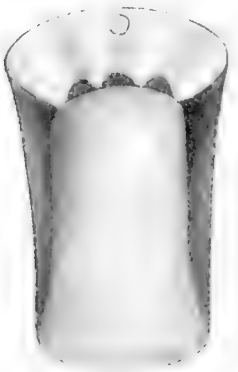

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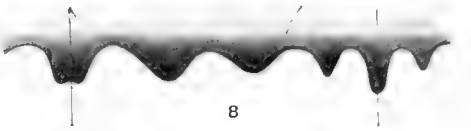

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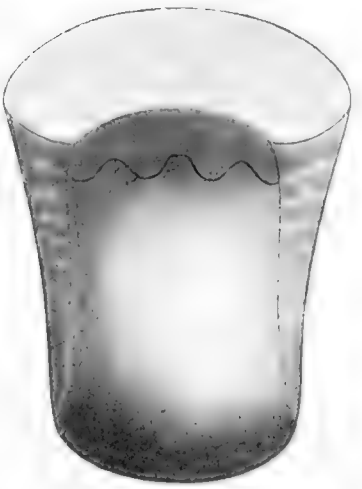

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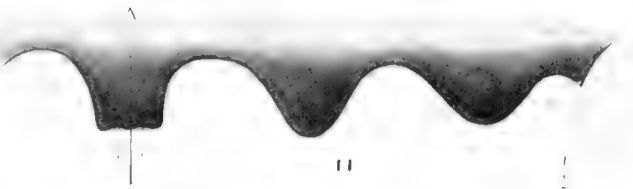

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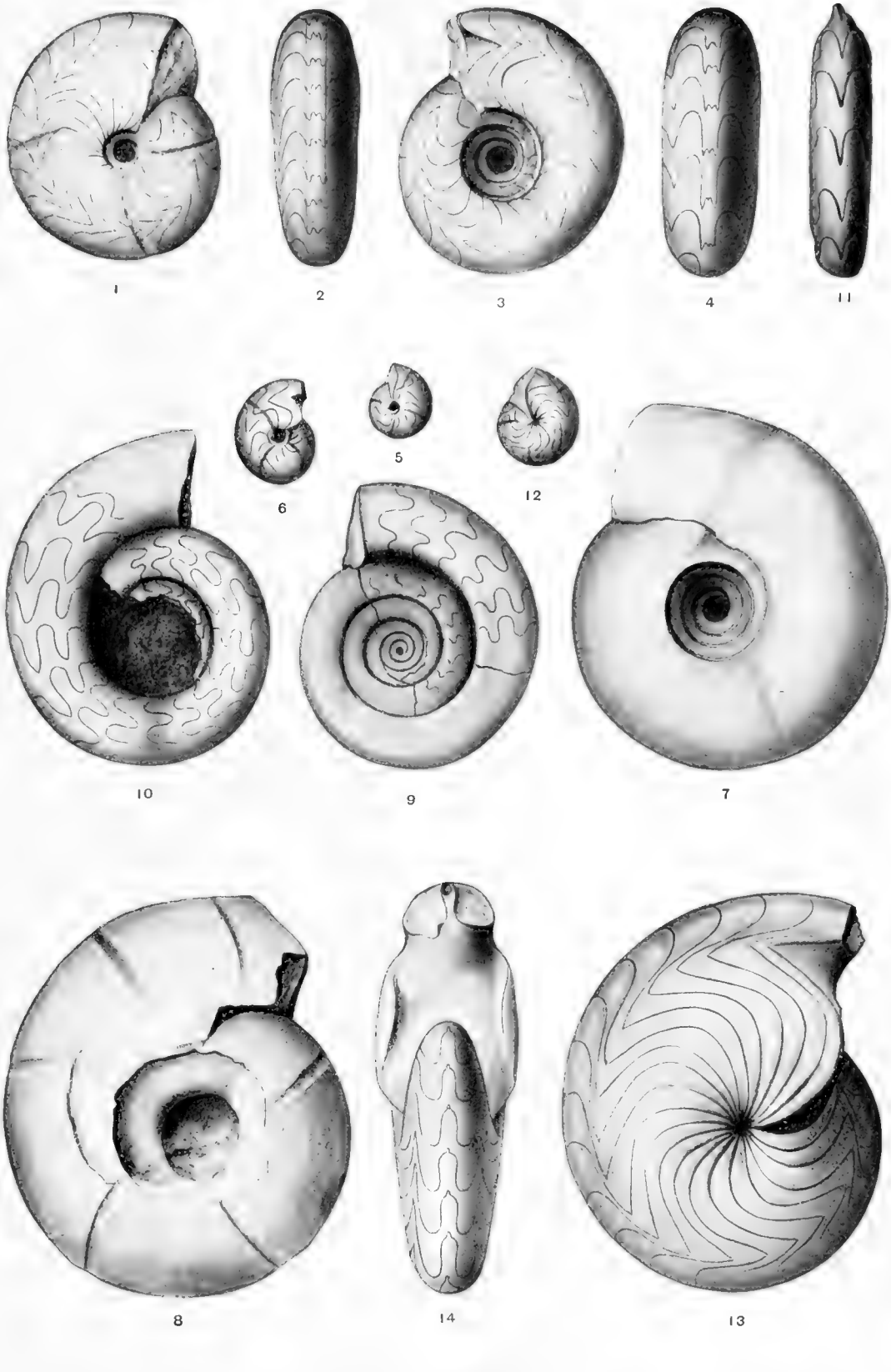
# PLATE XIX.

# PLATE XIX.



NOTE.—The figures on this plate are slightly reduced by photography from Pal. N. Y., Vol. V, Pt. II, Pl. LXXIII.

All specimens on this plate from the Lower Carboniferous, Kinderhook stage, goniatite bed, Rockford, Ind.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# PLATE XX.

# PLATE XX.

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FIGS. 1–10. SCHISTOCERAS HYATTI Smith, sp. nov ..... 104

Figs. 1 and 2. Transitional from paralegoceran to schistoceran stage, diameter 21 mm., twice enlarged.

Figs. 3 and 4. Early adult, schistoceran stage, diameter 40 mm., natural size, showing the surface of shell.

Figs. 5 and 6. Adult stage, diameter 43 mm., natural size. This was Hyatt's type of the genus *Schistoceras*.

Figs. 7 and 8. Adult stage, diameter 67 mm., natural size.

FIGS. 9–11. GONIOLOBOCERAS WELLERI Smith, sp. nov ..... 125

Adolescent, glyphioceran stage, diameter 7.5 mm., enlarged 5 times.

FIGS. 12–15. DIMORPHOCERAS TEXANUM Smith, sp. nov. (The cross section, fig. 13, is about two-thirds natural size.) ..... 126

NOTE.—All specimens on this plate from Upper Coal Measures, Cisco formation, Graham, Young County, Tex.


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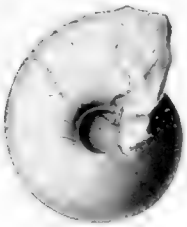
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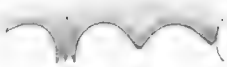
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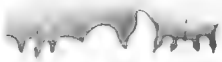
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# PLATE XXI.

# PLATE XXI.

Page.

FIGS. 1–6. GONIOLOBOCERAS WELLERI Smith, sp. nov ..... 125

Natural size.

Figs. 1 and 2. Early adolescent stage, with rounded abdomen.

Figs. 3 and 4. Adult stage, with angular and slightly furrowed abdomen.

Fig. 5. External septa.

Fig. 6. Internal septa.

FIGS. 7–9. GASTRIOCERAS GLOBULOSUM Meek and Worthen ..... 89

FIGS. 10–13. SCHISTOCERAS HYATTI Smith ..... 104

Fig. 10, a and b. Gastrioceran stage, 4 times enlarged; diameter 5.5 mm.

Fig. 11, a, b, and c. Paralegoceran stage, 4 times enlarged; diameter 10.5 mm.

Fig. 12. Septa transitional from paralegoceran to schistoceran stage; diameter 21 mm.; twice enlarged.

Fig. 13. Adult septa, diameter 42 mm., natural size.

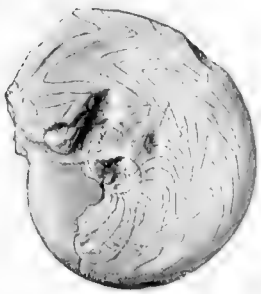
FIGS. 14–16. POPANOCERAS GANTI Smith, sp. nov ..... 132

(The details of the internal septa, fig. 16, could not be made out.)

FIGS. 17–19. AGATHICERAS CISCOENSE Smith, sp. nov ..... 131

FIGS. 20–22. SCHUCHERTITES GRAHAMI Smith, sp. nov ..... 50

NOTE.—All specimens on this plate from the Upper Coal Measures, Cisco formation, Graham, Young County, Tex.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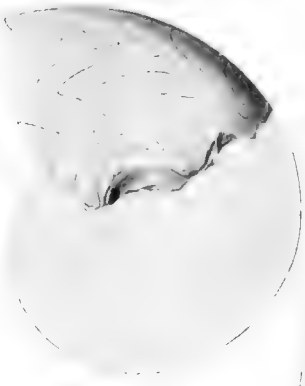
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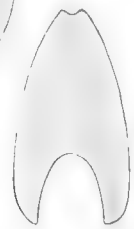
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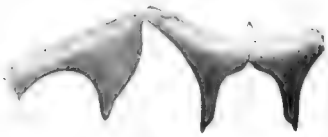
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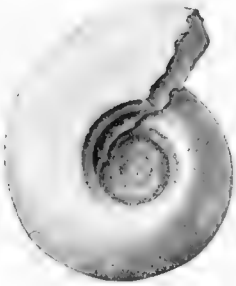
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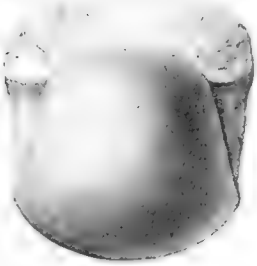
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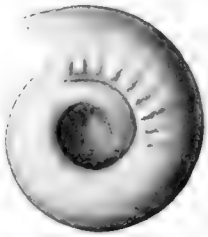
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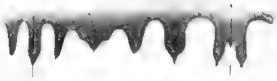
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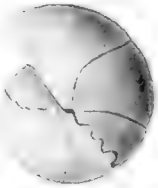
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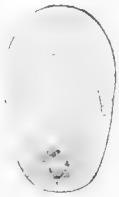
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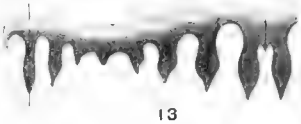
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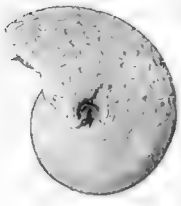
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# PLATE XXII.

# PLATE XXII.

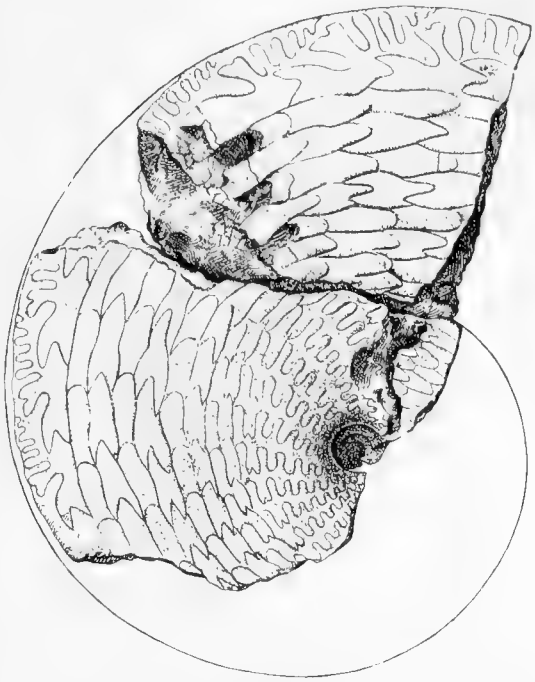
Page.

FIGS. 1–3. MEDLICOTTIA COPEI White ..... 48
Wichita Permian, military crossing of Big Wichita River, Baylor County, Tex.
Specimen in Nat. Mus.

FIGS. 4–8. WAAGENOCERAS CUMMINSI White ..... 139
Wichita Permian, locality same as above.
Specimen in Nat. Mus.

FIGS. 9–11. POPANOCERAS WALCOTTI White ..... 134
Wichita Permian, locality same as above.
Specimen in Nat. Mus.

NOTE.—This plate was Pl. I, Bull. U. S. Geol. Survey No. 77.



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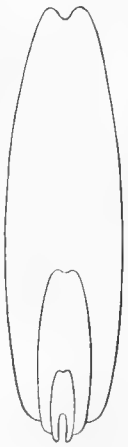

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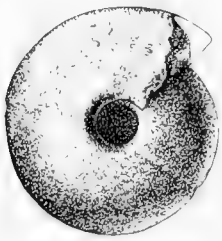

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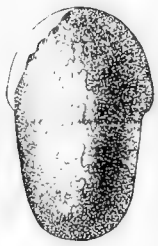

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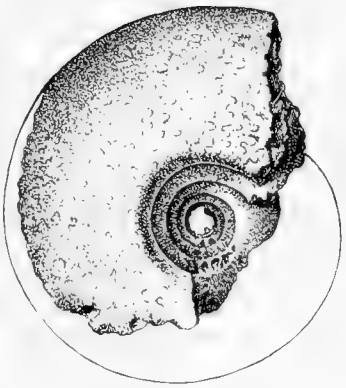

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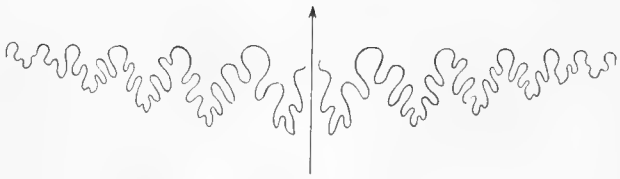

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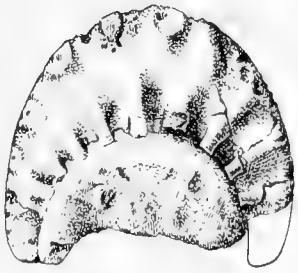

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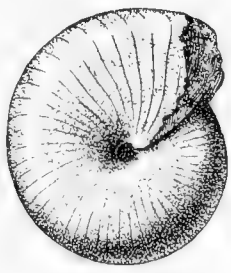

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# PLATE XXIII.

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PRODROMITES GORBYI Miller..... 37

Fig. 1. Miller's type specimen No. 6208, Walker Museum, from the Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pin Hook Bridge, Pettis County, Mo.

Fig. 2. Specimen No. 6474, paleontologic collection, Walker Museum, University of Chicago, from the Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pettis County, Mo.

NOTE.—Fig. 1 was Pl. VI, Jour. Geol., Vol. IX; specimen loaned by the University of Chicago. Fig. 2 is after Pl. VII, Jour. Geol., Vol. IX.

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# PLATE XXIV.

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FIGS. 1–4. PROLECANITES GURLEYI Smith, sp. nov ..... 53

Lower Carboniferous, Kinderhook stage, Cedar Gap, Wright County, Mo.

Figs. 1–3. Side, front, and rear view, enlarged twice.

Fig. 4. Septa from the same specimen, enlarged 4 times.

FIGS. 5–7. AGANIDES DISCOIDALIS Smith, sp. nov ..... 114

Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pettis County, Mo.

Figs. 5 and 6. Side and front views.

Fig. 7. Septa of same specimen, enlarged twice.

FIGS. 8–12. MUENSTEROCERAS OSAGENSE Swallow ..... 119

Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pettis County, Mo.

Figs. 8–10. Both sides and front, enlarged twice.

Figs. 11 and 12. Side view of same specimen, with part of the outer whorl removed, to show the septa (fig. 12), enlarged twice, septa enlarged 4 times.

FIGS. 13–20. GASTRIOCERAS WELLERI Smith, sp. nov ..... 98

Middle Coal Measures, Des Moines formation, Carroll County, Mo.

Figs. 13–15. Side, front, and rear views of the type specimen, enlarged twice.

Figs. 16–18. Side, front, and rear views of another specimen, showing the septa, enlarged twice.

Figs. 19 and 20. Side and front views of a smaller specimen, enlarged twice, to show the surface ornamentation.


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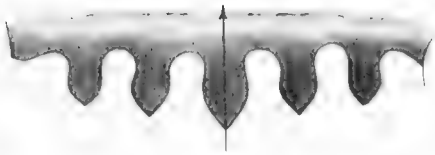
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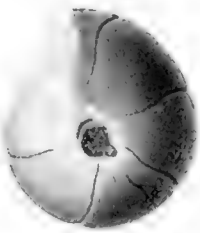
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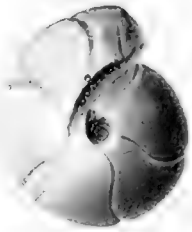
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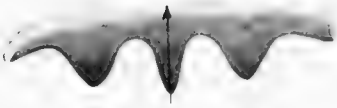
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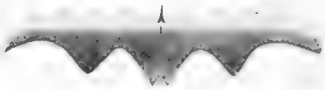
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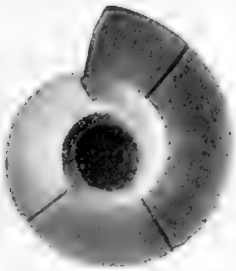
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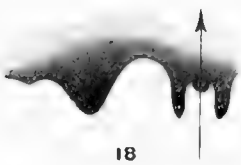
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# PLATE XXV.

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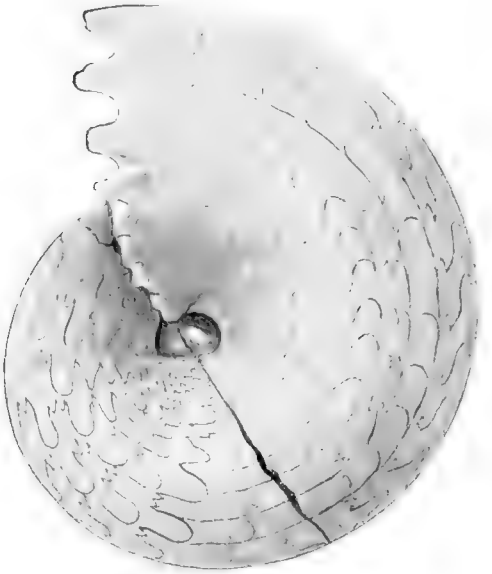
FIGS. 1 and 2. PRODROMITES GORBYI Miller ..... 37
Lower Carboniferous, Kinderhook, Burlington, Iowa. No. 6222, paleontologic collection, Walker Museum, University of Chicago.

FIGS. 3 and 4. PRODROMITES PRÆMATURUS Smith and Weller ..... 40
From the Lower Carboniferous, Kinderhook, of Rockford, Ind. No. 6223, paleontologic collection, Walker Museum, University of Chicago.

FIG. 5. Septa of HEDENSTRŒMIA MOJSISOVICSI Diener ..... 34
For comparison with the septa of *Prodromites*.

FIGS. 6–8. PRODROMITES ORNATUS Smith, sp. nov ..... 39
Lower Carboniferous, Kinderhook stage, Chouteau limestone, Pettis County, Mo.
Figs. 6–7. Side and front views, natural sizes.
Fig. 8. Septa, enlarged 3 times.

(NOTE.—Figs. 1–5, Pl. VIII, Jour. Geol., Vol. IX, No. 3, were loaned by the University of Chicago; fig. 5 is from Pal. Indica, Ser. XV, Cephalopoda of the Lower Trias, Pl. XX, fig. 1c.)



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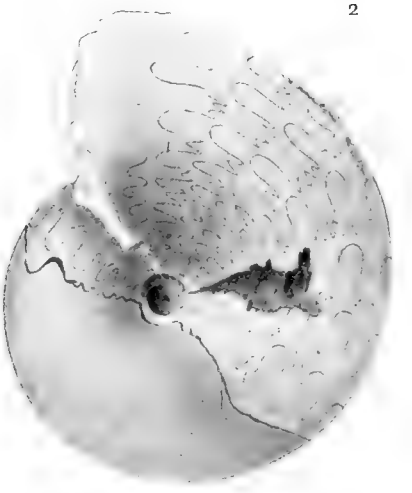

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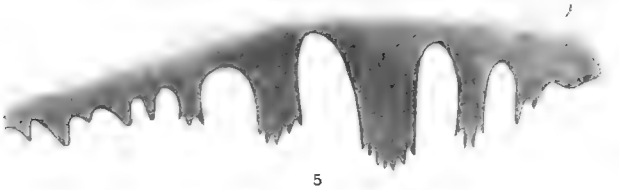

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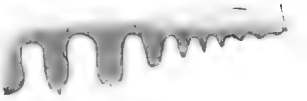

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# PLATE XXVI.

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FIGS. 1–5. GONIATITES CRENISTRIA Philips ..... 68

Figs. 1, 2. Early adult stage, 1½ times enlarged, Lower Carboniferous, St. Louis-Chester stage, Moorefield, Ark.

Fig. 3. Septa, natural size, Moorefield, Ark.

Fig. 4. Septa, from the Lower Carboniferous limestone of the Iberg, near Grund, in the Hartz, 1½ times enlarged.

Fig. 5. Surface ornamentation, Lower Carboniferous, St. Louis-Chester stage, Boles, Ark.

FIGS. 6–13. GONIATITES STRIATUS Sowerby ..... 80

Figs. 6, 7. Lower Carboniferous, St. Louis-Chester stage, Batesville, Ark., 9.3 mm. diameter, 5 times enlarged.

Fig. 8. Lower Carboniferous, St. Louis-Chester stage, Batesville, Ark., 14 mm. diameter, 1½ times enlarged.

Fig. 9. Adult septa enlarged, Batesville, Ark.

Fig. 10. Internal septa enlarged, Batesville, Ark.

Fig. 11. Septa of young twice enlarged, Batesville, Ark.

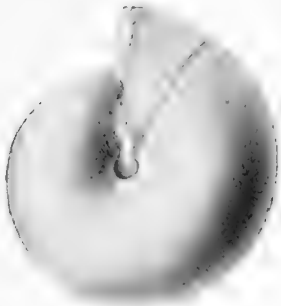
Figs. 12, 13. Adult, natural size, Batesville, Ark.

FIGS. 14–18. GONIATITES SUBCIRCULARIS Miller ..... 81

Figs. 14, 15. Three times enlarged, St. Louis-Chester stage, Batesville, Ark.

Figs. 16, 17. Twice enlarged, Batesville, Ark.

Fig. 18. Septa from the above specimen.



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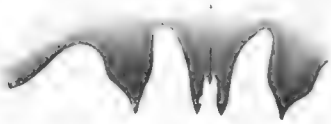

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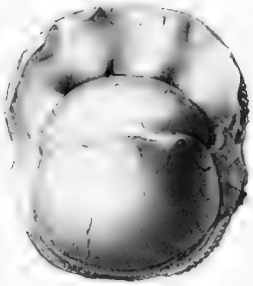

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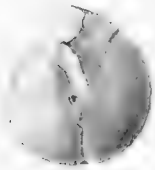

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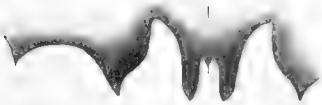

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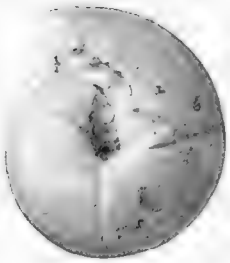

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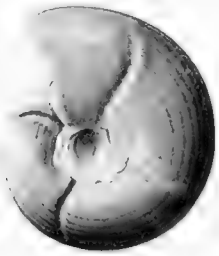

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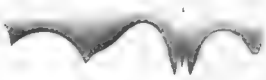

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WAAGENOCERAS HILLI Smith, sp. nov ..... 140

Upper Permian, Double Mountain formation, falls of Salt Croton Creek, Kent County, Tex. (Enlarged 1½ times.)

NOTE.—From photograph by Franklin, Palo Alto.

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GASTRIOCERAS EXCELSUM Meek ..... 88

Specimen No. 6226, paleontologic collection, Walker Museum, University of Chicago. Upper Coal Measures, Osage, Kans.

Fig. 1. Side view, natural size.

Fig. 2. Septa, natural size, traced from the specimen.

NOTE.—Photograph loaned by Dr. Stuart Weller, University of Chicago.

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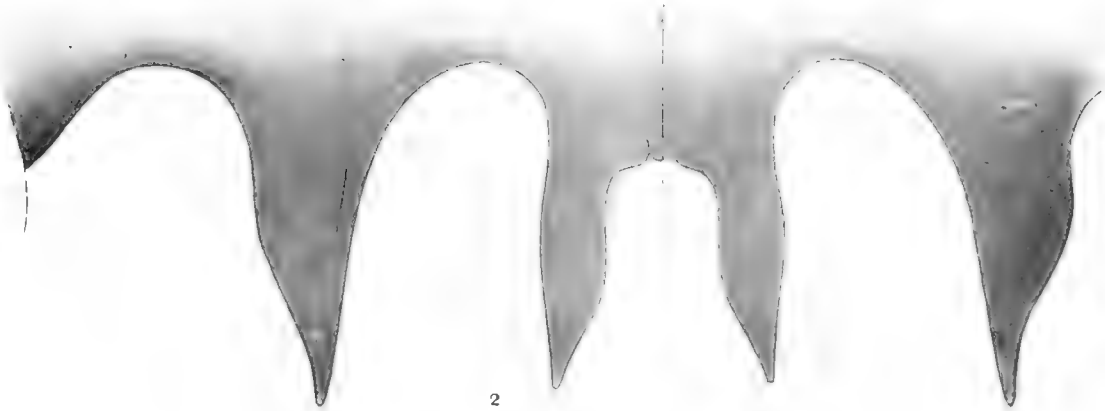

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CARBONIFEROUS AMMONOIDS.

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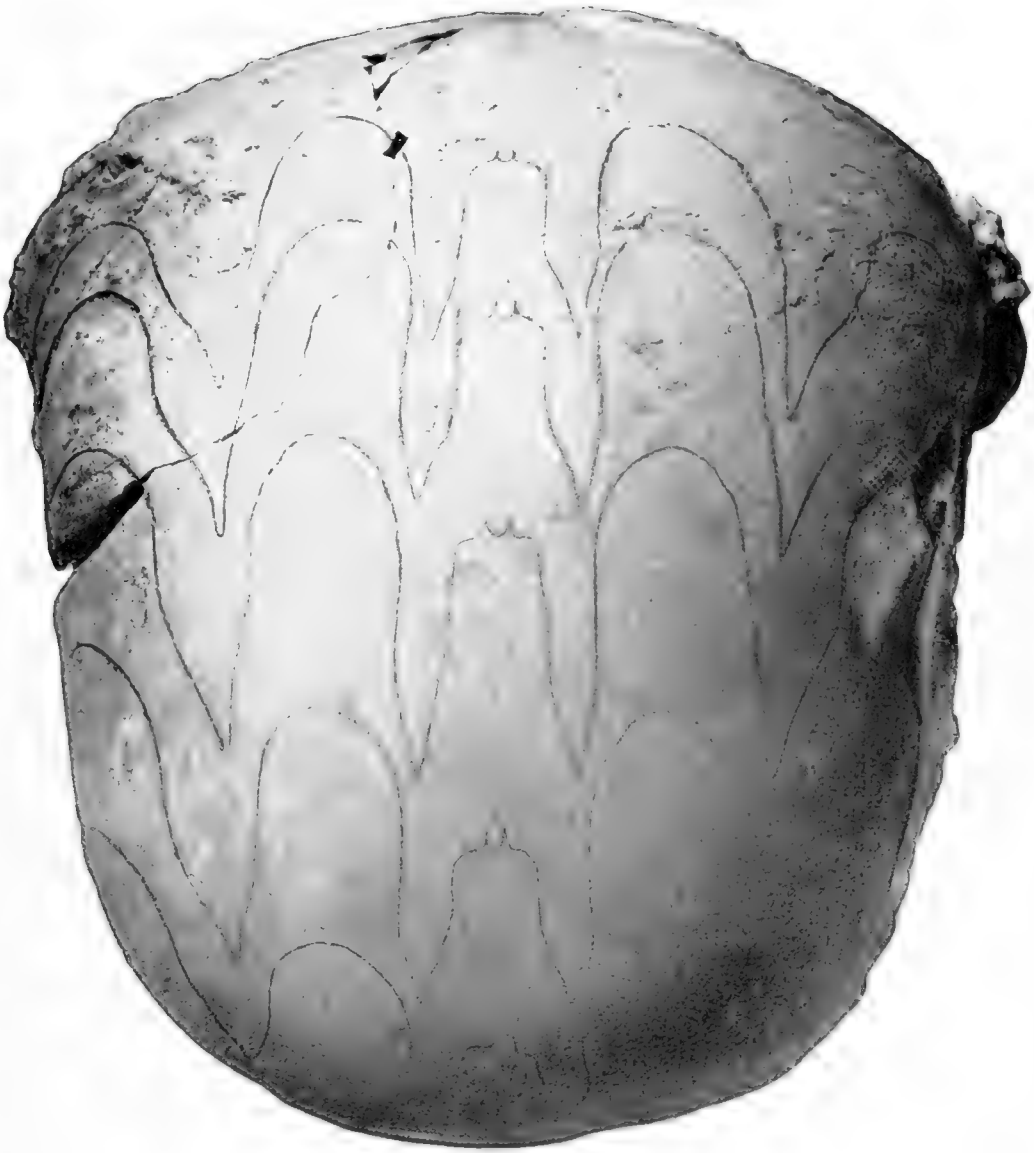
GASTRIOCERAS EXCELSUM Meek ..... 88

Specimen No. 6226, paleontologic collection, Walker Museum, University of Chicago.
Upper Coal Measures, Osage, Kans.
View from above, natural size.

NOTE.—Photograph loaned by Dr. Stuart Weller, University of Chicago.



CARBONIFEROUS AMMONOIDS.

# INDEX.

(Names in *italic* are synonyms; figures in **black-face type** are numbers of pages on which detailed descriptions appear; figures in *italic* denote illustrations.)

O

# PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Monograph XLII.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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