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LOWER TRIASSIC AMMONOIDS OF NORTH AMERICA

BY
JAMES PERRIN SMITH

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LOWER TRIASSIC AMMONOIDS OF NORTH AMERICA

By James Perrin Smith

INTRODUCTION [1]

The writer has been engaged, under the auspices of the United States Geological Survey, in the study of Lower Triassic faunas of North America since 1896, when the late Charles D. Walcott discovered the *Meekoceras*-bearing beds in the Inyo Range of California and submitted the material collected for identification. This work has been followed up by frequent journeys in the field in California, Nevada, and Idaho and occasional studies in the United States National Museum.

The writer has visited all the principal localities for Lower Triassic ammonoids known in America and has had the assistance of numerous field parties of the United States Geological Survey, of Stanford University, and of the University of California and also of numerous friends outside these organizations.

Deep obligations are acknowledged to the late Charles D. Walcott and Alpheus Hyatt, for their generous interest and encouragement in the beginning of this work, and to George Otis Smith, director, and David White and T. W. Stanton, of the United States Geological Survey, for the opportunity of carrying on the work and publishing the results.

The writer also acknowledges his indebtedness to Dr. John C. Merriam, Mr. Henry W. Turner, Mr. A. M. Strong, and Mr. Oscar H. Hershey for assistance in the field and for the use of collections made by them. Especial thanks are due to the late Robert S. Spence for his generous assistance in the field and for his skill and enthusiasm in collecting the Lower Triassic faunas of the Wasatch Mountains.

The writer is also greatly indebted to Prof. Charles Schuchert, former curator of paleontology in the United States National Museum, for access to the types of the Hayden Survey collections and for the use of material for study; also to Prof. A. L. Mathews for the use of collections made by him in Utah.

Sincere gratitude is here expressed to the late Prof. Carl Diener, of Vienna and the Geological Survey of India, for the exchange of specimens and for constant aid and constructive criticism through a correspondence lasting for 30 years.

The writer also feels a deep sense of obligation to Prof. G. von Arthaber, of Vienna, for his kindly interest and friendly suggestions that have been of great help in preparing the descriptions of this large and somewhat difficult fauna.

The writer desires to express his thanks to the people of those parts of California, Nevada, Idaho, and Utah where the collections were made, for their friendly helpfulness in the prosecution of the field work. He received everywhere the most sympathetic interest and cordial help.

The species of Lower Triassic ammonoids of North America described and illustrated in this paper are listed in the table below, which also shows their stratigraphic position in North America and their occurrence in other parts of the world.

Lower Triassic ammonoids of North America

Meekoceras zone of Idaho

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Lecanites arnoldi Hyatt and Smith	Pl. 28, figs. 8–10; pl. 39, figs. 9–12; pl. 64, figs. 1–16.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Lecanites knechti Hyatt and Smith	Pl. 9, figs. 11–16; pl. 28, figs. 1–7	do	
Xenodiscus cordilleranus Smith	Pl. 24, figs. 21–29	*Pseudosageceras multilobatum* subzone	
Xenodiscus gilberti Smith	Pl. 24, figs. 1–9	do	
Xenodiscus intermontanus Smith	Pl. 24, figs. 10–20	do	
Xenodiscus tarpeyi Smith	Pl. 25, figs. 4–6	do	
Xenodiscus toulai Smith	Pl. 25, figs. 1–3; pl. 53, figs. 9–12	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Xenodiscus waageni Hyatt and Smith	Pl. 39, figs. 3–8	do	
Xenodiscus whiteanus (Waagen)	Pl. 25, fig. 17	*Pseudosageceras multilobatum* subzone	
Ophiceras dieneri Hyatt and Smith	Pl. 8, figs. 16–29	do	
Flemingites aplanatus (White)	Pl. 11, figs. 1–14; pl. 22, figs. 1–23; pl. 39, figs. 1, 2; pl. 64, figs. 17–22.	*Pseudosageceras multilobatum* and *Owenites* subzone.	
Flemingites aspenensis Smith	Pl. 23, figs. 6–11	*Pseudosageceras multilobatum* subzone	
Flemingites bannockensis Smith	Pl. 23, figs. 18–26	do	
Flemingites cirratus (White)	Pl. 20, fig. 1; pl. 26, figs. 1–13	do	

[1] Prof. James Perrin Smith passed away January 1, 1931. It is greatly to be regretted that he did not live to see this product of his labors in type. The manuscript had received its final revision at his hands, however, and was awaiting publication at the time of his death. The proofs have been read entirely by others, but no changes have been made aside from the correction of obvious errors.—Editor.

Lower Triassic ammonoids of North America—Continued

Meekoceras zone of Idaho—Continued

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Flemingites russelli Hyatt and Smith	Pl. 1, figs. 1-3; pl. 26, figs. 14-23; pl. 70, figs. 1-3.	do	
Flemingites russelli var. gracilis Smith	Pl. 23, figs. 1-3	do	
Meekoceras arthaberi Smith	Pl. 32, figs. 26-33	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras cristatum Smith	Pl. 33, figs. 14-19; pl. 34, figs. 1-6	*Pseudosageceras multilobatum* subzone	
Meekoceras evansi Smith	Pl. 35, figs. 1-3; pl. 36, figs. 1-18	do	
Meekoceras gracilitatis White	Pl. 12, figs. 1-13; pl. 13, figs. 1-18; pl. 14, figs. 1-8; pl. 36, figs. 19-28; pl. 37, figs. 1-7; pl. 38, figs. 2-6; pl. 70, figs. 4-7.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras mushbachanum White	Pl. 15, figs. 1-9; pl. 16, figs. 1-3; pl. 18, figs. 1-7; pl. 38, fig. 1; pl. 70, figs. 8-10; pl. 74, figs. 1-25; pl. 75, figs. 1-6; pl. 76, figs. 1, 2.	do	Lower Triassic of Timor?
Meekoceras mushbachanum var. corrugatum Smith.	Pl. 38, fig. 1	*Pseudosageceras multilobatum* subzone.	
Meekoceras patelliforme Smith	Pl. 28, figs. 21-27; pl. 52, figs. 9-11	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras sylvanum Smith	Pl. 33, figs. 1-14	*Pseudosageceras multilobatum* subzone	
Clypeoceras muthianum (Krafft)	Pl. 27, figs. 1-7	do	*Flemingites* beds of India.
Dagnoceras bonnevillense Smith	Pl. 29, figs. 9-23	do	
Dagnoceras bridgesi Smith	Pl. 31, figs. 1-7	do	
Dagnoceras haydeni Smith	Pl. 29, figs. 1-8	do	
Dagnoceras pealei Smith	Pl. 29, figs. 24-37	do	
Hedenstroemia hyatti Smith	Pl. 27, figs. 13-18	do	
Hedenstroemia kossmati Hyatt and Smith	Pl. 28, figs. 11-16; pl. 41, figs. 1-10; pl. 67, figs. 3-7.	do	
Hedenstroemia tenuis Hyatt and Smith	Pl. 1, figs. 4-8	do	
Dalmatites richardsi Smith		do	
Juvenites dieneri Hyatt and Smith	Pl. 7, figs. 5-25; pl. 32, figs. 1-10	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Juvenites kraffti Smith	Pl. 21, figs. 1-10	*Pseudosageceras multilobatum* subzone	
Juvenites sanctorum Smith	Pl. 31, figs. 22-30	do	
Juvenites septentrionalis Smith	Pl. 31, figs. 31-40	do	
Paranannites aspenensis Hyatt and Smith	Pl. 8, figs. 1-15; pl. 73, figs. 1-30	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Paranannites columbianus Smith	Pl. 32, figs. 11-25	*Pseudosageceras multilobatum* subzone	
Paranannites compressus Smith	Pl. 31, figs. 19-21	do	
Paranannites pertenuis Smith	Pl. 31, figs. 13-15	do	
Prenkites depressus Smith	Pl. 31, figs. 16-18	do	
Thermalites thermarum Smith	Pl. 21, figs. 11-20	do	
Ussuria occidentalis Smith	Pl. 27, figs. 8-12	do	
Ussuria waageni Hyatt and Smith	Pl. 21, figs. 24-40; pl. 42, figs. 1-8; pl. 65, figs. 1-5; pl. 66, figs. 1-12; pl. 67, figs. 1, 2.	do	
Lanceolites compactus Hyatt and Smith	Pl. 4, figs. 4-10; pl. 5, figs. 7-9; pl. 21, figs. 21-23; pl. 28, figs. 17-20; pl. 40, figs. 9-11.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Cordillerites angulatus Hyatt and Smith	Pl. 2, figs. 1-8; pl. 42, figs. 14-20; pl. 68, figs. 1-10; pl. 71, figs. 1-6.	*Pseudosageceras multilobatum* subzone	
Aspenites acutus Hyatt and Smith	Pl. 2, figs. 9-13; pl. 3, figs. 1-5; pl. 30, figs. 1-26.	*Pseudosageceras multilobatum* and *Owenites* subzones.	*Owenites* beds of Timor.
Aspenites laevis Welter	Pl. 28, figs. 28-33	*Pseudosageceras multilobatum* subzone	Do.
Aspenites obtusus Smith	Pl. 31, figs. 8-10	do	
Pseudosageceras multilobatum Noetling	Pl. 4, figs. 1-3; pl. 5, figs. 1-6; pl. 25, figs. 7-16; pl. 63, figs. 1-6.	*Pseudosageceras multilobatum* and *Owenites* subzones and *Columbites* zone.	*Flemingites* beds of India and Timor.

Owenites fauna of California and Nevada

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Lecanites arnoldi Hyatt and Smith	Pl. 28, figs. 8-10; pl. 39, figs. 9-12; pl. 64, figs. 1-16.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Lecanites knechti Hyatt and Smith	Pl. 9, figs. 11-16; pl. 28, figs. 1-7	do	
Xenodiscus cordilleranus Smith	Pl. 24, figs. 21-29		
Xenodiscus marcoui Hyatt and Smith	Pl. 7, figs. 26-33	*Owenites* subzone	
Xenodiscus nevadanus Smith	Pl. 56, figs. 1-5	do	
Xenodiscus nivalis Diener	Pl. 56, figs. 6-12	do	*Flemingites* beds of India and Timor.
Xenodiscus toulai Smith	Pl. 25, figs. 1-3; pl. 53, figs. 9-12	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Xenodiscus waageni Hyatt and Smith	Pl. 39, figs. 3-8	do	
Ophiceras parvum Smith	Pl. 54, figs 25-30	*Owenites* subzone	
Ophiceras sakuntala Diener	Pl. 54, figs. 1-17; pl. 56, figs. 13-18	do	Lower Triassic of India and Albania.
Ophiceras subquadratum Smith	Pl. 54, figs. 18-24	do	
Flemingites aplanatus (White)	Pl. 11, figs. 1-14; pl. 22, figs. 1-23; pl. 39, figs. 1, 2; pl. 64, figs. 17-22.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras arthaberi Smith	Pl. 32, figs. 26-33	do	
Meekoceras elkoense Smith	Pl. 55, figs. 14-16	*Owenites* subzone	
Meekoceras gracilitatis White	Pl. 12, figs. 1-3; pl. 13, figs. 1-18; pl. 14, figs. 1-8; pl. 36, figs. 19-28; pl. 37, figs. 1-7; pl. 38, figs. 2-6; pl. 70, figs. 4-7.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras mushbachanum White	Pl. 15, figs. 1-9; pl. 16, figs. 1-3; pl. 18, figs. 1-7; pl. 38, fig. 1; pl. 70, figs. 8-10; pl. 75, figs. 1-6; pl. 76, figs. 1-3; pl. 79, figs. 1-23.	do	*Flemingites* beds of Timor?
Meekoceras newberryi Smith	Pl. 53, figs. 1-4	*Owenites* subzone	
Meekoceras patelliforme Smith	Pl. 28, figs. 21-27; pl. 52, figs. 9-11	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Meekoceras radiosum Waagen	Pl. 51, figs. 1-4	*Owenites* subzone	Lower Triassic of India and Albania.
Meekoceras sanctorum Smith	Pl. 49, figs. 1-4	*Columbites* zone	
Meekoceras strongi Smith	Pl. 52, figs. 12-17	*Owenites* subzones	
Meekoceras tuberculatum Smith	Pl. 50, figs. 1-4	do	
Clypeoceras hooveri Hyatt and Smith	Pl. 17, figs. 1-12	do	
Clypeoceras pusillum Smith	Pl. 51, figs. 11-13	do	
Hedenstroemia kossmati Hyatt and Smith	Pl. 28, figs. 11-16; pl. 41, figs. 1-10; pl. 67, figs. 3-7.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Anasibirites desertorum Smith	Pl. 51, figs. 7-10; pl. 56, figs. 19, 20	*Owenites* subzone	*Anasibirites* beds of Timor?
Anasibirites lindgreni Smith	Pl. 53, figs. 13-17	do	
Anasibirites noetlingi Hyatt and Smith	Pl. 9, figs. 1-3	do	
Goniodiscus typus Waagen		do	*Anasibirites* beds of India and Timor.

Lower Triassic ammonoids of North America—Continued

Owenites fauna of California and Nevada—Continued

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Dalmatites attenuatus Smith		*Owenites* subzone and *Tirolites* zone	
Inyoites oweni Hyatt and Smith	Pl. 6, figs. 1–16; pl. 40, figs. 1–8; pl. 69, figs. 1–9.	*Owenites* subzone	*Flemingites* beds of Svalbard?
Juvenites dieneri Hyatt and Smith	Pl. 7, figs. 5–25; pl. 32, figs. 1–10	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Paranannites aspenensis Hyatt and Smith	Pl. 8, figs. 1–15; pl. 73, figs. 1–30	do	
Danubites strongi Hyatt and Smith	Pl. 9, figs. 4–10	*Owenites* subzone	
Proptychites walcotti Hyatt and Smith	Pl. 19, figs. 1–7; pl. 52, figs. 18–20	do	
Proteusites rotundus Smith	Pl. 53, figs. 5–8	do	
Owenites carpenteri Smith	Pl. 54, figs. 31–34	do	
Owenites egrediens Welter	Pl. 52, figs. 6–8	do	*Owenites* beds of Timor.
Owenites koeneni Hyatt and Smith	Pl. 10, figs. 1–23	do	
Owenites zitteli Smith	Pl. 52, figs. 1–15	do	
Prosphingites austini Hyatt and Smith	Pl. 7, figs. 1–4	do	
Sturia compressa Hyatt and Smith	Pl. 3, figs. 6–11	do	
Sturia woodini Smith	Pl. 51, figs. 5, 6	do	
Lanceolites compactus Hyatt and Smith	Pl. 4, figs. 4–10; pl. 5, figs. 7–9; pl. 21, figs. 21–23; pl. 28, figs. 17–20; pl. 40, figs. 9–11.	*Pseudosageceras multilobatum* and *Owenites* subzones.	
Lanceolites bicarinatus Smith	Pl. 55, figs. 1–13	*Owenites* subzone	
Aspenites acutus Hyatt and Smith	Pl. 2, figs. 9–13; pl. 3, figs. 1–5; pl. 30, figs. 1–26.	*Pseudosageceras multilobatum* and *Owenites* subzones.	*Owenites* beds of Timor.
Pseudosageceras multilobatum Noetling	Pl. 4, figs. 1–3; pl. 5, figs. 1–6; pl. 25, figs. 7–16; pl. 63, figs. 1–6.	*Pseudosageceras multilobatum* and *Owenites* subzones and *Columbites* zone.	*Flemingites* beds of Timor and India.

Anasibirites fauna of Utah

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Pseudosageceras multilobatum Noetling		*Anasibirites* subzone	*Hedenstroemia* beds of India and Timor.
Cordillerites compressus Mathews	Pl. 79, figs. 3, 4	do	
Xenodiscus rotula Waagen	Pl. 79, figs. 5, 6	do	*Flemingites* beds of India and Timor.
Xenodiscus nivalis Diener	Pl. 79, figs. 1, 2	do	Do.
Meekoceras davisi Mathews	Pl. 79, figs. 7, 8	do	
Anasibirites angulosus (Waagen)	Pl. 79, figs. 13–15	do	*Anasibirites* beds of India and Timor.
Anasibirites bastini (Mathews)	Pl. 80, figs. 3–5	do	
Anasibirites emmonsi Mathews	Pl. 79, figs. 22–24	do	
Anasibirites hircinus (Waagen)	Pl. 79, figs. 11, 12	do	Do.
Anasibirites kingianus (Waagen)	Pl. 79, figs. 19–21	do	Do.
Anasibirites kingianus (Waagen) var. inaequicostatus Waagen.	Pl. 79, figs. 16, 17	do	Do.
Anasibirites mojsisovicsi Mathews	Pl. 80, figs. 1, 2	do	
Anasibirites multiformis Welter	Pl. 79, fig. 18	do	*Anasibirites* beds of Timor.
Anasibirites multiformis Welter var. hyatti Mathews.		do	
Anasibirites tenuistriatus (Waagen)	Pl. 79, figs. 9, 10	do	*Anasibirites* beds of India and Timor.
Goniodiscus ornatus Mathews	Pl. 80, figs. 11, 12	do	
Goniodiscus smithi (Mathews)	Pl. 80, figs. 13–15	do	
Goniodiscus typus Waagen	Pl. 80, figs. 6–8	do	Do.
Goniodiscus utahensis Mathews	Pl. 80, figs. 9, 10	do	
Kashmirites meeki (Mathews)	Pl. 81, figs. 1, 2	do	
Kashmirites perrini (Mathews)	Pl. 81, figs. 6–8	do	
Kashmirites resseri Mathews	Pl. 81, figs. 9, 10	do	
Kashmirites searleyi (Mathews)	Pl. 81, figs. 11, 12	do	
Kashmirites subarmatus Diener		do	Do.
Kashmirites wasatchensis Mathews	Pl. 81, figs. 3–5	do	

Tirolites fauna of Idaho

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Dalmatites attenuatus Smith	Pl. 57, figs. 11–13	*Owenites* subzone and *Tirolites* zone.	
Tirolites harti Smith	Pl. 57, figs. 9, 10	*Tirolites* zone	
Tirolites knighti Smith	Pl. 57, figs. 1–4	do	
Tirolites pealei Smith	Pl. 57, figs. 5–8	do	

Columbites fauna of Idaho

Name	Illustrations	Stratigraphic position	Occurrence elsewhere
Ophiceras jacksoni Hyatt and Smith	Pl. 62, figs. 11–21	*Columbites* zone	
Ophiceras spencei Hyatt and Smith	Pl. 62, figs. 1–10	do	
Meekoceras curticostatum Smith	Pl. 48, figs. 21–30	do	
Meekoceras micromphalus Smith	Pl. 49, figs. 5–11	do	
Meekoceras pilatum Hyatt and Smith	Pl. 63, figs. 7–13	do	
Meekoceras sanctorum Smith	Pl. 49, figs. 1–4	do	
Pseudharpoceras idahoense Smith	Pl. 49, figs. 17–19	do	
Tirolites illyricus Mojsisovics		do	Werfen beds of Tyrol.
Pseudosageceras multilobatum Noetling	Pl. 4, figs. 1–3; pl. 5, figs. 1–6; pl. 25, figs. 7–16; pl. 63, figs. 1–6.	*Pseudosageceras multilobatum* and *Owenites* subzones and *Columbites* zone.	*Flemingites* beds of India and Timor.
Celtites apostolicus Smith	Pl. 48, figs. 1–10	*Columbites* zone	
Celtites planovolvis Smith	Pl. 48, figs. 11–20	do	
Celtites ursensis Smith	Pl. 47, figs. 11–23	do	
Columbites consanguineus Smith	Pl. 46, figs. 1–13	do	
Columbites ligatus Smith	Pl. 47, figs. 1–8	do	
Columbites minimus Smith	Pl. 47, figs. 9, 10	do	
Columbites ornatus Smith	Pl. 46, figs. 14–21	do	
Columbites parisianus Hyatt and Smith	Pl. 1, figs. 9–14; pl. 61, figs. 1–21; pl. 72, figs. 1–24.	do	
Columbites spencei Smith	Pl. 77, figs. 1–21; pl. 78, figs. 1–16	do	

The present work is the fifth in a series planned many years ago, to cover the stratigraphy and geologic history of the Cephalopoda through the late Paleozoic and early Mesozoic eras. The other works of the series, in order of publication, are the following:

The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, 1903. The purpose of this monograph was to lay the foundation for the study of the ancestors of the Mesozoic faunas.

The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, 1905. This paper was written in conjunction with Alpheus Hyatt and described a typical species under each cephalopod genus known in the Triassic of North America at that time.

The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, 1914.

Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, 1927.

The writer has also completed two other monographs in the same series and on kindred subjects, as follows:

Permian ammonoids of Timor: 2e Nederlandsche Timor-Expeditie onder Leiding van Dr. H. G. Jonkert, uitgegeven door Dr. H. A. Brouwer: Jaarboek van het Mijnwezen in Ned. Indië, 1926, Verh. 1, 1927.

Lower Triassic ammonoids of Timor (MS.).

These papers have been of great value in the study of the genealogy and relationships of the early Mesozoic faunas of North America. Acknowledgment is hereby made to Dr. H. A. Brouwer, of Delft, Holland, for the opportunity of studying the collections made by him and his field parties in Timor.

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GENERAL FEATURES OF THE LOWER TRIASSIC AMMONOID FAUNA

The Lower Triassic ammonoid fauna of North America now amounts to 32 genera and 117 species, distributed among the following families: Xenodiscidae 25 species, Meekoceratidae 38, Hungaritidae 4, Ceratitidae 6, Thalassoceratidae 4, Pronoritidae 2, Haueritidae 2, Sageceratidae 4, Ptychitidae 16, Haloritidae 6, Arcestidae 1, and Celtitidae 9.

Only three genera are peculiar to America—*Lanceolites*, *Cordillerites*, and *Thermalites*—and even these will probably be discovered in other regions, just as has happened with other so-called American genera. *Meekoceras*, *Columbites*, *Paranannites*, *Juvenites*, *Owenites*, and *Inyoites* were first described from America, this being merely an accident of discovery, as they all occur in other regions.

The Xenodiscidae, Meekoceratidae, and Hungaritidae are almost certainly immigrants from the Indian region. The Pronoritidae and Thalassoceratidae are probably native Americans, as may be also the Arcestidae, if the early development of these stocks in the American "Upper Coal Measure" is an indication.

Tirolites, the most common representative of the Ceratitidae, is plainly an immigrant from the European Mediterranean.

The Celtitidae appear in America, on one side, and in Albania, on the other, but are wholly lacking in the Indian region, which lies between the two. It would seem that they can hardly be indigenous in either region where they are known but that they must be immigrants from some outside source connected with both regions but not with the Indian region. Such a source may be found in the Arctic province, for the *Columbites* fauna of Idaho shows strong affinities with that of the Olenek horizon in northern Siberia, and even one doubtful *Columbites* occurs there.[1] The migration from the Arctic region to Albania must have followed the ancient depression parallel with the Urals, along which, in Upper Triassic time, *Pseudomonotis ochotica* came to the eastern Mediterranean. The approach to the western American region must have been made through the Bering portal and along the ancient shoreline highway. Migrations along this line took place before and long after the *Columbites* epoch, so there is nothing improbable about it.

Meekoceras, *Clypeoceras*, *Ophiceras*, and *Xenodiscus* range through the entire Lower Triassic and are present in all the great regions. They are therefore not diagnostic as genera, although individual species are excellent index fossils.

Most of the other genera of the American Lower Triassic are limited in their geologic range, and some, such as *Tirolites* and *Columbites*, are zone markers.

Out of 32 genera of ammonoids in the Lower Triassic of North America 18 occur also in the Albanian fauna, and 16 in that of Timor, but only 9 are common to all three regions, namely, *Meekoceras*, *Clypeoceras*, *Ophiceras*, *Xenodiscus*, *Proptychites*, *Hedenstroemia*, *Anasibirites*, *Pseudosageceras*, and *Juvenites*.

These geographic relationships are considered fully in the section on interregional correlation zones.

Species of the Meekoceras zone nearly related to Indian forms

Western America		Indian region
Ophiceras sakuntala Diener	=	Ophiceras sakuntala Diener.
Ophiceras dieneri Hyatt and Smith.		Ophiceras demissum Oppel.
Xenodiscus nivalis Diener	=	Xenodiscus nivalis Diener.
Xenodiscus rotula Waagen		Xenodiscus rotula Waagen.
Flemingites aplanatus (White)		Flemingites rohilla Diener.
Flemingites cirratus (White)		Flemingites salya Diener.
Meekoceras arthaberi Smith		Meekoceras boreale Diener.
Meekoceras gracilitatis White		Meekoceras boreale Diener.
Meekoceras mushbachanum White.		?Meekoceras cf. M. mushbachanum.
Meekoceras radiosum Waagen	=	Meekoceras radiosum Waagen.
Meekoceras tuberculatum Smith.		Meekoceras fulguratum Waagen.
Clypeoceras muthianum (Krafft).	=	Clypeoceras muthianum (Krafft).
Anasibirites desertorum Smith		Anasibirites tenuistriatus Waagen.
Anasibirites cf. A. kingianus (Waagen).		?Anasibirites kingianus (Waagen).
Anasibirites angulosus (Waagen).		Anasibirites angulosus (Waagen).
Anasibirites tenuistriatus (Waagen).		Anasibirites tenuistriatus (Waagen).

[1] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., ser. 7, vol. 33, No. 6, p. 73, pl. 11, figs. 18, a, b, 1886.

Western America		Indian region
Anasibirites multiformis Welter		Anasibirites multiformis Welter.
Anasibirites lindgreni Smith		Anasibirites ibex Waagen.
Kashmirites wasatchensis Mathews.		Kashmirites subarmatus Diener.
Goniodiscus typus Waagen	=	Goniodiscus typus Waagen.
Hedenstroemia kossmati Hyatt and Smith.		Hedenstroemia mojsisovicsi Diener.
Inyoites oweni Hyatt and Smith.		Inyoites discoidalis Welter.
Ussuria waageni Hyatt and Smith.		Ussuria iwanowi Diener.
Aspenites acutus Hyatt and Smith.	=	Aspenites acutus Hyatt and Smith.
Aspenites laevis Welter	=	Aspenites laevis Welter.
Pseudosageceras multilobatum Noetling.	=	Pseudosageceras multilobatum Noetling.
Juvenites dieneri Hyatt and Smith.		Juvenites herberti Diener.
Juvenites sanctorum Smith		Juvenites medius Krafft.
Owenites egrediens Welter	=	Owenites egrediens Welter.

Species of the Columbites and Tirolites zones related to Mediterranean forms

Western America		Mediterranean
Columbites parisianus Hyatt and Smith.		Columbites dusmani Arthaber.
Columbites spencei Smith		Columbites europaeus Arthaber.
Tirolites harti Smith		Tirolites haueri Mojsisovics.
Tirolites knighti Smith		Tirolites cassianus Quenstedt.
Tirolites pealei Smith		Tirolites smiriagini Auerbach.
Tirolites illyricus Mojsisovics	=	Tirolites illyricus Mojsisovics.
Pseudharpoceras idahoense Smith.		Pseudharpoceras praematurum Arthaber.
Pseudosageceras multilobatum Noetling.		Pseudosageceras drinense Arthaber.
Meekoceras sanctorum Smith		Meekoceras marginale Arthaber.
Dalmatites attenuatus Smith		Dalmatites morlaceus Kittl.

Species of the Columbites and Tirolites zones related to Olenek forms

Western America	Olenek
Ophiceras jacksoni Hyatt and Smith.	"Xenodiscus" schmidti Mojsisovics.
Ophiceras spencei Hyatt and Smith.	"Xenodiscus" euomphalus Keyserling.
Meekoceras pilatum Hyatt and Smith.	Meekoceras rotundatum Mojsisovics.
Meekoceras micromphalus Smith.	Meekoceras keyserlingi Mojsisovics.
Meekoceras sanctorum Smith	Meekoceras affine Mojsisovics.
Columbites ligatus Smith	Columbites sp. indet.

LOWER TRIASSIC FAUNAL ZONES OF NORTH AMERICA

The Lower Triassic ammonoids described in this report were collected in southeastern Idaho, in the Inyo Range of California, at the Phelan ranch in Elko County, Nev., and in the Wasatch Mountains of Utah. They occur in three paleontologic zones, named, in ascending order, the *Meekoceras* zone, *Tirolites* zone, and *Columbites* zone. The geologic occurrence and characteristics of the faunas of these zones are briefly summarized on the following pages. Two older Lower Triassic faunal zones (the *Otoceras* and *Genodiscus* zones; see p. 13) have been discriminated in other parts of the world, but they have not been identified in North America.

MEEKOCERAS ZONE OF IDAHO

The *Meekoceras*-bearing beds, or *Meekoceras* zone, of Idaho corresponds faunally to the *Hedenstroemia* and *Sibirites spiniger* zones of the Himalayas and to the *Flemingites*, *Owenites*, and *Anasibirites* beds of the Salt Range of India, but the so-called *Meekoceras* beds of India are older and are not known to be represented by American cephalopod faunas. The *Meekoceras* zone of America was named and described first and of course will retain the name.

In this report three subzones are recognized within the *Meekoceras* zone. These subzones are here designated, in ascending order, *Pseudosageceras multilobatum*, *Owenites*, and *Anasibirites* subzones.

Although *Pseudosageceras multilobatum* is not restricted to the basal subzone of the *Meekoceras*-bearing beds but has been identified as high in the section as the *Columbites* zone, it nevertheless has its greatest development in the basal part of the *Meekoceras* zone and is a world-wide and characteristic species at this horizon. The name is therefore here used as an interregional term for the basal subzone of the *Meekoceras* zone. In North America this subzone is characterized by the abundance of typical *Meekoceras;* by the relative abundance of *Flemingites*, *Hedenstroemia*, *Xenodiscus*, *Ussuria*, *Pseudosageceras*, *Aspenites*, *Lanceolites*, *Paranannites*, *Cordillerites*, *Juvenites*, *Thermalites*, and *Dagnoceras;* and by the first appearance in America of the interregional Asiatic species *Pseudosageceras multilobatum*, *Aspenites acutus*, *A. laevis*, and *Clypeoceras muthianum*. These species, together with the large number of species closely related to Indian forms but not quite identical, place the correlation of this fauna beyond question.

Although the rocks that mark this horizon are widely distributed in Idaho, Utah, western Wyoming, Nevada, and southeastern California, the best collections have been made in the Wasatch Mountains of southeastern Idaho.

The *Pseudosageceras multilobatum* subzone lies at the bottom of the *Meekoceras* zone and of the Thaynes group,[2] and the principal collections were made in a layer of yellowish-gray and somewhat earthy limestone taken as the bottom of the Thaynes.

Locality 1 is in the SE. ¼ sec. 36, T. 5 S., R. 43 E., 1½ miles west of old Williamsburg, in Grays Range,

[2] Mansfield, G. R., Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152, pp. 87–94, 1927.

about 5 miles southeast of John Grays Lake, Caribou County, Idaho. This is White's original locality 1,[3] and the fossils from this horizon and locality are listed in column 1 of the accompanying table.

Locality 2 is in the SW. ¼ sec. 20, T. 8 S., R. 44 E., on Schmid Ridge, 1½ miles east of the junction of Johnson and Slug Creeks, Caribou County, Idaho, about 14 miles northeast of Soda Springs. This was locality 2 of White. The fossils are listed in column 2 of the table.

Locality 3 is in sec. 32, T. 8 S., R. 43 E., at the head of Wood Canyon, Aspen Range, Caribou County, Idaho, about 9 miles northeast of Soda Springs. The fossils are listed in column 3 of the table.

Locality 4 is in the NE. ¼ sec. 9, T. 14 S., R. 43 E., at the south side of the mouth of Paris Canyon, about 1 mile west of Paris, Bear Lake County, Idaho. The fossils are listed in column 4 of the table.

Locality 5 is in the SE. ¼ sec. 13, T. 15 S., R. 44 E., about 1 mile northeast of Hot Springs, Bear Lake County, Idaho, at the northeast end of Bear Lake. The fossils are listed in column 5 of the table.

Mansfield [4] has recently published detailed maps and descriptions of the stratigraphy of the Thaynes group, and in order to avoid unnecessary repetition here the reader is referred to his excellent work for such details.

Locality 4, Paris Canyon, is the only place where the *Pseudosageceras multilobatum* and *Anasibirites* subzones of the *Meekoceras* zone and the *Tirolites* and *Columbites* zones were seen in sequence, and the two latter zones are not known to be fossiliferous anywhere else in the region. The base of the *Anasibirites* subzone is poorly exposed a few feet above the *Pseudosageceras multilobatum* subzone on the south side of the canyon, on Otto Rohner's ranch. Several hundred feet, possibly 200 or 300, is covered by soil and the valley alluvium. Then, on the north side of the canyon, the outcrops of the *Tirolites* zone are marked by gray shales about 50 feet thick, and the *Columbites* zone is about 30 feet higher in the section.

All these faunal horizons lie within the Thaynes group. They are not distinguished as units in the mapping but are easily separated paleontologically and are of nearly world-wide significance.

[3] White, C. A., Triassic fossils from southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, pp. 105-118, 1880.

[4] Mansfield, G. R., op. cit., pls. 1-9, pp. 81-96.

Fauna of the Pseudosageceras multilobatum subzone of southeastern Idaho

[Species marked with an asterisk (*) occur also in the *Owenites* subzone of Inyo County, Calif.]

	1	2	3	4	5
*Lecanites arnoldi Hyatt and Smith	×	----	×	----	----
*Lecanites knechti Hyatt and Smith	----	----	×	----	----
Ophiceras dieneri Hyatt and Smith	----	----	×	----	----
Xenodiscus cordilleranus Smith	×	----	×	----	----
Xenodiscus gilberti Smith	----	----	×	----	----
Xenodiscus intermontanus Smith	----	×	×	----	----
Xenodiscus tarpeyi Smith	----	----	×	----	----
*Xenodiscus toulai Smith	----	----	×	----	----
*Xenodiscus waageni Hyatt and Smith	----	----	×	----	----
Xenodiscus whiteanus (Waagen)	----	×	----	----	----
*Meekoceras arthaberi Smith	×	×	×	----	×
Meekoceras cristatum Smith	×	×	×	----	×
Meekoceras evansi Smith	×	×	×	----	×
*Meekoceras gracilitatis White	×	×	×	×	×
*Meekoceras mushbachanum White	×	×	×	×	×
Meekoceras mushbachanum var. corrugatum Smith	×	×	×	----	×
Meekoceras patelliforme Smith	----	----	×	----	×
Meekoceras sylvanum Smith	×	×	×	----	×
Clypeoceras muthianum (Krafft)	×	----	×	----	×
Dagnoceras bonnevillense Smith	----	----	×	----	----
Dagnoceras bridgesi Smith	×	×	----	----	----
Dagnoceras haydeni Smith	----	×	----	----	×
Dagnoceras pealei Smith	×	×	----	----	×
*Flemingites aplanatus (White)	×	×	×	×	×
Flemingites aspenensis Smith	×	×	×	----	----
Flemingites bannockensis Smith	×	×	×	----	----
Flemingites cirratus (White)	×	----	×	----	×
Flemingites russelli Hyatt and Smith	×	×	×	----	×
Flemingites russelli Hyatt and Smith var. gracilis Smith	----	×	×	----	----
Hedenstroemia hyatti Smith	×	----	----	----	----
*Hedenstroemia kossmati Hyatt and Smith	×	----	×	----	×
Dalmatites richardsi Smith	----	----	----	----	×
Ussuria occidentalis Smith	----	----	×	----	----
Ussuria waageni Hyatt and Smith	----	----	×	----	----
Cordillerites angulatus Hyatt and Smith	×	----	×	----	×
*Lanceolites compactus Hyatt and Smith	×	×	×	×	×
*Aspenites acutus Hyatt and Smith	×	×	×	×	×
Aspenites laevis Welter	×	----	----	----	----
Aspenites obtusus Smith	----	----	----	----	×
*Pseudosageceras multilobatum Noetling	×	×	×	×	×
*Juvenites dieneri Hyatt and Smith	×	×	×	----	×
Juvenites kraffti Smith	×	----	----	×	×
Juvenites sanctorum Smith	----	----	×	----	----
Juvenites septentrionalis Smith	×	×	×	----	×
Paranannites aspenensis Hyatt and Smith	×	×	×	×	×
Paranannites columbianus Smith	×	----	×	----	×
Paranannites compressus Smith	----	----	×	----	×
Paranannites pertenuis Smith	----	----	×	----	----
Prenkites depressus Smith	----	----	----	----	×
Thermalites thermarum Smith	----	----	×	----	×

The characteristic species of the *Pseudosageceras multilobatum* subzone are listed in the table on page 16.

MEEKOCERAS ZONE OF CALIFORNIA

The *Meekoceras* zone of California is best known from the Inyo Range, on the east side of Owens Valley, 1½ miles east of the Union Spring, near the McAvoy trail over the Union Wash leading to Salinas Valley. This locality is about 15 miles southeast of Independence, Inyo County, Calif. The fossils were all found in a bed of gray limestone, not more than 12 feet thick, that crops out on the south side of the canyon near the trail. In geologic horizon the beds at this locality are equivalent to the upper part of the *Pseudosageceras multilobatum* subzone and the overlying *Owenites* subzone of southeastern Idaho, the two not being separated lithologically at this place.

The *Owenites* subzone, as exposed here, is characterized by the continued abundance of typical *Meekoceras*, *Aspenites*, *Lanceolites*, and *Pseudosageceras* and by the first appearance of *Owenites*, *Inyoites*, *Anasibirites*, and *Sturia;* also by the disappearance of typical *Flemingites*, *Ussuria*, and *Cordillerites*. The faunal association shows that this subzone corresponds to the *Owenites* subzone of the Phelan ranch, Elko County, Nev., and of Paris Canyon, Bear Lake County, Idaho.

The *Owenites* subzone has been differentiated outside of America only in Timor, where it was named [5] and where it is more sharply separated from the underlying *Pseudosageceras* zone and the overlying *Anasibirites* zone. It has not yet been segregated in the Himalayas and the Salt Range of India, where this part of the column is poorly represented. It occurs on Svalbard,[6] where species indicative of this horizon have been listed, though not yet described and figured.[7]

Of this fauna, *Owenites egrediens* and *Aspenites laevis* occur in the *Owenites* zone of Timor; *Inyoites* is represented in India and Timor by closely allied species; *Anasibirites* is represented in India and Timor in the *Anasibirites* zone by species nearly related. *Lanceolites* and *Sturia* are not yet known in the Indian region, but this lack is probably only temporary, for beds at this horizon are poorly developed in the places known there at present.

Fauna of the Owenites subzone of Inyo County, Calif.

[Species marked with an asterisk (*) occur also in the *Pseudosageceras multilobatum* subzone of southeastern Idaho]

*Lecanites arnoldi Hyatt and Smith.
*Lecanites knechti Hyatt and Smith.
Ophiceras involutum Smith.
Ophiceras parvum Smith.
Ophiceras sakuntala Diener.
Ophiceras subquadratum Smith.
Xenodiscus marcoui Hyatt and Smith.
Xenodiscus strongi Hyatt and Smith.
*Xenodiscus toulai Smith.
*Xenodiscus waageni Hyatt and Smith.
*Meekoceras arthaberi Smith.
*Meekoceras gracilitatis White.
*Meekoceras mushbachanum White.
Meekoceras newberryi Smith.
Meekoceras radiosum Waagen.
Meekoceras strongi Smith.
Meekoceras tuberculatum Smith.
Clypeoceras hooveri Hyatt and Smith.
Clypeoceras pusillum Smith.
*Flemingites aplanatus (White).
Anasibirites desertorum Smith.
Anasibirites lindgreni Smith.
Anasibirites noetlingi Hyatt and Smith.
Inyoites oweni Hyatt and Smith.
Sturia compressa Hyatt and Smith.
Sturia woodini Smith.
*Lanceolites compactus Hyatt and Smith.
Lanceolites bicarinatus Smith.
*Aspenites acutus Hyatt and Smith.
*Pseudosageceras multilobatum Noetling.
*Hedenstroemia kossmati Hyatt and Smith.
Owenites carpenteri Smith.
Owenites koeneni Hyatt and Smith.
Owenites egrediens Welter.
Owenites zitteli Smith.
Proptychites walcotti Hyatt and Smith.
*Juvenites dieneri Hyatt and Smith.
Proteusites rotundus Smith.
Prosphingites austini Hyatt and Smith.

The characteristic species of the *Owenites* subzone are listed in the table on page 16.

MEEKOCERAS ZONE OF PHELAN RANCH, ELKO COUNTY, NEV.

About 70 miles south of Wells, 3 miles west of the Phelan ranch, near the mouth of Cottonwood Canyon, on the east side of the Ruby Range, about 50 feet of sandy reddish-brown limestone, impregnated with iron, is exposed. The dip is low, to the east, away from the range, and the *Meekoceras* zone lies with an apparent unconformity upon the massive gray Pennsylvanian limestone.

Fossils are abundant but poorly preserved in the *Meekoceras* zone of this region. The locality was discovered by Oscar H. Hershey in 1905, and visited by the writer in 1911. The joint collections yielded the following species:

Fauna of the Meekoceras zone of Phelan ranch, Elko County, Nev.

[Species marked with an asterisk (*) occur also in the *Pseudosageceras multilobatum* subzone of southeastern Idaho; those marked with a dagger (†) occur also in the *Owenites* subzone of Union Wash, Inyo Mountains, Calif.]

*†Lecanites arnoldi Hyatt and Smith.
*†Lecanites knechti Hyatt and Smith.
†Ophiceras sakuntala Diener.
Xenodiscus nevadanus Smith.
Xenodiscus nivalis Diener.
*†Meekoceras gracilitatis White.
*†Meekoceras cf. M. mushbachanun White.
†Meekoceras cf. M. radiosum Waagen.

[5] Welter, O. A., Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 86, 1922.

[6] The group of islands in the Arctic Ocean lying east of Greenland, which has heretofore been designated the Spitsbergen Archipelago, has been placed by treaty under the dominion of Norway, and the name has been changed by Norway to Svalbard. See U. S. Geographic Board Decisions, June 8, 1928.

[7] Spath, L. F., On ammonites from Spitsbergen: Geol. Mag., vol. 58, pp. 301-350, 1921.

Dalmatites attenuatus Smith.
†Inyoites oweni Hyatt and Smith.
†Anasibirites desertorum Smith.
*†Pseudosageceras multilobatum Noetling.
*†Aspenites acutus Hyatt and Smith.
†Lanceolites bicarinatus Smith.
†Owenites cf. O. koeneni Hyatt and Smith.
*†Juvenites dieneri Hyatt and Smith.
*Paranannites aspenensis Hyatt and Smith.

The relationship of this fauna with the fauna of the Inyo Mountains of California is obviously closer than with the fauna of southeastern Idaho. However, it is intermediate between the two in affinities as in geographic position, being about 300 miles from each.

The horizon of the Nevada locality is probably at the base of the *Owenites* subzone of the *Meekoceras* zone.

FAUNA OF OWENITES SUBZONE OF SOUTHEASTERN IDAHO

At the mouth of Paris Canyon, 1 mile west of Paris, Bear Lake County, Idaho, in the upper part of the *Meekoceras* zone, are some obscure outcrops with a fauna slightly different from that of the *Pseudosageceras multilobatum* subzone. The fossils found here were few in number and poorly preserved, but they correspond to those of the *Owenites* subzone as developed in the Inyo Mountains of California and at the Phelan ranch on the east side of the Ruby Range in Nevada. The species identified from this horizon were as follows:

Anasibirites desertorum Smith.
Anasibirites lindgreni Smith.
Goniodiscus typus Waagen.
Lanceolites compactus Hyatt and Smith.
Aspenites acutus Hyatt and Smith.
Pseudosageceras multilobatum Noetling.
Juvenites kraffti Smith.
Paranannites aspenensis Hyatt and Smith.
Inyoites cf. I. oweni Hyatt and Smith.
Owenites cf. O. koeneni Hyatt and Smith.

FAUNA OF ANASIBIRITES SUBZONE OF UTAH

The *Anasibirites* faunal zone was first distinguished in the Salt Range of India, where Waagen [8] called it "the Upper Ceratite limestone" and assigned it to the Middle Triassic. Later studies in India by Von Krafft and Diener [9] have shown that this zone belongs to the Lower Triassic and occurs in the Himalayas immediately above the *Hedenstroemia* beds, the *Owenites* subzone either being absent or not recognized. Later the presence of the *Anasibirites* faunal zone in Svalbard was recorded by Spath [10] from the "lowest nodule beds" with *Keyserlingites*, *Goniodiscus*, and other forms. Still later this faunal zone was differentiated and fully described from Timor by Welter,[11] who published a great number of diagnostic species. The zone has also been discovered and collections have been made from it in the Wasatch Mountains of Utah by Mathews,[12] who has identified a rich fauna closely allied to that of the Salt Range and of Timor.

The writer has had for study the collections of the Brouwer expedition to Timor and has found in them a far richer fauna of the *Anasibirites* zone than has ever been seen before, with nearly all of Waagen's species of this genus and a great many more in a wonderful state of preservation. These collections contain a very complete representation of the Lower Triassic faunal zones, with a few species identical with those from America and many closely related. A full discussion of the interregional relationships is given in the section on interregional correlation zones of the Lower Triassic.

The *Anasibirites* zone in Utah has yielded the following species:

Pseudosageceras multilobatum Noetling.
Cordillerites compressus Mathews.
Xenodiscus rotula Waagen.
Xenodiscus nivalis Diener.
Meekoceras davisi Mathews.
Anasibirites angulosus (Waagen).
Anasibirites bastini (Mathews).
Anasibirites emmonsi Mathews.
Anasibirites hircinus (Waagen).
Anasibirites kingianus (Waagen).
Anasibirites kingianus (Waagen) var. inaequicostatus Waagen.
Anasibirites mojsisovicsi Mathews.
Anasibirites multiformis Welter.
Anasibirites multiformis (Welter) var. hyatti Mathews.
Anasibirites tenuistriatus Waagen.
Goniodiscus ornatus Mathews.
Goniodiscus smithi (Mathews).
Goniodiscus typus Waagen.
Goniodiscus utahensis Mathews.
Kashmirites meeki (Mathews).
Kashmirites perrini (Mathews).
Kashmirites resseri Mathews.
Kashmirites seerleyi (Mathews).
Kashmirites subarmatus Diener.
Kashmirites wasatchensis Mathews.

TIROLITES ZONE

The *Tirolites* zone is well known at but a single place—in Paris Canyon, 1½ miles west of Paris, Bear Lake County, Idaho—where it lies about 225 feet above the *Meekoceras* zone and about 30 feet below the *Columbites* zone. The fossils are few, poorly preserved, and confined to a bed of gray shale from 30 to 50 feet thick. *Tirolites* constitutes the most abundant and characteristic element of the fauna, with species closely allied with those of the Campil beds of the Tyrol, giving a definite correlation and marking the first appearance of Mediterranean types in the American Lower Triassic.

[8] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 3, 1895.

[9] Diener, Carl, The Trias of the Himalayas: India Geol. Survey Mem., vol. 36, pt. 3, pp. 33–35, 1912.

[10] Spath, L. F., On ammonites from Spitsbergen: Geol. Mag., vol. 58, pp. 301, 350, 1921.

[11] Welter, O. A., Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, 1922.

[12] Mathews, A. A. L., The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, 1929.

This faunal zone is not known in India, although *Tirolites* has been cited erroneously from both India and Timor.

Fauna of the Tirolites zone of Paris Canyon, southeastern Idaho

Dalmatites attenuatus Smith.
Tirolites harti Smith.
Tirolites knighti Smith.
Tirolites pealei Smith.
Nautilus sp. indet.
Orthoceras sp. indet.
Pseudomonotis idahoensis White.
Pseudomonotis pealei White.
Pugnoides triassicus Girty.
Pentacrinus (Isocrinus) smithi Clark and Twitchell.

COLUMBITES ZONE

The *Columbites* faunal zone is known to be abundantly fossiliferous at only one place in America—in Paris Canyon, 1½ miles west of Paris, Bear Lake County, Idaho. It lies about 30 feet above the *Tirolites* zone, which crops out in the same canyon. All the fossils were found in a bituminous layer of brown limestone, not over 6 inches thick. It is well down below the middle of the Thaynes group and should be found elsewhere in the Wasatch Mountains.

The *Columbites* fauna of Idaho is most closely related to that of Albania,[13] where Arthaber has described many kindred species; also to the *Leiophyllites* fauna of India and Timor. It is also distinctly correlative with the Olenek fauna of northern Siberia,[14] where several forms related to those of Idaho are found.

The *Columbites* zone is one of the most definite and satisfactory interregional correlation zones in the whole Mesozoic and has been of great use in determining the true stratigraphic succession in the Triassic of India, Timor, Siberia, and even the classic Mediterranean region. The characteristic genus *Columbites* is certainly not indigenous in either Idaho or Albania but is an immigrant into both regions from some outside source, which was probably the boreal region.

Fauna of the Columbites zone of Paris Canyon, southeastern Idaho

Ophiceras jacksoni Hyatt and Smith.
Ophiceras spencei Hyatt and Smith.
Meekoceras curticostatum Smith.
Meekoceras micromphalus Smith.
Meekoceras pilatum Hyatt and Smith.
Meekoceras sanctorum Smith.
Pseudharpoceras idahoense Smith.
Tirolites cf. T. illyricus Mojsisovics.
Pseudosageceras multilobatum Noetling.
Celtites apostolicus Smith.
Celtites planovolvis Smith.
Celtites ursensis Smith.
Columbites consanguineus Smith.
Columbites ligatus Smith.
Columbites minimus Smith.
Columbites ornatus Smith.
Columbites parisianus Hyatt and Smith.
Columbites spencei Smith.
Nautilus (Pleuronautilus) sp. indet.
Orthoceras sp. indet.
Cosmacanthus elegans Evans.

[13] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, pp. 169–276, 1911.

[14] Mojsisovics, E. von, Arktische Triasfaunen: Beiträge zur paläontologischen Characteristik der arktisch-pacifischen Triasprovinz: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, pp. 1–159, 1886.

LOWER TRIASSIC INTERREGIONAL CORRELATION ZONES

HISTORICAL SUMMARY

The Lower Triassic faunas have become known largely in the last 40 years. As they were found and described piecemeal in widely separated parts of the world, a great deal of confusion has resulted in their correlation, and a great deal has been written about the faunal and physical geography of the Lower Triassic that must be revised in the light of later discoveries.

For many years the writer has been collecting and studying the Lower Triassic faunas of North America and has also had for study the Lower Triassic ammonites of Timor, in the East Indies. He has now completed papers on these two faunas. These collections have thrown much light on the occurrence of interregional species and interregional zones.

In the past faunas that were not contemporaneous have been compared and contrasted with each other, and erroneous conclusions have been drawn as to separation of regions. There has also been much controversy as to whether certain faunas should be assigned to the Permian or to the Lower Triassic; it has also been debated rather acrimoniously whether certain faunas should be placed in the upper part of the Lower Triassic or in the lower part of the Middle Triassic.

As all these debatable faunas have been found in regions remote from European centers, it has been difficult to assemble collections satisfactory for accurate classification and discussion. Little by little the gaps have been filled out, and our knowledge of faunal zones in the Lower Triassic has become nearly as complete as it is of those in the Jurassic.

For nearly 50 years the relations of Triassic cephalopod genera to those of the Paleozoic have been a favorite field of study, as shown in the works of Branco, Hyatt, Karpinsky, Mojsisovics, Haug, Diener, Arthaber, Frech, and others. The lack of agreement between these investigators shows how difficult is the field, and how, with nearly the same premises, careful observers can come to very different conclusions. It becomes clear that the conclusions of these writers as to genetic relationships of the forms discussed are not facts but rather scientific interpretations of observed facts—a distinction not always easy to keep in mind.

In the field of phylogeny of ammonoids every investigator must pay constant and reverent tribute to the three masters and pioneers—Alpheus Hyatt, W. Branco, and A. Karpinsky. These leaders have blazed the way for all to follow. We can not always step in their steps—nor would they wish us to be slavish imitators—but we know that they were headed in the right direction, even though they may at times have strayed from the main path. It is a great advantage to this branch of biology that three men of such keen observation and far-seeing interpretation have set the pace.

Naturalists have sought for genetic series since the days of Darwin and have found a few, more or less convincing. But most of them are badly broken or are too short. It has been reserved for the Cephalopoda to give us genetic lines running unbroken from the Devonian to the end of the Cretaceous, checked at intervals by ontogenic series recapitulating at least part of the previous history. Compared with this the famous genealogy of the horse from the Eocene to the present is but ephemeral contemporary history. One may surely pardon the exuberant enthusiasm and confidence of students of ammonoid phylogeny, even while one smiles at some of the results. It is a big field, and there has not yet been enough time to thresh out the grain from the chaff. There is plenty of both, and the contemporary can not always distinguish the one from the other.

It must not be inferred from the writer's lack of agreement with many of the conclusions of other workers in the same field that he is moved by any personal bias or lack of appreciation of their high attainments in contributions to science. On the contrary, he stands on terms of cordial friendship with those with whom he has come into contact by personal association or correspondence. Also he feels the most sincere admiration for the publications of those with whom he is forced to disagree most frequently. But each contributor must state the case as he sees it, regardless of personal friendship for the living or of reverence for the honored dead. Otherwise there would be no progress.

These differences of opinion in biostratigraphy and in ammonoid phylogeny make the subject all the more interesting, for they show that this branch of science is still in the making and is far from being cut and dried. As a basis of phylogenetic study an accurate determination of successive faunal zones, especially of interregional zones, is indispensable. The smaller the unit that can actually be determined the more definite the correlations, and thus the more definite the data concerning occurrence of critical genera and species.

Fortunately the entire Triassic has been studied intensively in many parts of the world, and widespread faunal zones have been definitely established. This is especially true of the Lower Triassic, where five distinct zones may be recognized and correlated with considerable certainty, notably in the regions bordering on the Pacific Ocean. This success has been made possible by the explorations of many geologists in India, Madagascar, Timor, Siberia, and western America. Some of these explorers gave their lives in this work, and many gave their health. To them should be given all honor, for they were truly martyrs. They have left an imperishable monument in collections gathered and in notable publications on stratigraphy and the faunas collected by them. India has been in the front rank in the production of a noble array of monographs, but Austria, Holland, Russia, Germany, Italy, France, and America have each contributed a fair share to advancement of knowledge of this subject.

Diener [15] has given a very complete and satisfactory critical compilation of the distribution and correlation of Triassic faunas of the whole world, as they were known and interpreted in 1915. Fifteen years of study and exploration by many naturalists since that time have added much to our knowledge of geographic and zonal distribution of Triassic faunas and have necessitated some revision of their correlations. The present chapter is an attempt at such a revision, and the writer wishes here to make the fullest acknowledgment of indebtedness to the researches of Mojsisovics, Waagen, Frech, Noetling, Koken, Krafft, and Diener, on the Triassic of India; of Diener, Welter, Krumbeck, Arthaber, and Wanner on the Triassic of the Malay Archipelago; of Mojsisovics, Hauer, Toula, Diener, Laube, Arthaber, Renz, and Kittl on the Mediterranean province; of Mojsisovics, Boehm, Diener, and Spath on the Arctic region; and of Meek, White, and Hyatt on the American region. Without these brilliant contributions to ancient faunal geography no comparative study would be possible.

The writer especially wishes to express his debt to the classic monographs of Mojsisovics, the great master of Triassic paleontology, and to those of Diener, who, at the time of his death, was the honored dean and acknowledged leader of writers in this field. To them every student of Triassic paleontology turns for inspiration and guidance.

It will be seen that in the study of Lower Triassic stratigraphy we have long passed the stage of Quenstedt's local faunal units limited by lithology; that we have reached the stage of Oppel's formulation of interregional zones characterized by faunas dispersed and limited by geographic conditions; but that we have not yet entered the stage of Buckman's attempt at subdivision of biologic units into hemerae. Nor are we likely to enter that phase for some time to come, for even the partial success of such an attempt depends upon the

[15] Diener, Carl, Die marinen Reiche der Triasperiode: K. Akad. Wiss. Wien Denkschr., Band 92, 1916.

occurrence of fossil beds in easily accessible regions, with numerous local collectors. The good Lower Triassic faunas occur only in widely separated regions, all remote from centers of research, accessible only to the explorer, and usually not capable of intense local subdivision. It is also doubtful whether we shall ever have the data, either in maps or in collections of fossils, for such an attempt. In the meantime we may well give thanks for such knowledge as we have of the subject, for to acquire even that has required unremitting toil and arduous travel of geologic explorers for three-quarters of a century.

GEOGRAPHIC DISTRIBUTION OF LOWER TRIASSIC INTERREGIONAL ZONES

The geographic distribution of the Lower Triassic faunal zones of the world is shown on the map (fig. 1) and in the correlation chart facing page 14 and is briefly summarized below:

I. *Otoceras* zone. Known in the Himalayas of India as the *Otoceras* beds, near Lilang, in Spiti, and at the Shalshal Cliff near Rimkin Paiar, in Painkhanda.

II. *Genodiscus* zone. (See p. 15.) Known in the Salt Range of India as Lower Ceratite limestone; in the Himalayas as the so-called *Meekoceras* beds; in Timor as the *Ophiceras* beds; in Madagascar and at Ussuri Bay as the so-called *Meekoceras* beds; and probably in eastern Greenland. It is absent or unknown in the Arctic, Mediterranean, and western American regions.

III. *Meekoceras* zone. Subdivided into the *Pseudosageceras multilobatum*, *Owenites*, and *Anasibirites* subzones.

IIIa. *Pseudosageceras multilobatum* subzone. Practically worldwide. Known in the Salt Range of India as *Flemingites* beds or Ceratite marls and Ceratite sandstone; in the Himalayas as the *Hedenstroemia* beds; in Timor as the *Flemingites* beds or *Pseudosageceras* zone; at Ussuri Bay; in Madagascar; in Svalbard as the lower part of the *Posidonomya* beds; on the Caspian Sea as the *Paratirolites* beds; in Idaho and California as the *Pseudosageceras multilobatum* subzone. It is the first truly interregional zone of the Lower Triassic, widespread from the Indian Ocean to the Arctic and down to western America.

IIIb. *Owenites* subzone. Distinguished in Timor, Svalbard, Idaho, California, and Nevada.

IIIc. *Anasibirites* subzone. Known in the Salt Range as the Upper Ceratite limestone or *Anasibirites* beds; in the Himalayas as zone of "*Sibirites*" *spiniger;* in Timor as the *Anasibirites* beds; in Japan, as the *Meekoceras* beds; in Svalbard as the so-called *Flemingites* zone; in California, Utah, and Idaho as the upper subzone of the *Meekoceras* zone.

IV. *Tirolites* zone. Confined to the Mediterranean and the western American regions.

V. *Columbites* zone. Known in Albania and in Idaho as the *Columbites* zone; on the Olenek River, in Siberia, as the Olenek horizon; in Timor as the *Leiophyllites* beds; and doubtfully in the Himalayas as the "zone of *Rhynchonella griesbachi*" of the so-called "Lower Muschelkalk."

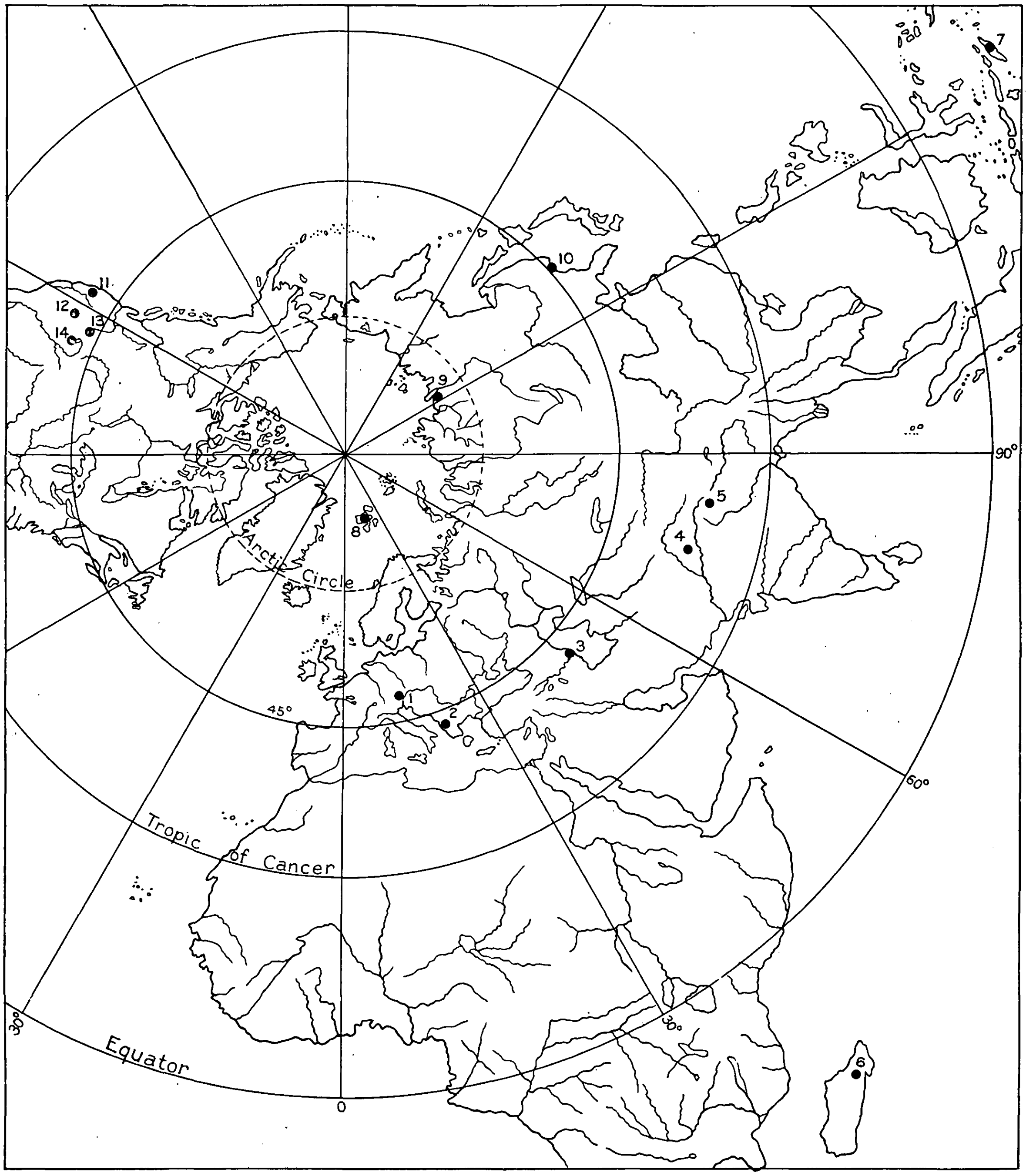

FIGURE 1.—Map showing geographic distribution of Lower Triassic faunas.

I. *Otoceras* fauna.
II. *Genodiscus* fauna.
IIIa. *Pseudosageceras multilobatum* fauna.
IIIb. *Owenites* fauna.
IIIc. *Anasibirites* fauna.
(IIIa–IIIc: III. *Meekoceras* fauna.)
IV. *Tirolites* fauna.
V. *Columbites* fauna.

Locality:
1. Tyrol; fauna IV.
2. Albania; fauna V.
3. Djulfa, on the Caspian Sea; fauna IIIa.
4. Salt Range of India; faunas II-IIIc and V?

Locality—Continued.
5. Himalayas of India; faunas I-IIIc and V?
6. Madagascar; faunas II-IIIa.
7. Timor; faunas II-V.
8. Svalbard; faunas IIIa-IIIc, and V?
9. Olenek River, Siberia; fauna V.
10. Ussuri Bay, eastern Siberia; faunas II-III.
11. California; faunas IIIa-IIIc.
12. Nevada; faunas IIIb-IIIc.
13. Idaho; faunas IIIa-IIIc, IV, and V.
14. Utah; fauna IIIc.

Correlation table of lower Triassic faunas

Zonal classification used in this report	Tyrol	Albania	India: Salt Range	India: Himalayas	Timor	Madagascar	Svalbard	Olenek	Ussuri Bay	Western America
V. *Columbites* zone		*Columbites* fauna	*Pseudharpoceras* beds	*Leiophyllites* beds with *Rhynchonella griesbachi*	*Leiophyllites* fauna		*Keyserlingites* fauna	*Keyserlingites* fauna		*Columbites* zone
IV. *Tirolites* zone	Campil beds with *Tirolites*									*Tirolites* zone of Idaho
III. *Meekoceras* zone: IIIc. *Anasibirites* subzone			Upper Ceratite limestone or *Anasibirites* beds	Zone of "*Sibirites*" *spiniger*	*Anasibirites* beds		*Anasibirites* beds (so-called "*Flemingites* zone")			*Meekoceras* zone: *Anasibirites* subzone
III. *Meekoceras* zone: IIIb. *Owenites* subzone			Absent or not recognized	Absent or not recognized	*Owenites* beds		Beds with *Inyoites*			*Meekoceras* zone: *Owenites* subzone
III. *Meekoceras* zone: IIIa. *Pseudosageceras multilobatum* subzone			Ceratite sandstone, or *Flemingites* beds	*Hedenstroemia* beds or zone of *Flemingites rohilla*	*Flemingites* beds or *Pseudosageceras* zone	(?)	Represented in lower part of *Posidonomya* beds		(?)	*Meekoceras* zone: *Pseudosageceras multilobatum* subzone
II. *Genodiscus* zone			Lower Ceratite limestone or so-called *Meekoceras* beds	So-called *Meekoceras* beds	*Ophiceras* beds	So-called *Meekoceras* beds			So-called *Meekoceras* beds	Not identified
I. *Otoceras* zone				*Otoceras* beds						Not identified

67664—32. (Face p. 14.)

GENERAL CHARACTERS OF THE LOWER TRIASSIC AMMONOID FAUNAS

OTOCERAS ZONE

The *Otoceras* zone contains, as characteristic fossils, *Otoceras woodwardi* Griesbach, *Ophiceras sakuntala* Diener, *O. tibeticum* Griesbach, *O. demissum* Oppel, *Proptychites scheibleri* Diener, *Prosphingites nala* Diener, *Xenodiscus himalayanus* Griesbach, and *Episageceras dalailamae* Diener. This horizon was assigned by Griesbach, Waagen, Mojsisovics, Diener, and Bittner to the Lower Triassic and by Noetling, Krafft, and Frech to the Permian.

The evidence as to the Lower Triassic age of the *Otoceras* fauna brought forward by Diener[16] is complete and most convincing. No further references will be given here, for Diener's paper is easily accessible and has a full bibliography.

This fauna is characterized by the flaring up of the Meekoceratidae from *Xenodiscus*, by the abundance of *Ophiceras* and *Otoceras*, and by the reappearance of Arcestidae in *Prosphingites*. It is entirely confined to the Indian region.

GENODISCUS ZONE

The zone here called the *Genodiscus* zone has been called in India the *Meekoceras* zone, but that name is a misnomer, for it was preoccupied by Peale[17] in designating a younger faunal zone in Idaho that is the equivalent of the *Flemingites* and *Hedenstroemia* beds of Timor and the Himalayas. It is therefore here called after the most characteristic element of the fauna from the subgeneric title applied to the group of "*Celtites*" *radiosus* and "*C. fortis*" (= *C. lidacensis*).

Characteristic species of this zone are *Genodiscus radiosus* Krafft, *G. lidacensis* Welter, *Meekoceras discoides* Waagen, *M. markhami* Diener, *Clypeoceras spitiense* Krafft, *C. brouweri* Smith, *Xenodiscus rotula* Waagen, *X. radians* Waagen, *Hedenstroemia lilangensis* Krafft, and *Ophiceras tibeticum* Griesbach.

This fauna is distinguished by the development of *Xenodiscus* into *Genodiscus*, the forerunner of *Anasibirites* and thus the probable ancestor of many of the group of Ceratitoidea, and also by the continued filiation of *Meekoceras* into its various branches. This fauna is still almost entirely confined to the Indo-Pacific region.

MEEKOCERAS ZONE

Pseudosageceras multilobatum subzone.—In the Salt Range of India the zone here called *Pseudosageceras multilobatum* subzone is known as the *Flemingites* beds or Ceratite sandstone; in the Himalayas as *Hedenstroemia* beds or zone of *Flemingites rohilla;* in Timor as the *Flemingites* beds; on the Caspian Sea as the *Paratirolites* beds; in Madagascar it is probably represented in the upper part of the so-called *Meekoceras* beds; at Ussuri Bay, in eastern Siberia, probably by the same horizon; in Svalbard it is represented in the lower part of the *Posidonomya* beds; in western America it comprises the lower and main part of the *Meekoceras* zone as originally named by Peale. This subzone is characterized by the great development of *Pseudosageceras, Ussuria, Flemingites, Hedenstroemia, Meekoceras,* and *Clypeoceras.* It is the first great world-wide zone of the Lower Triassic, characterized especially by *Pseudosageceras multilobatum, Xenodiscus nivalis,* and the giant *Flemingites.* It should not be called the *Flemingites* zone, nor the *Hedenstroemia* zone, as these genera are not confined to this horizon, nor are they common outside the Indian region. It might better be named after the most widely distributed characteristic species the zone of *Pseudosageceras multilobatum*, and it is so designated in this report. This species is fairly common in India, Timor, and western America (Idaho, Nevada, California), associated in all these regions with nearly related and commonly identical species. This is the widest distribution of a definite and restricted fauna in the Lower Triassic, though the term *Meekoceras* zone has been misapplied in regions outside of America, so that in the past it has meant different things in different regions.

The *Hedenstroemia* fauna of the Himalayas has been regarded by Diener[18] as the top of the Lower Triassic and the equivalent of the Olenek beds of Siberia and of the *Columbites* fauna of Albania. But in the Himalayas the *Anasibirites* beds occur above the *Hedenstroemia* zone and agree in position and fauna with the Upper Ceratite limestone or *Anasibirites* beds of the Salt Range, which, in Idaho lie between the *Hedenstroemia* and *Columbites* horizons. The succession in the Salt Range of India and in Idaho is clear and unmistakable and shows two distinct zones above the *Hedenstroemia* or *Flemingites* faunal zone and still certainly of Lower Triassic age. Thus the *Pseudosageceras multilobatum* subzone is really not very much higher than the middle of the Lower Triassic.

This zone is characterized by the great development of the so-called "Beloceratea" (*Pseudosageceras, Aspenites, Lanceolites, Cordillerites,* and *Ussuria*); by the rapid branching out of the *Meekoceras* stock into many subgenera and new genera, including *Hedenstroemia;* by the rapid rise of *Flemingites* from the older *Ophiceras;* and by the rapid development of Nannitidae into *Paranannites* and *Thermalites*, probable forerunners of Ptychitidae and Haloritidae.

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[16] Diener, Carl, The Triassic of the Himalayas: India Geol. Survey Mem., vol. 36, pt. 3, pp. 42–55, 1912.

[17] Peale, A. C., Report on the geology of the Green River district: U. S. Geol. and Geog. Survey Terr. Eleventh Ann. Rept., pp. 612, 622–628, 1879.

[18] Diener, Carl, Trias of the Himalayas: Geol. Survey Mem. India, vol. 36, pt. 3, pp. 36–42, 1912.

The time of the *Pseudosageceras multilobatum* subzone was characterized by the radial migration out of the Indian Ocean northward to the Arctic Ocean, southward to the East Indian Archipelago, Timor, and Madagascar, eastward to Ussuri Bay on the Siberian coast, and around the ancient shore line of the north Pacific to the Cordilleran Sea of California, Nevada, and Idaho. It must have been an epoch of exceedingly uniform climate and favorable conditions to allow this widespread migration with so little generic or specific change, when species could range more than halfway around the earth and from 10° S. to 80° N. and still be almost identical.

But some sort of barrier obstructed the way into the Mediterranean, for there this fauna is still unknown. The portal of Asia Minor was still closed, and it did not open until the *Tirolites* epoch.

Of course there were plenty of local differences between the faunal regions that did show connection, but they were not greater than can easily be explained by the wide separation of these regions: they do not imply actual isolation. Only the more hardy species could possibly make the long journeys from one region to another, but the fact remains that some did make them unchanged, whereas others were slightly modified on the way. Still others were stay at homes, remaining in the regions where they were developed. A comparative study of these three groups of forms makes possible a discrimination of ancient faunal regions.

Characteristic species of the Pseudosageceras multilobatum subzone of the Meekoceras zone

	Svalbard	Olenek	India		Timor	Ussuri	Idaho	California and Nevada
			Himalayas	Salt Range				
Pseudosageceras multilobatum Noetling			×	×	×		×	×
sp. indet. Diener						×		
Ussuria iwanowi Diener						×		
waageni Hyatt and Smith							×	
Aspenites acutus Hyatt and Smith					×		×	×
Lanceolites compactus Hyatt and Smith							×	×
Cordillerites angulatus Hyatt and Smith							×	
Flemingites compressus (White)				×	×			
cirratus (White)							×	
aplanatus (White)	(?)						×	×
rohilla Diener			×					
Meekoceras gracilitatis White							×	×
mushbachanum White	(?)				(?)		×	×
Clypeoceras muthianum (Krafft)			×				×	
Xenodiscus nivalis Diener			×		×			×
coronatus White				×	×			
Paratirolites kittli Stoyanow			(×)					
Parannanites aspenensis Hyatt and Smith							×	
Hedenstroemia kossmati Hyatt and Smith							×	
mojsisovicsi Diener		×?	×					
kasliuensis Haniel						×		

Owenites subzone.—The characteristic genera of the *Owenites* subzone are *Owenites* and *Inyoites*. The characteristic species are listed below:

Characteristic species of the Owenites subzone of the Meekoceras zone

	Albania	Svalbard	India		Timor	Idaho	California and Nevada
			Himalayas	Salt Range			
Owenites egrediens Welter					×		
simplex Welter					×		×
koeneni Hyatt and Smith					(?)		×
Aspenites laevis Welter					×	×	×
acutus Hyatt and Smith					×	×	×
Meekoceras yudisthira Diener			×		×		
jolinkense Krafft			×		×		
radiosum Waagen	×		×	×	×		×
Kashmirites densistriatus Welter					×		
subarmatus Diener			×		(?)		
armatus Waagen				×			
Inyoites oweni Hyatt and Smith		(?)					
kashmiricus Diener			×				×
discoidalis Welter					×		
Prosphingites austeni Hyatt and Smith							×
aequitorialis Smith					×		

Anasibirites subzone.—The *Anasibirites* subzone is characterized by the abundance of *Anasibirites, Stephanites*, and *Prionites*, by the radiation outward from the East Indian Archipelago, and by the identity, or near identity, of species in widely separated regions. It was first definitely recognized in the Salt Range of India, where Waagen [19] called it the Upper Ceratite limestone. It is also present in Svalbard, as described by Spath [20] in a preliminary paper. It is present in southeastern Idaho, California, and Nevada, where Hyatt and the writer [21] have recognized elements of this fauna in the upper part of the *Meekoceras* zone. It has since been found by A. A. L. Mathews in the Wasatch Mountains of Utah. It has also been found by Welter [22] to be well developed in Timor, where he was able to separate it into two subzones, an upper (IIIc of the present report) or *Anasibirites* subzone in a strict sense and a lower (IIIb of the present report) or *Owenites* subzone. This subdivision can be carried out with less certainty in Utah and California, where both those subzones seem to be best treated as parts of the *Meekoceras* zone. The *Anasibirites* fauna has been discovered in Japan, [23] where it was called the *Meekoceras* zone.

In the Himalayas of India the *Anasibirites* zone was discovered after the time of Waagen, and though the species were few it was definitely correlated with the Upper Ceratite limestone of the Salt Range, which had been assigned by Waagen [24] to the Middle Triassic. The beds in Svalbard were also placed by Mojsisovics [25] in the Muschelkalk. But there can now be no doubt that this faunal zone in both regions belongs to the Lower Triassic and is not even the top of that division, for in Idaho the *Columbites* zone lies about 300 feet higher in the same continuous section, and in the Salt Range, and somewhat doubtfully in the Himalayas of India, the equivalents of the *Columbites* zone lie above the *Anasibirites* zone. The same thing is probably true in Timor, but there the actual stratigraphic sequence is not known, because of the occurrence of the beds in isolated blocks, where the stratigraphy can only be inferred from the faunas.

Diener [26] accepts the zone of "*Sibirites*" *spiniger* in the Himalayas as the equivalent of the Upper Ceratite limestone of the Salt Range. But in the same chapter he correlates the *Hedenstroemia* beds of the Himalayas with the *Columbites* zone of Idaho and Albania. Now in Idaho the *Columbites* zone lies about 300 feet above the *Anasibirites* layer, which is at the top of the *Meekoceras* zone of that region, and the *Meekoceras* zone contains a rich fauna, consisting of *Pseudosageceras multilobatum*, with *Flemingites, Xenodiscus, Meekoceras, Hedenstroemia*, and others, all closely related to forms in the *Hedenstroemia* beds of India, and some of them probably even identical with the Indian forms. Thus the placing of the *Hedenstroemia* zone at the top of the Lower Triassic can no longer stand, nor can the equivalence of the *Hedenstroemia-Flemingites* zone to the Olenek faunal zone of Siberia and the Campil faunal zone of the Mediterranean region be upheld.

[19] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 3, 1895.

[20] Spath, L. F., On ammonites from Spitsbergen: Geol. Mag., vol. 58, pp. 297–305, 347–356, 1921.

[21] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, pp. 48–49. 1905.

[22] Welter, O. A., Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, 1922.

[23] Yehara, S., The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, 1927.

[24] Waagen, W., op. cit. (Salt Range fossils, vol. 2), p. 73.

[25] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 144, 1886.

[26] Diener, Carl, The Trias of the Himalayas: India Geol. Survey Mem., vol. 36, pt. 3, pp. 3b et seq., 1912.

Characteristic species of the Anasibirites subzone of the Meekoceras zone

	Svalbard	India		Timor	California and Nevada
		Himalayas	Salt Range		
Anasibirites kingianus (Waagen)			×	×	
ceratitoides (Waagen)	(?)		×	×	
inaequicostatus Waagen			×	×	
ibex (Waagen)	(?)		×	×	
angulosus (Waagen)	(?)		×	×	
hircinus (Waagen)			×	×	
lindgreni Hyatt and Smith					×
spiniger Krafft		×			
Goniodiscus typus Waagen	(?)		×	×	×
Meekoceras polare Mojsisovics	×				
lindstroemi Mojsisovics	×				
Prionites undatus Waagen			×		
laevis Welter				×	
Stephanites superbus Waagen			×		
Medlicottia noetlingi Haniel				×	

TIROLITES ZONE

The fauna of the classic Campil beds of the Tyrolian Alps and the Balkan Peninsula has been fully described by Kittl.[27] It comprises the uppermost fossil beds of the Lower Triassic in the standard Mediterranean sections. Its equivalents have been sought in other regions but found only in western America, in the *Tirolites* zone of Idaho.[28] Mojsisovics [29] thought that the Olenek fauna of northern Siberia should be correlated with the Campil horizon, and Diener [30] was of the opinion that the *Hedenstroemia* beds of the Himalayas were the representatives of the same zone. But it is now rather certain that those correlations were not exact, the *Hedenstroemia* fauna being older and the Olenek fauna slightly younger. The Campil beds probably include the time equivalents of the *Columbites* zone of Albania and Idaho, but that part of the Tyrolian standard section appears to be barren.

The fauna of this zone appears to be definitely Mediterranean in origin and to have reached western America by migration through the Atlantic before the deposition of the *Columbites* zone of Idaho and Albania, for in Idaho it underlies the *Columbites* zone by about 30 feet and is sharply separated from that zone. The characteristic genus of this fauna, *Tirolites*, has been listed from the *Hedenstroemia* beds of India [31] and from the *Owenites* beds of Timor,[32] but the specimens figured from both places are by no means convincing and rather improbable. Other characteristic genera are *Dinarites* and *Dalmatites*.

Several species of genuine *Tirolites* occur in the *Columbites* zone of Albania and one in that of Idaho, but the faunas of these two regions are too different from the Campil fauna for the unlikeness to be explained by difference of facies in contemporary beds. Besides, the *Tirolites* zone of Idaho distinctly underlies the *Columbites* zone and is very definitely separable in the same continuous section.

Possibly, if the division between Lower and Middle Triassic must be drawn sharply at the top of the Campil horizon, the Albanian and the Idaho *Columbites* faunas must be classed as Lower Muschelkalk. But how are we going to correlate any outside faunas of this age with the Alpine equivalents, which are as yet unknown? The zone of *Ceratites trinodosus* is probably Lower Muschelkalk but not lowest, and the zone of *Ceratites binodosus* seems to have been eliminated.

[27] Kittl, Ernst, Die Cephalopoden der Oberen Werfener Schichten von Muć in Dalmatien: K.-k. Geol. Reichsanstalt Abh., Band 20, Heft 7, 1903.

[28] Smith, J. P., The stratigraphy of the western American Trias: A. von Koenen's Festschrift, p. 398, 1907.

[29] Mojsisovics E. von, op. cit. (Arktische Triasfaunen), p. 142.

[30] Diener, Carl, op. cit. (The Trias of the Himalayas), pp. 36–42.

[31] Krafft, A. von, and Diener, Carl, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 122, 1909.

[32] Welter, O. A., op. cit. (Die Ammoniten der Unteren Trias von Timor), p. 149.

Characteristic species of the Tirolites zone

	Tyrol	Albania	Idaho
Tirolites cassianus Quenstedt	×		
idrianus Mojsisovics	×		
illyricus Mojsisovics	×	×	
spinosus Mojsisovics	×		
quenstedti Mojsisovics	×		
seminudus Mojsisovics	×	×	
harti Smith			×
pealei Smith			×
Dinarites dalmatinus Hauer	×		
muchianus Mojsisovics	×		
Dalmatites attenuatus Smith			×
morlaccus Kittl	×		

COLUMBITES ZONE

The *Columbites* zone is characterized by the wide distribution and abundance of *Columbites* and *Leiophyllites*, by the flaring up of Celtitinae and Haloritidae of Tropitoidea, and by filiation of Meekoceratidae into Ceratitidae. The fauna was first described by Hyatt and Smith [33] and correlated by them with the Olenek fauna of Siberia, a correlation that seems to stand the test of time. It was later described by Arthaber [34] from Albania and by him correlated with the Campil horizon of Tyrol because of the occurrence in it of several species of *Tirolites* already known in those beds. In Idaho the *Columbites* fauna occurs about 30 feet above the *Tirolites* zone, which in turn lies several hundred feet above the *Meekoceras* zone, the home of *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites aplanatus*, *F. cirratus*, *F. russelli*, *Hedenstroemia kossmati*, and *Pseudosageceras multilobatum*.

The *Columbites* fauna of Idaho contains numerous species of *Columbites*, *Celtites*, *Meekoceras*, *Xenaspis*, and *Pseudosageceras*, mostly related to forms from Albania and somewhat distantly to those of the Olenek fauna of Siberia—not at all to any known elsewhere.

The Albanian fauna contains all these elements and also *Proptychites*, *Sageceras*, *Albanites*, *Procarnites*, *Isculites*, *Protropites*, *Leiophyllites* and others, showing the richest variety of ammonoid genera known in the Lower Triassic and most beautifully presented in Arthaber's justly famous monograph.

The arguments presented in this and the following sections do not prove the Lower Triassic age of the *Columbites* fauna but do make it probable that the *Columbites* fauna, the Olenek fauna, and the so-called "Lower Muschelkalk" of the Himalayas are of the same age.

The Olenek fauna is known only from the vicinity of the mouth of the Olenek River in northern Siberia. It was described by Mojsisovics [35] and assigned by

[33] Hyatt, Alpheus, and Smith, J. P., op. cit. (Prof. Paper 40), pp. 19 et seq.

[34] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, pp. 174–194, 1911.

[35] Mojsisovics, E. von, op. cit. (Arktische Triasfaunen), p. 142.

him to the Campil horizon, although the two faunas have nothing in common. It contains numerous *Meekoceras*, *Xenodiscus*, *Keyserlingites*, *Czekanowskites*, *Olenekites*, one doubtful *Columbites*, and a few other genera, mostly with species decidedly unlike those of the rest of the world. Only *Meekoceras*, *Xenodiscus*, and *Columbites?* suggest relationship with the *Columbites* fauna of Idaho.

Noetling[36] makes a very strong argument for the Middle Triassic age of the Olenek fauna, but it has not met with general assent.

This same fauna may be represented in the upper part of the Lower Triassic section of Svalbard, for Spath[37] has listed from that island *Keyserlingites*, *Olenekites*, and other species closely related to if not identical with the Olenek species.

The *Leiophyllites* fauna of Timor, which apparently occurs at the top of the Lower Triassic of Timor[38] represents a faunal horizon not separated stratigraphically by the explorers in that region but none the less distinct, containing *Leiophyllites dieneri* Arthaber, *L. kingi* Diener, *L. pitamaha* Diener, *Albanites arbanus* Arthaber, *Procarnites kokeni* Arthaber, and *P. skanderbegis* Arthaber, all identical with species from the *Columbites* zone of Albania. Welter[39] lists also *Tirolites meridianus* and *Columbites* sp. from this fauna, but the "*Columbites*" is really *Isculites*, a primitive member of the Haloritidae, and the so-called *Tirolites* is probably identical with "*Sibirites*" *prahlada* Diener. However, even without *Columbites* and *Tirolites* the age determination is definite and can only be that of the *Columbites* zone of Albania. This discovery carries with it another determination of far-reaching importance. In the Himalayas of India the topmost beds of the Lower Triassic were for a long time supposed to lie at the *Hedenstroemia* horizon. Then the boundary was pushed upward to take in the *Anasibirites* beds of the Himalayas, the equivalent of the Upper Ceratite limestone of the Salt Range, which had formerly been classed by Waagen[40] as Middle Triassic. Now *Leiophyllites kingi* and *L. pitamaha* were described by Diener[41] from the so-called "Lower Muschelkalk" of India; both species occur in the *Columbites* beds of Albania and are fairly common at the same horizon in Timor. Krafft[42] insisted that the beds that carry *Leiophyllites* in India belonged to the Lower Triassic. It would now seem that he may have been right. At least there can be no question as to the correlation of the *Columbites* faunas of Idaho and Albania and little question as to the correctness of the correlation of these with the Olenek fauna of Siberia and the upper Campil beds of the Mediterranean. It may, however, eventually be necessary to place these faunas at the bottom of the Middle Triassic.

Among the outstanding characteristics of the faunal zone are the abundant occurrence of the genus *Columbites* in Idaho and Albania, the further branching out of the Gastrioceratea into Celtitidae (*Celtites*), and Haloritidae (*Isculites*), the branching out of the *Lytoceras-Phylloceras* stock (*Leiophyllites*), from *Xenaspis* or *Xenodiscus*; the steady approach of the Meekoceratidae toward Ceratitidae; the increase of the so-called "Beloceratea"; and the occurrence in the Salt Range of India and in Albania and Idaho of very closely related species of the odd hungarite form *Pseudharpoceras*. Good conditions and favorable temperature must have prevailed from the Equator to the Arctic, otherwise the rapid development and wide distribution could never have taken place.

This faunal zone sees all the phyla of Triassic ammonites already well established and ready to become the parents of the wonderfully rich families of the Middle and Upper Triassic. The dark ages have passed, and the golden age of the renaissance is at hand.

[36] Noetling, Fritz, Die asiatische Trias: Lethaea geognostica, Teil 2, Das Mesozoicum, Band 1, Trias, Lief. 2, p. 200, 1905.

[37] Spath, L. F., On ammonites from Spitsbergen: Geol. Mag., vol. 58, pp. 297-305, 347-356, 1921.

[38] Smith, J. P., Lower Triassic ammonoids of Timor (MS.).

[39] Welter, O. A., op. cit. (Die Ammoniten der Unteren Trias von Timor), pp. 149-150.

[40] Waagen, W., op. cit. (Salt Range fossils, vol. 2), p. 73.

[41] Diener, Carl, Cephalopoda of the Muschelkalk: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 2, pp. 108, 109, 1895.

[42] Krafft, A. von, in Hayden, H. H., Geology of Spiti: India Geol. Survey Mem., vol. 36, pt. 1, p. 68, 1912.

Characteristic species of the Columbites zone

	Tyrol	Albania	Olenek	India		Timor	Idaho
				Himalaya	Salt Range		
Columbites spencei Smith							×
parisianus Hyatt and Smith							×
europaeus Arthaber		×					
mirditensis Arthaber		×					
Celtites ursensis Smith							×
planorbis Smith							×
Arnautoceltites arnauticus Arthaber		×					
Isculites originis Arthaber		×					
stoliczkai Smith						×	
Protropites hilmi Arthaber		×					
Prosphingites ali Arthaber		×					
Xenodiscus sulioticus Arthaber		×					
jacksoni Hyatt and Smith							×
schmidti Mojsisovics			×				
Leiophyllites dieneri Arthaber		×				×	
pitamaha Diener		×		×		×	
kingi Diener		×		×		×	
pradyumna				×		×	
hara Diener		×		×			
Olenekites spiniplicatus Mojsisovics			×				
Tirolites illyricus Mojsisovics	×	×					×
rectangularis Mojsisovics	×	×					
seminudus Mojsisovics	×	×					
Keyserlingites subrobustus Mojsisovics			×				
Meekoceras sanctorum Smith							×
sibiricum Mojsisovics			×				
Proptychites latifimbriatus Waagen		×			×		
Sibirites pretiosus Mojsisovics			×				
Procarnites kokeni Arthaber		×				×	
skanderbegis Arthaber		×				×	
Hedenstroemia kastriotae Arthaber		×					
Sageceras albanicum Arthaber		×					
Pseudosageceras drinense Arthaber		×					
multilobatum Noetling							×
Albanites arbanus Arthaber		×				×	
osmanicus Arthaber		×					
triadicus Arthaber		×					
Pseudharpoceras		×			×		×

OUTLINE OF PHYLOGENY OF TRIASSIC AMMONITES

METHODS

The first step in the study of the phylogeny of ammonites is to assemble a series of adults in supposed genetic sequence and certainly in known stratigraphic order. This task is not so easy as it sounds, and most attempts of this sort have been at least partial failures. Waagen [43] made the first serious trial at an individual genetic series, although his Formenreihe was only a comparatively short one. Every classification in treatises on ammonites has been an attempt at finding genetic series, with what success one can easily guess on comparison of results.

The second step was taken by Hyatt,[44] who introduced the method of breaking out young stages of ammonites from the mature coils. This method is made possible by the fact that the mature shell envelops and protects the young part of the coil, thus preserving the entire life record, in so far as it is shown by the shell.

Of course it would be better to procure the young shells that had died in infancy or the larval stages, but they are seldom preserved, and also their recognition is uncertain.

Branco [45] followed the method of Hyatt but went much further in an attempt to formulate a general classification of ammonoids based on their larval stages. However, he did little in the way of comparing later larval forms with adult stages of antecedent forms, and hence his work was almost purely morphology and not phylogeny.

The most brilliant and satisfactory results yet obtained are those of Karpinsky [46] in the ontogenic study of late Paleozoic ammonoids. Some success was also attained by Würtenberger [47] and by Hyatt [48] in the investigation of Jurassic ammonites. Many other students have followed the lead of these pioneers with great success, though often with conflicting results.

[43] Waagen, W., Die Formenreihe des *Ammonites subradiatus:* Palaeont. Beitr. (Benecke & Waagen), Band 2, 1869.

[44] Hyatt, Alpheus, Fossil cephalopods of the Museum of Comparative Zoology; embryology: Harvard Coll. Mus. Comp. Zoology Bull., vol. 3, No. 5, 1872.

[45] Branco, W., Beiträge zur Entwickelungsgeschichte der fossilen Cephalopoden, Teil 2: Palaeontographica, Band 27, 1880.

[46] Karpinsky, A., Ueber die Ammoneen der Artinsk-Stufe und einige mit denselben verwandten carbonischen Formen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 37, No. 2, 1889.

[47] Würtenberger, L., Studien über die Stammesgeschichte der Ammoniten, 1880.

[48] Hyatt, Alpheus, Genesis of the Arietidae: Smithsonian Contr. to Knowledge, No. 673, 1889.

PRINCIPLES

If assembling series of adults and development series of their young is difficult, correct interpretation of these results in terms of phylogeny is still more difficult, to judge from the confusion and contradictions evident in classifications based on them.

Haug [49] has made an ambitious formulation of the relationships of Triassic to Paleozoic ammonoids, brilliant and stimulating but unable to stand the test of time and later discoveries. Frech [50] has applied this method to the study of Devonian, Carboniferous, and Triassic ammonites, reaching conclusions that are brilliant and daring, though not always convincing.

Arthaber [51] has summarized the results of his numerous studies of Triassic ammonoids in a systematic attempt at a phylogenetic classification. In this classification, however, he has paid too little attention to the young stages as checks on phylogeny. Wedekind [52] has carried on Branco's formulation of the morphology of ammonoids, in which he has been followed by Schindewolf [53] in the genetic classification of Devonian genera and by Schmidt [54] in the phylogeny of Carboniferous forms.

Buckman and Trueman have taken the lead in ontogenic classification of later Mesozoic genera, and both seem to have attained results of permanent value.

Mojsisovics carried on for more than 40 years his epochal studies of Triassic ammonites, always attempting a genetic classification, but the ontogenic check was lacking, and his taxonomy was largely empirical, though it has usually proved to be right. Waagen has followed the same principle in his ponderous works on Indian faunas, without the same degree of success.

For the past third of a century Carl Diener has been publishing a stately series of monographs dealing with the classification and biostratigraphy of Triassic ammonites. In these monographs he has used the ontogenic check where it was possible to do so, and consequently his results have won more general acceptance that those of any other writer on this subject.

A study of the works of the writers cited above shows that most of them are in agreement in most respects, which is more than could be expected if there were not some basic reason, and that reason is simply that they are at least approximately correct in their conclusions. Their agreement depends on this principle—that resemblance between forms of Cephalopoda usually means relationship. And this leads to serial resemblance and orderly modification in proper sequence.

The mistakes in classification and frequent lack of agreement come mainly from lack of material and from erroneous inferences as to what changes may have taken place during the gaps in the record. These gaps, though still a hindrance, are becoming less yearly. The most notable gaps at present are the lack of Tropitidae in horizons 1, 2, 3, and 4 of the Lower Triassic; Arcestidae, Haloritidae, Ptychitidae, and Haueritidae in the upper Permian; Sageceratidae in the "Coal Measures"? (Pennsylvanian), Permian, and horizons 1 and 2 of the Lower Triassic; and Xenodiscidae in the upper Mississippian and "Coal Measures" (Pennsylvanian). These gaps in the record show that there is much collecting still to be done in the upper Permian and Lower Triassic in the known regions; also that many missing records may be concealed in regions as yet unknown.

LIMITATIONS OF FIELD CONSIDERED

The ammonoid phylogeny here under consideration is limited to late Paleozoic and early Mesozoic faunas. The study of Devonian genera is still a source of conflict, with little agreement among the attackers of the problems, and is involved in a whirlpool of nomenclature.

Late Paleozoic and early Mesozoic genera repeat, in their ontogeny, their ancestral history with a fair degree of exactness, for they had not been greatly affected by unequal acceleration of development and scarcely at all by retardation or arrest of development. Their ontogeny is beautifully simple and direct, and in them it is easy to find genetic series of adult genera with which to compare the ontogenic series of stages in any species. Such simple development and positive recapitulation have been shown by the writer to exist in *Glyphioceras*, *Marathonites*, *Uddenites*, *Parapronorites*, *Daraelites*, and *Paralecanites* of the Carboniferous and in *Aspenites*, *Pseudosageceras*, *Cordillerites*, *Columbites*, *Tropigastrites*, *Tropites*, *Ussuria*, *Meekoceras*, *Xenodiscus*, and many others in the Triassic. Karpinsky has also traced the *Pronorites-Medlicottia* stock from the Carboniferous into the Mesozoic with complete recapitulation.

In later Mesozoic (Jurassic and Cretaceous) genera recapitulation of phylogeny in ontogeny is not so distinct, because all the disturbing factors—unequal acceleration or telescoping of characters, retardation, and developing of cenogenetic characters—have combined to obscure the record. Cretaceous and Jurassic ammonoids still have a goniatite stage at the beginning of their larval development, but it is no longer possible

[49] Haug, E., Les ammonites du Permien et du Trias: Soc. géol. France Bull., 3d ser., vol. 22, pp. 385–412, 1894; Études sur les goniatites: Soc. géol. France Mém., Paléontologie, Mém. 18, 1898.

[50] Frech, Fritz, Ueber devonische Ammoneen: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 14, 1900; Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, 1901.

[51] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, 1911.

[52] Wedekind, R., Die Genera der Palaeoammonoidea (Goniatiten): Palaeontographica, Band 62, pp. 83–184, 1917.

[53] Schindewolf, O. H., Beiträge zur Kenntniss des Paläozoicums in Oberfranken, Ostthüringen und dem sächsischen Vogtlande: Neues Jahrb., Beilage-Band 49, pp. 393–509, 1923.

[54] Schmidt, H., Die carbonischen Goniatiten Deutschlands: Preuss. geol. Landesanstalt Jahrb., Band 45, pp. 489–609, 1925.

to point out with certainty the particular ancestral goniatite genus. In sharp contrast with the uncertain and garbled recapitulation of ancient history is the positive testimony as to their immediate ancestry. The Phylloceratidæ and their kin are the only Jurassic and Cretaceous stock of which we know the ancient genealogy.

RECAPITULATION WITH EXAMPLES

As the result of more than half a century of intensive study of the ammonoids paleontologists have found that probably all ammonites and ceratites show, in their youth, goniatite stages. These stages are not all the same but very different, and at least some of them resemble in all essentials certain Paleozoic goniatite genera, which Hyatt called "radicles." In general the ammonites with similar young stages are sufficiently alike to be classed together. Very seldom does classification based on ontogeny contradict that based on external form and characters. The agreement is so evident to the worker in this group that he wonders at the doubt or negation of some naturalists, who affirm that recapitulation of phylogeny in ontogeny is an illogical fallacy.

The dissenting or doubting naturalists tell us that it would be very remarkable if young stages of later forms should resemble in any logical and consistent way the adult stages of their ancestors—that it is too fanciful to be true, and that recapitulation is a myth. How much more remarkable and improbable it would be if the young stages of a large group of manifestly related genera all resembled a certain antecedent genus purely by accidental adaptation; and if such surprising resemblances were uniformly shown, which is actually the fact, chance can not be conceived to have hit regularly and consistently upon them by adaptation alone. Heredity is the only possible explanation of the evidence.

All ammonites are supposed to show goniatitelike larval stages. All do, so far as they have been observed, and this statement applies to most of the known genera. All ammonites, however, do not show merely a generalized goniatitelike larval stage, but each group has its own particular sort of larval stage, and each of these stages is like a definite and not generalized Paleozoic goniatite genus or group of genera. This phenomenon is too constant and regular to be accidental. (See pls. 58, 59, and 60.)

Blind chance could hardly be conceived to have hit consistently upon the peculiar *Pronorites* stage of *Medlicottia*, *Uddenites*, and *Cordillerites*. (See pl. 60, fig. 14.) It would require some credulity to believe that the young of the Ceratitoidea all imitate, by mere chance, the definite group of *Prolecanites* and later that of the Xenodiscidae. (See pl. 59, figs. 8–35.) It would be hard to see how the Haueritidae by mere accident could duplicate, in their young stages, *Aphyllites* (pl. 60, figs. 10–13), and the Sageceratidae could hardly be imagined to duplicate by fortuitous and unmeaning variation the very characteristic Devonian genera *Beloceras* and *Timanites* (pl. 60, figs. 1–6 and 32). It would be surprising if the Tropitoidea, by mere chance, consistently imitated, in the gastrioceran young of *Celtites*, *Columbites*, *Tropigastrites*, and *Tropites*, the definite and salient characters of *Paragastrioceras*. (See pl. 58, figs. 1–44.) It would be unbelievable that the Arcestoidea alone would accidentally duplicate in their youth, regularly and consistently, *Adrianites* and *Marathonites*. (See pl. 59, figs. 1–6.)

If all these young shells were merely generalized forms, these resemblances might be thought to be accidental; but they are all intensely specialized groups, very definite and with salient characters, even in the small larval stages. The development history of the organisms themselves is the final court of appeal and has greater authority than ex cathedra statements from any source whatsoever.

All the Gastrioceratea, so far as known, have a distinct gastrioceran larval stage, as is especially well shown in the young of *Columbites spencei*, *Tropigastrites halli*, and *T. trojanus*, which duplicate in their youth the typical group of *Gastrioceras listeri*. This same radicle is indicated in the young of the group of *Tropites subbullatus*, *Paratropites sellai*, *Discotropites sandlingensis*, and *D. mojsvarensis* but of a much smaller size. (See pl. 58, figs. 1–41.) The group of *Gastrioceras globulosum* is duplicated in the young of the Haloritidae, *Acrochordiceras*, *Sagenites*, and *Juvavites*. (See pl. 58, figs. 36–44.)

The earlier Arcestoidea, such as *Marathonites* of the Cyclolobidae, show a gastrioceran stage in early youth that rapidly goes over into stages that resemble *Adrianites*. The later Arcestoidea, such as *Arcestes* of the Arcestidae, omit or slur over the gastrioceran stage but have a very definite *Adrianites* stage and later recapitulation of *Marathonites*. (See pl. 59, figs. 1–7.)

Most Permian and Triassic Gephyroceratea have obscured or lost the *Gephyroceras* stage, but it is retained distinctly in *Dalmatites* of the Hungaritidae and in *Hedenstroemia* of the Meekoceratidae; also in the *Timanites* stage of *Aspenites*. (See pl. 60, figs. 4–6, and 24–26.)

Among the Prolecanitoidea the Xenodiscidae, which include *Paralecanites*, *Lecanites*, *Xenodiscus*, *Ophiceras*, and *Flemingites*, recapitulate clearly *Prolecanites* and later *Lecanites*. Some of the Meekoceratidae, as *Meekoceras mushbachanum*, are known to recapitulate *Prolecanites*, but most of them apparently have lost or obscured that stage. (See pl. 59.) The more specialized Ceratitoidea, *Ceratites* and its subgenera or allied genera, have lost the *Prolecanites* stage but so far as known retain that of *Lecanites*, followed closely by one that corresponds to *Xenodiscus* of the subgeneric group *Genodiscus*. The latter stage is seen distinctly in the young of *Anasibirites*, *Ceratites*, *Paraceratites*, *Hollandites*, *Philippites*, *Beyrichites*, *Gymnotoceras*, *Anolcites*, *Nevadites*, and *Protrachyceras*. (See pl. 59.) The *Prolecanites* stage reappears by palingenesis in the late Triassic retarded or reversionary genera *Clionites* and *Polycyclus*. (See pl. 59, figs. 33–35.) The Pronoritoidea recapitulate a fairly definite *Prolecanites* stage in *Daraelites*, *Pronorites*, *Uddenites*, and *Medlicottia*, and all these repeat the particular radicle *Pronorites*, as does also *Cordillerites*. (See pl. 60.)

Of the Beloceratoidea *Aspenites*, *Pseudosageceras*, and *Sageceras* recapitulate *Beloceras* or some kindred form with fair distinctness. (See pl. 60.)

Among the Dimorphoceratoidea *Thalassoceras* repeats *Dimorphoceras*, and *Ussuria* recapitulates both *Dimorphoceras* and *Thalassoceras*. (See pl. 60.) *Lanceolites* recapitulates *Aphyllites*, and *Fremontites* repeats both *Aphyllites* and *Lanceolites*. (See pl. 60.)

The young stages referred to above are figured on Plates 58, 59, and 60, and elsewhere in the present work, under the descriptions of species and genera.

RADICLES

The radicles here considered are relatively simple Paleozoic goniatite genera, supposed to be ancestors of later and more complex groups. These primitive ancestral forms are recapitulated with more or less distinctness in the larval and adolescent stages of later genera, each major group having its own particular type of young stage.

Thus Plates 43, 44, and 45 are in a sense a gallery of ancestral portraits, in which the essential characters of the young stages of later generations may be discerned. But this statement is not meant to be taken too literally. It is not known, nor even thought, that the species chosen here for illustration are the actual ancestors, but merely that they are typical representatives of the groups that are believed to be ancestral. For it is highly probable that all genera were more or less polyphyletic and that they did not originate from a single pair or even from a single species but from several species varying more or less in a general direction.

The genus *Gephyroceras*, represented by *G. regale* (pl. 44, figs. 6–8) from the Upper Devonian, is typical of the Devonian and is recapitulated in the young of Xenodiscidae, Meekoceratidae, and Ceratitidae. It is not implied that this particular species, or even this particular genus, is the ancestor of the Gephyroceratea. It is merely one out of many that possess characteristics in common, indicating at least cousinship.

The genus *Prolecanites* is represented by *P. applanatus* Frech (pl. 44, fig. 1), which is the finest species of a world-wide lower Carboniferous group. This genus has been badly split up, unnecessarily renamed, and finally left out entirely in the 1924 edition of K. A. von Zittel's "Grundzüge der Paläontologie." But of course a group that was properly named and defined and that played an important part in cephalopod history can not be ignored and cast into oblivion. There are many species of it in the lower Carboniferous of Europe and America, good horizon markers and undoubtedly good breeders, for their characters reappear unmistakably in the young of the Xenodiscidae and Meekoceratidae in the Lower Triassic. Heredity will out.

The genus *Gonioloboceras*, represented by *G. welleri* Smith (pl. 43, figs. 1–3), is characteristic of the Carboniferous of North America and has perhaps less right in the family gallery than most of the others. It is a doubtful link in the line between the Gephyroceratidae and Dimorphoceratidae, a possible ancestor of *Neodimorphoceras* and of the Haueritidae, though a rather improbable one.

The genus *Neodimorphoceras* (pl. 43, figs. 4–7) was named by the writer [55] "*Texites*," but while his paper was in press he was anticipated by Schmidt,[56] who renamed the type species *Neodimorphoceras*. This genus is almost the only known link in the "Coal Measures" of North America between the Gephyroceratidae of the Devonian and the Thalassoceratidae of the Permian and Lower Triassic. It is also the only known genus of the "Coal Measures" that points toward the Haueritidae. However, the writer believes that *Neodimorphoceras* is not in the direct ancestral line of either Thalassoceratidae or Haueritidae but rather that it is what genealogists call a "collateral ancestor." *Dimorphoceras* comes nearer to filling the requirements of the ancestor of Thalassoceratidae.

For the sake of completeness the family gallery should contain a portrait of *Aganides* (*Brancoceras*, *Imitoceras*), which, according to Schmidt,[57] is the radicle of all Carboniferous goniatite genera. That assumption, however, is so patently impossible that no discussion is necessary. *Aganides* may be the ancestor of *Gonioloboceras*, and thus possibly of the Thalassoceratidae, but further its claims can hardly go.

The genus *Aphyllites*, represented by *A. marcellensis* (pl. 45, figs. 1–3), is diagnostic of the Devonian and ranges to the very base of the Carboniferous under the name *Agoniatites*. There are no upper Carboniferous

[55] Smith, J. P., Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 73, 1927.

[56] Schmidt, H., Die carbonischen Goniatiten Deutschlands: Preuss. geol. Landesanstalt Jahrb., Band 45, p. 600, 1925.

[57] Idem, p. 531.

(Pennsylvanian and Permian) representatives of it, and yet it is duplicated unmistakably in the young of *Lanceolites* of the Lower Triassic and of *Fremontites* of the Upper Triassic. Some genus as yet unknown or unpublished must have continued the line through the "Coal Measures" and Permian, and that genus could not have been *Neodimorphoceras*, though it must have been something like it, only without the rudimentary adventitious lobes and with a very large lateral, weakly serrated.

The genus *Beloceras*, represented by *B. multilobatum* (pl. 44, fig. 5), is characteristic of the Devonian. It is recapitulated distinctly in the young of *Pseudosageceras* and *Sageceras* and less definitely in the young of *Aspenites* of the Triassic.

The genus *Timanites*, represented by *T. acutus* (pl. 44, figs. 2–4), is typical of the Devonian and is supposed to be a connecting link between *Gephyroceras* and *Beloceras*. It is recapitulated only in the young of *Aspenites* of the Lower Triassic.

The genus *Prodromites*, represented by *P. gorbyi* (pl. 44, fig. 21), is known only in the lowest beds of the lower Carboniferous (Mississippian) of North America. This genus, which is the only certainly known member of the Beloceratea in the Carboniferous, can not be in the direct line, for it is more specialized than its Lower Triassic kinsmen, but it is introduced here to show the continuity of the stock.

The genus *Acrocanites* (pl. 44, fig. 9), known in the lower Carboniferous of Germany in a single fragmentary specimen, has been described as a member of the Prolecanitidae with beloceran shape and septa. When better known it will probably give a good connecting link between *Beloceras* and the Sageceratidae, for it is rather definitely recapitulated in their young. At present there is no known genus in the entire Carboniferous that fills these requirements.

The genus *Pronorites* (pl. 45, figs. 4–5), represented by *P. timorensis* of the lower Permian, a genus of established respectability, is fairly common from the top of the lower Carboniferous to the middle of the Permian and is recapitulated very definitely in the young of *Parapronorites*, *Medlicottia*, and *Uddenites* (pl. 45, figs. 12–13), less so in that of *Cordillerites*, and still less so in the young of *Daraelites*. The young of other members of the Pronoritidae have not been examined, for lack of suitable material.

The genus *Gastrioceras* is represented by *G. listeri* (pl. 43, figs. 8–13), the type of the genus, and by *G. welleri* (pl. 43, figs. 14–17), a typical member of the group of *G. globulosum*. The group of *G. listeri* is directly ancestral to the Permian *Paragastrioceras* (pl. 45, figs. 6–8), and through it to the grandparents of *Celtites*, *Columbites*, *Tropigastrites*, and *Tropites*. It is recapitulated very definitely in the young of all these genera. The group of *G. globulosum* includes the forebears of the true Ptychitidae, the Arcestidae, the Haloritidae, and probably of the Cladiscitidae. The genetic series *Juvenites*→*Thermalites*→*Isculites*→Haloritidae is fairly well established, with good recapitulation all along the line. The Ptychitidae appear to have branched off from this stock in *Paranannites* of the Lower Triassic and so far as their young have been observed give at least partial recapitulation.

The subgenus *Paragastrioceras* was named by Tchernow [58] to include the rather slender evolute forms of the Permian, such as *Gastrioceras zitteli* (pl. 45, figs. 6–8), which is here chosen to represent the group and to serve as type, as Tchernow appears not to have designated a type. It has been unnecessarily renamed by Wedekind [59] "*Girtyites*," but there is no uncertainty as to what Tchernow meant by *Paragastrioceras*, hence that name is coming into general use. Its first appearance is in *Gastrioceras branneri*,[60] in the lowest beds of the Pennsylvanian of North America. It is abundant and characteristic in the Permian of the Urals, Sicily, and Texas and grades over into *Celtites* and *Columbites* of the Lower Triassic, giving a perfect transition to the Tropitidae.

The genus *Agathiceras*, which is represented by *A. ciscoense* (pl. 43, figs. 22–24) of the Pennsylvanian, is characteristic of the "Coal Measures" and lower Permian. It is derived from *Gastrioceras* and is the probable ancestor of the Cladiscitidae. The genus has been regarded by Arthaber [61] as the radicle of the Arcestoidea, but that is due to a confusion of names and blending of this with *Adrianites*, the next genus to be treated.

The genus *Adrianites*, which is represented by *A. timorensis* (pl. 45, figs. 9–11) of the middle Permian, is derived from *Gastrioceras*, possibly through *Paralegoceras* and *Schistoceras*, and is ancestral to the Arcestidae, probably through *Marathonites* of the "Coal Measures" and Permian. *Marathonites* so far as known antedates *Adrianites* in its appearance on the scene, but this is probably only apparent, for the young of *Marathonites* and of all other Arcestidae that have been studied recapitulate *Adrianites* in no uncertain terms.

The genus *Marathonites* is represented by *M. ganti* (pl. 43, figs. 18–20) of the upper Pennsylvanian of America. This group was first included in *Popanoceras* and later in *Stacheoceras* but was finally segregated by Böse [62] to include the rather primitive members in the "Coal Measures" and Permian. As thus defined and restricted, it is a well-marked unit, recapitulated

[58] Tchernow, A., L'étage d'Artinsk: Soc. imp. nat. Moscou Bull., new ser., vol. 20, p. 392, 1907.

[59] Wedekind, R., Die Genera der Palaeoammonoidea: Palaeontographica, Band 62, p. 160, 1917.

[60] Smith, J. P., The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, p. 83, pl. 40, figs. 8–13, 1903.

[61] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 178, 1911.

[62] Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, west Texas: Texas Univ. Bull. 1762, p. 133, 1917.

in the young of more complex and later Arcestoidea. According to the definition, it is not a primary radicle, being a primitive ammonite, but it is very abundant in the lower Permian of Sicily, the Urals, Texas, and Timor and deserves recognition as a secondary radicle—a new starting point for a vigorous and prolific stock of world-wide significance.

The statements concerning the ontogeny of the ammonoids made here and elsewhere in this paper are not mere assertions but are based on observations made by the writer and published in the following works by him:

Permian ammonoids of Timor; 2e Nederlandsche Timor-Expeditie onder Leiding van Dr. H. G. Jonkert: Jaarboek van het Mijnwezen in Ned. Indië, 1926, Verh. 1, 1927.

Lower Triassic ammonoids of Timor (MS.).

The Triassic cephalopod genera of North America: U. S. Geol. Survey Prof. Paper 40, 1905.

The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, 1903.

The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, 1914.

Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, 1927.

The transitional Permian ammonoid fauna of Texas: Am. Jour. Sci., 5th ser., vol. 17, pp. 63–80, 1929.

Phylogeny of Lower Triassic ammonites

	Devonian	Mississippian and Pennsylvanian	Permian	Lower Triassic
Gephyroceratea	Phenacoceras.[a] Gephyroceras.[a] Prolecanitoidea.	Prolecanites.[a] Xenodiscidae.	Lecanites.[b] Paralecanites.[b] Paraceltites.[b] Xenodiscus.[c] Xenaspis.[c]	Lecanites.[b] Paralecanites.[b] Xenodiscus.[c] Xenaspis.[c] Genodiscus.[c] Paratirolites.[c] Ophiceras.[c] Flemingites.[c]
			Meekoceratidae.	Meekoceras.[c] Clypeoceras.[c] Prionites.[c] Dagnoceras.[c] Leiophyllites.[c] Anasibirites.[c] Kashmirites.[c]
		Hungaritidae.	Hungarites.[c] Otoceras.[c] Dalmatites.[b]	Inyoites.[c] Hungarites.[c] Otoceras.[c] Dalmatites.[c]
	Pronoritoidea.	Pronorites.[b] Pronoritidae.	Pronorites.[b] Medlicottia.[d] Parapronorites.[c] Uddenites.[c] Sicanites.[c] Daraelites.[c] Sundaites.[c]	Episageceras.[d] Albanites.[c] Cordillerites.[c]
	Aphyllites.[a] Dimorphoceratoidea.	Dimorphoceras.[b] Neodimorphoceras.[b]	Thalassoceras.[c] Thalassoceratidae. Haueritidae.	Ussuria.[d] Procarnites.[d] ?Sturia.[d] Lanceolites.[d]
	Beloceratoidea: Beloceras.[b] Timanites.[a]	Prodromites.[c] ?Acrocanites.[b]	Sageceratidae.	Sageceras.[c] Pseudosageceras.[c] Aspenites.[c]

[a] Simple goniatite stage. [b] Lobes beginning to subdivide. [c] Lobes serrated. [d] Ammonitic stage.

Phylogeny of Lower Triassic ammonites—Continued

	Devonian	Mississippian and Pennsylvanian	Permian	Lower Triassic
Gastrioceratea		Gastrioceras [a] Glyphioceras.[a] Homoceras.[a]	Paragastrioceras.[a] Tropitidae.	Celtites.[a] Columbites.[c] Protropites.[c]
		Haloritidae.	Timorites.[c] Hoffmannia.[b]	Thermalites.[c] Stephanites.[c] Isculites.[d] Acrochordiceras.[d]
		Agathiceras.[b] Schistoceras.[b] Paralegoceras.[b]	Ptychitidae. Agathiceras.[b] Arcestidae.[b] Adrianites.[b] Schistoceras.[b] Paralegoceras.[b]	Juvenites.[b] Paranannites.[c] Prosphingites.[c] Parapopanoceras.[d]
	Cyclolobidae.	Shumardites.[b] Marathonites.[c]	Shumardites.[b] Marathonites.[c] Perrinites.[d] Waagenoceras.[d] Cyclolobus.[d] Hyattoceras.[d]	

[a] Simple goniatite stage. [b] Lobes beginning to subdivide. [c] Lobes serrated. [d] Ammonitic stage.

Synopsis of phylogeny of Lower Triassic ammonites

Gephyroceratea:
- Prolecanites [a] — Ceratitoidea — Gymnitidae. → Pinacoceratidae.; → Phylloceratidae.; → Hungaritidae.
- Pronorites [a] — Medlicottiidae. → Noritidae.
- Dimorphoceras [a] — Thalassoceratidae.
- ? — Haueritidae.
- Beloceras [a] — Sageceratidae.

Gastrioceratea — Gastrioceras [a]:
- Arcestoidea. → Cladiscitidae.
- Tropitoidea — Tropitidae.; Haloritidae.
- Ptychitidae.

[a] Primary or goniatite radicles.

Timanites is the first ammonoid to develop true auxiliary lobes; *Beloceras* is the first to develop adventitious lobes; *Dimorphoceras* is the first to subdivide the primary lobes; *Prodromites* is the first to develop serrations on the lobes; *Perrinites* is the first to develop ammonitic lobes.

The most retarded forms in septal development are the most advanced in sculpture—for example, *Gastrioceras* and the Tropitidae.

The most accelerated in septal development are the most retarded in sculpture—for example, the Cyclobidae, and Arcestidae. Contrast also the Meekoceratidae and Ceratitidae (retarded in septation and accelerated in sculpture) with the Medlicottiidae, Thalassoceratidae, and Sageceratidae (accelerated in septation and retarded in sculpture). The explanation of this phenomenon is probably that as the simply septate forms grew larger they needed additional protection against fracture of the shell. This protection could be had in two ways—by complication of the septa or by roughening the sculpture. They did not need both, and accordingly some groups became trachyostracan (rough-shelled), with simpler septa, whereas others became leiostracan (smooth-shelled), with more complicated septa. This could and did happen within the same phylum, and consequently it can not be used in the segregation of major groups. The old classification of Leiostraca and Trachyostraca has been definitely abandoned.

Persistent goniatite stages in the Permian

Gastrioceratea:
- Hoffmannia Gemmellaro.
- Adrianites Gemmellaro.
- Agathiceras Gemmellaro.
- Paralegoceras Hyatt.
- Schistoceras Hyatt.
- Gastrioceras Hyatt.
- Paragastrioceras Tchernow.

Gephyroceratea:
- Pronorites Mojsisovics.
- Paraceltites Gemmellaro.
- Paralecanites Diener.
- ?Nomismoceras Hyatt.
- Lecanites Mojsisovics.

Persistent goniatite stages in the Lower Triassic

Gastrioceratea:
- Nannites Mojsisovics.
- Juvenites Smith.
- Arnautoceltites Diener.
- Celtites Mojsisovics.
- Styrites Mojsisovics.

Gephyroceratea:
- Lecanites Mojsisovics.
- Paralecanites Diener.
- ?Ambites Waagen.
- ?Kymatites Waagen.
- Hololobus Kittl.
- Beatites Arthaber.
- Proavites Arthaber.

Recapitulation of goniatite stages in the Permian

	Prolecanites	Paraceltites	Paralecanites
Paraceltites elegans Girty	×	×	------
multicostatus Böse	×	×	------
	Pronorites	Uddenites	Propinacoceras
Parapronorites	×	------	------
Medlicottia	×	×	×
Propinacoceras	×	×	×
Uddenites	×	×	------
Daraelites	×?	------	------
	Dimorphoceras	Thalassoceras	
Thalassoceras	×	×	------
	Gastrioceras	Paralegoceras	Shumardites
Marathonites	×	×?	×
Paralegoceras	×	×	------
Schistoceras	×	×	------
Shumardites	×	×?	×

Recapitulation of goniatite stages in the Triassic

	Gastrioceras	Celtites	Columbites	Tropigastrites
Celtites ursensis	×	×	------	------
planovolvis	×	×	------	------
Columbites parisianus	×	×	×	------
spencei	×	×	×	------
Tropigastrites	×	×	×	×
Tropites	×	×?	×?	×
Discotropites sandlingensis	×	×?	×?	×
Paratropites sellai	×	×?	×?	×
	Gastrioceras	Juvenites	Thermalites	
Thermalites thermarum	×	×	×	------
Juvenites kraffti	×	×	------	------
Metasibirites	×	×	×	------
Juvavites	×	×	×	------
Sagenites herbichi	×	×	×	------
Leconteiceras californicum	×	×	------	------

Recapitulation of goniatite stages in the Triassic—Continued

	Gastrioceras	Nannites	Paranannites	
Owenites koeneni	×	×	×	------
Paranannites aspenensis	×	×	×	------
	Gastrioceras	Adrianites	Prosphingites	
Parapopanoceras	×	×	(?)	------
Arcestes	×	×	(?)	------
	Gephyroceras	Prolecanites	Paralecanites	
Paralecanites arnoldi	×	×	×	------
Xenodiscus nivalis	×	×	×	------
bittneri	------	×	×	------
Ophiceras dieneri	------	×	×	------
jacksoni	------	------	×	------
Flemingites aplanatus	×	×	×	------
cirratus	------	×	×	------
russelli	------	×	×	------
Discophyllites patens	------	------	×	------
Leiophyllites kingi	------	------	×	------
pitamaha	------	×	×	------
Hedenstroemia kossmati	×	------	------	------
Meekoceras gracilitatis	×	------	×	------
mushbachanum	×	×	×	------
Polycyclus	×	×	×	------
Clypeoceras	×	×	------	------
Arpadites	------	×	×	------
Dagnoceras pealei	×	×	×	------
Anasibirites	×	×	×	------
Goniodiscus beyrichi	------	------	×	------
Inyoites oweni	×	×	×	------
Eutomoceras laubei	×	×	×	------
Dalmatites parvus	×	------	×	------
Carnites floridus	------	------	×	------
Longobardites nevadanus	------	------	×	------
Beyrichites rotelliformis	------	------	×	------
Hollandites organi	------	------	×	------
Nevadites merriami	------	------	×	------
Gymnotoceras blakei	------	------	×	------
	Gephyroceras	Timanites	Beloceras	
Aspenites acutus	×	×	×	------
Pseudosageceras multilobatum	------	------	×	------
Sageceras gabbi	------	------	×	------
	Aphyllites	Dimorphoceras	Thalassoceras	
Ussuria waageni	------	×	×	------
Lanceolites compactus	×	×?	------	------
bicarinatus	×	×?	------	------
Fremontites ashleyi	×	×?	------	------
	Pronorites	Uddenites		
Cordillerites angulatus	×	(?)	------	------

Geographic distribution of Lower Triassic genera of ammonites

	Tyrol	Albania	Arctic region	India	Timor	Western America
Xenodiscidae						
Paraceltites Gemmellaro	(?)					
Paralecanites Diener	×					×
Lecanites Mojsisovics		×		×		×
Proavites Arthaber	×			×		
Xenodiscus Waagen		×	×	×	×	×
Genodiscus Smith				×	×	
Paratirolites Stoyanow				×	×	(?)
Xenaspis Waagen		×	×	×		×
Ophiceras Griesbach		×		×	×	×
Flemingites Waagen			×	×	×	×
Phylloceratidae						
Leiophyllites Diener		×		×	×	(?)
Palaeophyllites?					×	
Meekoceratidae						
Sibirites Mojsisovics			×	(?)	(?)	
Anasibirites Mojsisovics		×	×	×	×	×
Goniodiscus Waagen			×	×	×	×
Kashmirites Diener				×	×	×
Epiceltites Arthaber		×				
Vishnuites Diener				×	(?)	
Hedenstroemia Waagen		×	×	×	×	×
Meekoceras Hyatt	×	×	×	×	×	×
Prionites Waagen			×	×	×	×
Clypeoceras Smith	×	×	×	×	×	×
Dagnoceras Arthaber		×				×
Ambites Waagen				×		
Kymatites Waagen	×			×		
Ceratitidae						
Tirolites Mojsisovics	×	×		(?)	(?)	×
Danubites Mojsisovics			(?)	(?)		(?)
Dinarites Mojsisovics	×			(?)		(?)
Olenekites Hyatt			×			
Keyserlingites Hyatt			×	(?)	(?)	×
Durgaites Diener				×		
Czekanowskites Diener			×	×		
Japonites Mojsisovics		×				
Hungaritidae						
Hungarites Mojsisovics			×	×	×	
Dalmatites Kittl	×					×
Doricranites Hyatt				(?)		
Otoceras Griesbach				×	(?)	
Stacheites Kittl	×			×		
Inyoites Hyatt and Smith			×	×	×	×
Pseudharpoceras Waagen		×		×		×
Hanielites Welter					×	
Sageceratidae						
Pseudosageceras Diener		×		×	×	×
Sageceras Mojsisovics		×				
Aspenites Hyatt and Smith				×?	×	×
Beatites Arthaber		×				
Beneckeia Mojsisovics	×					
Thalassoceratidae						
Procarnites Arthaber		×			×	
Ussuria Diener				×	(?)	×
Sturia Mojsisovics						×
Haueritidae						
Lanceolites Hyatt and Smith						×
Pronoritidae						
Episageceras Noetling				×	×	
Albanites Arthaber		×			×	
Cordillerites Hyatt and Smith						×
?Adrianites Arthaber		×				

Geographic distribution of Lower Triassic genera of ammonites—Continued

	Tyrol	Albania	Arctic region	India	Timor	Western America
Tropitidae						
Paragastrioceras Stolley				×?		
Celtites Mojsisovics		(?)				×
Arnautoceltites Diener		×				
Protropites Arthaber		×				
Columbites Hyatt and Smith		×	(?)			×
Styrites Mojsisovics		(?)				
Haloritidae						
Isculites Mojsisovics		×		×	×	
Thermalites Smith						×
Prenkites Arthaber		×			×	×
Stephanites Waagen			×	×		×
Acrochordiceras Hyatt		×		×		×?
Paragoceras Arthaber		×				
Arcestidae						
Prosphingites Mojsisovics		×	×	×	×	×
Parapopanoceras Haug			×			×
Ptychitidae						
Nannites Mojsisovics		×		×	×	×
Juvenites Smith		(?)		×		×
Paranannites Hyatt and Smith		×		×		×
Smithoceras Diener				×		
Owenites Hyatt and Smith					×	×
Proptychites Waagen		×		×	×	×

PHYLOGENETIC CLASSIFICATION

GEPHYROCERATEA

As here defined, the Gephyroceratea include the Gephyroceratea as named by Arthaber [63] and also his Beloceratea and the Gymnitinae out of his superfamily Tornoceratea. It is thus a clan, of less extent than a suborder and greater than a superfamily. This clan includes as superfamilies the Prolecanitoidea, Beloceratoidea, Dimorphoceratoidea, and Pronoritoidea.

All the genera and families that compose this clan are supposed to be descendants of the primary radicle *Gephyroceras* and have a short body chamber, laterally compressed whorls, and little sculpture. They range in septation from simple goniatitic lobes (*Gephyroceras, Timanites*) through multiplicate types (*Beloceras*) to highly specialized ammonitic septa (*Ussuria*, Haueritidae, Trachyceratea).

The group is roughly synonymous with "Prolécanitidés" of Haug, [64] excluding Agathiceratidae, Cyclolobidae, and Arcestidae (Gastrioceratea) and including Thalassoceratidae and Ceratitidae, which Haug placed under Glyphioceratidae.

Superfamily PROLECANITOIDEA

The name Prolecanitoidea is substituted for the older designation Prolecanitidae, which has been used for too many different things—for the family, for the superfamily, and even for a suborder. Also, the new term is in harmony with the long accepted usage of Tropitoidea and Arcestoidea for the respective superfamilies of equal rank with Prolecanitoidea. The superfamily Prolecanitoidea is nearly synonymous with Ceratitoidea but omits the Hungaritidae and includes the Gymnitidae, Phylloceratidae, and Xenodiscidae, as well as the ancestral family Prolecanitidae. It is nearly synonymous with the "Prolécanitidés" of Haug [65] but excludes the Arcestoidea and includes the Ceratitidae, which Haug placed under the superfamily Glyphioceratidae. Prolecanitoidea is not synonymous with the Prolecanitidae of Karpinsky, [66] who included in it also the Pronoritidae and Medlicottiidae. As restricted, the superfamily includes the Prolecanitidae, Xenodiscidae, Meekoceratidae, Gymnitidae, Phylloceratidae, Ceratitidae, and Trachyceratidae.

Family XENODISCIDAE

The phylogeny of the Xenodiscidae is of special significance, as it deals with forms transitional from simple Paleozoic goniatites to Triassic near-ammonites. This family is the ancestral group of the Ceratitoidea, a suborder which embraces à large majority of Triassic ammonites.

[63] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 177, 1911.

[64] Haug, E., Les ammonites du Permien et du Trias: Soc. géol. France Bull., 3d ser., vol. 22, p. 386, 1894.

[65] Idem, p. 386.

[66] Karpinsky, A., Ueber die Ammoneen der Artinsk-Stufe und einige mit denselben verwandten carbonischen Formen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 37, No. 2, p. 4, 1889.

The Ceratitoidea include the following families:

Xenodiscidae + Phylloceratidae + Gymnitidae.
Meekoceratidae.
Ceratitidae + Trachyceratea.
Hungaritidae.

Genetic relationships of Ceratitoidea

```
                                          |→Leiophyllites (Phyllocera-
                                          |      tidae)
                                     |→Xenaspis→Gymnites→(Pinaco-
                                     |      ceratidae)
Prolecanites→Lecanites→Xenodiscus→Meekoceras
                    |                |→Paratirolites→Anasibirites→
                    |                        Ceratites→Trachyceratea
                    |                                        |→Circumplicati
                    |→Hungaritidae
```

The primary radicle of the Xenodiscidae, and therefore of the Ceratitoidea, can be only *Prolecanites* of the Carboniferous, and only some such princely form as *Prolecanites applanatus* Frech [67] could be the ancestor of the stately species of *Xenodiscus*, *Ophiceras*, *Meekoceras*, and *Flemingites*, which even in the Lower Triassic still show their inheritance of noble blood.

The Xenodiscidae include *Paraceltites* Gemmellaro, of the Permian; *Paralecanites* Diener, of the Permian and Lower Triassic; *Lecanites* Mojsisovics, of the Permian (?) and Lower and Middle Triassic; *Proavites* Arthaber, of the Lower Triassic; *Xenodiscus* Waagen, of the Permian and Lower and Middle Triassic (including as subgenera *Xenaspis* Waagen, of the Permian and Lower Triassic; *Genodiscus* Smith [68] and *Paratirolites* Stoyanow of the Lower Triassic); *Ophiceras* Griesbach and *Flemingites* Waagen, of the Lower Triassic. The probable relationship of these genera is shown above.

Celtites and its kindred are omitted from the list, as they are now known to be derivatives from the stock of Gastrioceratea, and to be the probable ancestors of the Tropitidae.

Paraceltites, contrary to the opinion of Gemmellaro and of Diener and in accordance with that of Frech,[69] is removed from the Tropitidae and placed in the Xenodiscidae. It is clearly a ceratitoid and may even be synonymous with *Paralecanites*, as Frech thought. It gives a connecting link with the true Prolecanitidae of the Carboniferous, but none with the Tropitoidea.

Xenodiscus and its kindred are segregated in the family Xenodiscidae, though Arthaber [70] puts them in the Ptychitidae and under the suborder Tornoceratea.

The immediate family radicle, *Xenodiscus*, has been variously treated. Waagen, who named it, placed it under the Tropitidae. Arthaber [71] assigns this genus to the Ptychitidae, whereas *Ophiceras* was chosen by him as the radicle of the Meekoceratidae. Mojsisovics,[72] with his usual acumen, assigns *Xenodiscus* to the meekoceran stock. Diener [73] says that *Xenodiscus* was the radicle of Meekoceratidae and Ceratitidae but that *Ophiceras* must have been the immediate ancestor of *Meekoceras* and that another branch of *Ophiceras* developed into *Flemingites;* also that some species of *Flemingites* may have come directly from *Xenodiscus*.

The original home of the Xenodiscidae and Meekoceratidae was in the Indian Ocean or oriental region, from which in the *Genodiscus* epoch they spread outward to achieve nearly world-wide distribution in the zone of *Pseudosageceras multilobatum* (the *Flemingites* or *Hedenstroemia* zone of India) in every region except the Mediterranean. They were present and abundant in the Arctic, oriental, and western American regions, in great variety of genera and species, far surpassing their kinsmen and contemporaries the Pronoritidae, the only other race with an unquestioned family genealogy continuous from the Paleozoic into the Mesozoic.

This is the most definitely continuous line of ammonoids, connected by *Paraceltites*, *Paralecanites*, and *Lecanites* with *Prolecanites* of the Carboniferous. It was abundant in the oriental region throughout the Permian and Lower Triassic, merging into the Meekoceratidae and finally into the Ceratitidae. Then onward its course is secure, as the *Lytoceras-Phylloceras* stock, through the Jurassic and Cretaceous, to the end of the Mesozoic and the end of the race. It is probable that the aristocratic Sageceratidae and the somewhat more humble Tropitidae had an equally dramatic history, but through the vicissitudes of migration from one region to another their family records have been lost, and only part of them have been recovered.

Arthaber [74] is quite positive that *Ophiceras* and *Xenodiscus* have no genetic relationship and that they even belong to different families. Diener,[75] on the other hand, regards the two genera as almost synonymous, and although he recognizes *Ophiceras*, he emphasizes the uncertainty in assigning species to one or the other genus. The writer agrees with him completely, and so apparently do most other students of Triassic

67 Holzapfel, E., Die Cephalopoden-führenden Kalke des unteren Carbon von Erdbach-Breitscheid bei Herborn: Paleont. Abh., n. F., Band 1, p. 43, pl. 5, fig. 1, 1889.

68 *Genodiscus* Smith, n. subgen., type *Xenodiscus lidacensis* Welter (Die Ammoniten der unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 108, pl. 159, figs. 5–7, 18 = *Celtites fortis* Koken). [Professor Smith did not supply a diagnosis for this subgenus.—Editor.]

69 Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 634, 1902.

70 Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 227, 1911.

71 Arthaber, G. von, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 106, 1914.

72 Mojsisovics, E. von, Das Gebirge um Hallstatt; Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 325, 1902.

73 Diener, Carl, Die marinen Reiche der Triasperiode: K. Akad. Wiss. Wien Denkschr., Band 92, p. 497, 1916.

74 Arthaber, G. von, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 106, 1914.

75 Diener, Carl, op. cit. (Die marinen Reiche der Triasperiode), p. 497.

paleontology, as shown in the somewhat haphazard way in which some authors shift these species back and forth. The studies of Frech and of Krafft went a long way toward simplification of the classification of this group. We have reason to be deeply grateful to them and to lament their untimely death. Another generation of simplifiers is badly needed, for Diener has carried on the fight almost alone. Now he too is gone, the greatest figure and most stabilizing influence we have had in the study of Triassic paleontology and stratigraphy.

Family MEEKOCERATIDAE

This name Meekoceratidae is not used here in the sense in which it was used by Arthaber,[76] who had expanded the family to take in forms not admitted by Waagen nor by most other writers. As here restricted, the family includes *Meekoceras* Hyatt, *Clypeoceras* Smith (=*Aspidites* Waagen), *Prionites* Waagen, *Dagnoceras* Arthaber, *Kashmirites* Diener, *Anasibirites* Mojsisovics + *Goniodiscus* Waagen, *Epiceltites* Arthaber, and *Cuccoceras* Diener. All these genera are too closely related to be grouped in subfamilies. All are apparently derived from *Xenodiscus*, though probably from different species and possibly even from different groups of that genus.

The subfamily Lecanitinae is eliminated, *Lecanites* being transferred to the Xenodiscidae, and *Ambites*, *Kymatites*, *Parakymatites*, and *Proavites* also find their place in the same family, unless they fall into the oblivion of synonymy—the first three being possibly merely species of *Meekoceras* that have lost the serrations of the septa through etching or weathering and *Proavites* being possibly a synonym of *Lecanites*. Diener[77] prefers to use the name *Proavites* for the so-called *Lecanites* of the Lower Triassic, believing these forms not to be congeneric with the degenerate type of the Upper Triassic. However, as the writer has a continuous line of species all the way through from the Permian to the top of the Middle Triassic, he considers *Lecanites* a retarded genus and not a degenerate. The Hungaritinae are eliminated, because they form an independent family, in parallel development with the Xenodiscidae, from *Lecanites*.

The Arctoceratinae are omitted because *Arctoceras*, as the writer has shown,[78] is merely a synonym of *Meekoceras*, and *Dagnoceras* is too closely allied with *Meekoceras*, though in parallel development, to be separated from it. The young of *Dagnoceras* show close relationship to *Anasibirites*. *Ophiceras* is put back in its old position near *Flemingites* under the Xenodiscidae. *Beyrichites* is returned to the Ceratitidae, because of its close relationship to *Gymnotoceras* and the Geminati, as derivatives from *Anasibirites*. *Philippites* also is not included as a synonym of *Prionites* for the same reason, although it may be a descendant of that genus.

Anasibirites is included under the Meekoceratidae because it and its subgenus *Goniodiscus* show a development from a ribbed *Xenodiscus* and bear no resemblance in the young stages to the Gastrioceratea but in age revert to meekoceran or *Xenodiscus*-like forms. It is noteworthy as the probable ancestor of at least some of the groups classed under *Ceratites*.

In harmony with Diener,[79] *Kashmirites* is introduced as a probable ancestor of *Anasibirites* and descendant of *Xenodiscus*. The young stages of *Kashmirites* show very decided resemblances to *Paratirolites*, which is regarded as a subgenus under *Xenodiscus*.

Proptychites is excluded, in spite of the impossibility of separating some of its forms from *Meekoceras*. Many species assigned to *Proptychites* should more properly be given to *Acrochordiceras*, which, in agreement with Diener,[80] is now admitted to the Meekoceratidae. Diener would derive *Proptychites* (*Sibirites*) (=*Anasibirites*) and *Hedenstroemia* from *Meekoceras*, with which the writer agrees in part; Diener would further derive *Hollandites* and *Acrochordiceras* from the same source, with which the writer does not agree. He rather regards all the Circumplicati—*Hollandites* and *Philippites*—as derivatives of *Anasibirites*, and *Acrochordiceras* as a descendant of the same stock.

In agreement with Diener[81] the writer accepts *Xenodiscus* as the family radicle of Meekoceratidae, for all the principal members of that family show distinct *Xenodiscus* stages of growth and before that resemble *Lecanites* or *Paralecanites*.

Clypeoceras continues unchanged (under the name *Aspidites*),[82] and even *Prionites* is still visibly present in the Muschelkalk under the name *Hollandites*, with but slight modification. We have, then, sufficient overlapping between Meekoceratidae and Ceratitidae.

Family CERATITIDAE

The writer[83] has already published a full account of the classification and phylogeny of the Ceratitidae, in so far as they are represented in the American faunas or were known up to 1914. Since that time many discoveries have been made and additional publications issued, necessitating some changes in our ideas of the phylogenetic arrangement of the genera of the

[76] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr. Ungarns u. des Orients, Band 24, p. 236, 1911.

[77] Krafft, A. von, and Diener, Carl, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 73, 1909.

[78] Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 77, 1914.

[79] Diener, Carl, Die marinen Reiche der Triasperiode: K. Akad. Wiss. Wien Denkschr., Band 92, p. 498, 1916.

[80] Idem, pp. 497-498.

[81] Idem, p. 497.

[82] Arthaber, G. von, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 243, 1914.

[83] Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, pp. 68-121, 1914.

Ceratitidae. These publications are especially Arthaber's work on the Trias of Bithynia,[84] Diener's series of monographs that have thrown so much light on Triassic stratigraphy and paleontology,[85] and the two monographs by Welter [86] on the Triassic cephalopods of Timor. The genera admitted to the Ceratitidae in the restricted sense are *Ceratites* De Haan (Nodosi) (subgenera *Paraceratites* Hyatt, *Semiornites* Arthaber, and *Kellnerites* Arthaber), *Hollandites* Diener and *Philippites* Diener (Circumplicati), *Acrochordiceras* Hyatt, *Frechites* Smith, n. gen., *Gymnotoceras* Hyatt, *Haydenites* Diener, *Beyrichites* Waagen (the seven genera last mentioned derivatives of *Anasibirites*), *Keyserlingites* Hyatt (subgenus *Durgaites* Diener), *Olenekites* Hyatt, *Arpadites* Mojsisovics, *Danubites* Mojsisovics, *Dinarites* Mojsisovics, *Tirolites* Mojsisovics, and *Reiflingites* Arthaber.

Genus **FRECHITES** Smith, n. gen.

Type: *Ceratites humboldtensis* Hyatt and Smith.[87] The new genus *Frechites*, which was called by the writer [88] in 1905 "group of *Ceratites humboldtensis* Hyatt and Smith," should be given independent rank, for it can not be placed under the Nodosi nor yet very well under either the Geminati or the Circumplicati. The following description is quoted from the work cited.

With strong lateral and marginal tubercles and commonly a weak keel ridge. The young of this group resemble *Gymnotoceras*, and even at maturity the forms show great affinity with the Geminati. The septa are usually slightly ammonitic. This group has the greatest resemblance to the Germanic Nodosi, but this is probably due to convergence or possibly to atavism, for the Germanic group seems to have been derived directly from *Meekoceras*. The nearest Mediterranean relative appears to be *C. subnodosus* Mojsisovics. The length of the body chamber is more than three-fourths of a revolution, much greater than in the group of *C. nodosus*.

This genus is confined to the Middle Triassic zone of *Ceratites trinodosus*, in western America, where it is abundantly represented. The generic name is given in memory of that gallant and honorable fighter Fritz Frech, with whom nearly every contemporary worker had some sort of tilt but who always fought fairly.

The supposed phylogeny of the Ceratitidae was once extremely simple, the *Ceratites* being supposed to be descended from *Dinarites* and the Trachyceratea from *Tirolites*. Now, however, those two genera are thought by Philippi [89] to be merely retarded or reversionary members of the family and not to be radicles—an opinion with which the writer agrees. We must then, seek for the ancestral stock elsewhere. Nearly all writers have turned to the Meekoceratidae and disagree only as to the particular genus. Philippi [90] regards *Meekoceras* as the ancestor of the Nodosi. The writer [91] showed that *Meekoceras mushbachanum* in its development came from *Lecanites* and *Xenodiscus* and almost reached the stage of evolution of the Nodosi. However, we do not know that the Nodosi duplicate all that. Arthaber [92] accepts *Meekoceras* as ancestor of *Ceratites* but declines to accept *Xenodiscus* as a forebear of *Meekoceras;* instead, he chooses *Ophiceras*. This choice meets with partial assent from Diener,[93] who regards *Xenodiscus* as the radicle of the Meekoceratidae and Ceratitidae but thinks that *Ophiceras* was the connecting link between *Xenodiscus* and *Meekoceras*. Diener [94] would further derive the Nodosi from *Beyrichites* and *Hollandites*, with which the writer can not agree, for the Nodosi have ceratitic septa, whereas *Beyrichites* and *Hollandites* have ammonitic septa, a reversal of development hardly possible in a progressive series.

The writer is now inclined to believe that, although the Nodosi may have come directly from *Meekoceras*, the subgenera *Paraceratites*, *Semiornites*, and *Kellnerites* probably were derived from the *Genodiscus* → *Kashmirites* → *Anasibirites* stock, as shown by the young stages figured by the writer elsewhere.[95] The writer further believes that the Geminati and Circumplicati are a parallel development from the same stock, as shown by young stages figured in the work cited. At the time that paper was published it was thought that *Kellnerites* might be descended from *Olenekites*, but that opinion is now given up, and *Olenekites* itself is regarded as a side branch from the *Kashmirites* → *Anasibirites* stock. It must be remembered that only a few years ago we knew nothing of *Kashmirites*, and *Anasibirites* was known only by the few fragments described by Waagen from the Salt Range. Now we know them as a great worldwide stock, not of Gastrioceratea but of the true Meekoceratidae, abundant in the Oriental, western American, and Arctic regions, sparingly represented even in the Mediterranean.

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84 Arthaber, G. von, op. cit.

85 Diener, Carl, Die marinen Reiche der Triasperiode: K. Akad. Wiss. Wien Denkschr., Band 92, 1916; Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, 1917; Ammonoidea Trachyostraca aus Mittleren und Oberen Trias von Timor: Jaarboek van het Mijnwezen in Ned. Indië, Verh. 4, 1920.

86 Welter, O. A., Die Obertriadischen Ammoniten und Nautiloiden von Timor: Palaeontologie von Timor, Lief. 1, 1914; Die Ammoniten der Unteren Trias von Timor: Idem, Lief. 11, Abh. 19, 1922.

87 Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 170, pl. 57, figs. 1-23, 1905.

88 Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 79, 1914.

89 Philippi, E., Die Ceratiten des oberen deutschen Muschelkalkes: Paleont. Abh. (Dames & Koken), n. F., Band 4, p. 100, 1901.

90 Idem, p. 111.

91 Smith, J. P., op. cit. (Prof. Paper 83), pp. 77, 78.

92 Arthaber, G. von, op. cit. (Die Trias von Bithynien), p. 106.

93 Diener, Carl, Die marinen Reiche der Triasperiode: K. Akad. Wiss. Wien Denkschr., Band 92, p. 457, 1916.

94 Idem, p. 498.

95 Smith, J. P., op. cit. (Prof. Paper 83), pp. 72-80.

TRACHYCERATEA

The Trachyceratea, including *Trachyceras* Mojsisovics and its allies, were derived by Mojsisovics from *Tirolites* through *Balatonites*—a very unlikely source, according to present knowledge. The writer [96] has tried to show that the Trachyceratea came directly from the group of *Ceratites haguei* Smith (*Kellnerites* Arthaber) through *Nevadites*. This source is corroborated by the development of numerous species of *Nevadites*, *Anolcites*, *Trachyceras*, *Clionites*, and *Sirenites*. The so-called *Tirolites* stages of *Trachyceras* and *Clionites* are probably only palingenetic forms of *Paratirolites*. This conclusion simplifies matters and eliminates the necessity of supposing *Trachyceras* and its allies to be polyphyletic; it is also much more probable than the old idea.

Family GYMNITIDAE

The Gymnitidae were first placed by Mojsisovics [97] under the Ptychitidae, which were then a very heterogeneous assemblage. In a later work [98] he was inclined to derive *Gymnites* from *Daraelites*, a Permian member of the Pronoritidae. Waagen [99] classed *Gymnites* along with *Flemingites* and *Xenodiscus* under the family Gymnitidae, which is getting much nearer the true relationship. Arthaber [1] agrees with the earlier conclusion of Mojsisovics on the derivation of the family from *Xenodiscus*.

The writer [2] has shown that *Gymnites alexandrae* Smith in its youth goes through stages corresponding to *Xenaspis* and confirms the conclusion that *Gymnites* must have originated from the Xenodiscidae.

LYTOCERAS-PHYLLOCERAS STOCK

The *Lytoceras-Phylloceras* stock has long been a puzzle to paleontologists. Mojsisovics [3] attached it to the Lytoceratinae as descendants of *Lecanites* or *Prolecanites*, which comes very close to the modern view. Zittel [4] derives the Phylloceratidae from the Cyclolobidae and therefore, by inference, from the Gastrioceratea. Haug [5] traced them back to *Nomismoceras*, which is now commonly assigned to the Glyphioceratidae. Hyatt [6] derived the "Phyllocampyli" from the Prolecanitidae, a rather vague derivation. The first definite intimation of their correct position in the family line is from Arthaber,[7] who classifies *Monophyllites* along with *Xenodiscus*, although in the text he refrains from declaring the one to be descended from the other. The writer has had under study three of Arthaber's species, from the Lower Triassic of Timor—*Leiophyllites kingi* Diener, *L. dieneri* Arthaber, and *L. pitamaha* Diener. They are definitely transitional from *Xenaspis* to *Monophyllites* and in early youth show perfect *Xenaspis* stages. Still younger stages show a marked resemblance to *Prolecanites*. The genus *Palaeophyllites* Welter, from the Lower Triassic of Timor, seems to be a further step upward toward *Rhacophyllites*, both in sculpture and in septation, and shows that the Phylloceratidae were already well established in fairly typical development. The writer has studied the young of *Discophyllites patens* Mojsisovics, from the Upper Triassic of California,[8] and finds that in the adolescent stage this species is a perfect replica of *Monophyllites*. Also the larval stage of *Phylloceras ramosum*, of the Upper Cretaceous of California, resembles *Prolecanites*, whereas the early adolescent stages duplicate *Monophyllites* and *Discophyllites*. This would seem to show conclusively the persistence of the derivatives of the Xenodiscidae with easily recognizable characters from the Paleozoic to the end of the Mesozoic.

In recent years paleontologists have been prone to derive all Jurassic and Cretaceous ammonites from the *Phylloceras* stock, although they fail to show in their development any reminiscences of either Xenodiscidae or *Phylloceras*. It is rather remarkable that these Jurassic and Cretaceous forms should have lost their ancestral history so utterly, while *Phylloceras* should have retained it so clearly expressed. The writer has always had very grave doubts as to the correctness of the commonly accepted idea, but this must be decided by students of Jurassic and Cretaceous genera.

Family PINACOCERATIDAE

This outline has shown how the old family of Pinacoceratidae has been broken up, some members being assigned to the Pronoritidae, some to the Sageceratidae, some to the Haueritidae, and others given back to the enlarged gens of the Ceratitidae. But *Pinacoceras* and its immediate kin have been left somewhat stranded. Mojsisovics [9] had already indicated that the genus probably came from *Gymnites*. Arthaber [10] is inclined to follow him in this conclusion, which is definitely corroborated by Diener.[11]

96 Idem, pp. 121–137.

97 Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 231, 1882.

98 Mojsisovics, E. von, Das Gebirge um Hallstatt; Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 302, 1902.

99 Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 162, 1895.

1 Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 229, 1911.

2 Smith, J. P., op. cit. (Prof. Paper 83), p. 51.

3 Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 204, 1882.

4 Zittel, K. A. von, Grundzüge der Palaeontologie, Abt. 1, p. 567, 1924.

5 Haug, E., Études sur les Goniatites, p. 48, 1898.

6 Hyatt, Alpheus, Cephalopoda, in Eastman's translation of Zittel's Textbook of paleontology, vol. 1, p. 591, 1900.

7 Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 232.

8 Smith, J. P., Upper Triassic marine invertebrate faunas of North America. U. S. Geol. Survey Prof. Paper 141, 1927.

9 Mojsisovics, E. von, Das Gebirge um Hallstatt; Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 293, 1902.

10 Arthaber, G. von, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 155, 1914.

11 Diener, Carl, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 187, 1917.

With the eliminations noted above the Pinacoceratidae become a homogeneous group, quite definitely placed in the phylogenetic scheme. Diener has shown conclusively, in the work cited above, that the development of adventitious lobes, the character once thought most significant in defining this family, has come about wholly independently in many different stocks and is therefore of little taxonomic value.

Family HUNGARITIDAE

The Hungaritidae have usually been placed under the Ceratitidae in the broader sense, or immediately next to them. But Arthaber [12] and following him the writer [13] transferred a genus of this family, *Longobardites* Mojsisovics, to the Pinacoceratoidea because of the development of adventitious lobes. Diener [14] later restored *Longobardites* to its proper place.

However, the Hungaritidae should not be put under the Ceratitidae, even though some members of the two families in the Middle Triassic have been confused, nor should they even be regarded as derivatives of the typical Xenodiscidae. The Hungaritidae began their record with *Dalmatites* in the lower Permian, as a derivative from *Prolecanites*, and continued as *Otoceras* and *Hungarites* in the Lower Triassic and further as *Hungarites*, *Eutomoceras*, and *Halilucites* in the Middle Triassic. The *Lecanites* stage is known in the young of *Dalmatites*, *Longobardites*, and *Eutomoceras*, in the collection of the writer. We do not know that they lived into Upper Triassic time, although some of the specialized forms with adventitious lobes in that epoch may well have been derived from *Longobardites*. The so-called *Eutomoceras* of the Upper Triassic is a tropitoid, as shown by Hyatt and Smith,[15] and has been renamed *Discotropites*.

Superfamily BELOCERATOIDEA

The Beloceratoidea, as here defined, are restricted to *Beloceras* Hyatt and *Timanites* Mojsisovics, of the Devonian; *Prodromites* Smith and Weller and *?Acrocanites* Schindewolf, of the Carboniferous; *Pseudosageceras* Diener, *Sageceras* Mojsisovics, and *Aspenites* Hyatt and Smith, of the Triassic. It includes only forms that appear to be closely related to *Beloceras* and is therefore an exceedingly limited group. It is much less inclusive than Beloceratea, as expanded by Arthaber [16] to contain all forms with adventitious lobes, thus taking in the *Pronorites-Medlicottia* group, the *Thalassoceras-Ussuria* stock (the *Dimorphoceras* group), and the Carnitidae, which are a mixture of *Procarnites* (probably from the *Dimorphoceras* stock), *Carnites* and *Longobardites* (almost certainly from the *Hungarites* stock), and *Hedenstroemia* which is probably a derivative of *Meekoceras*.

It includes part, but only a very small part, of what Mojsisovics, Waagen, Diener, and the writer formerly called Pinacoceratoidea or Pinacoceratidae, but the genera included have no kinship with that family. The writer [17] has already expressed his doubts as to the value of adventitious lobes in taxonomy but continues to use the accepted nomenclature for the sake of uniformity. Mojsisovics [18] also questioned the value of adventitious lobes in classification of ammonite genera.

The sharpest and almost the only criticism of this basis of taxonomy has been given by Diener,[19] who has disrupted the supposed phylum entirely and left in it only the genus from which the name is taken. The writer agrees with Diener in most of this drastic procedure, but not as to the removal of *Pseudosageceras*, *Sageceras*, and *Aspenites*, for he has young stages of all three forms, at diameters of 4 to 5 millimeters, which show a very striking resemblance to *Beloceras* and the very early development of adventitious lobes. Diener would derive these three genera from *Meekoceras*, but the writer has examined the young stages of numerous species of that genus and of kindred genera in the Meekoceratidae and finds that they all resemble *Xenodiscus* and back of that *Prolecanites* and *Lecanites* and do not have the faintest likeness to the young of the Sageceratidae.

Meekoceras and its kindred were doubtless an exceedingly potent stock, but the writer can hardly agree that they are the parents of nearly all the Triassic ammonites outside the Gastrioceratea.

The details of the young stages of *Pseudosageceras*, *Sageceras*, and *Aspenites* will be given in full under the discussion of the Carnitidae. This supposed family comes under discussion here only because Arthaber [20] has united under this name *Ussuria*, *Procarnites*, and *Carnites*. The genus *Ussuria* has been shown by the writer [21] to belong definitely to the *Dimorphoceras-Thalassoceras* stock, whereas the two other genera of the group are said by Diener [22] to be derived from *Meekoceras*. The writer agrees with him partly, as to *Carnites*, for the young stages already figured by Mojsisovics tell the same story of relationship to either *Hungarites* or *Meekoceras*. But the young stages of *Procarnites* are not known, and the adult stages are so remarkably like *Ussuria* that it would seem there must be some real relationship.

[12] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 206, 1911.

[13] Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 50, 1914.

[14] Diener, Carl, op. cit. (Ueber Ammoniten mit Adventivloben), p. 177.

[15] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 61, 1905.

[16] Arthaber, G. von, op. cit. (Die Trias von Albanien), pp. 128 et seq.

[17] Hyatt, Alpheus, and Smith, J. P., op. cit. (Prof. Paper 40), p. 99.

[18] Mojsisovics, E. von, Das Gebirge um Hallstatt; Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 309, 1902.

[19] Diener, Carl, op. cit. (Ueber Ammoniten mit Adventivloben), pp. 164-194.

[20] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 211.

[21] Hyatt, Alpheus, and Smith, J. P., op. cit., p. 88.

[22] Diener, Carl, op. cit. (Ueber Ammoniten mit Adventivloben), p. 167.

Superfamily DIMORPHOCERATOIDEA

Family THALASSOCERATIDAE

Thalassoceras is known only in a few species, from the lower Permian of Texas, Timor, the Urals, and Sicily. In Sicily Gemmellaro [23] has described *T. microdiscus* as going through a stage corresponding to *Dimorphoceras*. The writer [24] has specimens that show the young stages of *Ussuria waageni* going through stages corresponding to *Dimorphoceras, Thalassoceras*, and typical *Ussuria*, successively, before reaching a higher subgeneric stage. Some of these are figured and described in the present paper.

Along with *Ussuria* the writer would further include *Sturia* Mojsisovics, in agreement with Mojsisovics, [25] although the young stages are entirely unknown. This genus appears in the Lower Triassic, shortly after *Ussuria*, without any other possible kinsmen, and would seem to fit in better with this group than with any other.

This statement applies also to *Procarnites* Arthaber, as stated in the preceding section under Carnitidae. Their reception here is therefore only tentative. Otherwise they are homeless.

Family HAUERITIDAE

The members of the Haueritidae were included by Arthaber [26] in the somewhat heterogeneous group Carnitidae. As restricted here only *Lanceolites* Hyatt and Smith, *Fremontites* Smith, *Hauerites* Mojsisovics, *Klamathites* Smith, and doubtfully *Arthaberites* Diener are included. It is shown above, under the Carnitidae, why *Ussuria, Procarnites*, and *Carnites* are separated and why the family itself has been rejected.

Mojsisovics [27] regarded *Hauerites* as a subgenus of *Cyrtopleurites* from some member of the Ceratitoidea allied to *Gymnotoceras*. The writer, however, basing his opinion on the young stages of *Lanceolites* and *Fremontites* and upon good adult specimens of *Klamathites* studied by him, thinks that here we have a compact family in no way connected with the groups to which they have been assigned. This family has been named by him Haueritidae.[28] The young of *Lanceolites* at a diameter of about 4 millimeters are perfect replicas of *Amphyllites;* then at a diameter of about 5 millimeters they resemble *Dimorphoceras* slightly but without the secondary division of the external lobe, thus corresponding either to some unknown genus of the Carboniferous or to some unknown species of *Dimorphoceras*. It may be that *Neodimorphoceras* Schmidt will give us the needed form, though it is not likely. At this stage the lateral lobe begins to be slightly serrated. At maturity the adventitious lobes are not yet really developed but can already be foreseen in the divisions of the external lobe.

At the Karnic horizon of the Upper Triassic appears *Fremontites*, which in youth shows decidedly these same stages and then subdivides the lobes more deeply, becoming much more like *Hauerites*, which occurs at the same horizon. A little higher up, toward the top of the Karnic, there appears the genus *Klamathites* with the same shape and with the same ground plan of septation but with much greater complication of division and development of the adventitious lobes.

Arthaberites Diener [29] may be the Middle Triassic intermediary between *Lanceolites* and *Fremontites* but is too little known for certain decision. The young stages of *Hauerites* itself have not been published, but the kinship with *Lanceolites* and *Fremontites* is beyond doubt, and their ontogeny, so completely unlike that of the Meekoceratidae and so consistent, assigns them to a uniform group. They are therefore placed as a branch of the Gephyroceratea, in parallel development with the Thalassoceratidae but not from the same primary radicle—not from *Dimorphoceras* but from some genus closely allied to it. The Haueritidae are not allied to *Carnites* and *Metacarnites*, which are referred to the meekoceran stock, nor to *Tibetites*, *Cyrtopleurites*, and *Bambanagites*, which are now placed in the Ceratitoidea as probable branches from the *Hungarites* phylum.

Superfamily PRONORITOIDEA

Family PRONORITIDAE

Karpinsky [30] has proved definitely that *Medlicottia* and its kinsmen came from *Pronorites*, though he was mistaken in deriving that genus from the mythical "*Ibergiceras*," which Holzapfel has since shown to be merely a young stage of *Pronorites* itself. None the less Karpinsky's great work is the most satisfactory and convincing exposition of recapitulation of the Ammonoidea yet brought forward, the model and the despair of all students of ammonite phylogeny. Simplex munditiis.

Böse [31] shows clearly that *Uddenites* Böse goes through a distinct *Pronorites* stage, although he thought it to be merely an insignificant side branch from the main stock. Another side branch gave us *Daraelites*, from which probably came *Albanites* of the Lower Triassic, and through that genus the

[23] Gemmellaro, G. G., La fauna dei calcari con Fusulina della Valle del Fiume Sosio nella provincia di Palermo, p. 72, 1887.

[24] Hyatt, Alpheus, and Smith, J. P., op. cit. (Prof. Paper 40), p. 88.

[25] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 306, 1902.

[26] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 211.

[27] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 517, 1893.

[28] Smith, J. P., Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 72, 1927.

[29] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 217, fig. 9.

[30] Karpinsky, A., Ueber die Ammoneen der Artinsks-Stufe und einige mit denselben verwandten carbonischen Formen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 37, No. 2, 1889.

[31] Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, west Texas: Texas Univ. Bull. 1762, p. 55, 1917.

Noritidae of the Middle Triassic. The writer [32] has tried to show that *Cordillerites* Hyatt and Smith, of the Lower Triassic of Idaho, goes through a *Pronorites* stage in its youth. But Diener [33] refuses to accept this conclusion and instead would derive *Cordillerites* from *Meekoceras*. The writer has examined anew the young stages of *Cordillerites* and still finds them like *Pronorites*, without any resemblance to *Meekoceras* and the Xenodiscidae, with the very early development of the angulate whorl and adventitious lobes. These do not form from the external saddle in *Cordillerites*, as they are said to do in *Medlicottia*, but from the external lobe. The formation of the adventitious lobes is an inherent, hereditary character, not late and cenogenetic, as in *Hedenstroemia*.

The genera now admitted to the Pronoritidae are *Pronorites* Mojsisovics (Carboniferous and Permian), *Parapronorites* Gemmellaro, *Medlicottia* Waagen (subgenera *Episageceras* Noetling, *Propinacoceras* Gemmellaro, and *Artinskia* Karpinsky), *Sicanites* Gemmellaro, *Uddenites* Böse, *Sundaites* Haniel, *Daraelites* Gemmellaro, *Albanites* Arthaber, and *Cordillerites* Hyatt and Smith. All these forms are confined to the Paleozoic, except *Episageceras*, which ranges up into the Lower Triassic, and *Albanites* and *Cordillerites*, which are confined to the Lower Triassic.

GASTRIOCERATEA

The clan Gastrioceratea as here defined includes the Gastrioceratea as defined by Arthaber [34] but is more extensive, taking in also his Agathiceratea as derivatives of *Gastrioceras*. It also includes Ptychitidae s. s., exclusive of the Gymnitidae, which are now placed under the Prolecanitoidea of the Gephyroceratea.

The Gastrioceratea have a prevailingly long body chamber and robust whorls. The sculpture is highly developed in the Tropitidae, less so in the Haloritidae, and nearly lacking in the Arcestoidea. The septa range from simply goniatitic (*Gastrioceras*, *Agathiceras*, and *Celtites*), through nearly ammonitic (*Marathonites*, *Protropites*, and *Columbites*), to highly complex ammonitic (*Tropites*, *Halorites*, *Juvavites*, *Waagenoceras*, and *Arcestes*).

It is certain that before the end of the Permian the Gastrioceratea had branched out into two phyla—Arcestoidea and Tropitoidea—and that the latter had already begun to divide into two families—the Celtitidae, forerunners of the Tropitidae, and the Haloritidae.

The Arcestoidea are nearly world-wide in the Permian, as *Agathiceras*, *Adrianites*, *Shumardites*, *Marathonites*, *Perrinites*, *Waagenoceras*, and a few other less common genera, all members of the highly accelerated Cyclolobidae, descendants of the group of *Gastrioceras globulosum*.

The Haloritidae are known as yet in the Permian only in the doubtful *Hoffmannia* of Sicily and in the rare *Timorites* Haniel, which is the predecessor but probably not the ancestor of the Triassic members of this stock. Its value lies only in showing the continuity of the race.

The Tropitidae are known as yet in the Permian only as a continuation of the main line in *Paragastrioceras*; for *Xenodiscus* and *Paraceltites* have been dropped from the family, as shown above.

No Gastrioceratea are known in the uppermost Permian anywhere, nor in the lowest beds of the Lower Triassic, until the reappearance of the Arcestoidea in *Prosphingites*, the most primitive member of the Arcestidae, in the American, Indian, and Arctic regions. Bonnet [35] cites *Gastrioceras abichianum* from the Lower Triassic of Armenia, a find which is improbable and has not been verified.

Superfamily TROPITOIDEA

Family CELTITIDAE

The most primitive group of Tropitoidea is the family Celtitidae, here restricted to *Celtites* Mojsisovics, *Columbites* Hyatt and Smith, and *Arnautoceltites* Diener. *Xenodiscus* and *Paraceltites* have been dropped from the family and referred to the Xenodiscidae, under the Ceratitoidea.

No Celtitidae are known anywhere below the *Columbites* zone of the Lower Triassic, but there they appear abundantly in the Mediterranean (Albanian) and western American regions and doubtfully in the Arctic region. It may be that the Arctic region was their original home and that they persisted there during the lost interval, to reappear as *Celtites* and *Columbites* in western America and as *Columbites* and *Protropites* in Albania. This reappearance looks like the result of a possible radial migration southwestward through the depression along the Ural Mountains to Albania and southeastward through the marginal sea to western America. At any rate they lived on somewhere, certainly not in the Indian region, in which the Tropitidae appear to be lacking until Upper Triassic time.

In this feature the contrast with the history of the Gephyroceratea is strong. That group, which includes Xenodiscidae and Pronoritidae, is clearly radial from the Indian region, abundant in the Permian and Lower Triassic, with continuous series of both stocks, reaching out as immigrants to other regions.

Celtites Mojsisovics is the most likely connecting link between the Tropitidae and their gastrioceran ancestry, although it may be a side branch and not

[32] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, pp. 109–113, pls. 2, 68, 71, and 75, 1905.

[33] Diener, Carl, op. cit. (Ueber Ammoniten mit Adventivloben), p. 175.

[34] Arthaber, G. von., op. cit. (Die Trias von Albanien), p. 179.

[35] Bonnet, P. N., Sur une mission en Transcaucasie (1911): Soc. géol. France Compt. rend., Année 1912, p. 115.

the main line. This genus has been assigned by many writers to the Ceratitoidea, because of mistaken notions as to its kinship with *Xenodiscus* and *Paraceltites*. Also, until recently, it has been known only as a degenerate group in the Middle and Upper Triassic. The species described by Waagen from the Lower Triassic of India have been transferred to *Xenodiscus* and *Kashmirites* because of their short body chamber and strongly serrated lobes. Those species described from the Salt Range of India by Koken [36]—"*Celtites*" *fortis* and "*C.*" *radiosus*—are placed in a new subgenus of *Xenodiscus*. *Epiceltites* Arthaber is placed under the *Anasibirites* group, and *Celtites arnauticus* Arthaber,[37] from the Lower Triassic of Albania, has been renamed "*Arnautoceltites*" by Diener [38] and is probably a very primitive offshoot of the gastrioceran stock, retarded in those characters and not up to the development of *Celtites*.

However, three genuine species of *Celtites* are known in the *Columbites* fauna, near the top of the Lower Triassic of Idaho. These species—*Celtites ursensis* Smith, *C. planovolvis* Smith, and *C. apostolicus* Smith, are little-modified derivatives of *Paragastrioceras* Tchernow. They have gastrioceran septa, long body chambers, periodic constrictions, trapezoidal cross-sections, rather well-defined spiral lines on the shell, and, in the youthful stages, the broad-flattened whorl and umbilical nodes of typical *Gastrioceras*. In fact, they differ from that genus only in the bifid antisiphonal lobe, in the greater evolution and slenderness of the whorls, and in the reduction of sculpture at maturity. These species tend to bridge over the gap in the history of the Tropitidae that formerly existed from the upper Permian to the Middle Triassic. We may confidently expect to find true *Celtites* all through the Lower Triassic and down to the middle Permian, overlapping with *Paragastrioceras*.

From *Celtites* the steps upward are easy and natural, and the genealogy of the Tropitidae is simple. *Columbites* is probably a connecting link between the Tropitidae of the Triassic and the Glyphioceratidae of the Carboniferous. For a long time *Celtites* has been regarded by some paleontologists as the ancestor of the Tropitidae, in spite of the fact that no certain members of the Tropitidae were known to have young stages resembling *Celtites*. This view was held because the ontogeny of the Tropitidae points to an evolute ancestor with long body chamber and lateral ribs and destitute of keel and abdominal furrows. *Columbites* meets these requirements and is like the young stages of the more primitive members of the Tropitidae, whereas *Celtites* is somewhat retrograde and almost too primitive to be the radicle. *Columbites* is apparently tending directly toward the Tropitidae. In its youth it is decidedly like *Gastrioceras* and *Paragastrioceras*, and in adolescence it takes on the serrations of the lobes. The development of two species of this genus has been fully described by the writer,[39] and the young stages of *C. parisianus* Hyatt and Smith and of *C. spencei* Smith are fully figured, with detailed comparisons with *Gastrioceras*. In 1911 Arthaber [40] described from Albania several species of *Columbites*, which appear to approach *Tropites* more nearly than the American species do, in spite of his somewhat adverse opinion. At that time Arthaber could not know of the intergradation of *Columbites* and *Tropigastrites*, which was not published until 1914 and consequently was inaccessible to him for several years.

The writer does not mean to assert that any known species of *Columbites* in either the American or the Albanian fauna was the ancestor of *Tropites* but that something like a *Columbites* certainly was.

Columbites is chiefly characteristic of the Lower Triassic *Columbites* zone of Idaho and Albania, but some retarded species are found in the Middle Triassic of Nevada.

Family TROPITIDAE

Mojsisovics [41] has assumed that the Tropitidae developed out of *Gastrioceras* of the Carboniferous, in spite of the enormous gap that existed from the Permian to the Upper Triassic. It was supposed that *Paraceltites* of the Permian and *Isculites* of the Middle Triassic partly filled the gap, but the former genus is now assigned to Xenodiscidae and the latter to Haloritidae. The writer [42] has described several species of *Columbites* from the Lower Triassic of Idaho, and in the second paper listed he has named several species of the then new genus *Tropigastrites* from the Middle Triassic of Nevada.

Arthaber [43] recognized *Columbites* as a common member of the Lower Triassic fauna of Albania, and along with it he described the genus *Protropites*, which in his opinion has even greater right than *Columbites* to be considered the radicle of the Tropitidae. It is certainly true that the late larval stages of *Tropites subbullatus*, *Paratropites sellai*, and *Discotropites sandlingensis*, as figured by the writer [44] in 1905, six years

[36] Noetling, Fritz, Die asiatische Trias: Lethaea geognostica, Teil 2, Das Mesozoicum, Band 1, Trias, Lief. 2, pl. 22, figs. 1, 2, and explanation of plate, 1905.

[37] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 266.

[38] Diener, Carl, Neue Tropitoidea: Akad. Wiss. Wien Denkschr., Band 97, p. 512, 1919.

[39] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 51, 1905. Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, pp. 36, 37, 1914.

[40] Arthaber, G. von, op. cit. (Die Trias von Albanien), pp. 260-264.

[41] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 7, 1893.

[42] Hyatt, Alpheus, and Smith, J. P., op. cit. (Prof. Paper 40), p. 50. Smith, J. P., op. cit. (Prof. Paper 83), p. 36.

[43] Arthaber, G. von, op. cit. (Die Trias von Albanien), pp. 179, 260.

[44] Hyatt, Alpheus, and Smith, J. P., op. cit. (*Paratropites sellai*, pl. 31, figs. 14-33; *Discotropites sandlingensis*, pl. 36, figs. 1-9; *Tropites subbullatus*, pl. 79, figs. 1-6).

before the publication of Arthaber's work, resemble greatly the adults of *Protropites*. The writer accepts *Protropites* as an ancestral form but considers it a possible link between *Columbites* and *Tropigastrites*.

In the development of several genera of Tropitidae, as studied by the writer, the "*Columbites*," "*Protropites*," and "*Tropigastrites*" stages are so telescoped by unequal acceleration that it is impossible to segregate them. Reversionary or retarded groups, such as *Margarites*, *Styrites*, *Sibyllites*, and *Tropiceltites*, give strong reminiscences of the Lower and Middle Triassic ancestors but can not be correlated definitely with them. But all Tropitidae, and indeed all Tropitoidea, show in the larval stages perfect recapitulations of *Gastrioceras*, which become gradually smaller as we come up the geologic column. Therefore there is more complete agreement as to the genealogy of this group than as to that of any other phylum of ammonoids.

Family HALORITIDAE

By nearly all writers the Haloritidae have been regarded as a branch of the Tropitidae and as derivatives of the same stock of Gastrioceratea. But the writer is of the opinion that although the Haloritidae sprang from *Gastrioceras*, it was not from the main line, or of the group of *G. listeri*, but from the group of *G. globulosum* and that the divergence began even in the "Coal Measures."

Timorites Haniel, from the Permian of Timor, shows the family already differentiated then, as does *Hoffmannia* Gemmellaro, of the Sicilian Permian.

Juvenites Smith shows the first step upward from *Gastrioceras* in the *Pseudosageceras multilobatum* subzone of the Lower Triassic of Idaho. The next step is shown by *Thermalites* Smith, in the same beds, in which the septa have become slightly serrated. Both these genera are distinctly gastrioceran until nearly grown. The next sign of progress is seen in *Isculites* Mojsisovics, in the *Columbites* zone, in which the septa have become slightly ammonitic.

It was once generally thought that the needed Lower Triassic ancestral link was supplied by *Sibirites* or *Anasibirites*.[45] But this group, at least the *Anasibirites* part of it, is now definitely placed in the Meekoceratidae. However, *Isculites* gives a good connection with the varied Haloritidae of the Karnic and Noric horizons.

In the Upper Triassic *Juvavites* and *Sagenites* are the most abundant groups, followed closely by *Halorites* and its kindred. The first two of these show in their development distinct gastrioceran stages, followed by suggestions of *Isculites*.

In the Upper Karnic there are also numerous retrograde or retarded genera, such as *Leconteiceras* Smith, *Homerites* Mojsisovics, and *Metasibirites* Mojsisovics, which have stopped almost in the *Gastrioceras* stage but in their sculpture still show remnants of the characters of their more progressive kinsmen. *Metasibirites* was described by Mojsisovics [46] as a subgenus under *Sibirites*, and the assignment of *Sibirites* to the Haloritidae has caused confusion. In its development *Metasibirites* is clearly a member of the Gastrioceratea, whereas *Sibirites* almost certainly belongs to Ceratitoidea.

The development of the retrograde genera of the Haloritidae listed above has been fully described by the writer.[47]

Superfamily ARCESTOIDEA

The group here called the Arcestoidea has been called by Arthaber [48] Agathiceratea, a name which is hardly applicable as a general term for the phylum, as only the Arcestidae s. s., and the Cladiscitidae could have come from *Agathiceras*.

The first of the Arcestoidea to deploy from the parent *Gastrioceras* were the Cyclolobidae, which seem to have branched out from the group of *Gastrioceras globulosum* in the "Coal Measures," as *Paralegoceras*, *Shumardites*, and *Marathonites*. These forms have been fully described by the writer,[49] by Böse,[50] and by Haniel.[51]

All these true Cyclolobidea (excluding of course *Monophyllites* and its kindred) have apparently developed out of *Shumardites*, early reaching the transitional genus *Marathonites*, which is widespread in the lower Permian of the Ural region, Sicily, Texas, and Timor, and going on into *Perrinites*, *Waagenoceras*, and *Cyclolobus*. All these are now fairly common and well-known genera, and the young stages of most of them have been studied and described in published works by the writer.

It is not known that the Cyclolobidae continued into the Triassic, but Arthaber [52] shows that *Joannites* and its kin probably form such a continuation.

Family ARCESTIDAE

The true Arcestidae appear to have branched off from *Adrianites* Gemmellaro, of the lower Permian, and continued into the Lower Triassic in the form of *Prosphingites* Mojsisovics, which, although the earli-

[45] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 254. Arthaber accepts *Sibirites* as a member of the Meekoceratidae but places *Anasibirites* (*Pseudosibirites* Arthaber) under the Acrochordiceratidae.

[46] Mojsisovics, E. von, Beiträge zur Kenntniss der obertriadischen Cephalopoden Faunen des Himalaya: K. Akad. Wiss. Wien Denkschr., Band 63, p. 616, 1896.

[47] Hyatt, Alpheus, and Smith, J. P., op. cit. (Prof. Paper 40), p. 35. Smith, J. P., Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, pp. 21-25, 1927.

[48] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 178.

[49] Smith, J. P., The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, pp. 99, 134, 1903; Permian ammonoids of Timor: 2e Nederlandsche Timor-Expeditie onder Leiding van Dr. H. G. Jonkert: Jaarboek van het Mijnwezen in Ned. Indië, 1926, Verh. 1, pp. 31, 46, 1927.

[50] Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, western Texas: Texas Univ. Bull. 1762, pp. 99, 133, 1917.

[51] Haniel, C. A., Die Cephalopoden der Dyas von Timor: Paläontologie von Timor, Lief. 3, Abh. 6, pp. 58-65, 1915.

[52] Arthaber, G. von, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 164, 1914.

est known member, may not be the true radicle. *Parapopanoceras* Haug is another Lower Triassic genus of this phylum, but typical Arcestidae are unknown before the Middle Triassic. The stock persists until the end of the Triassic, still in its monotonous uniformity but with great wealth of species.

The writer has studied the young of *Parapopanoceras* and of numerous species of *Arcestes*, and all show striking similarity to round *Gastrioceras* and to typical *Adrianites*.

Family PTYCHITIDAE

The Ptychitidae have been most variously treated of all the so-called families of Triassic ammonoids and have been an extremely unsatisfactory mixture of heterogeneous elements. Mojsisovics[53] originally included the group under the superfamily Pinacoceratidae. Arthaber[54] puts the Ptychitidae under the phylum Tornoceratea and still includes the Gymnitinae in the family. He would thus include a large portion of Frech's Xenodiscidae, also *Gymnites* and its kindred and the early Phylloceratidae. The phylum Tornoceratea is not now generally accepted; few of the genera under it, if any, could have come from *Tornoceras* directly, for it is too far back to be accepted as a definite radicle.

In the sixth edition of Zittel's work[55] the Carnitinae and Gymnitinae are still included under Ptychitidae, although the other incongruous elements are left out.

As here restricted the Ptychitidae include *Nannites* Mojsisovics, *Paranannites* Hyatt and Smith, *Owenites* Hyatt and Smith, *Proptychites* Waagen, and *Ptychites* Mojsisovics. All these forms are very similar in the young stages, recapitulating perfectly *Gastrioceras*, with its broad roundish whorls and strong periodic constrictions. The septa change gradually from the goniatitic *Nannites*, through the ceratitic *Paranannites* and *Owenites*, to the ammonitic *Ptychites*.

The writer would also class under Ptychitidae those forms described by Hauer[56] from the Muschelkalk of Bosnia as *Proteusites* and also as the group of *Ceratites decrescens*. These species, of which the young stages have not been described, are clearly Gastrioceratea and apparently more nearly related to *Ptychites* than to the Haloritidae. The late larval stage of *Ptychites seebachi* Mojsisovics greatly resembles *Proteusites*, but this does not mean very much, for the two are approximately contemporaneous, and it is not known that *Proteusites* antedates *Ptychites*.

[53] Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 244, 1882.

[54] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 177, 1911.

[55] Zittel, K. A. von, Grundzüge der Palaeontologie, 6th ed. (edited by Ferdinand Broili), p. 560, 1924.

[56] Hauer, F. von, Beiträge zur Kenntniss der Cephalopoden aus der Trias von Bosnien: K. Akad. Wiss. Wien Denkschr., Band 59, p. 267, 1892.

SYSTEMATIC DESCRIPTIONS

Clan GEPHYROCERATEA

Superfamily PROLECANITOIDEA

Form evolute or involute, laterally compressed; body chamber usually short but long in some genera; surface commonly ornamented with ribs, in some forms with knots or spines. Septa goniatitic in some primitive forms, ceratitic in most, and ammonitic in a few highly specialized genera.

The Prolecanitoidea form a remarkably homogeneous group, but it is so various that, although the relationship is plain, there is great difficulty in giving a diagnosis that will include all the families and genera. Frech[57] used the name Ceratitoidea for the group, but he included also the Ptychitidae and the Tropitidae in it. With the exclusion of these foreign elements, however, the group, as he established it, appears to be phylogenetically homogeneous, although the members may differ as widely from one another in appearance as they do from members of other suborders. The Hungaritidae, Meekoceratidae, and Gymnitidae had been previously classed as Leiostraca and the Ceratitidae as Trachyostraca, an arbitrary separation, based on the character of the sculpture in some forms. Frech showed that rough-shelled and smooth-shelled genera might occur in any of the families and represented only stages of development. The more primitive members of each family are smooth-shelled, whereas most of the highly specialized members become rough-shelled.

The young stages of all the Prolecanitoidea, so far as known, are evolute, discoidal, little embracing, resembling *Paralecanites* Diener, which may be considered the radicle of the group and the connecting link with the true Prolecanitidae of the Carboniferous. Some few of the primitive types persist until the Triassic, such as *Lecanites*, which lived on until the Upper Triassic, and the retrograde genera revert to this type.

Under the Prolecanitoidea are included the Xenodiscidae, the Meekoceratidae, the Hungaritidae, the Phylloceratidae, the Gymnitidae, the Ceratitidae, and the Trachyceratea. All these families are supposed to have become extinct by the end of the Triassic except the Phylloceratidae, which persisted until near the end of the Cretaceous.

Family XENODISCIDAE

Form evolute, discoidal, laterally compressed. Body chamber variable in length. Surface ornamented with lateral ribs or folds. Septa goniatitic or ceratitic.

The Xenodiscidae were formerly regarded as a subfamily under the Tropitidae purely on account of

[57] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, p. 478, 1901.

their lateral ribs and supposed long body chamber. But no member of the Tropitidae has young stages that in any way resemble *Xenodiscus*, and the characters on which that reference was based occur in other groups. The Xenodiscidae can not have descended from the Glyphioceratidae, the group in which the ancestors of *Tropites* are to be sought, but from some member of the Prolecanitidae. The kinship of this group with the primitive members of the Ceratitidae, Hungaritidae, and Meekoceratidae is evident and acknowledged by most students of ammonoids. Frech probably had this family in mind when he included the Tropitidae in the suborder Ceratitoidea, although the true Tropitidae can not have any kinship with it.

The Xenodiscidae are represented in the Permian of Asia by *Lecanites*, *Xenodiscus*, and *Xenaspis;* in the Permian of the Mediterranean region by *Paraceltites* and *Paralecanites;* in the Permian of America by *Paraceltites* and *Paralecanites;* in the Lower Triassic of Asia by *Lecanites*, *Flemingites*, *Xenodiscus*, *Ophiceras*, and *Xenaspis;* and in the Lower Triassic of America and the Mediterranean by the same genera, except that *Flemingites* is not yet known in the faunas of the ancient Mediterranean. *Xenodiscus*, at least, and probably *Flemingites* are common in the Arctic Lower Triassic.

It is now pretty generally accepted that the Xenodiscidae include the ancestors of the Meekoceratidae and Ceratitidae and thus, secondarily, of the Gymnitidae and Phylloceratidae.

Genus LECANITES Mojsisovics

1882. *Lecanites*. Mojsisovics, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 199.

1895. *Lecanites*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 12th ser., Salt Range fossils, vol. 2, p. 275.

1896. *Lecanites*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 146.

1902. *Lecanites*. Frech, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 634.

1905. *Lecanites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 137.

1908. *Lecanites*. Arthaber, Ueber die Entdeckung von Untertrias in Albanien: Geol. Gesell. Wien Mitt., Band 1, p. 268.

1911. *Lecanites*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, vol. 24, p. 237.

1914. *Lecanites*. Smith, Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 65.

1915. *Proavites*. Diener, Cephalopoda Triadica; Fossilium Catalogus; I, Animalia, pt. 8, p. 228.

Not 1896. *Proavites*. Arthaber, Die Cephalopoden Fauna der Reiflinger Kalke: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 10, p. 104.

Type: "*Ceratites*" *glaucus* Muenster.[58]

Evolute, discoidal; little-embracing whorls, laterally flattened, and higher than wide. Wide umbilicus, whorls increasing slowly in height. Abdomen narrow, either flattened or rounded. Surface smooth or sculptured with radial folds. Body chamber short. not more than three-quarters of a revolution in length. Septa goniatitic, lobes and saddles all entire. The external lobe is invariably divided by a siphonal saddle. There are two lateral lobes present in all species and commonly a small auxiliary.

Lecanites, even at maturity, has a strong resemblance to *Gephyroceras*, as described and limited by Holzapfel.[59] *Lecanites vogdesi* closely resembles *G. uchtense* Holzapfel[60] of the upper Devonian of Russia. *Gephyroceras* is probably the ultimate radicle of *Lecanites* and thus of the entire group of Ceratitoidea, but the intermediate or secondary radicle was probably *Prolecanites* of the Carboniferous. *Nomismoceras* is thought by some to have been the secondary radicle but is too little known and is very improbable. It is doubtful whether the Middle Triassic species of *Lecanites* are congeneric with the Lower Triassic forms assigned to this genus. The former may be fixed or even retarded species, whereas the latter are progressive, radicle types. Diener[61] places the species of Lower Triassic age, previously assigned to *Lecanites*, under the genus *Proavites* Arthaber.[62] But this does not make the case any better, for *Proavites* is also probably only a degenerate descendant of the Meekoceratidae and has little resemblance to the typical *Lecanites* of the Lower Triassic. If a change in name must be made it will be a great deal safer to fall back upon the name *Paralecanites* Diener, even though it is not well established. The writer proposes to do this and to treat *Paralecanites* as a subgenus, to include the simple, progressive ancestral types of the Lower Triassic.

Subgenus PARALECANITES Diener

1897. *Paralecanites*. Diener, K. Akad. Wiss. Wien Sitzungsber., Band 106, p. 66.

1901. *Paraceltites* (part). Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, p. 552.

1901. *Paralecanites*. Diener, Ueber die systematische Stellung der Ammoniten des südalpinen Bellerophonkalkes: Centralbl. Mineralogie, 1901, No. 14, p. 436.

1905. *Paralecanites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 136.

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58 Muenster, G. Graf zu, Ueber das Kalkmergel-Lager von St. Cassian in Tyrol: Neues Jahrb., 1834, p. 11, pl. 1, fig. 1; also in Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 200; pl. 30, figs. 1-6; pl. 53, fig. 14, 1882.

59 Holzapfel, E., Die Cephalopoden des Domanik im südlichen Timan: Com. géol. [St. Pétersbourg] Mém., vol. 12, No. 3, p. 27, 1899.

60 Idem, pl. 5, figs. 4-7.

61 Diener, Carl, Fossilium Catalogus; I, Animalia, pt. 8, Cephalopoda Triadica, p. 228, 1915.

62 Arthaber, G. von, Die Cephalopoden Fauna der Reiflinger Kalke: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 10, Heft 1, p. 104, 1896.

Type: *Paralecanites sextensis* Diener.

This subgenus is characterized by its evolute, little-embracing, low whorls, wide umbilicus, almost total absence of sculpture, and goniatitic septa. The ventral lobe is divided, and there are two laterals, with no auxiliary lobe. The internal lobes are unknown on the type but presumably would consist of an antisiphonal lobe flanked by an internal lateral, as this is the arrangement in all primitive ammonites of this group.

These characters agree in all essentials with the genus *Lecanites* Mojsisovics, except in the absence of the auxiliary lobe, and Diener regards *Paralecanites* as the stock from which sprang *Lecanites* and the Meekoceratidae.

Frech [63] regards *Paralecanites* as synonymous with *Paraceltites* Gemmellaro, disregarding the sculpture and the shape of the external lobe in *Paraceltites*. The latter character is probably not fundamental, for *Paraceltites elegans* Girty and *P. multicostatus* Böse both show a slight division of the external lobe. The length of the body chamber is also doubtful in all these forms.

Horizon and locality: *Paralecanites* was first known from the Permian of the Alps, but species agreeing in all essentials with the generic characters of the type have been found in the Lower Triassic *Meekoceras* zone of southeastern Idaho, associated with a typical Lower Triassic fauna. Also most of the so-called *Lecanites* described by Waagen from the Salt Range of India and by Arthaber from the *Columbites* zone of Albania would fall under the subgenus *Paralecanites*.

Lecanites (Paralecanites) arnoldi Hyatt and Smith

Plate 28, Figures 8–10; Plate 39, Figures 9–12; Plate 59, Figures 8–10; Plate 64, Figures 1–16

1905. *Paralecanites arnoldi*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 136, pl. 64, figs. 1–16; pl. 77, figs. 9–12.

Form evolute; whorls subquadratic in cross section, slightly higher than wide, low and increasing very slowly in height, little embracing, and scarcely indented by the inner whorls. The sides and venter are flattened, the umbilical shoulders are rounded, and the ventral shoulders subangular, this character being more pronounced in the late adolescent stages than at maturity.

The umbilicus is very wide and shallow, being nearly half the entire diameter of the shell.

The septa are goniatitic, consisting of a divided ventral lobe, a large first lateral lobe, and a small second lateral just above the umbilical shoulder. There is no auxiliary lobe, but the internal lateral is visible, on account of the evolution of the shell, outside the umbilical suture. The antisiphonal lobe is long and divided.

The septa are exactly like those of *Lecanites* except in the lack of an auxiliary lobe, there being only 8 lobes in *Paralecanites* and 10 in *Lecanites* s. s.

The surface at maturity is nearly smooth, ornamented only with nearly obsolete low radial folds. In early youth, up to a diameter of about 5 millimeters, the folds are much stronger and the cast is marked with distinct constrictions that run from the umbilicus across the venter. At this stage, also, the cross section of the whorl is rounded instead of subquadratic and the ventral lobe is undivided, the division taking place at a diameter of a little more than 5 millimeters.

This early adolescent stage of *Paralecanites* is like that of *Xenodiscus*, as described and figured in this paper, and the mature form is very like the larval stages of *Meekoceras*. This resemblance points to *Paralecanites* as the radicle of the Meekoceratidae, a family which must have developed in the Permian, for highly specialized representatives are known at the very bottom of the Triassic and, indeed, in a formation considered by some authorities to be upper Permian. *Paralecanites arnoldi* can not therefore be the radicle but is merely a little-modified survival of the ancestral form.

It is highly probable that *Paralecanites*, or some similar form, was the family radicle, not only of the Meekoceratidae but also of all the true Prolecanitoidea. It is also probable that this form came from the earlier Paleozoic genus *Prolecanites*, through the Permian *Paraceltites*. This relationship would make the Prolecanitoidea descendants of the direct line of Prolecanitidae, whereas *Medlicottia* and its allies are descended from a side branch of the same stock.

Horizon and locality: *Meekoceras* zone, Lower Triassic, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Pseudosageceras multilobatum*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Paranannites aspenensis*, *Flemingites russelli*, and many other forms characteristic of the Lower Triassic.

Lecanites (Paralecanites) knechti Hyatt and Smith

Plate 9, Figures 11–16; Plate 28, Figures 1–7

1905. *Lecanites knechti*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 138, pl. 9, figs. 11–16.

Evolute, discoidal, laterally compressed; wide, shallow umbilicus; sides flattened, umbilical shoulders broadly rounded; venter rather broad and rounded, so that there are no distinct abdominal shoulders.

[63] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, p. 478, 1901.

Whorls increasing slowly in height and little embracing, concealing only about one-third of the inner volution and being indented to only one-sixth of the height by it. The width of the whorl is nearly three-fourths of the height.

Surface smooth, only casts that show no ribs nor folds being known.

Septa goniatitic, external lobe divided into two narrow short branches, which fall on the abdominal shoulders; first lateral longer and much broader; second lateral nearly as broad as the first but much shorter. Auxiliary lobe lacking entirely. Internal septa consisting of a long antisiphonal lobe and a short shallow lateral, just inside the umbilical suture. The form and septa are exactly like those of the young of *Flemingites aplanatus*, but the lobes of *Flemingites* become serrated at a very early adolescent stage, whereas those of *Lecanites* remain goniatitic.

Lecanites knechti belongs to the group of *L. gangeticus* De Koninck, characterized by the possession of rounded instead of angular and flattened venters, and in shape it is most nearly related to the Salt Range species of India, but differs in lacking the auxiliary lobe and in not having any varices on the shell.

L. knechti also resembles *L. glaucus* Muenster, the type of the genus, but is somewhat more evolute than that species and lacks the auxiliary, which is present on the type species.

There are in the Lower Triassic of America several species of *Xenodiscus* that agree closely with this species of *Lecanites*, except that they possess ceratitic lobes and thus are more highly developed, either out of it or some similar member of the same genus. They all go through a *Lecanites* stage.

Relative dimensions of the type of Lecanites knechti

Diameter	100
Height of last whorl	35
Height of last whorl from preceding	30
Width of last whorl	26
Width of umbilicus	39
Involution	5

Actual diameter of the type specimen, 30 millimeters.

Horizon and locality: *Lecanites knechti* was found by J. P. Smith in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of the Inyo Range in Union Wash, about 1½ miles east of Union Spring, about 15 miles southeast of Independence, Inyo County, Calif. It was associated with *Meekoceras gracilitatis* White, *M. mushbachanum* White, and many other characteristic species of the Lower Triassic.

It was also found in the *Meekoceras* zone, at Wood Canyon, Aspen Ridge, Idaho, 9 miles east of Soda Springs, in approximately the same fauna as in California but lower in the *Meekoceras* zone.

Genus XENODISCUS Waagen

1879. *Xenodiscus* (part). Waagen, *Productus* limestone fossils: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 1, p. 32.
1886. *Xenodiscus*. Mojsisovics, Arktische Triasfaunen: Acad. imp. sci. [St.-Pétersbourg] Mém., 7th ser., vol. 33, No. 6, p. 74.
1895. *Xenodiscus*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 161.
1895. *Xenodiscus*. Diener, Cephalopoda of the Muschelkalk: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 2, p. 110.
1897. *Danubites*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 24.
1900. *Wyomingites*. Hyatt, Cephalopods, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 556.
1902. *Xenodiscus*. Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 634a.
1903. *Proceratites*. Kittl, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol Reichsanstalt Wien Abh., Band 20, Heft 1, p. 28.
1909. *Xenodiscus*. Diener and Krafft, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 83.
1911. *Xenodiscus*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 227.
1913. *Xenodiscus*. Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 2.
1914. *Xenodiscus*. Smith, Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 55.
1922. *Xenodiscus*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 106.
1927. *Xenodiscus*. Yehara, The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, p. 163.
1927. *Xenodiscus*. Smith, Permian ammonoids of Timor: 2e Nederlandsche Timor-Expeditie onder Leiding van Dr. H. G. Jonkert: Jaarboek van het Mijnwezen in Ned.-Indië, 1926, Verh. 1, p. 28.
1929. *Xenodiscus*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1.

Type: *Xenodiscus plicatus* Waagen.[64]

Evolute, discoidal, little embracing, increasing slowly in height, widely umbilicate, laterally compressed. Body chamber said to be long but in reality not so. Lateral sculpture strong, even on inner whorls, consisting of strong folds running from the umbilicus up the sides. Venter abruptly rounded. Septa ceratitic, lobes and saddles short.

When this genus was first named, Waagen placed it in the Leiostraca, in close relationship with *Gymnites*.

[64] Waagen, W., *Productus* limestone fossils: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 1, p. 34, pl. 2, figs. 1, 1a, 1f, 1879.

Further study, however, convinced him that this would apply only to one species classed under *Xenodiscus*, which he afterward separated under the name *Xenaspis carbonaria* Waagen. The type, *Xenodiscus plicatus*, was then classed under the Celtitinae, subfamily of the Tropitidae. In the meantime Mojsisovics,[65] under the supposition that "*Ceratites*" *carbonarius* was the type of *Xenodiscus*, classed *X. plicatus* under the group of Ceratites obsoleti, which he afterward designated by the subgeneric title *Danubites*. The Middle Triassic species classed by Diener under *Xenodiscus* belong to *Xenaspis*. Thus only the type, *Xenodiscus plicatus* Waagen, remained under this genus. It became therefore extremely easy to determine the generic characters. It is not so easy, however, to determine the systematic position. Waagen considered it to be intermediate between *Paraceltites* and *Celtites*, but this view has nothing to sustain it. The possession of a long body chamber alone is not sufficient to place this genus in the Tropitidae, for the writer has demonstrated that members both of the Ptychitidae and of the Ceratitidae may have body chambers at least a revolution long. It is also very doubtful whether the type of *Xenodiscus* possesses a body chamber as long as a full revolution.

Frech[66] classes *Xenodiscus*, *Xenaspis*, *Hungarites*, and *Otoceras* together as the subfamily Xenodiscinae under the Ceratitoidea. By leaving out *Hungarites* and *Otoceras* this is a proper classification, for *Xenodiscus* and *Xenaspis* are certainly related to the general group of ceratitic ammonites, either as ancestors or as survivals of ancestral types, whereas *Hungarites* and *Otoceras* are more specialized and have no right to be classed in the ancestral group. It is highly probable that the Meekoceratidae, the Hungaritidae, and the Ceratitidae all sprang from a common stock—the Xenodiscinae—and that this group took its origin from some primitive form like *Paralecanites*. But this differentiation must have taken place before the upper Permian, for there we have *Xenodiscus*, *Xenaspis*, *Paraceltites*, *Paralecanites*, *Otoceras*, and *Hungarites*, all flourishing simultaneously.

The genus *Xenodiscus* has been completely revised, restricted, and expanded by Krafft and Diener.[67] These authors include in *Xenodiscus* most of the Lower Triassic species formerly ascribed to *Danubites*, nearly all of *Gyronites*, many of *Prionolobus*, and some of the so-called *Celtites*. This arrangement expands *Xenodiscus* far beyond what Waagen intended the genus to include and will probably necessitate subdividing it into several subgenera. This has already been partly done, in the recognition of *Paratirolites* Stoyanow and *Xenaspis* Waagen as subgenera, and of the unnamed group of *Xenodiscus nivalis* as nearly related to *Paratirolites*. Among these different forms may be found the ancestors of *Ophiceras*, *Flemingites*, *Meekoceras*, *Anasibirites*, and even of the multiform group of *Ceratites* itself.

The following species of *Xenodiscus* are recognized in the Lower Triassic of America: Group of *Xenodiscus plicatus* Waagen, *Xenodiscus* s. s.: *X. cordilleranus* Smith, *X. gilberti* Smith, *X. intermontanus* Smith, *X. rotula* Waagen, *X. toulai* Smith, *X. waageni* Hyatt and Smith, *X. whiteanus* Waagen; group of *Xenodiscus nivalis*: *X. nivalis* Diener; group of *Xenodiscus carbonarius* Waagen, subgenus *Xenaspis* Waagen: *X. marcoui* Hyatt and Smith.

Xenodiscus cordilleranus Smith, n. sp.

Plate 24, Figures 21–29

Shell small, evolute, discoidal, widely umbilicate, somewhat compressed laterally, little embracing. Cross section of whorl subquadratic, with abruptly rounded umbilical and ventral shoulders. Ornamented with fine, strong transverse ribs that cross the venter without interruption. These ribs are bundled somewhat after the manner of those on *Cuccoceras*, suggesting kinship and possible ancestry of that Middle Triassic genus. The form is more like *Ophiceras*, but the absence of the spiral striae does not permit a reference to this genus. The septa are ceratitic, with three external serrated lobes, the auxiliary not being developed.

The height of the last whorl is less than one-third of the diameter of the shell. The width is two-thirds of the height; the width of the umbilicus is three-sevenths of the diameter of the shell. The outer whorl embraces two-fifths of the inner and is indented to one-fourth of the height.

Xenodiscus cordilleranus has some resemblance to *X. intermontanus* but differing in its squarer whorl and much stronger sculpture.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Aspenites acutus*, *Pseudosageceras multilobatum*, and other forms.

Xenodiscus gilberti Smith, n. sp.

Plate 24, Figures 1–9

Shell small, discoidal, laterally compressed, moderately umbilicate, with gently curving sides and narrow, slightly flattened venter. Surface with very fine but distinct radial ribs that curve forward on the flanks.

[65] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 20, 1886.

[66] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, p. 478, 1901.

[67] Krafft, A. von, and Diener, Carl, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, No. 1, pp. 83 et seq., 1909.

Septa ceratitic, with three external rounded saddles and three broad serrated lobes. The auxiliary (or fourth lobe) is not developed. The height of the last whorl is two-fifths of the diameter of the shell, and the width is slightly more than half the height. The width of the umbilicus is about one-third of the diameter of the shell. The outer whorl embraces two-fifths of the inner and is indented by it to one-fifth of the height.

Xenodiscus gilberti is not closely related to any other species in the Lower Triassic of America but resembles *X. schmidti* Mojsisovics,[68] of the Lower Triassic Olenek fauna of Siberia, differing in its somewhat stronger sculpture and slightly more compressed whorl. It can not be the young of *Meekoceras sylvanum*, being more evolute than even the young of that species and having stronger sculpture. It is much more compressed than the young of *Flemingites aplanatus* and lacks the spiral lines that appear at an early stage on all *Flemingites*.

Named in memory of G. K. Gilbert.

Horizon and locality: Rare in the Lower Triassic zone of *Meekoceras*, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, Idaho; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Pseudosageceras multilobatum*, and other forms.

Xenodiscus intermontanus Smith, n. sp.

Plate 24, Figures 10–20

Shell rather small, evolute, somewhat compressed laterally, widely umbilicate, with abrupt umbilical shoulders, convex flanks, gently rounded ventral shoulders, and broadly rounded venter. Surface ornamented with fine striae of growth and broad obscure folds. Septa ceratitic, with four external serrated lobes. Length of body chamber seven-eighths of a revolution.

The height of the last whorl is about one-third of the diameter of the shell; the width is two-thirds of the height; the width of the umbilicus is one-third of the diameter of the shell.

Xenodiscus intermontanus is very closely related to *X. himalayanus* Griesbach,[69] of the Lower Triassic of India, but differs in the more robust whorls and greater flattening of the venter, as well as in the less individualized auxiliary lobe.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Aspenites acutus*, *Lanceolites compactus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, *Paranannites aspenensis*, *Juvenites kraffti*, and other forms; also at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs, in the same horizon and fauna.

[68] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 78, pl. 11, figs. 9–10, 1886.

[69] Diener, Carl, Cephalopoda of the Lower Trias: Palaeontologia Indica, 15th ser., vol. 2, pt. 1, p. 41, pl. 14, fig. 14, 1897.

Xenodiscus nivalis Diener

Plate 56, Figures 6–12; Plate 79, Figures 1, 2

1897. *Danubites nivalis*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 51, pl. 15, figs. 17–19.

1909. *Xenodiscus nivalis*. Krafft and Diener, Lower Triassic Cephalopoda of Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, No. 1, p. 102, pl. 24, figs. 1, 2, 3, 5; pl. 25, fig. 5.

1922. *Xenodiscus nivalis*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 107, pl. 159, figs. 19, 20.

1929. *Xenodiscus hannai*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 5, pl. 1, figs. 1, 4.

Shell of medium size, very evolute, discoidal, somewhat compressed laterally, with subrectangular cross section, little embracing, and little indented by the inner whorl. Ornamented with strong lateral ribs that become nearly obsolete on the venter, crossing it only as low folds. These ribs are commonly so coarse as to become almost knobs. Septa ceratitic, with rounded saddles and four external well-developed serrated lobes. Length of body chamber not visible on the American specimens but on a fine series from Timor are seen to be about seven-eighths of a revolution.

Xenodiscus nivalis was first described from the Lower Triassic *Hedenstroemia* beds of the Himalayas in India; it has since been found to be abundant at the same horizon, and in the same association, on Timor, in the East Indies. It is not nearly related to any other species in that region or in America, standing alone as a representative of a group closely allied to *Paratirolites* Stoyanow,[70] of the Lower Triassic of the Caspian region and of Madagascar. This group has not had a subgeneric name given to it, probably because only one species of it has been found. Several varieties of it have been found in the *Flemingites* beds of Timor, all intergrading with the typical form. The American specimens all belong to the typical form.

Horizon and locality: Very rare in the *Owenites* subzone of the *Meekoceras* zone of the Phelan ranch, mouth of Cottonwood Canyon, east side of the Ruby Range, Nev., about 70 miles south of Wells; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Inyoites oweni*, *Aspenites acutus*, *Lanceolites bicarinatus*, *Pseudosageceras multilobatum*, and other forms. It occurs sparingly in the *Anasibirites* beds of Fort Douglas, Utah.

[70] Stoyanow, A. A., On the character of the boundary of Paleozoic and Mesozoic near Djulfa: Russ. k. mineral. Gesell. Verh., 2d ser., Band 47, pt. 3, p. 75, 1909.

Xenodiscus rotula Waagen

Plate 79, Figures 5, 6

1895. *Gyronites rotula.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 300, pl. 38, figs. 3–5.
1895. *Gyronites radians.* Waagen, op. cit., p. 302, pl. 38, figs. 6–8.
1909. *Xenodiscus rotula.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, No. 1, p. 93, pl. 23, figs. 4, 5; pl. 27, figs. 4, 5.
1913. *Xenodiscus rotula.* Diener, Triassic fauna of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 12, fig. 2.
1929. *Ophiceras matheri.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 4, pl. 1, figs. 38–40.
1929. *Xenodiscus douglasi.* Mathews, op. cit., p. 5, pl. 1, figs. 5–7.
Not 1922. *Xenodiscus rotula.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 106, pl. 159, figs. 8–10; pl. 160, figs. 3, 4.

Form evolute, discoidal, laterally compressed; whorls slowly increasing in height, embracing, and slightly indented by the inner volution. Sides nearly flat and parallel. Shoulders rounded. Umbilicus very wide and shallow, being nearly one-half the diameter of the shell. Inner wall nearly vertical. Height of the last whorl less than twice its greatest thickness and nearly one-fourth its diameter. It is indented to one-fourth its height by the inner volution and conceals about one-third of this volution. Venter rounded and smooth. The shell is thin and smooth. Surface ornamented with many wide, nearly straight, weak folds which are bent forward near the outer margins of the side walls and cross the venter in a progressive manner. They are well defined near the umbilical shoulder on the side wall and show on all the volutions. Sutures ceratitic, with entire saddles and a divided ventral lobe.

This species was first described from the Lower Triassic of India; it is fairly common in the *Flemingites* beds of Timor and occurs sparingly in the *Anasibirites* beds of Utah, where it was described under the name *Ophiceras matheri.* The description given above is taken from Mathews's text, cited in the synonymy of this species.

Horizon and locality: Pinecrest formation, on the ridge between Parleys and Mill Canyons, central Wasatch Range, Utah.

Xenodiscus tarpeyi Smith, n. sp.

Plate 25, Figures 4–6

Evolute, discoidal, laterally compressed, widely umbilicate; sides flat, umbilical shoulders abruptly rounded, venter gently rounded. The surface is nearly smooth, with very faint radial folds.

The septa are serrated, with rounded entire saddles and four serrated lobes—an external, two lateral, and a differentiated auxiliary.

The outer whorl is two-fifths of the diameter of the shell, and embraces one-third of the inner; the width is four-fifths of the height. The width of the umbilicus is one-third the diameter of the shell. The length of the body chamber appears to be nearly or quite an entire revolution, which, however, appears to be not unprecedented in *Xenodiscus* and *Xenaspis.*

Xenodiscus tarpeyi has some resemblance to *Flemingites russelli* but differs in being more compressed and with flatter venter than that species and also in lacking the strong spiral lines. It differs from *Flemingites aplanatus* in somewhat the same way but has not the strongly subquadratic section of that species. In fact, it has a general resemblance to many species of so-called *Xenodiscus, Xenaspis, Ophiceras,* and *Flemingites* of the Lower Triassic, which only goes to emphasize the near kinship of these forms and to minimize the importance of these artificial generic distinctions.

Named in honor of David Tarpey, who assisted in the collection of this fauna.

Horizon and locality: Very rare in the Lower Triassic *Pseudosageceras multilobatum* subzone of the *Meekoceras* zone, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, southeastern Idaho; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Cordillerites angulatus, Lanceolites compactus, Aspenites acutus,* and other forms.

It was also doubtfully identified in the *Owenites* subzone of Union Wash, Inyo Mountains, Inyo County, Calif.

Xenodiscus toulai Smith, n. sp.

Plate 25, Figures 1–3; Plate 53, Figures 9–12

Form evolute, laterally compressed, widely umbilicate. Umbilical shoulders indistinct, sides sloping gradually to the rather narrowly rounded venter. Whorls rather high, with the greatest breadth low down toward the umbilical shoulders. Surface strongly sculptured with fine straight transverse ribs that become obsolete at the venter. Septa ceratitic, with rounded saddles and four serrated external lobes. Length of body chamber not visible on the few specimens known.

Xenodiscus toulai is closely related to "*Prionolobus*" *falcatum* Waagen, from the Salt Range of India, differing in the greater narrowing of the whorl toward the top and in the less distinct umbilical shoulders. It also resembles *Xenodiscus himalayanus* Griesbach, from the Lower Triassic of the Himalayas, but has finer sculpture and straight instead of somewhat curved ribs.

The species is named in honor of Franz Toula, in recognition of his contributions to Triassic paleontology.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone of locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs, southeast Idaho; also one specimen in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif. At the Idaho locality it was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Lanceolites compactus*, *Pseudosageceras multilobatum*, and other forms. At the California locality it was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Lanceolites compactus*, *L. bicarinatus*, *Pseudosageceras multilobatum*, *Inyoites oweni*, *Owenites koeneni*, *Anasibirites desertorum*, *A. noetlingi*, and other forms. The horizon in California is evidently somewhat higher than that in Idaho.

Xenodiscus waageni Hyatt and Smith

Plate 23, Figures 12–17; Plate 39, Figures 3–8

1905. *Meekoceras (Prionolobus) waageni*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 150, pl. 77, figs. 3–8.

Evolute, discoidal, laterally compressed. Whorls little embracing and little indented by the inner volutions. Sides flattened convex, venter narrow and rounded; greatest width at a point on a level with the top of the inner whorl. Umbilical shoulders gently rounded, umbilicus wide and shallow.

Surface ornamented only with low radial folds, visible only on the shell.

Septa ceratitic; external lobe divided by a siphonal notch into two short branches; first lateral long; second lateral about two-thirds of the size of the first. Auxiliary series consisting of a straight row of denticulations on the umbilical slope. The antisiphonal lobe is flanked by a single internal lateral. The height of the last whorl is about twice its width and two-fifths of the total diameter. It is impressed by the inner whorl to one-fourth of its height and conceals slightly more than one-half of the inner whorl. The width of the umbilicus is two-fifths of the total diameter of the shell.

Horizon and locality: *Xenodiscus waageni* was found by A. M. Strong in the *Owenites* subzone of the Lower Triassic *Meekoceras* zone of the Inyo Range, 1½ miles east of Union Spring, on the old McAvoy trail across to Salinas Valley, 15 miles southeast of Independence, Inyo County, Calif. It was also found in the *Meekoceras* zone of southeast Idaho, at locality 1, 5 miles east of Grays Lake; at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs. The species is associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, *Paranannites aspenensis*, and other forms.

Xenodiscus whiteanus (Waagen)

Plate 25, Figure 17

1880. *Meekoceras aplanatum* (part). White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, pl. 31, fig. 1c (not figs. 1a, b, and d, ≐ *Flemingites aplanatus*).
1895. *Danubites whiteanus*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 290.

Shell small, evolute, discoidal, laterally compressed, slender, little embracing, whorls with convex flanks and venter. Septa ceratitic, with rounded saddles and three external serrated lobes. Surface ornamented with very fine transverse folds.

Xenodiscus whiteanus was included by White[71] under what is now called *Flemingites aplanatus*, but an examination of the original in the United States National Museum failed to show any spiral striae that would throw the form under either *Flemingites* or *Ophiceras*. It is much too slender to be the young of *F. aplanatus* and also more slender than *Xenodiscus waageni*, the only form with which it might be compared. No other specimen than the one figured by White has ever been found, although the writer has collected at all the Triassic localities in Idaho frequently.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone in southeastern Idaho, at locality 2, Slug Creek, Aspen Mountains, about 14 miles east of Soda Springs, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, and other forms.

Subgenus XENASPIS Waagen

1895. *Xenaspis*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 161.
1895. *Xenaspis*. Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 38.
1897. *Xenaspis*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 83.
1902. *Xenodiscus* (part). Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 634a.
1903. *Proceratites*. Kittl, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 28.

[71] White, C. A., U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1 pl. 31, 1880.

1905. *Xenaspis*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 115.

1911. *Xenaspis*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 230.

Moderately long body chamber; whorl evolute, little embracing, discoidal; wide, shallow umbilicus, caused by the slow increase in height and thickness of the whorls. Lateral sculpture faint, the inner volutions being smooth. Septa ceratitic, lobes and saddles short, the two laterals longer than the external. The internal septa consist of a short, bifid antisiphonal lobe, flanked by a lateral on the umbilical suture, which might be considered an auxiliary lobe. Waagen [72] first assigned this form to his genus *Xenodiscus* and then separated it from that group on account of its faint lateral sculpture, as contrasted with the strong folds of *Xenodiscus plicatus* Waagen, the type of the genus.

As thus defined *Xenaspis* is known in the upper Permian of the Salt Range and the Himalayas in India; the Lower Triassic *Meekoceras* zone of the Inyo Range in California; the Lower Triassic *Columbites* zone of Albania; and the Middle Triassic of eastern Siberia and India.

Frech,[73] in his revision of the ammonites of the Permian, drops the genus *Xenaspis* as insufficiently differentiated from *Xenodiscus*. The writer has, however, retained the subgenus as Waagen defined it, because it seems to have given rise to the Gymnitidae, whereas *Xenodiscus* seems to have been the radicle of many of the highly ornamented ammonites of the Triassic. This separation is artificial but not more so than that in many other groups of Triassic ammonites. The confusion existing at present would not be helped by assigning all the evolute discoidal ceratitic ammonites of the Permian and Lower Triassic to *Xenodiscus* and *Ophiceras*, for the differentiation of these two genera is just as artificial and difficult as that of *Xenaspis* from *Xenodiscus*.

The Gymnitidae, Meekoceratidae, and Ceratitidae were certainly differentiated in the Lower Triassic, and it is probable that evolute discoidal ceratitic genera of all three families ought to be recognized in the Permian. Waagen's classification is an attempt to do this.

Xenodiscus (Xenaspis) marcoui Hyatt and Smith

Plate 7, Figures 26–33

1905. *Xenaspis marcoui*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 116, pl. 7, figs. 26–33.

1927. *Xenaspis* cf. *X. marcoui*. Yehara, The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, p. 165, pl. 16, figs. 1–4.

Evolute, discoidal, laterally compressed. Whorl little embracing and little indented by the inner volution. Sides flattened convex, venter narrow and rounded. Umbilicus wide and shallow. The height of the last whorl is three-eighths of the diameter of the shell, and the width is two-thirds of the height. It is indented to about one-fourth of its height by the inner whorl. The width of the umbilicus is one-third of the total diameter.

The surface is ornamented with low radial folds, never forming ribs. The body chamber is at least a revolution long.

The septa are ceratitic. The ventral lobe is divided by a shallow siphonal saddle into two short goniatitic branches. The first and second laterals are serrated, and the auxiliary lobe is goniatitic. The antisiphonal lobe is long, narrow, and entire, flanked by a similar internal lateral on each side.

Xenaspis marcoui differs from *X. carbonaria* Waagen in the flattening of the whorl and in having the external lobe goniatitic instead of serrated.

Horizon and locality: This species was found by J. P. Smith in the *Owenites* subzone of the *Meekoceras* zone of the Lower Triassic of the Inyo Mountains, in Union Wash, 1½ miles east of Union Spring, 15 miles southeast of Independence, Inyo County, Calif. It was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites aplanatus*, *Pseudosageceras multilobatum*, and many other characteristic species of the Lower Triassic.

Xenodiscus (Xenaspis) nevadanus Smith, n. sp.

Plate 56, Figures 1–5

Shell of moderate size, evolute, discoidal, widely umbilicate, whorls little embracing and little indented by the inner whorls. Sides somewhat flattened, umbilical shoulders very abrupt, ventral shoulders gently rounded, venter rather narrow and rounded. Surface nearly smooth, with very gentle transverse folds. Septa serrated, with entire saddles, and three external serrated lobes, no auxiliary being visible above the umbilical suture.

The height of the whorl is greater than one-fourth of the diameter of the shell; the width of the last whorl is three-fourths of the height; the indentation is one-seventh of the height. The width of the umbilicus is three-sevenths of the diameter of the shell. The largest specimen found had a diameter of 50 millimeters and was entirely septate.

Xenodiscus nevadanus is not nearly related to any other species of American fauna.

[72] Waagen, W., *Productus* limestone fossils: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 1, p. 35, 1879.

[73] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 634a, 1902.

Horizon and locality: Rather rare in the *Owenites* subzone of the Lower Triassic, of the Phelan ranch on the east side of the Elko Mountains, at the mouth of Cottonwood Canyon, Elko County, Nev.; associated with *Meekoceras gracilitatis*, *Owenites* cf. *O. koeneni*, *Lanceolites bicarinatus*, *Inyoites oweni*, *Pseudosageceras multilobatum*, *Anasibirites desertorum*, and other forms.

Genus OPHICERAS Griesbach

1880. *Ophiceras*. Griesbach, Palaeontological notes on the Lower Trias of the Himalayas: India Geol. Survey Rec., vol. 13, p. 109.

1895. *Ophiceras*. Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 43.

1897. *Ophiceras*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 100.

1902. *Ophiceras*. Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 636.

1905. *Ophiceras*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 117.

1913. *Ophiceras*. Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 14.

1922. *Ophiceras*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 103.

1927. *Ophiceras*. Yehara, The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, p. 161.

Not 1929. *Ophiceras*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 4.

Type: *Ophiceras tibeticum* Griesbach.[74]

Evolute, little embracing; whorls increasing slowly in height; umbilicus wide and moderately deep. Surface ornamented with faint folds and cross striae, sometimes with coarse lateral ribs in age. The inner casts are ornamented with a delicate spiral striation, formed by the inner pearly layer of the shell, which is unknown on any other group of ammonites, although *Flemingites*, *Sturia*, and some shells of *Ceratites* and *Tropites* have the external striation. On account of this peculiar sculpture Diener classes this genus with the Gymnitinae, along with *Flemingites*.

The septa are ceratitic; the lobes and saddles usually ong and narrow, there being the usual number, the divided external, the two laterals, and the small auxiliary on the umbilical shoulder. Mojsisovics [75] described under the name of *Xenodiscus karpinskyi* a species that may belong to *Ophiceras*. Waagen [76] thought that of the species described by Griesbach as *Ophiceras*, only *O. tibeticum* could remain under that genus and that the others should be classed under *Gyronites*. Mojsisovics [77] at first considered *Ophiceras* merely as a synonym of *Xenodiscus*. In a later work he still considered most species of *Ophiceras* to belong to *Xenodiscus*, but *O. himalayanum* Griesbach and *X. plicatus* Waagen he placed in the group of Ceratites obsoleti, to which he afterward gave the name of *Danubites*.

It will be seen from this review that this genus has been variously misinterpreted or else ignored, and Waagen's recognition of even one species was due to his mistake of supposing that there was an adventitious lobe. This lobe has been shown by Diener not to exist on the type, and Waagen's error was due to a poor drawing.

Ophiceras resembles *Danubites*, from which it is distinguished by its spiral sculpture on the inner layer of the shell; from *Xenaspis* it is distinguished in the same way, also by its shorter body chamber; from *Xenodiscus*, by these same characters and by its fainter sculpture on the inner whorls. *Gyronites* is much more difficult to separate from *Ophiceras* because of the uncertainty of its characters; many species that were assigned by Waagen to *Gyronites* may belong to *Ophiceras*, but the diagnostic mark, the spiral striation, appears only on the cast, as that disappears when the shell is preserved, and also when the specimen is poorly preserved. *Ophiceras* is characteristic of the Lower Triassic, being known in beds of that age in India and eastern Siberia, in the *Meekoceras* zone in the Aspen Mountains of Idaho, and in the same zone in the Inyo Range of California and in the *Columbites* zone of Idaho and Albania.

Frech [78] assigns the *Ophiceras* beds of India and Siberia to the upper Permian, but there is no longer any question of the abundant occurrence of *Ophiceras* in the Lower Triassic in Asia, Europe, and western America.

Ophiceras dieneri Hyatt and Smith

Plate 8, Figures 16–29

1905. *Ophiceras dieneri*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 118, pl. 8, figs. 16–29.

Evolute, discoidal, laterally compressed, widely umbilicate. Whorls little embracing and little indented by the inner volution. The height of the whorl is less than one-third of the total diameter of the shell, and the width is three-fourths of the height. It embraces about one-third of the inner volution. The width of the umbilicus is nearly half the total diameter of the shell. The umbilical shoulders are rounded,

[74] Griesbach, C. L., Palaeontological notes on the Lower Trias of the Himalayas: India Geol. Survey Rec., vol. 13, p. 109, pl. 3, figs. 1–7, 1880.

[75] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 75, 1886.

[76] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 6, pt. 2, p. 209, 1895.

[77] Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k geol. Reichsanstalt Wien Abh., vol. 10, p. 232, 1882.

[78] Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, pp. 628–639, 1902.

with gentle inward slope; the flanks are convex, with the greatest width at half the height of the whorl. The abdominal shoulders are abrupt, subangular; the venter flat and rather narrow. There are no ribs on the shell but only low radial folds. The surface is ornamented with fine spiral lines, which are seldom preserved. This ornamentation is the distinguishing character of the genus.

The septa are ceratitic. The external lobe is divided by a short, narrow, siphonal saddle into two small unserrated lobes; the first lateral lobe long and narrow, the second very small. Both lateral lobes are slightly serrated; on the umbilical suture there is a small auxiliary, unserrated.

This species is most nearly related to *Ophiceras demissum* Oppel, as figured and described by Diener.[79] But in the Indian species the radial sculpture is stronger and the spiral lines weaker than on *Ophiceras dieneri*. The faunal association of the two is approximately the same, and the differences here noted are not greater than those often found between varieties of the same species.

Horizon and locality: In the Lower Triassic *Meekoceras* zone of southeastern Idaho, in the Aspen Mountains, Wood Canyon, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, F. aplanatus, Clypeoceras, Hedenstroemia, Xenodiscus*, and many other forms characteristic of the *Meekoceras* zone.

Ophiceras jacksoni Hyatt and Smith

Plate 62, Figures 11–21

1905. *Prionolobus jacksoni*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 151, pl. 62, figs. 11–21.

Form evolute, discoidal, laterally compressed. Whorls of moderate height but increasing slowly in height; rather deeply embracing, and deeply indented by the inner volutions. Sides flattened, umbilical shoulders gently rounded, venter highly arched and narrow; no ventral shoulders perceptible. Umbilicus wide and shallow. The height of the whorl is about two-fifths of the total diameter of the shell, and the width half of the height. The indentation is somewhat less than one-third of the height. The width of the umbilicus is about three-tenths of the total diameter of the shell.

The surface is smooth, ornamented only with cross striae of growth and very fine spiral lines. The septa are ceratitic, lobes all serrated, and saddles all rounded and entire. The general character of the septa is the same as that of *Meekoceras* s. s., but there is no fourth lateral lobe; instead there is a long, straight row of denticulations. This character of the septation was supposed to distinguish *Prionolobus* from *Ophiceras*, which is very similar to it in form and character. But now *Prionolobus* has been definitely discarded, and this species would then fall under *Ophiceras*.

Ophiceras jacksoni differs from *Xenodiscus waageni* in being more robust and involute and in the more rapid increase in height of the whorls. It differs from *Ophiceras spencei* in the character of the septa and in lacking the constrictions that occur on the cast of that species. It does not resemble closely any of the Indian species ascribed by Waagen to *Prionolobus* but agrees with them all in having the straight row of denticulations instead of the auxiliary lobe.

Horizon and locality: *Ophiceras jacksoni* is common in the Lower Triassic *Columbites* zone above the *Meekoceras* zone 1 mile west of Paris, Idaho, locality 1981, United States Geological Survey, associated with *Columbites parisianus, Meekoceras pilatum, Pseudosageceras multilobatum, Ophiceras spencei, Celtites ursensis*, and many others. What is probably the same species was found in the *Meekoceras* zone in Wood Canyon, 9 miles east of Soda Springs, Idaho, and in the *Owenites* subzone in Union Wash, in the Inyo Range, 1½ miles east of Union Spring, 15 miles southeast of Independence, Inyo County, Calif.

The figured specimens all came from locality 1981, near Paris, Idaho, and are in the collection of the United States Geological Survey.

Ophiceras parvum Smith, n. sp.

Plate 54, Figures 25–30

Shell small, discoidal, laterally compressed, widely umbilicate; whorls higher than wide, with abrupt ventral and umbilical shoulders, gently sloping sides, and rather narrow flattened venter. Surface with very weak folds and fine growth lines. Septa with four external serrated lobes and three rounded saddles. These lobes have the conventional shape of the genus, somewhat compressed and elongate.

Ophiceras parvum is closely related to *O. subquadratum*, with which it is associated, differing chiefly in the more compressed whorl and narrower umbilicus. It is not closely related to any of the Asiatic species of this genus.

Horizon and locality: Rather common in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, in Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Meekoceras gracilitatis, Owenites koeneni, Inyoites oweni, Anasibirites desertorum, A. noetlingi, Lanceolites bicarinatus*, and other forms.

[79] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, p. 121, pl. 14, figs. 1–7, 1897.

Ophiceras sakuntala Diener

Plate 54, Figures 1–17; Plate 56, Figures 13–18

1897. *Ophiceras sakuntala.* Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 114, pl. 10, figs. 1–7; pl. 11, figs. 1, 2, 4.

1911. *Ophiceras sakuntala.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 239, pl. 21, fig. 4.

Form evolute, discoidal, laterally compressed, widely umbilicate, sides flattened, venter narrowly rounded. Surface with very fine radial lines and weak folds. Septa ceratitic, with three rounded saddles and four elongate serrated lobes, of which the first lateral is much the largest.

Ophiceras sakuntala was first described from the Lower Triassic of India; it has since been found in the Lower Triassic *Columbites* zone of Albania.

Horizon and locality: Rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone in Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; also very rare in the same zone at the mouth of Cottonwood Canyon, about 4 miles southwest of the Phelan ranch, east side of the Ruby Range, about 70 miles south of Wells, Nev. At both localities it was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Inyoites oweni*, *Owenites koeneni*, *Anasibirites desertorum*, *Lanceolites bicarinatus*, *Pseudosageceras multilobatum*, and other characteristic species.

Ophiceras spencei Hyatt and Smith

Plate 62, Figures 1–10

1905. *Ophiceras spencei*, Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 119, pl. 62, figs. 1–10.

Evolute, discoidal, laterally compressed. Whorl of medium height but increasing slowly. Deeply embracing; deeply indented by the inner volutions. Umbilical shoulders abruptly rounded, sides flattened; venter rounded, bordered by rounded but rather abrupt abdominal shoulders. The outer whorl envelops a little over half of the inner and is indented to one-fourth of its height. The height of the whorl is two-fifths of the total diameter of the shell, and the width is five-eighths of the height. The umbilicus is wide and shallow, being slightly less than one-third of the total diameter of the shell.

The surface is ornamented with numerous weak forward-curving constrictions, visible chiefly on the cast, and with fine cross striae of growth, visible only on the outer shell.

Septa ceratitic, with entire saddles, a divided external lobe, two principal laterals and an auxiliary, all serrated.

The form greatly resembles that of *Ophiceras jacksoni*, from which *Ophiceras spencei* may easily be distinguished by the sculpture and the individualized auxiliary lobe. This species also resembles *Ophiceras ptychodes* Diener, of the Lower Triassic *Otoceras* beds of India, but has slightly weaker sculpture than the Indian species, the folds being weaker and more strongly curved.

The two species agree in outer form and septa and in having the folds on the cast and only the cross striae of growth visible on the outer shell. The two species might well be considered as only varieties of the same form, if the association in which the two occur were not different. The *Otoceras* beds in India, in which *Ophiceras ptychodes* occurs, are now regarded by some authors as Permian; but the associated species in the Idaho beds make such a reference extremely improbable, especially as several of the species are also common at the *Meekoceras gracilitatis* horizon, of the age of which there can be no question.

Horizon and locality: *Ophiceras spencei* is rare in the Lower Triassic *Columbites* zone 1 mile west of Paris, Bear Lake County, Idaho, in brownish bituminous limestones, associated with *Columbites parisianus*, *Meekoceras pilatum*, *Ophiceras jacksoni*, *Pseudosageceras*, *Celtites*, and many others less characteristic. The horizon lies above that of *Meekoceras gracilitatis*, which occurs near by in gray limestones like those of the Aspen Mountains near Soda Springs.

Ophiceras subquadratum Smith, n. sp.

Plate 54, Figures 18–24

Shell small, robust, widely umbilicate, with abruptly rounded umbilical and subangular ventral shoulders. Whorls subquadratic in section, slightly higher than wide. Surface smooth, without ribs or folds.

Septa ceratitic, with very short ventral lobes, long and narrow first lateral, small second lateral, and no auxiliary. The height of the last whorl is two-fifths of the diameter of the shell, the width is slightly less than the height, and the width of the umbilicus is one-third of the diameter of the shell.

Ophiceras subquadratum is rather closely related to *O. parvum*, with which it is associated, differing in its more robust whorls and greater evolution.

Horizon and locality: Rather common in the *Owenites* subzone of the *Meekoceras* zone in Union Wash, Inyo Mountains, Inyo County, Calif., associated with *Meekoceras gracilitatis*, *Inyoites oweni*, *Owenites koeneni*, *Lanceolites bicarinatus*, *Anasibirites noetlingi*, *A. desertorum*, *Pseudosageceras multilobatum*, and other forms. It is rather rare at the same horizon at the mouth of Cottonwood Canyon, 4 miles southwest of the Phelan ranch, east side of the Ruby Range, 70 miles south of Wells, Nev., in approximately the same association.

Genus FLEMINGITES Waagen

1892. *Flemingites.* Waagen, Preliminary notice on the Triassic deposits of the Salt Range: India Geol. Survey Rec., vol. 25, pt. 4, p. 184.
1892. *Flemingites.* Waagen, Vorläufige Mittheilung über die Ablagerungen der Trias in der Salt Range: K.-k. geol. Reichsanstalt Wien Jahrb., Band 42, pt. 2, p. 380.
1895. *Flemingites.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 185.
1897. *Flemingites.* Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 90.
1902. *Flemingites.* Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 638.
1902. *Flemingites.* Frech, Ueber Trias-Ammoniten aus Kaschmir: Centralbl. Mineralogie, Band 3, No. 5, p. 134.
1904. *Flemingites.* Smith, The comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 377.
1905. *Flemingites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 120.
1909. *Flemingites.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 106.
1913. *Flemingites.* Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, No. 1, p. 20.
1922. *Flemingites.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologia von Timor, Lief. 11, Abh. 19, p. 113.

Type: "*Ceratites*" *flemingianus* De Koninck,[80] from the Lower Trias of the Salt Range.

Form evolute, little embracing; wide, shallow umbilicus; whorls robust, usually a little higher than wide, increasing very slowly in size; sides rounded; venter somewhat flattened and usually considerably narrower than the greatest breadth of the whorl. Strong, lateral cross ribs or folds, which are never dichotomous and do not cross the venter, are commonly present. Strong, fine spiral ridges on all parts of the external shell, appearing also on the casts.

Septa distinctly ceratitic, with rounded entire saddles and long serrated lobes, of which there are an external lobe divided by a broad siphonal saddle, two principal laterals, and an auxiliary. In more specialized forms the siphonal saddle is broken up by secondary divisions that almost reach the importance of adventitious lobes.

Waagen compares this genus with *Ceratites* but notes that the form is more evolute and the spiral lines stronger than on that genus, also that the lateral sculpture does not break up into knots or dichotomous ribs. He places *Flemingites* in the Leiostraca, in spite of the coarse ribs that occur on most species of the genus.

[80] De Koninck, L., Geol. Soc. London Quart. Jour., vol. 19, p. 10, pl. 7, fig. 1, 1863.

Flemingites is one of the most definite and consistent genera in the Lower Triassic. Its young stages are decidedly like *Prolecanites*, and its immediate ancestor almost certainly *Ophiceras*. It is almost entirely confined to the *Pseudosageceras multilobatum* subzone of the *Meekoceras* zone of the Lower Triassic.

In America the genus is represented by *Flemingites aplanatus* White, *F. aspenensis* Smith, *F. bannockensis* Smith, *F. cirratus* White, *F. russelli* Hyatt and Smith, *F. russelli* var. *gracilis* Smith.

Flemingites aplanatus (White)

Plate 11, Figures 1–14; Plate 22, Figures 1–23; Plate 39, Figures 1, 2; Plate 64, Figures 17–32

1879. *Meekoceras aplanatum.* White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 5, p. 112.
1880. *Meekoceras aplanatum.* White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 112, pl. 31, fig. 1 a, b, d (not fig. c, which is *Danubites whiteanus* Waagen).
1886. *Xenodiscus aplanatus.* Mojsisovics, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 75.
1895. *Xenaspis? aplanata.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 290.
1900. *Wyomingites aplanatus.* Hyatt, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 556.
1902. *Ophiceras aplanatum.* Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 631, fig. e.
1904. *Meekoceras aplanatum.* Smith, The comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 373, pl. 41, figs. 4–6.
1905. *Meekoceras aplanatum.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 146, pl. 11, figs. 1–14; pl. 64, figs. 17–22; pl. 77, figs. 1, 2.

Evolute, discoidal, laterally compressed; wide, shallow umbilicus; whorls increasing slowly in height, little embracing, outer whorl concealing but little of the inner and indented to less than one-fourth of its height by it. Breadth of whorl a little over half its height, and one-fifth of the diameter of the shell; height of whorl a little more than one-third of the total diameter. Width of umbilicus equal to height of whorl. Umbilical shoulders abruptly rounded but not angular. Sides gently rounded, greatest breadth of whorl at a point half way between the base and the venter. Abdomen flattened, narrow, with subangular abdominal shoulders.

Surface ornamented with cross striae and folds, which may become quite strong on the body chamber. Numerous typical specimens from the type locality and other localities show strong spiral striae on the shell, thus placing the species in the group of *Fleming-*

ites rohilla Diener, somewhat intermediate between *Ophiceras* and typical *Flemingites*.

Septa ceratitic, saddles all rounded and entire, lobes partly serrated, partly entire. The external lobe is divided by a shallow siphonal saddle into two narrow branches, which are slightly denticulate, though usually entire. These divisions of the lobe fall upon the abdominal shoulder angles. The first lateral lobe is distinctly serrated, longer than the external, and much wider; the second lateral is usually entire, although in some specimens it may be slightly denticulated. There is no auxiliary series. The internal septa consist of a short bifid antisiphonal lobe and a short, shallow entire lateral, just inside the umbilical suture. These septa are very like those of *Xenaspis* Waagen, except in the difference in the sizes of the lobes. This resemblance becomes more significant when it is known that *Flemingites aplanatus* has a body chamber at least three-quarters of a revolution in length.

F. aplanatus White resembles in form *Gyronites frequens* Waagen [81] but differs in lacking the auxiliary lobe. It also agrees in septa with *Gyronites nangaensis* Waagen[82] but is slightly more involute than that species and has the lobes not so long.

Relative dimensions of Flemingites aplanatus

Diameter	100
Height of last whorl	37
Height of last whorl from the preceding	27
Width of last whorl	20
Width of umbilicus	37
Involution	10

In small specimens the whorl is more robust, broader in proportion to its height, and more deeply embracing, although the form is always evolute, even in the early stages of growth. The young whorls are rounded, the angular shoulders being a character of adolescence. The adolescent shell agrees in all respects with *Lecanites*, and this species gives a transition from that genus through *Xenodiscus* to *Flemingites*.

Hyatt [83] took *F. aplanatus* as the type of a new but undescribed genus *Wyomingites*, but this statement was intended to refer to the form described by Waagen as *Gyronites whiteanus* and not to the typical *F. aplanatus*. It was unknown to Hyatt that Waagen had already renamed this form.

Horizon and locality: *Flemingites aplanatus* White was found by the United States Geological Survey in the Lower Triassic *Meekoceras* zone in southeastern Idaho, about 5 miles southeast of Grays Lake (locality 1, United States Geological and Geographical Survey of the Territories), and also about 15 miles a little west of south from the lake. Alpheus Hyatt also found it in Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, Idaho. J. P. Smith found it in the Lower Triassic *Meekoceras* zone of the Inyo Range, east side of Owens Valley in Union Wash, near Union Spring, about 15 miles southeast of Independence, Inyo County, Calif.

Flemingites aspenensis Smith, n. sp.

Plate 23, Figures 6–11

Shell of moderate size, discoidal, evolute, widely umbilicate, little embracing, and little impressed by the inner whorl. Umbilicus shallow, with abrupt shoulders; sides flattened but converging slightly toward the subangular ventral shoulders that border the flat narrow venter. Surface with weak folds and strong spiral lines. Septa ceratitic, with entire saddles and four serrated lobes, of which the ventral is short and narrow, the first lateral rather large, the second lateral small, and the auxiliary barely individualized.

Flemingites aspenensis is very closely related to *F. rohilla* Diener, of the Lower Triassic *Hedenstroemia* beds of India, differing in its smaller size and less individualized auxiliary lobe. It is also very like *F. aplanatus*, with which it is associated, differing in its more compressed and slightly more involute whorls.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Pseudosageceras multilobatum*, and other forms.

Flemingites bannockensis Smith, n. sp.

Plate 23, Figures 18–26

Shell of moderate size, discoidal, widely umbilicate, evolute, little embracing, and little impressed by the inner whorl. Cross section subquadratic, with abruptly rounded, almost subangular ventral and umbilical shoulders, flattened sides, and rather broad, flattened venter. Surface with very strong spiral lines, visible on the outer shell and the cast. Septa ceratitic, with three well-defined saddles and four external lobes, of which the auxiliary on the umbilical slope is only slightly individualized.

Flemingites bannockensis is very closely related to *F. aplanatus*, from which it differs in the wider umbilicus, squarer whorls, weaker sculpture, and slower rate of increase of height of the whorls. It differs from *F.*

[81] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 292, pl. 33, figs. 1–4, 1895.

[82] Idem, p. 297, pl. 32, fig. 5 a–c.

[83] Hyatt, Alpheus, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 556, 1900.

aspenensis in the thicker whorls, wider umbilicus, and slower rate of increase, as well as in the much stronger spiral lines.

Horizon and locality: Very rare in the Lower Triassic zone of *Meekoceras*, in southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs. The species is associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Pseudosageceras multilobatum*, and other forms.

Flemingites cirratus (White)

Plate 20, Figure 1; Plate 26, Figures 1–12

1880. *Arcestes cirratus*. White, Triassic fossils of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 116.

Shell very large, evolute, laterally compressed, little embracing, with abrupt umbilical shoulders, flattened sides, abruptly rounded ventral shoulders, and rounded venter. Ornamented with very strong spiral ridges but lacking the transverse ribs that are usual on *Flemingites*. Septa ceratitic, with entire rounded saddles, and four strongly serrated external lobes.

The height of the last whorl is one-third of the diameter of the shell; the width is half the height; the width of the umbilicus is nearly one-third of the diameter of the shell. The outer whorl embraces half of the inner and is indented to one-eighth of the height.

The young shells go through a stage resembling *Lecanites*, at a diameter of 5 to 10 millimeters, followed by one resembling *Xenodiscus*, at a diameter of about 12 millimeters.

Flemingites cirratus was described as *Arcestes* but has no resemblance to that genus. An examination of the very poor type specimen in the United States National Museum made the identification possible, for White's type was very briefly described and never figured.

Flemingites cirratus is a member of the typical group of the genus and very closely related to *F. salya* Diener,[84] from the *Flemingites* or *Hedenstroemia* beds of India; the two might even be identical, but neither is sufficiently well preserved or well enough known for such an identification to be more than conjectural.

It is also very similar to *F. flemingianus* De Koninck, from the Salt Range of India, but is more involute and lacks the strong lateral folds of the Indian species. *F. flemingianus* is the type of the genus and one of the largest members, rivaled closely by its American kinsman.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; at Rohner's ranch, mouth of Paris Canyon, 1 mile west of Paris; at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Paranannites aspenensis*, and other forms.

[84] The Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 2, pt. 1, p. 96, pl. 19, figs. 1, a–b, 1897.

Flemingites russelli Hyatt and Smith

Plate 1, Figures 1–3; Plate 26, Figures 14–23; Plate 70, Figures 1–3

1904. *Flemingites russelli* (Hyatt and Smith MS.). Smith, The comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 378, pl. 42, fig. 5; pl. 43, figs. 5, 6.

1905. *Flemingites russelli*, Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 121, pl. 1, figs. 1–3; pl. 70, figs. 1–3.

Evolute, discoidal, laterally compressed; wide umbilicus; whorls not deeply embracing, outer whorl covering only one-third of the inner and indented by it to about one-sixth of its height. This feature shows that although the form is evolute the increase in height of whorls is great. Umbilicus shallow and umbilical shoulders rounded; sides gently convex. Whorls twice as high as broad; venter narrow and somewhat rounded. Sides ornamented with strong folds in mature shell, nearly smooth in young shells. Surface of cast ornamented with fine, distinct spiral lines. Septa ceratitic, four serrated lobes and three rounded entire saddles on each side. The external lobe is broad, divided by a deep siphonal saddle. The first lateral is twice as long as the external and has about four serrations; the second lateral is narrow; and the auxiliary series consists of four or five denticulations, forming a broad lobe. The saddles are all similar in shape and broader than the lobes.

Dimensions of the type specimen of Flemingites russelli

	Millimeters
Diameter	104
Height of last whorl	37
Height of last whorl from preceding	30
Width of last whorl	20
Involution	7
Width of umbilicus	32

Horizon and locality: In the Lower Triassic *Meekoceras* zone of Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho; associated with *Pseudosageceras*, *Meekoceras gracilitatis* White, *M.* (*Koninckites*) *mushbachanum* White.

Flemingites russelli Hyatt and Smith var. gracilis Smith, n. var.

Plate 23, Figures 1–5

Shell large, evolute, discoidal, laterally compressed, widely umbilicate, little embracing, and little indented by the inner whorl. Surface with gentle radial folds and weak spiral lines. Septa ceratitic, with rounded saddles and four external serrated lobes.

Flemingites russelli var. *gracilis* differs from the typical species in its greater evolution, wider umbilicus, and slower increase in the height of its whorl. These differences are hardly specific, and the two seem to intergrade.

Horizon and locality: Rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; associated with the typical form of *F. russelli*, *Meekoceras gracilitatis*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, *Aspenites acutus*, and other forms.

Family MEEKOCERATIDAE

Form laterally compressed, discoidal, evolute in the primitive genera, involute in more specialized groups. Surface smooth or ornamented with weak folds, more rarely with distinct ribs. Body chamber short. Septa goniatitic or ceratitic, becoming slightly ammonitic in a few species. The Meekoceratidae have commonly been regarded as a subfamily under the Ptychitidae, but they differ from that group in their more compressed form and evolute discoidal young, which resemble the genus *Lecanites*, the probable radicle of the family.

Waagen [85] was the first to class this group as an independent family, on account of the large number of genera or subgenera in it and the evident phylogenetic relationship between them. This family, as Waagen defines it, is the most homogeneous among Triassic ammonites, the most perfect gradation existing between the genera composing it, so much so that Diener has regarded all the Meekoceratidae as belonging to the genus *Meekoceras*, with the exception of *Anasibirites*, more recently assigned to this family.

The Meekoceratidae are composed of *Meekoceras* (with the so-called subgenera *Gyronites*, *Koninckites*, *Prionolobus* and *Kingites*), *Anasibirites*, *Hedenstroemia*, *Dagnoceras*, *Clypeoceras*, and *Beyrichites*, all occurring in the Lower Triassic, except *Beyrichites*, and all the others confined to that division except *Clypeoceras*, which is found rarely in the Middle Triassic. *Beyrichites* is characteristic of the Middle Triassic of the Alps, India, and America. With these two exceptions the Meekoceratidae are characteristic of the Lower Triassic of western America, Siberia, India, and the ancient Mediterranean.

Frech [86] proposed to abandon altogether the family Meekoceratidae and the genus *Meekoceras*, dividing the species assigned to this group between *Prionolobus* *Ophiceras*, and *Aspidites*. But this arrangement is not in accordance with the rules of priority nor with the relationships of the species concerned.

[85] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 236, 1895.

[86] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 630, 1902.

Genus MEEKOCERAS Hyatt

1879. *Meekoceras*. Hyatt, in White, Fossils of the Jura-Trias of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Bull., vol. 5, p. 111.

1880. *Meekoceras*. Hyatt, in White, Triassic fossils of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 112.

1882. *Meekoceras* (part). Mojsisovics, Die Cephalopoden der Mediterranen Trias-provinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 213.

1886. *Meekoceras* (part). Mojsisovics, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser. vol. 33, No. 6, p. 79.

1895. *Meekoceras*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 236.

1895. *Meekoceras*. Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 46.

1897. *Meekoceras*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 126.

1900. *Arctoceras*. Hyatt, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 559.

1903. *Meekoceras*. Kittl, Die Cephalopoden der oberen Werfener Schichter von Muć in Dalmatied: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 69.

1904. *Meekoceras*. Smith, The comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 367.

1905. *Meekoceras*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 140.

1909. *Meekoceras*. Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 16.

1911. *Meekoceras*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 243.

1913. *Meekoceras*. Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 25.

1914. *Meekoceras*. Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 77.

1922. *Meekoceras*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 126.

1927. *Meekoceras*. Yehara, The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, p. 153.

1929. *Meekoceras*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 6.

Not 1895. *Meekoceras*. Diener, Cephalopoda of the Muschelkalk: India Geol. Survey, Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 2, p. 40.

Type: *Meekoceras gracilitatis* White.[87]

Form compressed, discoidal, involute or evolute, sides flattened; venter narrow, either flattened or rounded, no keels nor furrows; umbilicus narrow or wide. Body chamber short. Surface smooth or ornamented with lateral folds; no tubercles, spines, or spiral ridges. Septa ceratitic, with rounded entire saddles and serrated lobes. The external lobe is short and divided by a siphonal saddle; the two lateral lobes are longer, and there is an auxiliary series present in most forms, consisting either of a single lobe (serrated or goniatitic) or of a series of denticulations, some of which may be partly individualized into lobes. The internal septa consist of a divided antisiphonal lobe, flanked by a single lateral, although in some specimens there may be internal auxiliaries.

Perhaps no other genus of ammonites has been so variously treated as *Meekoceras*, for the reason that it is very variable and also because in the first description no type was expressly given, and three species, differing in essential respects, were simultaneously described—"*Meekoceras*" *aplanatum* White, *M. mushbachanum* White, and *M. gracilitatis* White, in the order given. But in the diagnosis of the genus Hyatt first mentions *M. gracilitatis*. Thus, according to usage, either "*M.*" *aplanatum* or *M. gracilitatis* might be chosen as the type. Of these *M. gracilitatis* alone agrees with the generic diagnosis, for it has the fourth lobe as an auxiliary series of denticulations and does not have a distinct saddle between this lobe and the umbilical suture. Also "*Meekoceras*" *aplanatum* is now classed under *Flemingites*, as it has all the characters of that genus, including the strong spiral lines on the outer shell.

Besides the three species mentioned, Hyatt also included in his generic diagnosis previously described species that have since been assigned to *Balatonites*, *Hungarites*, *Xenaspis*, and *Celtites*, which clearly have no relationship to the typical members of the genus. The writer regards all forms that agree with *M. mushbachanum* or *M. gracilitatis* as belonging to *Meekoceras* in the broader sense.

Mojsisovics[88] was the next to treat of this genus, in which he included a number of forms now assigned to *Proptychites* and *Beyrichites*, thus giving *Meekoceras* an unwarranted extension beyond the limits assigned by Hyatt. In a later paper Mojsisovics[89] still further extended the genus in one direction to take in forms now assigned to *Hedenstroemia* but limited it on the other to involute forms. All evolute, open-coiled forms were assigned to *Xenodiscus* Waagen, although Mojsisovics confessed that this was purely because *Xenodiscus* seemed to be the ancestor of *Gymnites*.

Meekoceras was next treated by Waagen,[90] who regarded *M. gracilitatis* as the type and placed all other kindred but dissimilar forms under different genera, thus restricting the genus to narrower limits than was intended by Hyatt. The evolute forms without the auxiliaries were placed under a new genus, *Gyronites*, which would include most of the forms assigned by Mojsisovics to *Xenodiscus*. Species with a fourth lateral lobe followed by an auxiliary series were classed under the genus *Koninckites* Waagen, whereas forms in which the auxiliary series is not individualized but consists of only a few denticulations were placed under *Kingites* Waagen.

Diener[91] regards *Kingites* and *Koninckites* merely as subgenera of *Meekoceras*, and in this conclusion the writer agrees with him. In a still later work[92] Diener includes also *Aspidites* Waagen and *Beyrichites* Waagen as subgenera under *Meekoceras*. But these two types are different from any species included by Hyatt under the original description, and it seems best to let them stand as independent genera. *Kingites* is now definitely discarded, its species going back to *Meekoceras*.

As thus defined, *Meekoceras* in the broader sense would include all species similar to the typical forms, and the species nearest to *M. gracilitatis* White would be classed in *Meekoceras* in the limited sense.

Examination of the types in the United States National Museum has shown that *Meekoceras mushbachanum* has all the characters assigned by Waagen to *Koninckites*, and as this species was one of the types of *Meekoceras* all species similar to *M. mushbachanum* are classed in the subgenus *Koninckites*, under *Meekoceras* in the broader sense. *Clypeoceras* (*Aspidites*) and *Beyrichites* are regarded by the writer as independent genera. The systematic position of *Prionolobus* is somewhat doubtful, but it should probably be a synonym of *Meekoceras*, though most of its species will go to *Xenodiscus* or *Ophiceras*.

Frech[93] has recently proposed to drop the family Meekoceratidae and the genus *Meekoceras*, dividing the species belonging to that genus between *Ophiceras*, *Prionolobus*, and *Aspidites*, although all the genera mentioned were described after *Meekoceras*, which was first described in 1879 and described and fully illustrated in 1880. Frech's reasons for these changes were that Hyatt included in his original description of *Meekoceras* not only the three American species that

[87] White, C. A., Fossils of the Jura-Trias of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Bull., vol. 5, p. 111, 1879; Triassic fossils of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 112, pl. 31, figs. 2 a-d, 1880.

[88] Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 213, 1882.

[89] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 79, 1886.

[90] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 236, 1895.

[91] Diener, Carl, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 46, 1895.

[92] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 126, 1897.

[93] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 630, 1902.

differ in certain noteworthy characters but also foreign species later assigned to *Balatonites*, *Xenaspis*, *Hungarites*, and *Celtites*. Of course, it was a mistake to include these elements in *Meekoceras*, but the citation of them as species under that genus does not make any confusion as to the limits of the group. Three American species were fully described and figured, and one of the three was certainly the type.[94] The fact that later writers have extended the genus *Meekoceras* to take in heterogeneous elements does not invalidate it. If any such rule in nomenclature should be accepted almost every genus of ammonites would be thrown out and new names substituted.

As thus restricted, *Meekoceras* is entirely confined to the Lower Triassic, in which it is very abundant in California, Idaho, India and Siberia.

Meekoceras arthaberi Smith, n. sp.

Plate 32, Figures 26–33

Shell small, involute, laterally compressed, with nearly closed umbilicus, flattened sides, angular ventral shoulders and rather broad, flat venter. Surface nearly smooth, with only fine growth lines. Septa ceratitic, with three well-defined saddles and four serrated lobes, the auxiliary being well developed on the umbilical slope. The septa are close set, and the lobes are broader than is usual on this genus.

Meekoceras arthaberi is more robust and more narrowly umbilicate than *M. gracilitatis*. It differs from *M. boreale* Diener, of the Lower Triassic of India, in its more flattened whorl and more closely set septa.

Named in honor of Prof. G. von Arthaber, in recognition of his contributions to Triassic paleontology.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, and other forms.

Meekoceras cristatum Smith, n. sp.

Plate 33, Figures 15–20; Plate 34, Figures 1–6

Shell large, discoidal, evolute, laterally compressed, rather widely umbilicate with rounded umbilical and subangular ventral shoulders. Flanks gently arched, venter narrow and somewhat flattened. Surface bears fine radial ribs that cross the venter, giving it a crenulate or cristate sculpture. Septa ceratitic, with three well-defined saddles and four serrated lobes.

Meekoceras cristatum in early youth is very like *M. gracilitatis*, but the egression of the whorl begins at a much earlier stage, and the crenulation of the surface sets in early, distinguishing the two species readily. It has a greater resemblance to *M. sylvanum*, from which it is distinguished by its much stronger sculpture.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, and other forms.

Meekoceras curticostatum Smith, n. sp.

Plate 48, Figures 21–30

Shell rather large, laterally compressed, moderately widely umbilicate, discoidal. Whorls narrow, with abrupt umbilical shoulders and narrowly rounded venter. Surface with somewhat distant lateral ribs that run from the umbilicus two-thirds of the distance up the flanks. There are about 20 of these ribs to a revolution. Septa ceratitic, with four external lobes, all serrated, and rounded saddles. The height of the last whorl is five-twelfths of the diameter of the shell, the width is two-fifths of the height, and the width of the umbilicus is somewhat less than one-fourth of the diameter of the shell.

Meekoceras curticostatum has some resemblance to *M. pilatum*, with which it is associated, differing in the wider umbilicus, more compressed whorls, weaker and more numerous ribs. It is not nearly related to any other known species.

Horizon and locality: Rather rare in the Lower Triassic *Columbites* zone of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Columbites parisianus*, *C. spencei*, *Ophiceras spencei*, *O. jacksoni*, *Pseudharpoceras idahoense*, and other forms.

Meekoceras elkoense Smith, n. sp.

Plate 55, Figures 14–16

Shell of moderate size, laterally compressed, involute, deeply embracing, narrowly umbilicate, with abrupt umbilical shoulders, slightly convex sides, with distinct concavity below the sharp ventral angles. Surface nearly smooth. Septa ceratitic, with four well-developed external serrated lobes.

The height of the last whorl is more than one-third of the diameter of the shell; the width is greater than one-half the height; the width of the umbilicus is about one-third of the diameter of the shell. The outer whorl embraces two-thirds of the inner.

[94] Alpheus Hyatt told the writer, in June, 1900, that he has always regarded *Meekoceras gracilitatis* as the generic type, as the generic diagnosis shows.

Meekoceras elkoense is most nearly related to *M. radiosum*, differing in its more open umbilicus and less embracing whorl, also in the more pronounced concavity below the ventral shoulder angles; in septa the two species are very similar.

Horizon and locality: Very rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, at the Phelan ranch, mouth of Cottonwood Canyon, east side of the Ruby Range, Elko County, Nev., about 70 miles south of Wells; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Inyoites oweni*, *Anasibirites desertorum*, *Lanceolites bicarinatus*, *Pseudosageceras multilobatum*, and other forms.

Meekoceras gracilitatis White

Plate 12, Figures 1–13; Plate 13, Figures 1–18; Plate 14' Figures 1–8; Plate 36, Figures 19–28; Plate 37, Figures 1–7; Plate 38, Figures 1–6; Plate 70, Figures 4–7

1879. *Meekoceras gracilitatis*. White, Fossils of the Jura-Trias of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Bull., vol. 5, p. 114.

1880. *Meekoceras gracilitatis*. White, Triassic fossils of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 115, pl. 31, figs. 2 a–d.

1902. *Prionolobus gracilitatis*. Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 631, fig. 2.

1904. *Meekoceras gracilitatis*. Smith, The comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 370, pl. 42, figs. 1–4; pl. 43, figs. 3, 4.

1905. *Meekoceras gracilitatis*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 143, pl. 12, figs. 1–13; pl. 13, figs. 1–18; pl. 14, figs. 1–8; pl. 70, figs. 4–7.

Shell compressed, involute, discoidal, deeply embracing, outer whorl concealing three-fourths of the inner and being indented to one-third of its height by the inner whorl. Umbilicus narrow but open and rather shallow, the width being about one-sixth of the diameter of the shell. The whorl increases rather rapidly in height, the altitude being slightly more than twice the breadth of the whorl and half the total diameter. The sides are gently convex, from the abruptly rounded umbilical shoulder; the greatest thickness of the whorl lies at a point even with the top of the inner whorl, thus giving a lenticular appearance to the shell. Venter flattened, biangular, with broad flat space and sharp abdominal shoulder angles.

Surface ornamented with low folds and radial striae of growth, which in age cross the venter in faint corrugations. No true ribs nor spines are ever present.

Septa ceratitic, saddles all rounded and entire, lobes all serrated. Ventral short, divided by a broad, shallow siphonal saddle; first lateral broad and deeper; second lateral narrow as the ventral; auxiliary series consisting of a short, straight row of denticulations following the third lateral saddle, forming merely an unindividualized lobe, which, however, is sharply distinguished from the saddle. The inner septa consist of a rather short divided antisiphonal lobe, with a single lateral.

The young shells are much more involute than mature forms, the umbilicus growing wider with age, and the whorls less deeply embracing. The relative width of the umbilicus, however, seems to be variable, also the abruptness or roundness of the umbilical shoulders. Diener [95] thinks that White has confused two species in his figures of *M. gracilitatis*, and that Plate 31, Figure 2b, in White's paper represents a different species from Figure 2a. But the difference lies rather in the drawing than in the original specimens. The septa on White's original are as shown in Plate 31, Figure 2d, of White's paper, except that the denticulations are not sufficiently strongly marked in the drawing, and the innermost saddle is more sharply defined from the auxiliary denticulations than in the figure. In some unfigured specimens, however, there does not seem to be any separation at all of the saddle and the auxiliary series. These specimens in all other respects seem to belong to *M. gracilitatis* and were probably the cause of the ambiguities in Hyatt's and White's descriptions. These forms would fall under Waagen's genus *Kingites*, but they are probably nothing more than individual variations of *M. gracilitatis*, and for the present they are not included in the specific diagnosis, for it is essential to establish the exact meaning of this species.

M. gracilitatis White is nearly related to *M. boreale* Diener of the Lower Triassic of India and Siberia but differs in not having the auxiliary series individualized, also in the slightly wider umbilicus. There are, however, in the American Lower Triassic, species with the umbilicus as narrow or even narrower than that of *M. boreale*, but on all of them the auxiliary series is unindividualized.

Horizon and locality: *Meekoceras gracilitatis* White was found by Peale in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at two places—5 miles south of Grays Lake and about 15 miles a little east of south from this lake. Alpheus Hyatt also found this species in Wood Canyon, about 9 miles east of Soda Springs, Idaho, associated with *M. mushbachanum* White, *Pseudosageceras multilobatum* Noetling, *Flemingites russelli* Hyatt and Smith, *F. aplanatus* White, *Ussuria waageni*, and other characteristic species. J. P. Smith found *M. gracilitatis* in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, near Union Spring, east side of Owens Valley, Inyo Range, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Inyoites oweni*, *Owenites koeneni*, *Pseudosageceras multilobatum*, and other forms.

[95] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 132, 1897.

Meekoceras davisi Mathews

Plate 79, Figures 7, 8

1929. *Meekoceras davisi.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 6, pl. 1, figs. 12–14.
1929. *Meekoceras hertleini.* Mathews, op. cit., p. 6, pl. 1, figs. 8–11.

The specific description given below is quoted from Mathews:

The form is extremely involute, discoidal, thin, gently compressed laterally; high whorls, completely embracing, and deeply indented by the inner volution. The sides are nearly flat, being only slightly compressed, and slope from the umbilicus uniformly to the ventral shoulder. The ventral shoulder is sharply angular and appears to form a keel due to the narrow channeled venter; the umbilical shoulder is angular. The inner wall is vertical. The umbilicus is extremely narrow and deep, being only one twenty-second of the diameter of the shell. The height of the last whorl is over twice its greatest thickness and four-sevenths of its diameter. It is indented to one-half its height by the preceding whorl and completely conceals this whorl. The distance across the penultimate volution from umbilical suture to umbilical suture is five-eighths its involution. The venter is narrow, concave, and smooth. The living chamber comprises nearly one-half of the last whorl. The shell is very thin and smooth.

The surface is ornamented by a few indistinct, wide, progressive radial folds, which are most prominent near the umbilicus and become obsolete three-fourths the distance to the outer margin of the side wall.

The sutures are ceratitic, consisting of a ventral and two lateral lobes. The ventral lobe is divided by a notched wedge-shaped siphonal saddle. The lateral prongs are serrated by five denticulations. The first and second lateral lobes are narrow and serrated. The lateral saddles are all smooth and wide.

The first whorl is nearly round and little embracing; the second whorl is elliptical with the long axis of the ellipse in the plane of the shell. The whorl is embracing. The third and remaining whorls possess the adult characters. The shell develops rapidly in height after the second volution.

Horizon and locality: Lower *Anasibirites* bed, Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Meekoceras micromphalus Smith, n. sp.

Plate 49, Figures 5–11

Shell rather small, with very narrow umbilicus, whorls strongly compressed laterally, and narrowly rounded venter. Surface with very weak radial folds. Septa with rounded saddles, a small ventral lobe divided into two short branches, a rather large first lateral, a smaller second lateral, and an auxiliary lobe not individualized but consisting of a long series of denticulations. The height of the last whorl is greater than half the diameter of the shell; the width is three-sevenths of the height; the width of the umbilicus is less than one-seventh of the diameter of the shell. The outer whorl embraces nearly all of the inner and is impressed by that whorl to nearly one-third of its height.

Meekoceras micromphalus is very closely related to *M. keyserlingi* Mojsisovics, of the Lower Triassic Olenek beds of Siberia, differing only in the slightly wider umbilicus. The Arctic species was chosen by Waagen [96] as the type of his new *Kingites*, which is no longer recognized as distinct from *Meekoceras*, to which both *M. keyserlingi* and *M. micromphalus* are now assigned.

Horizon and locality: Rather rare in the Lower Triassic zone of *Columbites*, at Paris Canyon, 1 mile west of Paris, Idaho; associated with *Meekoceras curticostatum*, *M. pilatum*, *Columbites parisianus*, *C. spencei*, *Pseudharpoceras idahoense*, and other forms.

Meekoceras patelliforme Smith, n. sp.

Plate 28, Figures 21–27; Plate 52, Figures 9–11

Shell small, laterally compressed, involute, deeply embracing, with flattened sides, nearly parallel, and rounded venter without distinct shoulders. Surface nearly smooth, with fine striae of growth. Septa distinctly ceratitic, with entire saddles and four serrated lobes, the auxiliary being well individualized, the siphonal and laterals long and rather narrow.

The height of the last whorl is two-fifths of the diameter of the shell; the width is one-third of the height; the width of the umbilicus is one-fifth of the diameter of the shell. The outer whorl embraces two-thirds of the inner and is indented to one-fourth of the height.

Meekoceras patelliforme is very like *M. sanctorum* of the *Columbites* zone of Idaho but differs in its slightly wider umbilicus, more nearly parallel sides, more rounded venter, and longer lobes.

Horizon and locality: Rather common in the *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles east of Grays Lake; locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; at the mouth of Paris Canyon, 1 mile west of Paris. The species is associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Pseudosageceras multilobatum*, *Ussuria waageni*, *Parannanites aspenensis*, and other forms.

Also occurs in the *Owenites* subzone, of Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif., associated with *Owenites koeneni*, *Inyoites oweni*, *Anasibirites desertorum*, and other forms.

[96] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 230, 1895.

Meekoceras pilatum Hyatt and Smith

Plate 63, Figures 7–13

1905. *Meekoceras pilatum.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 144, pl. 63, figs. 3–9.

Form involute, laterally compressed; whorls high, with flattened sides broadly rounded venter, without distinct abdominal shoulders. Umbilical shoulders abrupt and somewhat angular. Whorls deeply embracing, and deeply indented by the inner volutions. The height of the whorl is slightly less than half the total diameter of the shell, and the width is half the height. The whorl is indented to one-fourth its height by the preceding volution. The width of the umbilicus is one-fourth of the total diameter of the shell.

The surface of both shell and cast is ornamented with coarse radial ribs, which run from the umbilicus straight up the flanks and become obsolete on the shoulders. In addition to these ribs there are the usual curved striae of growth, showing only to the surface of the shell.

The septa are of the usual *Meekoceras* type, with the saddles all rounded and entire and the lobes all serrated. The external lobe is short and narrow, divided by a small siphonal saddle; the first lateral lobe is broad and deep; the second lateral narrow and long; the auxiliary lobe is not individualized but resembles that of *Meekoceras gracilitatis.*

Horizon and locality: In the Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho, locality 1981, United States Geological Survey, associated with *Columbites parisianus, Pseudosageceras multilobatum, Ophiceras jacksoni, Ophiceras spencei,* and other forms; collected by R. S. Spence.

Meekoceras radiosum Waagen

Plate 51, Figures 1–4

1895. *Meekoceras radiosum.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 257, pl. 36, figs. 2a–d.

1909. *Meekoceras radiosum.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 16, No. 1, p. 34.

1911. *Meekoceras radiosum.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 246, pl. 21, fig. 14.

Shell rather small, laterally compressed, very involute, with high, slightly convex flanks and rather distinct concavity below the narrow and biangular venter. Whorls very deeply embracing. Surface with fine radial ribs, suggesting kinship with *Anasibirites.* Septa with four external serrated lobes, the auxiliary being distinctly individualized.

Meekoceras radiosum is more robust than either *M. gracilitatis* or *M. boreale.* It is more closely related to *M. elkoense* but differs in its greater involution, less compressed whorl, stronger sculpture, and the distinct fourth lobe.

Horizon and locality: Rather common in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis, Owenites koeneni, Inyoites oweni, Lanceolites bicarinatus, Aspenites acutus, Sturia compressa, Pseudosageceras multilobatum, Anasibirites desertorum,* and other forms.

It was first described from the Ceratite sandstone of the Salt Range of India. Arthaber has also described it from the *Columbites* zone of Albania. It is therefore a very widely distributed species and not confined to a narrow horizon of the Lower Triassic.

Meekoceras sanctorum Smith, n. sp.

Plate 49, Figures 1–4

Shell rather small, laterally compressed, narrowly umbilicate, with a subangular roof-shaped venter. Surface almost smooth, with very faint radial folds. Septa with four external lobes and three saddles. The height of the last whorl is half the diameter of the shell; the width is two-fifths of the height; the last whorl embraces nearly all of the inner and is impressed to one-sixth of its height.

Meekoceras sanctorum is very closely related to *M. affine* Mojsisovics [97] of the Lower Triassic Olenek beds of Siberia, differing only in being slightly more robust. This species adds another link to the connection between the *Columbites* fauna of Idaho and the Olenek fauna of Siberia.

Horizon and locality: Rather rare in the Lower Triassic *Columbites* zone of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Columbites parisianus, C. spencei, Ophiceras spencei, Meekoceras pilatum, M. micromphalus, M. curticostatum, Pseudharpoceras idahoense, Tirolites* cf. *seminudus, Celtites ursensis,* and other forms.

Meekoceras sylvanum Smith, n. sp.

Plate 33, Figures 1–14

Shell large, discoidal, laterally compressed, rather widely umbilicate, with flattened sides, narrow biangular venter, and subangular ventral shoulders. Surface with faint radial folds, especially on the body chamber. Septa ceratitic, with four external serrated lobes and three rounded saddles.

Meekoceras sylvanum is very closely related to *M. gracilitatis,* from which it differs in the wider umbilicus;

[97] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 86, pl. 11, fig. 17, 1886.

it also greatly resembles *M. hodgsoni* Diener, of the Lower Triassic of the Himalayas, differing in the greater thickness of the whorl. From *Meekoceras vercherei* Waagen, from the Lower Triassic of the Salt Range of India, it differs in lacking the long auxiliary series of lobes; from its near kinsman *Meekoceras disciforme* Krafft and Diener, of the Lower Triassic of the Himalayas, it differs in its greater involution. Its greatest kinship, however, is with *M. gracilitatis*, of which it would have been considered a variety if it were not for the constantly much greater evolution, which persists down even to the end of the larval stage.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; at locality 1, 5 miles east of Grays Lake; at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; associated with *Meekoceras mushbachanum*, *M. gracilitatis*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Pseudosageceras multilobatum*, *Lanceolites compactus*, and other forms.

Subgenus KONINCKITES Waagen

1895. *Koninckites.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 258.
1895. *Koninckites.* Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 53.
1896. *Koninckites.* Toula, Eine Muschelkalkfauna am Golfe von Ismid in Kleinasien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 10, p. 177.
1897. *Koninckites.* Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 139.
1902. *Aspidites* (part). Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637.
1904. *Koninckites.* Smith, Comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 375.
1905. *Koninckites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 148.
1909. *Koninckites.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 64.

Type: *Koninckites vetustus* Waagen.[98]

Evolute, discoidal, laterally compressed, narrow venter, either flattened or rounded. Sides flattened and entire form not robust. Umbilicus wider than in typical members of *Meekoceras* s. s. and lateral ornamentation commonly stronger, in the form of coarse radial ribs or folds.

Septa as in *Meekoceras* s. s., but the auxiliary lobe is individualized, followed by a distinct auxiliary saddle, and this by a series of denticulations, forming a second auxiliary lobe on the umbilical shoulder. This subgenus embraces a number of species from the Lower Triassic of the Salt Range, the Himalayas, Ussuri Bay, and the mouth of the Olenek River, in northern Siberia. Waagen did not know that *Meekoceras mushbachanum* White possessed all the essential characters of *Koninckites*, for the figure of the septa of that species is not exact. But as this is the case, and as *M. mushbachanum* was one of the three species given as typical members of *Meekoceras*, this group of species, characterized by the greater evolution, the more rugose shell, and the fourth lobe with the auxiliary denticulations, is regarded merely as a subgenus. There are in the American Triassic, both in Idaho and California, several species that will fall into this division.

Frech[99] proposes to drop *Koninckites*, referring the species described by Waagen under that name to *Aspidites*. Although this reference is, no doubt, correct for some of those species, it is not correct for the type, nor for the species like the type, one of which is *Meekoceras* (*Koninckites*) *mushbachanum*.

Meekoceras (Koninckites) evansi Smith, n. sp.

Plate 35, Figures 1–3; Plate 36, Figures 1–18

Shell large, robust, moderately evolute, discoidal, with rounded umbilical shoulders, slightly convex sides, and gently rounded venter. Surface with fine radial folds and fine growth lines. Septa ceratitic, with entire saddles, and serrated lobes. The ventral lobe is divided into two rather short branches; the first lateral is large, the second lateral is smaller, and following this there is a short but distinct series of auxiliary lobes, decreasing in size and complexity toward the umbilicus.

The height of the last whorl is slightly less than half the diameter of the shell, and the width is less than three-fourths of the height. The width of the umbilicus is one-fourth of the diameter of the shell.

In youth, up to a diameter of 7 millimeters, the shell is in the *Lecanites* stage, thick set, robust, low whorled. It then becomes flattened, the whorl becomes higher and the umbilicus relatively narrower; this transitional stage persists up to a diameter of about 40 millimeters, when the width of the umbilicus is about one-fifth of the diameter of the shell. At a diameter of about 50 millimeters the fine lateral folds or ribs begin to develop, and the umbilicus becomes proportionately wider. The young stages are therefore very unlike the mature form and could easily be taken for different species.

Meekoceras evansi is very closely related to *M. mushbachanum*, differing in its greater involution, greater compression and weaker sculpture. It also

[98] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 261, pl. 27, figs. 4, 5.

[99] Frech, F., Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637, 1902.

resembles "*Koninckites*" *vetustus* Waagen [1] but is less robust, and does not have the auxiliary series of lobes so sharply defined. It is distinguished by its large size from all other American species of *Meekoceras* except *M. mushbachanum*. Chambered specimens as much as 72 millimeters in diameter have been found, which would indicate that the species reached the diameter of more than 100 millimeters.

Named in honor of Dr. H. M. Evans, who assisted in collecting this fauna.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone, of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; locality 2, Slug Creek, 14 miles east of Soda Springs; locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; locality 5, 1 mile east of Hot Springs, at the north end of Bear Lake; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Pseudosageceras multilobatum*, and other forms.

Meekoceras (Koninckites) mushbachanum White

Plate 15, Figures 1–9; Plate 16, Figures 1–3; Plate 18, Figures 1–7; Plate 38, Figure 1; Plate 59, Figures 17–21; Plate 70, Figures 8–10; Plate 74, Figures 1–23; Plate 75, Figures 1–6; Plate 76, Figures 1–3

1879. *Meekoceras mushbachanum*. White, Fossils of the Jura-Trias of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Bull., vol. 5, p. 113.

1880. *Meekoceras mushbachanum*. White, Triassic fossils of southeastern Idaho: U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 114, pl. 32, fig. 1 a–d.

1902. *Prionolobus mushbachanus*. Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 631, fig. c.

1904. *Meekoceras mushbachanum*. Smith, Comparative stratigraphy of the marine Trias of western America: California Acad. Sci. Proc., 3d ser., vol. 1, p. 376, pl. 41, figs. 1–3; pl. 43, figs. 1, 2.

1905. *Meekoceras* (*Koninckites*) *mushbachanum*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 149, pl. 15, figs. 1–9; pl. 16, figs. 1–3; pl. 18, figs. 1–7; pl. 70, figs. 8–10.

1914. *Meekoceras mushbachanum*. Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 77, pl. 72, figs. 1, 2; pl. 73, figs. 1–6; pl. 74, figs. 1–23.

Compressed, involute, discoidal, whorls rather deeply embracing, covering nearly three-fifths of the inner volution and being indented to one-fourth of its height by it. Umbilicus wide, shallow; umbilical shoulders abruptly rounded. Sides more flattened than in *M. gracilitatis* White, gently convex up to the abruptly rounded narrow venter. Height of whorl twice its breadth and nearly half the entire diameter. Width of umbilicus nearly one-fourth of the entire diameter of the shell. Greatest breadth of whorl at a point halfway between base and venter.

Surface ornamented with sharp cross striae, slightly curved, and faint low folds, especially in age.

Septa ceratitic; saddles all rounded and entire, lobes all serrated. Ventral lobe divided by a broad, shallow siphonal saddle, the two divisions being serrated with about five denticulations; the first lateral is somewhat deeper and broader; the second lateral about half as deep as the first, and about two-thirds its width; the first auxiliary is small, shallow, provided with several denticulations; then follows a distinct auxiliary saddle, with a row of denticulations between that and the umbilicus. The internal septa consist of a moderately long antisiphonal lobe, and a single lateral.

Horizon and locality: *Meekoceras* (*Koninckites*) *mushbachanum* White is rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, where it was found at a place 5 miles southeast of Grays Lake and at another place 15 miles a little east of south from that lake. Alpheus Hyatt also found it at Wood Canyon, about 9 miles east of Soda Springs, Idaho. J. P. Smith found it in the Lower Triassic *Meekoceras* zone of the Inyo Range, in Union Wash, near Union Spring, east side of Owens Valley, about 15 miles southeast of Independence, Inyo County, Calif. In both Idaho and California it was associated with *Meekoceras gracilitatis*, *Pseudosageceras multilobatum*, and many other forms characteristic of the Lower Triassic of the regions around the Pacific.

Meekoceras (Koninckites) mushbachanum White, var. corrugatum Smith, n. var.

Plate 38, Figure 1

Shell large, evolute, widely umbilicate, laterally compressed, with flattened sides, and rounded venter. Surface bears coarse radial ribs that run straight up the flanks and become nearly obsolete on the venter. Septa and shape of the whorl exactly like those of *Meekoceras mushbachanum*. It also greatly resembles *Meekoceras costatum* Oeberg, as figured and described by Mojsisovics,[2] but differs in the straighter ribs. It is undoubtedly merely a variant from the typical form, with no stratigraphic significance, and is here figured and named in order to form a complete record of the group of so-called "*Arctoceras*," the discrimination of which has caused so much unnecessary confusion in the classification of the Meekoceratidae.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles east of Grays Lake; at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; at locality 5, 1 mile east of Hot Springs, north end of Bear Lake; at all these localities in the

[1] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 261, pl. 27, figs. 4, 5, 1895.

[2] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., p. 36, pl. 7, fig. 3, 1886.

same beds and faunal association as the typical form of the species.

Meekoceras (Koninckites) newberryi Smith, n. sp.

Plate 53, Figures 1–4

Shell large, evolute, laterally compressed; whorls high, with narrow but rounded venter. Umbilicus wide, with abruptly rounded shoulders. Surface nearly smooth, with very gentle folds and weak growth lines. Septa ceratitic, with rounded saddles and serrated lobes, of which the auxiliary consists of a series of small individuals, decreasing in size toward the umbilicus.

The height of the last whorl is two-fifths of the diameter of the shell; the width is half the height. The width of the umbilicus is one-third of the diameter of the shell. The last whorl embraces two-fifths of the inner and is indented by it to one-fourth of the height.

Meekoceras newberryi is closely related to *M. mushbachanum*, differing in its greater compression and weaker sculpture.

Named in honor of J. S. Newberry.

Horizon and locality: Rather common in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; associated with: *Meekoceras gracilitatis, Owenites koeneni, Inyoites oweni, Lanceolites bicarinatus, Aspenites acutus, Anasibirites desertorum, Pseudosageceras multilobatum*, and other forms.

Meekoceras (Koninckites) strongi Smith, n. sp.

Plate 52, Figures 12–17

Shell large, discoidal, evolute, widely umbilicate, with slow increase in height of whorl and rapid increase in diameter of the umbilicus. Whorls with flattened sides, gently rounded umbilical shoulders, and narrow arched venter, without ventral shoulders. Septa with rounded entire saddles, a short divided ventral lobe, large first lateral, somewhat smaller second lateral, a well-individualized auxiliary, followed by a short series of auxiliaries not individualized, all the lobes serrated. The internal septa show a large antisiphonal, flanked by a much smaller lateral lobe. The septa are very like those of *Meekoceras mushbachanum*.

The height of the whorl is somewhat less than half the diameter of the shell, the width of the whorl is less than half the height; the outer whorl embraces two-thirds of the inner and is indented by it to two-sevenths of the height. The width of the umbilicus is less than one-third of the diameter of the shell.

Meekoceras strongi is rather closely related to *M. mushbachanum*, differing in its greater compression and narrower venter, gentler slope of the umbilical shoulders, and greater convergence of the flanks toward the venter.

Named in honor of Mr. A. M. Strong, who assisted in collecting this fauna.

Horizon and locality: Rather rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis, Pseudosageceras multilobatum, Owenites koeneni, Inyoites oweni, Anasibirites desertorum, Lanceolites bicarinatus, Sturia compressa*, and other forms.

Meekoceras (Koninckites) tuberculatum Smith, n. sp.

Plate 50, Figures 1–4

Shell very large, discoidal, evolute, laterally compressed, widely umbilicate, with sides flattened and venter rounded. Surface with very weak folds, and fine umbilical nodes or tubercles, 14 to a revolution. Septa ceratitic, with three broadly rounded saddles and four strongly serrated lobes.

The height of the last whorl is three-sevenths of the diameter of the shell, and the width is slightly less than half the height. The outer whorl embraces half the inner and is indented by it to one-fourth of the height. The width of the umbilicus is one-fourth of the diameter of the shell. Imperfect specimens up to a diameter of 150 millimeters were found that lack the body chamber, which would add more than 50 millimeters to the diameter.

Meekoceras tuberculatum has some resemblance to *M. fulguratum* Waagen, of the Lower Triassic of the Salt Range in India, but differs in possession of the row of umbilical nodes. It also resembles "*Ceratites*" *oebergi* Mojsisovics,[3] of the Lower Triassic of Svalbard, but differs in its broader lobes.

Horizon and locality: Very rare in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis, Inyoites oweni, Owenites koeneni, Lanceolites bicarinatus, Anasibirites desertorum, A. noetlingi, Pseudosageceras multilobatum, Juvenites dieneri*, and other forms.

Genus CLYPEOCERAS Smith

1895. *Aspidites.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 215.
1897. *Aspidites.* Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 145.
1902. *Aspidites* (part). Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637.
1903. *Aspidites.* Arthaber, Neue Funde in den Werfener Schichten und im Muschelkalke des südlichen Bakony: Resultate der wissenchaftlichen Erforschung des Balatonsees, Band 1, Teil 1, p. 18.

[3] Mojsisovics, E. von, op. cit., p. 33, pl. 7, figs. 5, 6; pl. 8, figs. 1, 3.

1905. *Aspidites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 152.
1913. *Clypeoceras.* Smith, Ammonoidea, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 645.
1914. *Aspidites.* Arthaber, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 113.
Not 1876. *Aspidites.* Peters, K. Akad. Wiss. Berlin Monatsber., p. 914. (A snake.)

Type: *Aspidites superbus* Waagen.[4]

Laterally compressed, discoidal, involute; whorls deeply embracing and deeply indented by the inner whorls, increasing rapidly in height. Sides only slightly convex, sloping up to the rather narrow venter, which may be either angular or rounded but never provided with keels or furrows. Umbilicus usually narrow. Surface smooth or ornamented with radial striae and folds. No ribs visible at any stage of growth. Body chamber short, as in most discoidal shells.

Septa distinctly ceratitic, with rounded saddles and serrated lobes. The external lobe is divided into two branches by a siphonal saddle which may itself be serrated but not to the extent of forming adventitious lobes. The first and second laterals are large and deep, and the denticulations may run high up on the sides of the saddles. The auxiliary series is very long and complicated, consisting of several denticulations united into a broad auxiliary lobe, followed by a number of irregular lobes of greater or less size, not individualized. The saddles are usually long and narrower than the lobes. The internal septa consist of a divided antisiphonal lobe, with a principal internal lateral and an auxiliary series inside the umbilical suture.

This genus greatly resembles the subgenus *Koninckites* but differs in the greater involution and the greater complexity of the auxiliary series, both external and internal; it may very likely have developed out of *Koninckites*. Another genus with which it may be compared is *Clypites*, which, however, has adventitious lobes and also has the auxiliary series much simpler; also *Clypites* is usually more involute than *Clypeoceras*, although this character alone would not be sufficient for separation.

Clypeoceras has been found in the Lower Triassic of the Salt Range and the Himalayas in India and in Hungary, Timor, and Albania; Alpheus Hyatt found it in the *Meekoceras* zone of Aspen Ridge, near Soda Springs, in southeastern Idaho, and J. P. Smith found it in the same zone in the Inyo Mountains of Inyo County, Calif., in both places associated with *Meekoceras gracilitatis* White. It is therefore a world-wide Lower Triassic genus.

[4] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 218, pl. 23; pl. 24, fig. 1, a-b, 1895

Clypeoceras hooveri Hyatt and Smith

Plate 17, Figures 1–12

1905. *Aspidites hooveri.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 153, pl. 17, figs. 1–12.

Form compressed, discoidal, involute, deeply embracing, inner whorls almost completely concealed by the outer and indenting the outer to nearly half its height. Umbilicus narrow, the umbilical shoulders of the succeeding whorls being so gently rounded and meeting each other at so nearly the same angle that the umbilicus makes a deep and craterlike conical depression. Sides gently convex, from the craterlike walls of the umbilicus to the rounded and rather narrow venter. Greatest breadth of the whorl at a point halfway from base to venter.

Surface ornamented with fine cross striae, which are visible only in the few places where the shell is preserved. The body chamber appears to have been two-thirds of the last revolution.

Septa ceratitic, but some of the saddles have become slightly ammonitic. The external lobe is broad and divided into the broad branches by a shallow siphonal saddle, which is digitate, but not to the extent of forming adventitious lobes.

The first lateral lobe is equally broad and twice as deep; the second lateral lobe is about two-thirds the depth of the first. Then comes the auxiliary series, consisting of a small, somewhat individualized, first auxiliary, followed by a long, irregular series of denticulations, making more or less distinct lobes and saddles but smaller than the first.

The first lateral saddle is long, narrow, and denticulate to the apex on the upper side; the second is similar in shape but longer and entire; the third, which separates the second lateral lobe from the auxiliary series, is shallow, broad, and denticulate all around. The septa are more highly specialized than those of any other known species of *Clypeoceras*, being more like those of *Proptychites ammonoides* Waagen.[5] But in *Clypeoceras hooveri* the saddles are narrower, the first lateral saddle denticulate only on the upper side, and the secondary lobes in the auxiliary series much smaller and more distinct. Also the first and second lateral lobes are not rounded at the end but square, and the denticulations are fewer. *Proptychites ammonoides* is quite robust, the whorl being nearly twice as thick proportionally as in *Clypeoceras hooveri*.

[5] Idem, p. 171, pl. 17, figs. a–c.

Dimensions of Clypeoceras hooveri

Type specimen

	Millimeters
Diameter	124
Height of last whorl	60
Height of last whorl from the preceding	34
Width of last whorl	22
Width of umbilicus	14
Involution	26

A smaller specimen

Diameter	21
Height of last whorl	9
Height of last whorl from the preceding	7
Width of last whorl	5
Width of umbilicus	6
Involution	2

The smaller specimen was broken so as to expose the inner whorls, and at the diameter of 5 millimeters showed a distinct *Lecanites* stage, similar to that of *Meekoceras gracilitatis*. No other proof is needed of the relationship and derivation of this genus.

Horizon and locality: *Clypeoceras hooveri* was found by J. P. Smith in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, of the Inyo Range, east side of Owens Valley, in Union Wash, about 1½ miles east of Union Spring and 15 miles southeast of Independence, Inyo County, Calif. It was associated with *Meekoceras gracilitatis* White, *Meekoceras mushbachanum* White, *Flemingites aplanatus* White, and many other forms.

Clypeoceras muthianum (Krafft)

Plate 27, Figures 1–7

1909. *Aspidites muthianus*. Krafft, in Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 59, pl. 6, fig. 5; pl. 15, figs. 1, 2.

Shell rather large, high whorled, narrowly umbilicate laterally compressed, with narrow and gently rounded venter. Surface smooth, with only fine growth lines. Septa ceratitic, with rounded entire saddles and very strongly serrated lobes. The external lobe is divided into two short and rather broad branches; the saddle between the external and first lateral lobe is long and strongly constricted toward the base. The first lateral lobe is long and broad, with very numerous and long serrations; the second lateral is about half as large; then follows a long auxiliary series, decreasing in size and complexity toward the umbilicus.

The largest specimen found had a diameter of 70 millimeters; in a typical specimen the height of the last whorl is slightly less than half of the diameter of the shell; the width is slightly less than half the height; and the width of the umbilicus is one-seventh of the diameter of the shell.

The American specimens agree perfectly with "*Aspidites*" *muthianus* from the *Hedenstroemia* beds of the Himalayas, as figured by Krafft and Diener in the work cited above, and the faunal association is the same in the two regions. It is not surprising to find generalized forms resembling each other in widely separated regions, but *Clypeoceras muthianum* is a highly specialized type with may peculiar characters that would attract the attention of the systematist at once. However, *Clypeoceras muthianum* does not stand alone in showing connection between India and western America during this epoch; *Xenodiscus nivalis*, *Pseudosageceras multilobatum*, and *Owenites egrediens* appear to occur on both sides of the Pacific Ocean, and many species of *Meekoceras* are so closely related that separation is difficult or even arbitrary.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone (*Pseudosageceras multilobatum* subzone) at the head of Wood Canyon (locality 3), Aspen Mountains, 9 miles east of Soda Springs, Idaho; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. cirratus*, *F. aplanatus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Pseudosageceras multilobatum*, *Aspenites acutus*, and other forms.

The species was first described from the *Hedenstroemia* beds of India, in very much the same faunal association, with *Meekoceras*, *Hedenstroemia*, *Flemingites*, *Pseudosageceras*, and other forms very closely related to American species.

Clypeoceras pusillum Smith, n. sp.

Plate 51, Figures 11–13

Shell small, involute, laterally compressed, with flattened sides, narrow umbilicus, and narrow flattened venter bordered by blunt angles. Surface smooth. Septa ceratitic, with rounded saddles and serrated lobes of which there are a small external, two larger laterals, and a long auxiliary series, reducing in size toward the umbilicus.

Dimensions of the type specimen of Clypeoceras pusillum

	Millimeters
Diameter	20
Height of last whorl	11
Height of last whorl from the preceding	5. 5
Width of last whorl	4
Width of umbilicus	2. 5

Clypeoceras pusillum is closely related to "*Aspidites*" *eurasiaticus* Frech, as figured by Arthaber,[6] but it differs from the Hungarian species in its much smaller size and much longer and more complex auxiliary series of lobes.

Horizon and locality: Very rare in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis*, *Clypeoceras hooveri*, *Anasibirites noetlingi*, *A. deser-*

[6] Arthaber, G. von, Neue Funde in den Werfener Schichten und im Muschelkalke des südlichen Bakony: Resultate der wissenschaftlichen Erforschung des Balatonsees, Band 1, Teil 1, p. 18, pl. 1, figs. 1 a–c, 1903.

torum, *Inyoites oweni*, *Owenites koeneni*, *Lanceolites compactus*, *Sturia compressa*, *Pseudosageceras multilobatum*, and other forms.

Genus DAGNOCERAS Arthaber

1911. *Dagnoceras*. Arthaber, Die Trias von Albanien: Beitr' Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 240.

Type: *Dagnoceras komanum* Arthaber.[7]

Arthaber in his work cited describes a group of meekoceran forms, from the *Columbites* beds, under the name *Dagnoceras*, family Arctoceratinae, without citation of a type. The first species mentioned in the diagnosis is *D. komanum* Arthaber, which therefore automatically becomes the type, although it is by no means the most characteristic form.

All the species listed are moderately involute, rather robust, and with narrow venters and very simple serrated lobes.

Arthaber overlooks the fact that "*Arctoceras*" is merely *Meekoceras* of the group of *M. mushbachanum* and that the so-called family Arctoceratinae does not exist.

In the *Meekoceras* zone of Idaho there are four species that belong to this group, *Dagnoceras*, characterized by the thick flanks and narrow venters and by having the young extremely robust and with the strong collar ribs suggestive of *Paratirolites*. It is not known that the Albanian species possess the latter character, for no young specimens were figured and described.

The writer regards *Dagnoceras* as a valid group, more nearly related to *Anasibirites* than to *Meekoceras*.

The American species referred to *Dagnoceras* are *D. bridgesi* Smith, *D. bonnevillense* Smith, *D. haydeni* Smith, and *D. pealei* Smith, all from the *Pseudosageceras multilobatum* subzone of the *Meekoceras* zone of southeastern Idaho. Of these *D. haydeni* is the most characteristic and has the generic characters in most marked degree. It is rather probable that Arthaber's species assigned to *Dagnoceras* are not all congeneric, but this could be decided only by an ontogenic study of them, which was not possible with the material available. *Dagnoceras terbunicum* Arthaber is the only Albanian species with any close resemblance to the American and should have been chosen as the type, as it is well represented in the fauna described.

The writer regards this group as a parallel development with *Meekoceras* from *Xenodiscus*, and from the subgenus *Paratirolites* or some kindred form. The young stages of the American species are entirely unlike those of *Meekoceras* and are fairly consistently uniform. Therefore they are assigned to the genus *Dagnoceras*, in spite of the doubt as to the unity of the Albanian species and of the doubt as to what is the type.

Horizon and locality: Rather common in the Lower Triassic *Columbites* zone of Albania; rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho.

Dagnoceras bonnevillense Smith, n. sp.

Plate 29, Figures 9–23

Shell small, involute, strongly compressed laterally, arched sides, and narrow venter, with blunt marginal angles but no ventral furrow. Surface smooth. Septa ceratitic, with four external serrated lobes, of which the auxiliary is not individualized but consists of a few serrations.

The height of the last whorl is three-fourths of the diameter of the shell, the width is more than one-third of the height; the width of the umbilicus is greater than one-fourth of the diameter of the shell.

Dagnoceras bonnevillense resembles *D. haydeni* but is less evolute, is more gibbous and less egredient and has less sharp ventral keels but no ventral furrow.

Horizon and locality: Rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Pseudosageceras multilobatum*, *Paranannites aspenensis*, *Juvenites kraffti*, and other forms.

Dagnoceras bridgesi Smith, n. sp.

Plate 31, Figures 1–7

Shell small, involute, laterally compressed, narrowly umbilicate, deeply embracing. Whorls flattened, with greatest breadth at the umbilical shoulder, tapering gently to the narrow biangular venter. Ventral furrow pronounced, founded by rather sharp keels. Surface nearly smooth. Septa ceratitic, with the fourth or auxiliary lobe consisting of an obscure row of denticulations, not individualized.

Dagnoceras bridgesi differs from *D. haydeni* in its more compressed and less evolving whorl and narrower umbilicus. It is thicker than *D. pealei*, with deeper umbilicus and steeper umbilical walls.

Named in memory of James Bridges, who assisted in collecting this fauna and working out the stratigraphy of the Lower Triassic of Idaho.

Horizon and locality: Rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, *Xenodiscus intermontanus*, *Pseudosageceras multilobatum*, and other forms.

[7] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 242, pl. 21, figs. 11 a–c.

Dagnoceras haydeni Smith, n. sp.

Plate 29, Figures 1–8

Shell small, laterally compressed, rather widely umbilicate; high whorl with greatest thickness at the umbilicus, sloping to the very narrow biangular venter. The umbilicus is wide, and the whorl decidedly egredient. In youth the whorl is coronate, with distinct collar ribs like those of *Anasibirites*.

The septa are ceratitic, with rounded entire saddles and three external lobes, being thus simpler than those of *Meekoceras*. The length of the body chamber is uncertain but appears to be less than a revolution.

The height of the last whorl is less than half the diameter of the shell; the width is half the height; the width of the umbilicus is one-fourth of the diameter of the shell. The outer whorl embraces three-fifths of the inner and is indented by it to one-third of the height.

Dagnoceras haydeni is closely related to *D. terbunicum* Arthaber from Albania, agreeing in the narrow biangular venter, in the thickening at the umbilicus, and in the possession of only three external lobes, which are very similar on the two species. It differs from *D. terbunicum* in the wider and more egredient umbilicus and in the thicker whorl.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras mushbachanum, M. gracilitatis, Flemingites russelli, Hedenstroemia kossmati, Lanceolites compactus, Cordillerites angulatus, Aspenites acutus, Pseudosageceras multilobatum,* and other forms.

Dagnoceras pealei Smith, n. sp.

Plate 29, Figures 24–37

Shell small, laterally compressed, involute, narrowly umbilicate, deeply embracing. Sides flattened, converging gently to the narrow biangular venter, with narrow ventral furrow. Surface nearly smooth, with fine transverse striae. Septa ceratitic, with four external serrated lobes, of which the auxiliary is broken up into a series of denticulations like that supposed to be characteristic of "*Prionolobus*."

Dagnoceras pealei is thinner and less egredient than the other American members of this group. It is very similar to *Xenodiscus schmidti* Mojsisovics,[8] and especially to Figures 11 a–c of Mojsisovics's plate, which Waagen [9] names as a new species, "*Gyronites*" *mojsisovicsi* Waagen. It differs from the Arctic species chiefly in the less sharp ventral keels and the narrower ventral space between the angles. In septa and shape the two agree perfectly.

Named in honor of A. C. Peale, whose work on the geology of southeastern Idaho has been invaluable to later workers in that region.

Horizon and locality: Rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Ussuria waageni, Aspenites acutus, Cordillerites angulatus, Lanceolites compactus, Paranannites aspenensis, Juvenites kraffti, Prenkites depressus, Pseudosageceras multilobatum, Ophiceras dieneri,* and other forms.

Genus KASHMIRITES Diener

1913. *Kashmirites.* Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser. vol. 5, Mem. 1, p. 33.

1922. *Kashmirites.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 120.

1929. *Kashmirites.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 36.

1929. *Wasatchites.* Mathews, op. cit., p. 40.

Type: Group of "*Celtites*" *armatus* Waagen.

Shell robust, moderately evolute, rather widely umbilicate; cross section subquadratic, with height approximately equal to the breadth. Sculpture consisting of sharp, undivided ribs that begin in nodes on the umbilical shoulders, run straight up the flanks, and cross the venter with considerable reduction in size, and without a forward-bending sinus. Septa ceratitic, with rounded saddles; there is a divided ventral lobe, a very large first lateral, a smaller second lateral, and a small auxiliary outside the umbilical suture; the internal septa show a long antisiphonal lobe (divided?) flanked by a small lateral.

The body chamber is said by Welter to be about three-quarters of a revolution in length.

Diener, in describing this genus, stated that it was a derivative of *Xenodiscus* and a near relative of *Sibirites* (= *Anasibirites*). The writer would go still further and state that *Kashmirites* is derived from the *Paratirolites* group of *Xenodiscus* and that it was the ancestor of *Anasibirites*, giving a much needed link between the Xenodiscidae and that branch of the Meekoceratidae. The young of those species of *Kashmirites* that have been studied resemble closely the adults of *Paratirolites*.

Kashmirites, so far as known, is restricted to the *Flemingites* or *Hedenstroemia* beds of India; to the *Owenites* zone of Timor (which lies just between the *Pseudosageceras multilobatum* and *Anasibirites* zones); and to the *Anasibirites* subzone of the *Meekoceras* zone of Utah. The genus is therefore a successor to

[8] Mojsisovics, E. von, Die Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 77, pl. 11, figs. 7–11, 1886.

[9] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 290, 1895.

Genodiscus, of which it is supposed to be a descendant, and a predecessor of *Anasibirites*, of which it is probably the ancestor.

Mathews has described in the paper cited above several species of *Kashmirites* from the *Anasibirites* subzone of Utah, along with the supposedly new genus *Wasatchites*, which, however, agrees in all essentials with typical *Kashmirites* and is listed in the synonymy of that genus.

Kashmirites meeki (Mathews)

Plate 81, Figures 1, 2

1929. *Wasatchites meeki*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 41, pl. 7, figs. 1–3; pl. 8, figs. 11–14.

The specific description is quoted from the paper by Mathews, cited above.

This form is involute, discoidal, rugose, laterally compressed; whorls high, deeply embracing, and well indented by the preceding volution. The sides are nearly flat, sloping rapidly from the umbilical shoulder to the outer margin. The ventral shoulder is square. The umbilical shoulder is square, possessing well-defined, somewhat elongated, sharp nodes, with the elongation crossing the whorl. The umbilicus is narrow and deep, being one-fourth the diameter of the shell. The height of the last whorl is a little greater than its greatest thickness and one-half its diameter. It is indented to one-third its height by the penultimate volution and conceals three-fourths of this volution. The distance across the penultimate volution from suture to suture is greater than the involution. The venter is slightly arched and highly sculptured. The living chamber is fully one-half the last volution. The shell is thick. The cross section of the last whorl is trapezoidal.

The surface is ornamented with distinct nodes at the umbilical shoulder, which give rise to indistinct, flexuous, radial ribs that become somewhat prominent as they cross the ventral shoulder. They cross the venter in a low arc. The surface sculpture shows on the preceding volutions. The entire surface is covered with extremely fine, flexuous costae.

The sutures are ceratitic. The ventral lobe is divided by a moderately deep siphonal saddle. The lateral prongs are deeply serrated. The first lateral lobe is broad and moderately long, the second is short and broad; both are serrated. The lateral saddles are broad and smooth. The sutures are slightly incised.

Horizon and locality: Upper *Anasibirites* bed, Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Kashmirites perrini (Mathews)

Plate 81, Figures 6–8

1929. *Wasatchites perrini*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 40.

1929. *Wasatchites magnus*. Mathews, op. cit., p. 41, pl. 11, figs. 1, 2.

This species was chosen by Mathews as the type of a supposedly new genus, "*Wasatchites*," but as the characters of the type agree in all essentials with those of *Kashmirites*, it is placed under that genus, and *Wasatchites* is put in synonymy.

The specific diagnosis is quoted from the work of Mathews, cited above.

This form is involute, discoidal, rugose, laterally compressed; whorls high, moderately embracing, and well indented by the penultimate volution. The sides are nearly flat and slope rapidly from the umbilical to the ventral shoulder. The ventral shoulder is angular. The umbilical shoulder is angular, possessing well-developed, long, sharp nodes. The inner wall is nearly vertical. The umbilicus is moderately wide and deep; it is about one-third the diameter of the shell and three times its own depth. (The measurements were taken from the depression between the nodes.) The height of the last whorl is nearly twice its greatest thickness and less than one-half its diameter. It is indented to nearly one-fourth its height by the preceding volution and conceals over half of this volution. The distance across the penultimate volution from suture to suture is nearly twice the involution. The venter is slightly arched, broad, and highly sculptured. The living chamber is fully one-half the last whorl. The cross section of the last whorl is broadly trapezoidal. The shell is very thick and appears to consist of an inner and an outer layer.

The surface is ornamented with broad, prominent, nearly straight radial ribs, which bend forward near the ventral shoulder where they become enlarged, forming a distinct nodose character. They originate in groups of three on the highly developed nodes or spines of the umbilical shoulder and after traversing the side wall cross the venter in a straight line. The ornamentation shows on all of the whorls. The sutures are ceratitic. The ventral lobe is narrow, occupying one-half the venter, and is divided by a wide, short siphonal saddle. The lateral prongs are serrated. The first lateral lobe is long and narrow; the second is short, narrow, and may ride the umbilical nodes; both lobes are deeply serrated. The auxiliary lobe is wide, deep, and crosses the inner wall in a retrogressive manner. The third lateral saddle is broad, shallow, and rides the umbilical shoulder. The sutures are not incised. The early whorls are rugose, about as broad as high, and the adult characters show on the fourth volution.

This species is somewhat similar to *Ceratites subrobustus* Mojsisovics. It has a square outline, more highly developed sculpture; the umbilical nodes are much more intensely developed; the venter is flat and the sutures are less ceratitic.

Horizon and locality: Upper *Anasibirites* bed, Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Kashmirites resseri Mathews

Plate 81, Figures 9, 10

1929. *Kashmirites resseri*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 38, pl. 8, figs. 4–7.

The specific diagnosis of *Kashmirites resseri* is quoted from the paper of Mathews, cited above.

This form is involute, discoidal, thin, laterally compressed; whorls high, deeply embracing, and well indented by the preceding volution. The sides are slightly convex and slope rapidly from the umbilical to the ventral shoulder. The ventral shoulder is square. The umbilical shoulder is slightly rounded. The inner wall is wide and nearly vertical. The umbilicus is wide and moderately deep, being one-fifth the diameter of the shell. The height of the last whorl is one and one-half times its width and one-half the diameter of the shell. It is indented to one-third its height by the preceding volution and conceals three-fourths of this volution. The distance across the penultimate volution from suture to suture nearly equals the involution. The venter is flat and moderately wide. The cross section of the last whorl is nearly trapezoidal. The surface is ornamented by a few widely spaced, straight radial ribs, which become indistinct near the ventral shoulder. These cross the venter in a straight line. The cross section of the first whorl is ellipsoidal with the long axis of the ellipse transverse to the plane of the shell; the second whorl is ellipsoidal with the long axis of the ellipse in the plane of the shell; the third whorl takes on the characteristics of the adult.

This species has many characteristics like *Goniodiscus* and may eventually be assigned to that genus. However, the sculpture on the side walls is more distinct; the cross section of the whorl is trapezoidal, and the sutures are like those of *Kashmirites*.

Horizon and locality: Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Kashmirites seerleyi (Mathews)

Plate 81, Figures 11, 12

1929. *Keyserlingites seerleyi*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 39, pl. 8, figs. 8–10.

This species was described under *Keyserlingites* Hyatt but clearly is a member of *Kashmirites*. The specific diagnosis is quoted from Mathews's paper, cited above.

The shell is involute, moderately embracing, discoidal, thick, rugose; whorls moderately high, embracing, and slightly indented by the preceding volution. The sides are well rounded and grade into the shoulders, forming a wide arc. The venter is rounded, grading into the flanks without forming distinct shoulders. The umbilical shoulder is rounded; the inner wall sloping. The umbilicus is wide and deep. The height of the last whorl is a little more than its greatest thickness and less than one-third its diameter. It is indented to more than one-third its height by the inner volution and conceals nearly half of this volution. The distance across the penultimate volution from suture to suture is one and one-half times its involution. The whorls slowly increase in height. The cross section of the last whorl is broadly ellipsoidal.

The surface is ornamented by large, well-defined, slightly flexuous radial ribs, which originate in prominent nodes on the umbilical shoulder. Four ribs originate from one node. These ribs cross the venter in nearly a straight line, becoming somewhat enlarged at the ventral shoulder. The inner wall is plain, not being marked by either ribs or costae. The umbilical nodes show on the preceding volutions, becoming less sharp and more elongated on the inner whorls.

The sutures are ceratitic. The ventral lobe is long, narrow, and divided by a deep, narrow siphonal saddle, which is notched at its base. The lateral prongs are denticulated. The first lateral is long, narrow, and deeply serrated; the second is broad, short, and deeply serrated. The saddles are wide, deep, and smooth. The first lateral crosses a part of the venter. The suture crosses the inner wall in nearly a straight line.

This species quickly develops from its early to its adult stages. The adult characters show on the third volution and remain constant thereafter.

This species is very similar to *Ceratites robustus* Mojsisovics, but the long axis of the ellipsoidal cross section is in the plane of the whorl; the whorls are more evenly spiral, and four ribs originate in a single node. The species is not common.

Horizon and locality: Upper *Anasibirites* beds, Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Kashmirites subarmatus Diener

1913. *Kashmirites subarmatus*. Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 36, pl. 5, figs. 2, 3.

1922. *Kashmirites subarmatus*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 121, pl. 164, figs. 6–8.

1929. *Kashmirites subarmatus*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 36, pl. 7, figs. 40–45.

The specific description is quoted by Mathews from Diener's work, cited above.

In its general shape, involution, and in the outlines of the cross section our species agrees fairly well with *K. armatus*. The umbilicus is impressed less deeply than in *K. blaschkei*. Umbilical margin acute, siphonal margin obtusely rounded. Greatest transverse diameter corresponding to the umbilical edge.

It is especially in some of the inner nuclei that the siphonal area is arched more distinctly than in the full-grown individuals. Lateral parts flat.

Sculpture consisting of single radial ribs, which originate in the umbilical edge and run in a straight direction toward the siphonal margin, where they are slightly turned forward and rise occasionally into indistinct tubercles. Some ribs are also elevated above the general level at the place where they originate near the umbilical edge. In the inner nuclei the ribs attain their greatest strength in the umbilical region and become gradually obsolete before reaching the siphonal margin, but in adult individuals the majority of ribs are of equal strength during their entire extent. The siphonal area is not smooth but crossed by the ribs symmetrically from either side. The external ribs are, however, considerably inferior in strength to the lateral ones.

The sculpture—and this is the chief difference from the ornamentation noticed in *K. armatus*—is very irregular, not only in different specimens, but often in the same individual, according to different stages of growth. In young specimens, as a rule, the ribs are less numerous and, consequently, arranged at greater distances than in full-grown individuals. * * * At the commencement of the last volution the number of ribs is very small, not larger proportionately than in the nucleus mentioned above.

The ribs are stout and of equal strength throughout. In the remaining portion of this whorl the ribs are crowded. * * *

In the anterior region adjoining the aperture the ribs again become less numerous and stout and are elevated considerably along the siphonal and umbilical margins.

Dimensions.—The measurements of my largest specimen are as follows:

	Millimeters
Diameter of the shell	51
Diameter of the umbilicus	21
Height of the last volution	16
Thickness of the last volution	18

Sutures.—The sutural line is well preserved in the specimen illustrated in Plate 5, Figure 3, especially in the last septa. Lobes elongated and narrow. Principal lateral lobe with three distinct denticulations in its base. Two lateral lobes and saddles and a small auxiliary lobe outside the umbilical suture. Siphonal and principal lateral saddles of nearly equal size. Second lateral saddle considerably smaller.

Mathews adds the following comment:

The ribs of the Utah specimens are more strongly developed near the umbilical shoulder than on Diener's type, but the other characters are practically identical. Therefore, it is safe to refer the specimens to this species.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

Kashmirites wasatchensis Mathews

Plate 81, Figures 3–5

1929. *Kashmirites wasatchensis.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 37, pl. 6, figs. 26–28.

1929. *Kashmirites thornei.* Mathews, op. cit., p. 38, pl. 6, figs. 22–25.

1929. *Kashmirites gilberti.* Mathews, op. cit., p. 38, pl. 7, figs. 4–9.

1929. *Wasatchites quadratus.* Mathews, op. cit., p. 42, pl. 7, figs. 23–25.

This common and variable species has been described by Mathews under a variety of names. The specific description is quoted from his diagnosis of *Kashmirites wasatchensis*, in the work cited above.

Involute, discoidal, thick, robust, laterally compressed; whorl high, slightly embracing, and indented by the preceding volution. Sides flat and slope gently from the umbilical to the ventral shoulder. Shoulders square. Umbilicus wide and very deep. It is three-eighths the diameter of the shell and three times its own depth. Inner wall is wide and vertical. Height of the last whorl is less than one-half the diameter of the shell and a little greater than its greatest thickness. It is indented to one-third its height by the preceding volution and conceals nearly one-half this volution. Distance across the penultimate volution from suture to suture is greater than the involution. Venter is nearly flat and wide. Cross section of the last whorl is trapezoidal. Shell is very thick.

Surface is ornamented by coarse, flat ribs, which form nodes on the umbilical and ventral shoulders. The ribs cross the venter in nearly a straight line. Nodes show on the preceding volutions.

Sutures are ceratitic. The two lateral lobes are serrated. The first lateral is long and narrow; the second is broad, shallow, and rides the ribs. The ventral lobe is broad and divided by a deep siphonal saddle. The lateral prongs are denticulate.

Remarks: This species is similar to *Kashmirites subarmatus* Diener, but the cross section of the last whorl is less quadrate, the ribs are less distinct, the involution is greater and the sutures are ceratitic. It is similar to *Kashmirites acutangulatus* Welter; but the ribs are less distinct, the nodes are better defined on the umbilical shoulder, and the ventral lobe is serrated.

Horizon and locality: Upper *Anasibirites* beds, Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Genus ANASIBIRITES Mojsisovics

1895. *Sibirites.* Waagen, Fossils of the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 104.

1896. *Anasibirites.* Mojsisovics, Beiträge zur Kenntniss der obertriadischen Cephalopodenfaunen des Himalaya: K. Akad. Wiss. Wien, Math.-nat. Klasse, Denkschr., Band 63, p. 615.

1899. *Anasibirites.* Mojsisovics, Upper Triassic cephalopod faunae of the Himalaya: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 3, pt. 1, p. 49.

1905. *Sibirites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 48.

1909. *Sibirites.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 124.

1911. *Pseudosibirites.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 254.

1913. *Sibirites.* Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, Mem. 1, p. 31.

1914. *Anasibirites.* Arthaber, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 178.

1922. *Anasibirites.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 138.

1927. *Sibirites.* Yehara, The Lower Triassic cephalopod and bivalve fauna of Shikoku: Japanese Jour. Geology and Geography, vol. 5, No. 4, p. 167.

1929. *Anasibirites.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 7.

1929. *Gurleyites.* Mathews, idem, p. 43.

Not 1886. *Sibirites.* Mojsisovics, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 58.

Type: "*Sibirites*" *kingianus* Waagen,[10] from the Lower Triassic upper Ceratite limestone (*Anasibirites* beds), of the Salt Range in India.

Shell moderately involute, somewhat compressed laterally; venter rounded or flat, in some specimens with a shallow depression bordered by shoulder angles. Cross section rounded or subangular, usually higher than wide. Sculpture consisting of numerous ribs, usually single, running nearly straight up the flanks, crossing the venter in a shallow, forward-pointing series. These ribs at maturity are mostly very fine, coarser in youth, and almost invariably bundled; they became nearly obsolete at maturity.

In the adolescent stages there are invariably rather coarse ribs, and every third or fourth one stands out above the others as a distinct collar rib. This is the most striking character of the genus, recapitulating the coarse-ribbed Permian *Xenodiscus*.

The septa are invariably serrated, with rounded and entire saddles. The external lobe is divided by a shallow saddle into two rather narrow branches that may be either goniatitic or serrated. The first and second lateral lobes are invariably serrated, and the auxiliary may be either goniatitic or serrated. The internal septa show a very long tongue-shaped anti-

[10] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 108, pl. 8, figs. 1, 2, 1895.

siphonal (bifid?), flanked by a shallow serrated internal lateral.

The length of the body chamber is about three-fourths of a revolution. Waagen, who named the first species of this genus, states that the body chamber is very long, which has not been substantiated. Arthaber[11] also says that the body chamber of *Pseudosibirites* is very long, basing his statement upon Waagen's supposed observation. Welter,[12] after an examination of a large number of specimens, states that the length of the body chamber is not greater than three-fourths of a revolution. This statement agrees with the observations of the writer, made upon a very much larger number of individuals.

Anasibirites was originally included in *Sibirites*, and Mojsisovics's original description, although his type was the Lower Triassic Arctic *Sibirites pretiosus*, seems to have been based largely on the Upper Triassic group of "*Sibirites*," now referred to *Metasibirites*, of the family Haloritidae.

Krafft and Diener[13] regard *Sibirites* and *Anasibirites* as synonyms and members of the Meekoceratidae. This view may be correct, for the long body chamber, supposed to be characteristic of the Arctic *Sibirites*, and the alternate meeting of the ribs on the venter are probably no more true of them than for the forms from India referred to *Anasibirites*.

The true *Sibirites* are generally regarded as members of the Haloritidae, but Arthaber[14] places *Sibirites* in the Meekoceratidae, and *Anasibirites* (=*Pseudosibirites*) in the Gastrioceratea. There can, however, now be no doubt that *Anasibirites* is a member of the Meekoceratidae, a ceratitoid, with no kinship with *Metasibirites*, and that it is a descendant of *Xenodiscus* and a probable ancestor of at least some of the groups of *Ceratites*. The immediate progenitor of *Anasibirites* may have been *Kashmirites*, which antedates *Anasibirites* in geologic occurrence and greatly resembles the adolescent stages of it.

Anasibirites was once believed to be very rare, as it was known only in a few fragments from the Upper Ceratite limestone of the Salt Range. Now it is known to be very abundant at the same horizon—the *Anasibirites* zone—in India, Timor, Svalbard, and Utah.

Anasibirites angulosus (Waagen)

Plate 79, Figures 13–15

1895. *Sibirites angulosus*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 117, pl. 8, figs. 12a–c, 13a, b.

1905. *Sibirites angulosus*. Noetling, Die asiatische Trias: Lethaea geognostica, Teil 2, Das Mesozoicum, Band 1, Trias, pl. 28, fig. 4.

1929. *Anasibirites pseudoibex*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 21, pl. 3, figs. 28–31; pl. 7, fig. 46.

This species was first described from the *Anasibirites* beds of India. It is rather common at the same horizon in Timor and has been described by Mathews from the *Anasibirites* beds of Utah under the name *A. pseudoibex*. The description below is taken from Mathews's description of that species.

The shell is involute, discoidal, rugose, embracing; high angular whorl moderately indented by the penultimate volution. The sides are flat and slope from the umbilical shoulder to the ventral shoulder. The umbilical shoulder is sharply rounded, and the inner wall is vertical. The ventral shoulder is sharply angular. The living chamber is more than one-half of the last volution. The umbilicus is moderately wide, showing one-half of the preceding volution. It is one-fourth the diameter of the shell, and its shoulder diameter is over twice its depth. The height of the last whorl is one and one-fourth times its thickness and less than one-half its diameter. It is indented to less than one-third its height by the penultimate volution and conceals one-half of this volution. The width of the shell is one-third its diameter. The distance across the penultimate volution from suture to suture is nearly twice the involution. The venter is one-half the width of the shell and is uniformly flat and uniformly sculptured.

The surface is ornamented with prominent, heavy, coarse, flexuous, progressive radial ribs, which are uniform and evenly spaced across the venter. They cross the venter in a wide progressive arc with the steepest slope toward the aperture. The primary ribs originate in the umbilical suture, cross the inner wall in a retrogressive manner, become somewhat enlarged where they cross the umbilical shoulder, and are somewhat less distinct on the flanks. Some primaries bifurcate at the umbilical shoulder and cross the side wall with equal intensity. The auxiliary ribs originate either at the umbilical suture, on the inner wall, or on the lateral wall and cross the surface in line with the primaries. There is no regularity as to the origin or distribution of the auxiliaries.

The sutures are ceratitic. The saddles are all evenly rounded and the lobes serrated. There are four serrations on the first lateral and two on the second, while the ventral lobe has two. The sutures are distinctly separated one from the other, the base of the saddle being even with the crest of the lobe of the next preceding suture.

This species may be confused with *Sibirites ibex* Waagen but is distinct from that species in possessing distinct auxiliary ribs, its trapezoidal form, its large umbilicus, and its sloping lateral walls. It is somewhat similar to *Sibirites eichwaldi* Keyserling, but the ribs cross the venter in a straight continuous line and there is no ventral furrow.

Horizon and locality: Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Anasibirites bastini Mathews

Plate 80, Figures 3–5

1929. *Gurleyites bastini*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 49, pl. 10, figs. 7–11.

This species was described as belonging to a supposedly new genus but is clearly a typical member of

[11] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 254, 1911.

[12] Welter, O. A., Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 139, 1922.

[13] Krafft, A. von, and Diener, Carl, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, p. 179, 1909.

[14] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 254, 1911.

Anasibirites. The diagnosis given below is quoted from that of Mathews.

This shell is involute, obovate, thin, laterally compressed; whorls high, moderately embracing, and indented by the inner volution. The sides are slightly convex and slope gently from the umbilical shoulders to the outer margins. The venter is slightly arched and smooth. The ventral shoulder is nearly square; the umbilical sharply rounded. The inner wall is nearly vertical. The umbilicus is broad, very shallow, and ellipsoidal. Its long diameter is nearly one-fourth the greatest diameter of the shell and twice its own depth. The height of the last whorl is one and one-half times its greatest width and two-fifths its diameter. It is indented to one-third its height by the preceding volution and conceals nearly one-half this volution. The distance across the penultimate whorl from suture to suture is four-sevenths the greatest breadth of the shell and equal to the involution. The living chamber straightens and comprises nearly one-half of the last whorl.

The surface is ornamented with prominent, flexuous radial ribs, which, on the last whorl, develop high, very prominent elongated nodes on the umbilical shoulder. In the earlier whorls the ribs are less distinct, more evenly developed, and more regular. The entire surface is covered with very fine, flexuous costae. The larger ribs form indistinct nodes at the ventral shoulder and cross the venter in an almost straight line. The inner whorls show ornamentation.

The sutures are ceratitic. The ventral lobe is divided by a V-shaped siphonal saddle. The lateral prongs are serrated. The lateral lobes are moderately broad, long, and deeply denticulated. The lateral saddles are wide and smooth.

Horizon and locality: Upper *Anasibirites* bed, Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

Anasibirites desertorum Smith, n. sp.

Plate 52, Figures 7–11; Plate 56, Figures 19, 20

Shell robust, laterally compressed, involute, deeply embracing, with steep umbilical walls, gently arching flanks, angular ventral shoulders, and rather narrow flattened venter. Ornamented with fine ribs that curve gently forward on the flanks and cross the venter without interruption. These ribs are somewhat bundled on the flanks but irregularly. Septa ceratitic.

The height of the last whorl is half the diameter of the shell; the width is two-thirds of the height; the width of the umbilicus is somewhat less than one-fourth of the diameter of the shell. The outer whorl embraces two-thirds of the inner and is indented to nearly one-third of the height.

Anasibirites desertorum is very similar to *A. tenuistriatus* Waagen,[15] from the Lower Triassic *Anasibirites* beds of the Salt Range in India. Waagen's illustrations are confessedly restorations from fragments, but the resemblance to *A. desertorum* is very striking.

Horizon and locality: Rare in the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; also at the same horizon at the mouth of Cottonwood Canyon, Phelan ranch, east side of the Ruby Range, Elko County, Nev.; also at the same horizon at Rohner's ranch, mouth of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Owenites koeneni*, *Inyoites oweni*, *Lanceolites bicarinatus*, *Pseudosageceras multilobatum*, and other forms.

Anasibirites emmonsi Mathews

Plate 79, Figures 22, 24

1929. *Anasibirites emmonsi.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 14, pl. 2, figs. 20–26.
1929. *Anasibirites welleri.* Mathews, op. cit., p. 14, pl. 2, figs. 17–19.
1929. *Anasibirites crickmayi.* Mathews, op. cit., p. 16, pl. 3, figs. 24–27.
1929. *Anasibirites vanbuskirki.* Mathews, op. cit., p. 26, pl. 4, figs. 36–38.

This species is closely related to *Anasibirites tenuistriatus* Waagen and to *A. multiformis* Welter but seems to be sufficiently differentiated from both. However, *A. welleri*, *A. crickmayi*, and *A. vanbuskirki* must be put in the synonymy of *A. emmonsi.*

The description given below is quoted from that of *A. emmonsi* by Mathews in the paper cited above.

This form is reasonably compressed, involute, discoidal, with whorls deeply embracing, covering nearly five-eighths of the preceding volution, and being indented to one-third its height. The umbilicus is moderately wide and shallow; the shoulders are abruptly rounded. The sides are nearly flat, being curved near the margins, with the highest point near the umbilical shoulder. The inner wall is highly inclined. The height of the last whorl is a little less than one and two-thirds times its greatest width and nearly one-half its diameter. The distance across the penultimate volution from suture to suture is equal to its involution. The cross section of the last whorl is broadly trapezoidal.

The surface is ornamented with very fine, closely set, indistinct, flexuous radial ribs, that originate in the umbilical suture, separate as they cross the lateral wall, and become most distinct on the venter. There is a well-developed grouping of the sculpture consisting of from seven to nine ribs, which is distinct on the side walls and venter.

The cross section of the first whorl is rounded, and broader than deep; the second whorl is elliptical, the plane of the ellipse is the same as that of the shell; and the third volution has the same characters as the adult.

The sutures are ceratitic, consisting of two smooth lateral saddles and two lobes. The lobes are notched by five and four serrations, on the first and second laterals, respectively. The siphonal saddle is well developed between the simple serrated ventral-lobe prongs.

This species is chaaracterized by its width, its very fine ribs, its uniformity in the gradual development of its coils, and its comparatively wide venter.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

[15] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 124, pl. 9, figs. 1, 2, 1895.

Anasibirites hircinus (Waagen)

Plate 79, Figures 11, 12

1895. *Sibirites hircinus.* Waagen, Fossils from the Ceratite formation: Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 123, pl. 9, fig. 4.

1929. *Anasibirites blackwelderi.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 13, pl. 2, figs. 10–14.

This species was first described from the *Anasibirites* beds of India; it occurs at the same horizon on Timor and has been described, under the name *Anasibirites blackwelderi,* from Utah. The diagnosis given below is taken from Mathews's description of that supposed species.

This form is involute, nearly discoidal, very thin, laterally compressed, with whorls high, deeply embracing, and well indented by the penultimate volution. The sides are nearly flat and slope gently from the umbilical shoulder to the ventral shoulder. The venter is flat, and the ventral shoulder is square. The umbilical shoulder is slightly rounded. The inner wall is sloping at an angle of about 60° to the surface of the preceding volution. The umbilicus is medium sized, shallow and approximately as wide as the greatest breadth of the shell. It is one-fifth the diameter. The height of the last whorl is nearly twice its thickness and one-half its diameter. It is indented to almost one-third its height by the penultimate volution and conceals three-fourths of this volution. The distance across the penultimate volution from umbilical suture to umbilical suture equals the involution.

The surface is ornamented with nearly uniform, distinct, flexuous radial ribs. Some of these ribs bifurcate on the side walls. The ribs cross the venter in a slightly progressive manner. The entire surface is covered with very fine costae.

The first whorl is wider than its height; the second whorl is about equal; the third whorl is elliptical with the long axis in the plane of the shell; and the fourth whorl has the character of the adult. The siphuncle is ventral throughout the entire series.

This species is characterized by its highly compressed condition. It is a common form in the *Anasibirites* beds.

Horizon and locality: Pinecrest formation, Fort Douglas Military Reservation, Utah.

Anasibirites kingianus (Waagen)

Plate 79, Figures 19–21

1895. *Sibirites kingianus.* Waagen, Fossils from the Ceratite formation: Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 108, pl. 8, figs. 1 a–c, 2 a–c.

1922. *Anasibirites multiformis* (part). Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 138, pl. 169, figs. 9–16, Forma 1; pl. 170, figs. 6–10, Forma 5.

1929. *Anasibirites edsoni.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 27, pl. 4, figs. 29–32.

1929. *Anasibirites bassleri.* Mathews, op. cit., p. 28, pl. 4, figs. 33–35.

1929. *Anasibirites kingianus.* Mathews, op. cit., p. 8, pl. 7, figs. 14–22.

This form is involute, discoidal, thick, with whorl high, embracing, and moderately indented by the penultimate volution. The sides are broadly curved. The arc formed by a cord drawn from shoulder to shoulder is moderately high with the greatest curve toward the umbilical shoulder. The shoulders are broadly rounded, and the inner wall is nearly vertical. The venter is wide and broadly arched. It is three-fourths the greatest width of the shell. The living chamber comprises three-fourths of the last volution. The cross section of the living chamber is quadrangular with sides nearly equal. The height of the last whorl is a little greater than its greatest thickness and one-half its diameter. The diameter of the umbilicus is nearly one-fourth the diameter of the shell. It is one-third as deep as it is broad. The distance across the penultimate volution from suture to suture is one-half the greatest breadth of the shell and greater than the involution.

The surface is ornamented with regular, fine, flexuous, even, radial ribs, which are grouped across the umbilical shoulder in such a manner as to form elongated ridges. The ribs originate in the umbilical suture, crossing the shoulder and side wall in a progressive manner, becoming more pronounced and distinct as they cross the venter, where they are again grouped forming indistinct folds.

The sutures are ceratitic, forming three even, deep saddles and two lobes on the side wall. The siphonal saddle is distinct, deep, and smooth. The ventral lobe has two prongs which are serrated by two denticulations.

This species is characterized by its thickness, its wide venter, and its rather loose coil.

Horizon and locality: Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

This species was first described from the *Anasibirites* beds of India. It is abundant in the same horizon on Timor. The description given above is taken from Mathews's description of *Anasibirites bassleri,* a synonym of *A. kingianus.*

Anasibirites kingianus (Waagen) var. inaequicostatus Waagen

Plate 79, Figures 16, 17

1895. *Anasibirites inaequicostatus.* Waagen, Fossils from the Ceratite formation: Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 113, pl. 8, figs. 7 a, b; 8 b.

1922. *Anasibirites multiformis* (part). Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 138, pl. 169, figs. 17, 18; pl. 170, figs. 6–10. (Not pl. 169, figs. 14–16.)

1929. *Anasibirites perrini.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 18, pl. 3, figs. 34–36.

The specific description is quoted from Mathews's paper, cited above.

This form is compressed, involute, discoidal; whorls high, moderately embracing, covering one-half of the inner volution. It is indented to one-fourth its height by this volution. The umbilicus is wide and shallow and reveals all of the inner whorls. The umbilical shoulder is sharply rounded. The ventral shoulder is broadly rounded; the inner wall is almost vertical. The sides are convex, with the greatest convexity near the umbilical shoulder. The greatest width of the shell is midway between the shoulders. The whorl is high, being less than one-half the diameter. It is indented to one-fourth its height by the preceding volution. The thickness is three-fourths the height and less than one-third the diameter. On another specimen the distance across the penultimate volution from suture to suture is greater than its involution. The venter is well developed, is flat or depressed on the abandoned portion of the shell and rounded on the living chamber. The living chamber comprises more than one-half the last volution.

The surface is ornamented with well-developed, irregular, flexuous, progressive radial ribs, consisting of one primary to every five secondaries. The primary is followed by a distinct furrow, which extends from the umbilical shoulder across the venter. The ribs show the same arrangement on all preceding whorls. As the ribs cross the venter they become highly progressive and deeply arched. The ribs are much less distinct on the living chamber than on the abandoned part of the shell.

The sutures are ceratitic, consisting of three lateral saddles and two lobes. The sutures ride the ribs.

This variety was described as a species by Waagen from the *Anasibirites* beds of India. It is common at the same horizon on Timor. It occurs sparingly in the Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Anasibirites lindgreni Smith, n. sp.

Plate 53, Figures 13–17

Shell of moderate size, robust, somewhat compressed laterally, openly umbilicate, with abruptly rounded umbilica shoulders, subangular ventral shoulders, and flattened venter. Ornamented with numerous coarse lateral ribs that extend across the venter, and with short knobs or tubercles at the ventral angle. These knobs become obsolete in age. Septa unknown.

The outer whorl is greater than half the diameter of the shell; the width is about three-fourths of the height; the width of the umbilicus is one-fifth of the diameter of the shell.

Anasibirites lindgreni resemble *A. noetlingi*; differing in its fewer and coarser ribs. It has also a near kinship with *A. ibex* Waagen [16] of the *Anasibirites* beds of India, from which it differs in its more numerous ribs and its more robust and less compressed whorl.

Named in honor of Dr. Waldemar Lindgren.

Horizon and locality: Rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, at Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Inyoites oweni*, *Lanceolites bicarinatus*, *Anasibirites noetlingi*, *A. desertorum*, *Pseudosageceras multilobatum*, and other forms.

Anasibirites mojsisovicsi Mathews

Plate 80, Figures 1, 2

1929. *Anasibirites mojsisovicsi*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 30, pl. 5, figs. 1–3.

1929. *Anasibirites gibsoni*. Mathews, op. cit., p. 29, pl. 5, figs. 4, 5.

The diagnosis of this species is taken from that given by Mathews. *Anasibirites gibsoni* can hardly be anything but the young of *A. mojsisovicsi* and is therefore listed in synonymy.

This species is compressed, moderately involute, discoidal; whorl high and deeply embracing. The umbilicus is broad and shallow, being one-fourth the diameter of the shell and three times its depth. The umbilical shoulder is sharply rounded; the ventral shoulder is angular. The sides are convex, with the highest point one-half the distance between the shoulders. The height of the last whorl is nearly twice its thickness and less than one-half its diameter. It is indented by the penultimate volution to nearly one-half its height and conceals a little more than one-half of this volution. The distance across the penultimate volution from suture to suture nearly equals its involution. The venter is narrow, being one-third the greatest width of the shell, and concave. The ribs and venter form an interrupted, irregular double keel. The living chamber comprises more than one-half the last whorl.

The surface is ornamented with very coarse, prominent, irregular, progressive, flexuous, radial ribs, which become nearly obsolete across the venter. The ribs originate in the umbilical suture, cross the inner wall in a retrogressive manner, make a broad curve as they cross the umbilical shoulder, and cross the lateral wall in a wavy manner, ending abruptly in distinct nodes at the ventral shoulder.

The sutures are ceratitic, being composed of three saddles and two lobes. The lobes are broad and serrated by four and three serrations on the first and second laterals, respectively. The saddles are broadly rounded and are not incised.

This species is entirely different from any other described.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

Anasibirites multiformis Welter

Plate 79, Figure 18

1922. *Anasibirites multiformis*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 138, pl. 169, figs. 17, 18, 21, 22; pl. 170, figs. 1–5; pl. 171, figs. 1–3. (Not pl. 169, figs. 16, 19–20, 23–27; nor pl. 170, figs. 6–19; nor pl. 171, figs. 4–17.)

1929. *Anasibirites alternatus*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 23, pl. 4, figs. 22, 23.

1929. *Anasibirites romeri*. Mathews, op. cit., p. 23, pl. 4, figs. 24, 25.

1929. *Anasibirites madisoni*. Mathews, op. cit., p. 11, pl. 1, figs. 23–26.

This species is exceedingly common in the *Anasibirites* beds of Timor; it has been described by Mathews, under the three names given above, from the same horizon in Utah. The description given below is taken from that by Mathews of *A. alternatus*.

The form is discoidal, moderately involute, rugose, laterally compressed, with medium width, and with whorls moderately high and embracing. The umbilical shoulder is not prominent; the inner walls slope at an angle of about 45°, and the umbilicus is wide and shallow. The ventral shoulders are sharply curved; the sides are flattened, somewhat curved, and slope gently from the greatest width of the shell to the umbilical shoulder and more steeply to the ventral shoulder. The venter is wide, forming about two-thirds the greatest width of the shell and greatly curved. The height of the last whorl is one-fourth greater than its greatest thickness and one-half the diameter of the shell. The last volution conceals about one-half the penultimate volution.

The surface is ornamented with very strong, slightly progressive radial ribs. The prominent primary ribs are very well

[16] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 121, pl. 9, fig. 3, 1895.

developed, and the secondary ribs, which alternate with the primaries, are well developed but less prominent. The intensity of the ribs increases from the umbilical shoulder toward the venter, where they reach their maximum development. The ribs are sharp and alternate as they cross the venter. Very fine costae cover the entire surface. Every second primary rib of the last volution corresponds with the primary rib of the next preceding volution in such a manner that the penultimate volution is marked on the umbilical shoulder and inner wall with two secondary ribs between two primaries. This unusual character gives a beautiful sculpture to the species.

Horizon and locality: Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Anasibirites multiformis Welter var. hyatti Mathews

1929. *Anasibirites hyatti*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 30.

The description given below is taken from that by Mathews of the supposed species *Anasibirites hyatti*, which can not be more than a variety of the oriental *A. multiformis*.

The shell is involute, obovate, laterally compressed, with whorls high, deeply embracing, and well indented by the penultimate volution. The sides are a flattened curve with the highest peak of the curve about midway between the two shoulders. The inner wall is nearly vertical; the ventral shoulder is roughly angular, and the umbilical shoulder forms a wide curve. The umbilicus is broadly elliptical, narrow, and shows only about one-sixth of the preceding volution. The height of the last whorl is nearly twice its thickness and one-half its diameter. It is indented to one-half its height by the penultimate volution and conceals five-sixths of that volution. The width of the shell is one-third its diameter. The distance across the penultimate volution from suture to suture is five-eighths its breadth and equal to the involution. The venter is five-eighths the greatest width of the shell and is flat.

The surface is ornamented with prominent, well-defined, flexuous, progressive radial ribs, which cross the venter in a straight line. The arrangement of the ribs shows a grouping of two or three primaries with two to four secondaries between. The primary ribs start on the umbilical shoulder and continue prominently across the lateral wall to the ventral shoulder. The secondary ribs rise in the umbilical suture, follow the general outline of the primaries, but do not become decidedly enlarged until they reach the venter, where they are evenly spaced and equally developed with the primaries. The whole surface is covered with very fine costae.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

Anasibirites noetlingi (Hyatt and Smith)

Plate 9, Figures 1–3

1905. *Sibirites noetlingi*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 49, pl. 9, figs. 1–3.

Shell moderately involute, laterally compressed. Whorl deeply embracing, increasing slowly in height, not deeply indented by the inner volutions. Sides flattened, umbilical shoulder subangular, venter broad and flattened. Umbilicus moderately wide and deep, showing all the interior volutions. The height of the last whorl is about three-sevenths of the total diameter, and it is indented to slightly more than one-fourth of its height by the inner volution. The width of the whorl is more than three-fourths of the height. The width of the umbilicus is one-fourth of the total diameter.

Surface ornamented with radial flexuous ribs, fine and coarse ribs alternating. These begin, without knots, on the umbilicus, curve gently forward high up on the flanks, and then run straight across the venter. There is a faint suggestion of nodes where the ribs cross the abdominal shoulders.

The septa are unknown.

Anasibirites noetlingi is nearly allied to *A. hircinus* Waagen,[17] from the Upper Ceratite limestone of India, but differs from that species in its fine sculpture and more numerous ribs. They both, however, belong to the same group.

Horizon and locality: *Anasibirites noetlingi* was found by J. P. Smith in the Lower Triassic *Meekoceras* zone of the Inyo Range, 1½ miles east of Union Spring, on the old McAvoy trail across to Saline Valley, on the east side of Owens Valley, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *M. newberryi*, *Owenites koeneni*, *Inyoites oweni*, *Pseudosageceras multilobatum*, and many other species.

Anasibirites tenuistriatus (Waagen)

Plate 79, Figures 9, 10

1895. *Sibirites tenuistriatus*. Waagen, Fossils from the Ceratite formation: Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 124, pl. 9, figs. 1 a–d, 2 a–e.
1929. *Anasibirites salisburyi*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 9, pl. 1, figs. 27, 29; pl. 2, figs. 1, 2.
1929. *Anasibirites johannseni*. Mathews, op. cit., p. 12, pl. 1, figs. 34, 36, 37.
1929. *Anasibirites whitei*. Mathews, op. cit., p. 12, pl. 1, fig. 35; pl. 2, figs. 15, 16.
1929. *Anasibirites fisheri*. Mathews, op. cit., p. 13, pl. 2, figs. 3–9.
1929. *Anasibirites powelli*. Mathews, op. cit., p. 15, pl. 3, figs. 1–5.
1929. *Anasibirites whitfieldi*. Mathews, op. cit., p. 16, pl. 3, figs. 6–8.
1929. *Anasibirites veranus*. Mathews, op. cit., p. 17, pl. 3, figs. 18–23.
1929. *Anasibirites ketchami*. Mathews, op. cit., p. 18, pl. 3, figs. 12–17.
1929. *Anasibirites weaveri*. Mathews, op. cit., p. 19, pl. 3, figs. 10, 11, 32, 33.
1929. *Anasibirites wardi*. Mathews, op. cit., p. 19, pl. 2, figs. 27–29.
1929. *Anasibirites mcclintocki*. Mathews, op. cit., p. 22, pl. 4, figs. 1–6.
1929. *Anasibirites dieneri*. Mathews, op. cit., p. 24, pl. 4, figs. 19, 20.
1929. *Anasibirites clarki*. Mathews, op. cit., p. 25, pl. 4, figs. 26–28.

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17 Waagen, W., op. cit., p. 123, pl. 9, fig. 4.

1929. *Anasibirites bretzi.* Mathews, op. cit., p. 25, pl. 4, figs. 14–18; pl. 7, fig. 13.
1929. *Anasibirites rollini.* Mathews, op. cit., p. 27, pl. 1, figs. 30–33; pl. 4, figs. 10–13.
1929. *Anasibirites gayi.* Mathews, op. cit., p. 28, pl. 4, figs. 7–9.

This exceedingly variable species was first described by Waagen from the *Anasibirites* beds of India. It is common at the same horizon in Timor. Mathews has described it under a variety of names from the *Anasibirites* beds of Utah, and the description given below is taken from his description of "*Anasibirites mcclintocki.*"

The shell is involute, discoidal, laterally compressed, thin, with whorl high, moderately embracing, and well indented by the penultimate volution. The sides are flatly curved, with the more gentle slope toward the ventral margin. The greatest breadth of the shell is at the umbilical shoulder. The inner wall is steep, forming an angle of about 50° with the side of the penultimate volution. The ventral shoulders are square. The umbilicus is reasonably wide and shows about one-third of the preceding volution, and is about one-fifth the diameter of the shell. The height of the last whorl is about one and one-half times the greatest width of the shell and is a little less than one-half the greatest diameter. It is indented to about one-third of its height by the penultimate volution and conceals about two-thirds of this volution. The width of the shell is one-third of its diameter. The living chamber comprises one-half of the last volution. The distance across the penultimate volution from suture to suture is a little greater than one-half of the greatest breadth of the shell and a little more than the involution. The diameter of the umbilicus is one-fourth the diameter of the shell and is twice as great as its depth. The venter is uniformly flat and is one-half the greatest width of the shell.

The surface is ornamented with well-defined, variable, flexuous, progressive radial ribs, which cross the venter in a slightly progressive arc. The ribs become crowded at the umbilical shoulder and unite, forming a somewhat indistinct elongated tubercle. These are connected with the umbilical suture by a slight elevation. The ribs are grouped in pairs set off by a distinct furrow which crosses the venter in line with the primaries.

This species is a progressive form and is not similar to any other.

Horizon and locality: Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Subgenus GONIODISCUS Waagen[17a]

1895. *Goniodiscus.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 126.
1929. *Goniodiscus.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 31.

Type: *Goniodiscus typus* Waagen.[18]

Shell laterally compressed, involute, with narrow venter, very slightly convex sides, and flattened biangular venter. The whorl is considerably higher than wide. The surface has fine threadlike ribs and weak folds that cross the venter. Septa ceratitic, with rounded saddles and four external serrated lobes.

Waagen[19] refers this so-called genus to the Noritidae, on account of the siphonal notch in the median saddle, which was supposed to make the ventral lobe tripartite. The subgenus has, however, not the faintest resemblance to the Noritidae and clearly belongs to the greater group of *Anasibirites*, from which it may be distinguished only by obsolescence of the sculpture. It is merely a group of species under that genus, separated only for convenience and because of its abundance in the Lower Triassic of Timor.

The group is confined to the *Anasibirites* zone, near the top of the Lower Triassic in India, Timor, and western America. In the last-named region it is represented by four species, *Anasibirites* (*Goniodiscus*) *typus* Waagen, *A. ornatus*, *A. smithi*, and *A. utahensis*.

Anasibirites (Goniodiscus) ornatus Mathews

Plate 80, Figures 11, 12

1929. *Goniodiscus ornatus.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 34, pl. 6, figs. 6–9.

The description given below is quoted from that of Mathews.

The form is obovate, thin, laterally compressed; whorl high, deeply embracing, and well indented by the preceding volution. The sides are broadly convex, with the greatest convexity near the umbilical shoulder. The ventral shoulder is angular, the umbilical shoulder broadly rounded. The inner wall is nearly vertical. The venter is flat and narrow. The umbilicus is roughly elliptical, narrow, and moderately deep, being one-fourth the diameter of the shell and nearly one-half as deep as broad. The height of the last whorl is one-half the diameter and one and one-half times its greatest thickness. It is indented to one-third its height by the penultimate volution and conceals about two-thirds of this volution. The distance across the preceding volution from suture to suture is more than one-half its greatest thickness and equal to the involution. The living chamber comprises more than one-half the last whorl. The shell is thin and smooth.

The surface is ornamented with a few rather distinct, flexuous radial folds or ribs, which originate in the umbilical suture, cross the inner wall in a retrogressive manner, forming a wide arc across the umbilical shoulder, where they become most prominent, then cross the side wall in an almost straight line, ending at the ventral shoulder. On the venter an indistinct siphonal ridge is noticeable.

The sutures on another specimen are ceratitic and almost identical with the sutures of *Goniodiscus typus* Waagen. However, they are more deeply incised.

The second whorl is smooth and nearly the same shape as the adult, but the venter is rounded. The third whorl has the same characteristics as the adult, except that the lateral folds are much more highly developed. The fourth whorl possesses all of the adult characteristics.

[17a] This name is preoccupied by *Goniodiscus* Mueller and Troschel, 1842, and has been replaced by *Hemiprionites* (Spath, L. F., Corrections of cephalopod nomenclature: The Naturalist, No. 871, p. 270, August, 1929). The correction was not noted by Professor Smith, and it has seemed best to leave his text as originally written.—Editor.

[18] Waagen, W., op. cit., p. 128, pl. 9, figs. 7, 8.

[19] Idem, p. 150.

This species is characterized by its obovate shape, its ornamentation on the side walls, its flat narrow venter, and lacks the characteristic ventral keels.

Horizon and locality: Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Anasibirites (Goniodiscus) smithi (Mathews)

Plate 80, Figures 13–15

1929. *Gurleyites smithi.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 43, pl. 10, figs. 1–6.

This species was chosen by Mathews as the type of a supposedly new genus, *Gurleyites*. It is a typical *Goniodiscus*, however, and the genus *Gurleyites* is dropped. The specific diagnosis given below is quoted from that of Mathews.

The form is involute, obovate, laterally compressed, somewhat robust, with high whorls. The early whorls are moderately embracing; the last whorls slightly embracing and indented by the inner volution. The sides are moderately convex and slope gradually from near the umbilical shoulders to the outer margins. The venter is slightly arched and nearly smooth. The ventral shoulder is obtuse; the umbilical shoulder slightly rounded. Inner wall is vertical. Umbilicus is moderately broad, shallow, and ellipsoidal, its long diameter being nearly one-fourth the greatest diameter of the shell and three times its own depth. The height of the last whorl is one and three-fifths times its greatest width and less than one-half of its diameter. It is indented to three-eighths its height by the inner volution and conceals over one-half this volution. The distance across the penultimate volution from umbilical suture to umbilical suture is one-half the greatest width of the shell and nearly equals the involution. The living chamber straightens and comprises one-half the last whorl.

The surface is ornamented with a few large, irregular, sigmoidal radial ribs, which are most prominent on the ventral shoulder. Some bifurcate on the side wall. The entire surface is covered by large, flexuous, radial auxiliary ribs or costae, which terminate in the ventral shoulder. The venter is crossed by indistinct, straight, broad, wavy undulations of the shell. The costae cross the inner wall in a retrogressive manner from the umbilical suture. The sculpture shows on the preceding volution.

The sutures are ceratitic, consisting of three lateral saddles and three lobes. The saddles are deep, broad, and smooth. The first lateral lobe is long and well developed, the second is one-half the size of the first, and the third may be considered the auxiliary. All the lobes are deeply denticulated. The ventral lobe is broad, moderately long, and divided by a wide, smooth siphonal saddle. The lateral prongs are sharply incised by four graduated serrations. The protoconch is large and nearly spherical; the first whorl is ellipsoidal with the long axis transverse to the plane of the shell. The second whorl as well as the remaining whorls have the characters of the adult.

This species has some characteristics of *Meekoceras malayicum* Welter; but it is more evolute, the umbilicus is ellipsoidal, the living chamber straightens, the venter is more nearly flat, the ornamentation is less highly developed, and the siphonal saddle is broad, shallow, and smooth.

Horizon and locality: Found only in the uppermost *Anasibirites* bed, Pinecrest formation, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Anasibirites (Goniodiscus) typus Waagen

Plate 31, Figures 11, 12

1895. *Goniodiscus typus.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 128, pl. 9, figs. 7–10.

1922. *Anasibirites multiformis* (part). Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, pl. 171, figs. 4–7. (Exclusive of text and other figures.)

1929. *Goniodiscus typus.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 31, pl. 5, figs. 12–21.

1929. *Goniodiscus americanus.* Mathews, op. cit., p. 32, pl. 5, figs. 22–27.

1929. *Goniodiscus walcotti.* Mathews, op. cit., p. 32, pl. 6, figs. 1–5.

1929. *Goniodiscus shumardi.* Mathews, op. cit., p. 33, pl. 6, figs. 11–14.

1929. *Goniodiscus slocumi.* Mathews, op. cit., p. 34, pl. 6, figs. 15–17.

Form robust, involute, laterally compressed, with narrow umbilicus, flanks sloping gently upward from the abruptly rounded umbilical shoulders to the flat biangular venter. Surface with fine radial folds and nearly obsolete striae of growth.

The height of the whorl is slightly less than half the diameter of the shell, and the width is less than three-fourths of the height. The width of the umbilicus is about one-fifth of the diameter of the shell. The outer whorl embraces nearly all of the inner and is indented by it to one-third of the height.

Horizon and locality: Very rare in the *Anasibirites* subzone of the Lower Triassic *Meekoceras* zone, at Rohner's ranch, south side of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Owenites* cf. *O. koeneni*, *Inyoites* sp.; also somewhat doubtfully identified from the same horizon in Union Wash, Inyo County, Calif., associated with *Owenites koeneni*, *Inyoites oweni*, *Anasibirites desertorum*, and other forms. It was first described from the Upper Ceratite limestone, *Anasibirites* zone, of the Salt Range, India. It is very common in the *Anasibirites* beds of Timor, associated with many species of *Anasibirites*, closely related to the American species.

This species has later been found by A. A. L. Mathews to be very common in the *Anasibirites* beds of Utah, where he has described it under a variety of names. The additional diagnosis given below is quoted from his description of *Goniodiscus typus*, for he has had much better material than the writer has had.

Disciform, involute, laterally compressed; whorls high, deeply embracing, and very well indented by the preceding volution. The sides are nearly flat, sloping from the greatest width of the shell to both shoulders. The cross section shows a nearly uniform low arc, with the highest point of the arc nearer the umbilical than the ventral shoulder. The ventral shoulder is angular, caused by a slight depression of the side wall just before it joins the venter. The umbilical shoulder is sharply rounded. The inner wall is nearly vertical. The umbilicus is narrow and deep. Its diameter is two and one-half times its depth and more than one-fourth the diameter of the shell. The height of the last whorl is one and one-half times its greatest thickness and one-half of the diameter. It is indented by the penultimate volution to one-third its height and conceals five-sixths of this volution. The distance across the penultimate volution from suture to suture is one-half the greatest width of the shell, equal to the width of the venter, and equal to the involution. The venter is smooth, nearly flat, and slightly arched. It shows indistinct parallel flutings. The living chamber comprises three-fourths of the last whorl. The shell is smooth and thin. It shows very little ornamentation and that only near the umbilical shoulder on the side wall. These are very faint, broad folds, which become obscure before they reach the ventral shoulder.

The sutures are ceratitic, consisting of three saddles and two distinct lobes. Two saddles are deep and smooth, the last lateral being shallow, poorly defined, and broad. The first lateral lobe is somewhat elongated, wide, and notched by six serrations; the second lateral is broad, short, and notched by four serrations. The auxiliary series consists of a short curved row of serrations following the third saddle. The ventral lobe is divided into three parts, with a low siphonal notch and two serrations on each side prong. The first lateral rides the keel.

This form is identical with *Goniodiscus typus* Waagen. Waagen made no mention of the flutings on the venter, but indistinct lines are indicated in his drawings. The redescription is taken from a specimen which is the same size as the original type. Many specimens are fully twice that size. Waagen described his species from fragments and small specimens, whereas the writer has many specimens, some very large and with shells well preserved. As the shell attained larger dimensions, the sculpture remained weak.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

?Anasibirites (Goniodiscus) varians Mathews

1929. *Goniodiscus? varians*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 35, pl. 7, figs. 26–39.

This doubtful species is the young of almost any species of *Goniodiscus*, or of several. It can hardly be recognized as independent but is listed here for the sake of completeness.

Horizon and locality: Pinecrest formation, *Anasibirites* subzone, Cephalopod Gulch, Fort Douglas Military Reservation, Utah.

Anasibirites (Goniodiscus) utahensis Mathews

Plate 80, Figures 9, 10

1929. *Goniodiscus utahensis*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 33, pl. 6, figs. 29–31.

The description given below is quoted from that of Mathews.

Form involute, moderately thick, laterally compressed; whorl high, deeply embracing, and well indented by the inner volution. The sides are broadly convex, sloping equally from the greatest width of the shell to the shoulders. Just before reaching the ventral shoulder they flatten slightly. The venter is broad and flat. It unites with the side walls in such a manner as to form two rudimentary keels. The umbilical shoulder is sharply rounded. The inner wall is nearly vertical. The umbilicus is very narrow and deep. The height of the last whorl is one-half the diameter, and its thickness is equal to three-fifths of its height. It is indented to four-fifths its greatest thickness and one-half its height by the preceding volution and conceals five-sixths of this volution. The distance across the inner volution from suture to suture is three-fourths the involution. The living chamber is greater than one-half the last volution. The shell is thin and smooth.

The surface is marked by indistinct, broad, flexuous, radial folds, which form broad undulations on the venter, producing a wavy appearance.

The sutures are ceratitic, consisting of the same number of lobes, saddles, and the same arrangement as in *Goniodiscus typus* Waagen.

This species is characterized by its remarkable breadth and its peculiar, indistinct sculpture or markings.

Horizon and locality: Pinecrest formation, Pinecrest Ridge, Fort Douglas Military Reservation, Utah.

Genus HEDENSTROEMIA Waagen

1895. *Hedenstroemia*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 140.

1897. *Hedenstroemia*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 60.

1900. *Hedenstroemia*. Hyatt, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology, vol. 1 (translated by C. R. Eastman), p. 555.

1900. *Anahedenstroemia*. Hyatt, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology, vol. 1 (translated by C. R. Eastman), p. 555.

1905. *Hedenstroemia*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 100.

1909. *Hedenstroemia*. Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, pt. 1, p. 147.

1911. *Hedenstroemia*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, vol. 24, p. 207.

1915. *Hedenstroemia*. Haniel, Die Cephalopoden der Dyas von Timor: Palaeontologie von Timor, Lief. 3, Abh. 6, p. 148.

1917. *Hedenstroemia*. Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 169.

1922. *Hedenstroemia*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 96.

Septa complex, consisting of one or two adventitious lobes, three or more laterals, and a long auxiliary series. The lobes are all serrated and the saddles entire.

Hedenstroemia resembles *Pseudosageceras*, with which it is associated, in form but differs from that genus in lacking the lanceolate type of lobes. It also resembles *Cordillerites* Hyatt and Smith but does not have the complexity of the lateral lobes nor the tongue-shaped bifid lobes of the auxiliary series that are characteristic of *Cordillerites*.

The type species of *Hedenstroemia* was assigned by Mojsisovics to *Meekoceras*, but that genus never has adventitious lobes, nor a long series of auxiliaries, and therefore Waagen placed it in a new genus under the subfamily Hedenstroeminae in the Pinacoceratidae. This assignment was accepted by Diener,[20] who added another species, *H. mojsisovicsi* Diener. *Meekoceras furcatum* Mojsisovics was also included by Waagen and Diener in *Hedenstroemia*, but Haug[21] assigned it to *Norites*, to which it has a certain resemblance in form. Mojsisovics[22] has chosen this species as the type of a new genus, *Tellerites*, under the family Noritidae.

Diener[23] has withdrawn *Hedenstroemia* from the Pinacoceratidae or the Beloceratea, and placed it again under the Meekoceratidae, as Mojsisovics did when he named the first species of the group. The writer agrees with him in this, for young specimens of *Hedenstroemia kossmati* are decidedly meekoceran in their septa and have no resemblance to the young of *Pseudosageceras* or *Aspenites*. The possession of adventitious lobes is not enough to place a form under Beloceratea.

Horizon and locality: *Hedenstroemia* was first found in the upper part of the Lower Triassic in northern Siberia and in the Himalaya Mountains in India. It has also been found by J. P. Smith in the *Meekoceras* zone of the Lower Triassic of southeastern Idaho and eastern California, in both places associated with *Meekoceras gracilitatis* and many other characteristic forms. It is also quite common in the Lower Triassic of Timor, and at the corresponding horizon in Albania.

Hedenstroemia hyatti Smith, n. sp.

Plate 27, Figures 13–18

Form involute, laterally compressed, deeply embracing, narrowly umbilicate; with biangular, narrow venter and shallow ventral furrow. Surface nearly smooth, with fine striae of growth.

Septa ceratitic, with rounded, entire saddles and serrated lobes, consisting of an adventitious lobe, short and weakly developed; a long, narrow external lobe; a large first lateral, longer and wider; a shorter, narrower second lateral; and a short series of auxiliaries, decreasing in size toward the umbilicus.

Hedenstroemia hyatti is very closely related to *H. kossmati*, from which it differs in its smaller size, broader venter, and thicker whorl. It might be a variety of that species, but no intergradations have been observed.

Named in memory of Alpheus Hyatt.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone, at locality 1, 5 miles east of Grays Lake, southeastern Idaho; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites aplanatus*, *F. aspenensis*, *Clypeoceras muthianum*, *Hedenstroemia kossmati*, *Pseudosageceras multilobatum*, *Lanceolites compactus*, *Cordillerites angulatus*, *Aspenites acutus*, and many other characteristic species.

Hedenstroemia kossmati Hyatt and Smith

Plate 28, Figures 11–16; Plate 41, Figures 1–10; Plate 67, Figures 3–7

1905. *Hedenstroemia kossmati*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 101, pl. 67, figs. 3–7; pl. 84, figs. 1–10.

Involute, discoidal; whorls laterally compressed, high and increasing rapidly in height. Venter narrow, triangular, and with slight ventral depression between the shoulder angles. Umbilicus narrow, almost closed. Surface smooth on both shell and cast.

The septa are complex, consisting of an adventitious series of lobes, laterals, and a long auxiliary series. The first adventitious lobe is short and narrow, less than half the size of the second lateral; the first lateral is slightly longer and about twice as broad as the adventitious lobe, and the second lateral is shorter and nearly as broad. The third lateral is shallow but shaped like the second. These are all distinctly serrated. Then follows a long series of short tongue-shaped auxiliaries, growing smaller toward the umbilicus.

In the later adolescent stage the ventral furrow is distinct but disappears before maturity. In the earlier adolescent stage the venter is rounded, the whorl proportionally more robust, and the surface is sculptured with lateral ribs. The young stages are somewhat like those of the Meekoceratidae, to which the genus is now assigned.

Hedenstroemia kossmati is evidently closely allied to *H. mojsisovicsi* Diener [24] of the Lower Triassic of India, from which it differs chiefly in the narrowness of the umbilicus—the shape of the whorl, the smooth surface, and the character of the septa being virtually identical in the two species. It is thought best, however, for the present to keep them separate, until sufficient material of the Indian and the American forms should be found to show whether they are perfectly similar at the same size.

Horizon and locality: *Hedenstroemia kossmati* was found by J. P. Smith in the Lower Triassic *Meekoceras*

[20] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 60, 1897.

[21] Haug, E., Les ammonites du Permien et du Trias: Soc. géol. France Bull., 3d ser., vol. 22, p. 393, 1894.

[22] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 311, 1902.

[23] Diener, Carl, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 169, 1917.

[24] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 63, pl. 20, fig. 1, 1897.

zone, at the head of Wood Canyon, 9 miles east of Soda Springs, in the Aspen Ridge, in southeastern Idaho, associated with *Meekoceras gracilitatis* White, *M. mushbachanum* White, *Flemingites*, *Ussuria*, *Cordillerites*, *Nannites*, *Ophiceras*, *Aspenites*, *Pseudosageceras*, and many other forms characteristic of the Lower Triassic. Probably the same species was found by J. P. Smith in the *Meekoceras* zone of Union Canyon, in the Inyo Range, about 15 miles southeast of Independence, Inyo County, Calif., associated with virtually the same fauna.

Hedenstroemia, in both Asia and America, is characteristic of an upper horizon of the Lower Triassic, the *Flemingites* beds, or what was formerly called by Diener the *Subrobustus* beds, later the *Hedenstroemia* beds, for the associated faunas are very similar in India, Siberia, Idaho, and California.

Subgenus CLYPITES Waagen

1895. *Clypites*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 142.
1902. *Aspidites* (part). Frech, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637.
1905. *Clypites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 103.

Type: *Clypites typicus* Waagen.[25]

Involute, laterally compressed, deeply embracing, inner whorls concealed by the outer; umbilicus narrow; sides flattened; venter flattened, narrow, with sharp abdominal shoulder angles, which may even almost form lateral keels bordering an abdominal furrow. Surface smooth, except the faint radial folds and striae. Septa ceratitic, external lobe divided by a broad saddle, which is broken up by adventitious lobes and saddles; first lateral lobe strongly developed; second lateral lobe in some specimens not differentiated, auxiliary series long, consisting of small, irregular lobes and saddles, as in *Aspidites*, but usually simpler than in that genus.

Clypites is probably no more than a subgenus under *Hedenstroemia* Waagen, but in *Hedenstroemia* both the adventitious and the auxiliary series of lobes and saddles are much more individualized. It has some resemblance to *Aspenites* Hyatt and Smith, but this genus has a sharp venter, with a keel, and is much more compressed laterally. *Aspenites*, however, seems to be closely related to *Prodromites* Smith and Weller, of the Mississippian (lower Carboniferous), which may be a connecting link between them and *Beloceras*, whereas *Clypites* and *Hedenstroemia* seem to belong to the Meekoceratidae.

Clypites is known only from the Lower Triassic Ceratite formation, of the Salt Range in India, and Alpheus Hyatt found one species in the Lower Triassic *Meekoceras* zone of the Aspen Ridge, southeastern Idaho.

[25] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 143, pl. 21, figs. 7a, b, 1895.

Hedenstroemia (Clypites) tenuis Hyatt and Smith

Plate 1, Figures 4–8

1905. *Clypites tenuis*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 103, pl. 1, figs. 4–8.

Form involute, discoidal, laterally compressed, deeply embracing. Whorl high and narrow, with flattened sides, and narrow-channeled venter with biangular margins. Umbilicus closed. Surface of cast smooth, shell unknown.

Septa lanceolate, with auxiliary, lateral, and adventitious series. The external lobe is divided by a small siphonal notch into two short ventrals; the adventitious lobes consist of a single pair of serrated lobes; the two laterals are broader, longer, and more distinctly serrated; the auxiliary series consists of several short, pointed lobes, with broadly rounded saddles.

In youth the venter is biangular, without the channel; the ventral lobe is undivided, thus forming, with the two adventitious lobes, a trifid external.

The septa are simpler than on any of the species described by Waagen, but the resemblance is sufficient to class them in the same genus. This species has a considerable resemblance to *Aspenites* Hyatt and Smith, but differs in its biangular instead of acute venter. It is not impossible that *Clypites tenuis* may be the young of *Hedenstroemia kossmati*, but the writer has not had at his disposal sufficient material to show the intergradation of the forms.

Horizon and locality: In the *Meekoceras* zone, about 9 miles east of Soda Springs, Idaho, in Wood Canyon, near the divide, associated with *Meekoceras gracilitatis*, and *M. mushbachanum*. Collected by Alpheus Hyatt, 1888.

Family HUNGARITIDAE

Forms involute, laterally compressed, discoidal, venter narrow, and surmounted by a keel. Septa ceratitic. Surface either smooth or ornamented with folds or ribs.

The Hungaritidae have usually been regarded as a subfamily of the Ptychitidae but differ from that group in having evolute, discoidal young, whereas the Ptychitidae are invariably subglobose in the young stages. The Hungaritidae have usually been regarded as Leiostraca, in spite of their close resemblance to *Ceratites*, but Arthaber[26] has shown that the group is inseparable from the Ceratitoidea.

The Hungaritidae are known first from the Permian of Armenia, where they are represented by *Hungarites*

[26] Arthaber, G. von, Das jüngere Palaeozoicum aus der Araxes-Enge bei Djulfa: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 12, p. 220, 1900.

and *Otoceras*, both of which genera occur also in the Triassic, the former being especially characteristic of the Middle Triassic and the latter not being found in later beds than the very lowest horizon of the Triassic. In America the family is represented by six genera—*Inyoites* Hyatt and Smith, *Pseudharpoceras* Waagen, and *Dalmatites* Kittl in the Lower Triassic, and *Hungarites*, *Longobardites*, *Dalmatites*, and *Eutomoceras* in the Middle Triassic.

Genus INYOITES Hyatt and Smith

1905. *Inyoites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 134.

1913. *Inyoites*. Diener, Triassic faunae of Kashmir: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 5, No. 1, p. 71.

1922. *Vishnuites* (part). Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 137.

Type: *Inyoites oweni* Hyatt and Smith.

Body chamber long, comprising an entire volution; form compressed, evolute, little embracing; wide, shallow umbilicus, flattened sides, acute venter with high hollow keel. Strong lateral ribs, which run straight from the umbilical shoulder toward the venter.

Septa ceratitic, consisting of rounded entire saddles and serrated lobes. The external lobe is divided by a siphonal saddle; the two principal laterals are of about the same size as the external, and there is a single serrated auxiliary. The long body chamber, the lateral ribs, and the high keel resemble *Eutomoceras*, but that genus is involute and has knots on the lateral ribs.

This genus has a certain resemblance to *Clinolobus* Gemmellaro, from the Permian of Sicily, but differs in its lateral sculpture and ceratitic lobes.

Inyoites is classed with the Hungaritidae on account of its evolute form, ceratitic septa, and acute venter; it differs from *Hungarites* in the possession of a long body chamber and high hollow keel and in lacking the abdominal shoulder angles. This genus is at present represented by a single species in the Lower Triassic *Meekoceras* zone of the Inyo Range, Inyo County, Calif.; by *Inyoites kashmiricus* Diener, from the Himalayas; by *Inyoites* (*Vishnuites*) *discoidalis* Welter, from Timor; and by an undescribed species from the *Meekoceras* beds of Svalbard.

Inyoites oweni Hyatt and Smith

Plate 6, Figures 1–16; Plate 40, Figures 1–8; Plate 69, Figures 1–9

1905. *Inyoites oweni*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 134, pl. 6, figs. 1–16; pl. 69, figs. 1–9; pl. 78, figs. 1–8.

Laterally compressed, evolute, discoidal. Whorls thin, flattened, with acute venter and high hollow keel. Little embracing and not deeply indented by the inner volutions. Umbilicus wide and shallow, exposing the inner whorls. The height of the whorl is twice the width and about one-third of the entire diameter. The indentation or involution is one-fourth of the height. The width of the umbilicus is one-third of the total diameter.

The surface is ornamented with fine strong lateral ribs that run from the umbilicus straight up the sides and disappear below the base of the keel and also with fine straight radial striae that run higher up on the sides than the ribs.

The septa are ceratitic, saddles all rounded and entire, lobes all distinctly serrated. The external lobe is divided by a small siphonal saddle, the first and second laterals are of about the same size as the external; the auxiliary lobe is smaller but still serrated. The body chamber is long, at least one revolution.

The young of this species are robust, with low evolute whorls and coarse lateral ribs.

Horizon and locality: *Inyoites oweni* was found by Walcott in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of the Inyo Range, on the old McAvoy trail, 1½ miles above Union Spring, east side of Owens Valley, about 3 miles east of the Reward mill, and about 15 miles southeast of Independence, Inyo, County, Calif. This species was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Pseudosageceras multilobatum*, and many other forms characteristic of the Lower Triassic.

Genus DALMATITES Kittl

1903. *Dalmatites*. Kittl, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 72.

1907. *Dalmatites*. Diener, The fauna of the Himalayan Muschelkalk: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 5, Mem. 2, p. 93.

1914. *Dalmatites*. Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 58.

Type: *Dalmatites morlaccus* Kittl, upper Werfen beds of Dalmatia.

Form high whorled, laterally compressed, involute, narrowly umbilicate. Whorls deeply embracing and deeply indented by the inner volutions. Venter rises sharply to a narrow keel-like ridge, without ventral shoulders. Septa ceratitic, with rounded entire saddles and four slightly serrated lobes, external two laterals, and a small auxiliary. Body chamber two-thirds of a revolution in length. *Dalmatites* resembles *Hungarites* but differs in the greater simplicity of the septa, the absence of ventral shoulder angles, and the weaker sculpture. From *Eutomoceras* it may be distinguished by the same characters. In general appearance it is closer to *Longobardites*, but differs in the greater simplicity of the septa. The more complex *Longobardites* may have developed out of the simpler

Dalmatites by the addition of the auxiliary and the beginning of the adventitious series of lobes.

No genus is described in the Permian from which *Dalmatites* may have originated, but the writer has in his collection an undescribed species from the lower Permian of the Chinati Mountains, of Texas, that has all the characters of *Dalmatites*. Diener has described a species from India, from the Muschelkalk.

Horizon and locality: *Dalmatites* is represented in the Triassic of America by four species—two from the Lower Triassic of Idaho and two—*D. minutus* Smith and *D. parvus* Smith—from the Middle Triassic of the West Humboldt Range, Nev.

Dalmatites attenuatus Smith, n. sp.

Plate 57, Figures 11–13

Form involute, laterally compressed, rather widely umbilicate, with acute venter. Surface with faint radial folds. Septa with a small external lobe, two larger laterals, and a small auxiliary. The saddles are rounded, and weak serrations may be seen on the lobes, almost obliterated by weathering.

The height of the last whorl is half the diameter of the shell, and the width is one-third of the height. The width of the umbilicus is slightly greater than one-third of the diameter of the shell.

Dalmatites attenuatus is nearly related to *D. morlaccus* Kittl, of the *Tirolites* fauna of Dalmatia,[27] but is thinner and more acute than the European species.

Horizon and locality: Very rare (one specimen) in the *Tirolites* zone of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Tirolites harti*, *T. pealei*, *T. knighti*, and other forms. It was also found in the *Owenites* subzone of the *Meekoceras* zone at the Phelan ranch, mouth of Cottonwood Canyon, east side of the Ruby Range, Nev., about 70 miles south of Wells; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Inyoites oweni*, *Lanceolites bicarinatus*, *Pseudosageceras multilobatum*, and other forms.

Dalmatites richardsi Smith, n. sp.

Shell small, involute, laterally compressed, deeply embracing; whorls high, with flattened sides, distinct ventral shoulder, and sharp keel ridge. Surface nearly smooth. Septa ceratitic, with rounded saddles and four well-developed serrated lobes; the auxiliary is followed by a short series of serrations toward the umbilical suture.

The height of the outer whorl is half the diameter of the shell, and the width is one-third of the height; the width of the umbilicus is one-sixth of the diameter of the shell. The outer whorl embraces nearly all of the inner and is indented to nearly half the height.

Dalmatites richardsi is closely related to *D. attenuatus*, differing in its slightly more robust whorl, distinct shoulders, and more complex septa.

Named in honor of Mr. J. E. Richards.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites cirratus*, *F. russelli*, *Cordillerites angulatus*, *Lanceolites compactus*, *Aspenites acutus*, *Hedenstroemia kossmati*, *Pseudosageceras multilobatum*, and other forms.

Genus PSEUDHARPOCERAS Waagen

1895. *Pseudharpoceras*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 130.

1911. *Tropiceltites* (part). Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 268.

Type: *Pseudharpoceras spiniger* Waagen,[28] from the Lower Triassic equivalent of the *Columbites* zone in the Salt Range of India.

Waagen described this genus as evolute, widely umbilicate, with falciform ribs, ventral keel bordered by furrows, and a few knobs or incipient spines on the ribs. Septa very simple, with but a single lateral lobe, whether serrated or goniatitic could not be ascertained. He compared it with *Tropites* of the Upper Triassic and with *Harpoceras* of the Lower Jurassic but had no definite idea of its affinities.

Arthaber[29] described "*Tropiceltites*" *praematurus*, from the Lower Triassic *Columbites* zone of Albania, which is not a *Tropiceltites* and evidently belongs to *Pseudharpoceras*.

A very similar species occurs in the *Columbites* zone of Idaho and in the same association as in Albania. All three are evidently aberrant members of the Hungaritidae, and all occur at the same horizon and in the same general faunal association. We must therefore retain Waagen's genus, however unsatisfactorily founded and described, for it turns out to be an interregional index for the *Columbites* zone of the Lower Triassic.

Pseudharpoceras idahoense Smith, n. sp.

Plate 49, Figures 17–19

Shell small, evolute, little embracing, whorls subrectangular in section, with abrupt umbilical and ventral shoulders, strong ventral keel bordered by furrows, and sharp lateral falciform ribs. Septa with three external lobes and a long internal antisiphonal lobe flanked by a short lateral. Whether the septa are ceratitic or goniatitic could not be determined on the

[27] Kittl, Ernst, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 73, pl. 4, figs. 4-7, 1903.

[28] Waagen, W., op. cit., p. 130, pl. 21, fig. 1.

[29] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 27, p. 268, pl. 24, figs. 9, 10, 1914.

two specimens found; nor could the length of the body chamber be ascertained.

Pseudharpoceras idahoense is closely related to *P. spiniger* Waagen,[30] of the upper part of the Lower Triassic of India, differing in its broader and lower whorl. It is also more robust than *P. praematurum* Arthaber,[31] from the Lower Triassic *Columbites* zone of Albania, but is sufficiently similar to be placed in the same genus.

Horizon and locality: Very rare in the Lower Triassic *Columbites* zone of southeastern Idaho, at Paris Canyon, 1 mile west of Paris; associated with *Meekoceras pilatum, M. curticostatum, M. sanctorum, Columbites parisianus, C. spencei, Ophiceras spencei, O. jacksoni*, and *Pseudosageceras multilobatum* in a fauna certainly related to those of the *Columbites* zone of Albania and of the Olenek River in northern Siberia.

Family CERATITIDAE

Form usually evolute but involute in some groups; laterally compressed, robust. Surface usually ornamented with ribs or spines and in some forms with ventral keels. Body chamber short in most genera, but in a few it is long. Septa ceratitic in nearly all genera but goniatitic in some primitive and in some reversionary genera; ammonitic in some highly specialized forms.

The Ceratitidae formerly included all ammonites with ceratitic septa, but it was gradually found out that most Triassic families contained genera with this sort of septation, and so the group was finally restricted to those in the development series of *Ceratites nodosus*. Even with this restriction the family has been large and unwieldy, for many genera that have little kinship with the type resemble it greatly, and many others that are closely related to it genetically do not resemble it at all. The classification of this family therefore can not be based on mere resemblance, but on development series and on ontogenic studies of the various genera.

The most primitive members of the family are all evolute, little-embracing forms with very simple septa, and the young stages of all the genera, except the most specialized, are of this type. This indicates that the family radicle is to be sought in an evolute form with simple septa. More than this, all the earliest known members of the family have little sculpture, and the adolescent stages of most genera, except the highly specialized later forms, are nearly smooth. This indicates that this family had a common origin with the Meekoceratidae and the Hungaritidae, in some genus with the characters of *Lecanites*. Although the later genera of all three families can easily be distinguished from one another, the earlier ones can not; and, further, the young stages of all three groups are very similar, which is sufficient justification for placing all three in the suborder Ceratitoidea.

The most elaborate and systematic classification of the Ceratitidae has been attempted by Mojsisovics,[32] who divided the family as follows:

Subfamily Dinaritinae:
- Phylum 1. Dinaritea, containing *Dinarites, Ceratites*, and *Arpadites*, with a number of subgenera or subordinate genera.
- Phylum 2. Heraclitea, containing *Heraclites* and *Cyrtopleurites*.
- Phylum 3. Orthopleuritea, containing *Polycyclus, Choristoceras, Rhabdoceras*, and *Cochloceras*.

Subfamily Tirolitinae:
- Phylum 1. Tirolitea, containing *Tirolites* and *Badiotites*.
- Phylum 2. Distichitea, containing *Distichites* and *Ectolcites*.
- Phylum 3. Trachyceratea, containing *Trachyceras, Eremites, Sandlingites, Clydonites*, and *Sirenites*.

The Dinaritinae were supposed to develop out of *Dinarites* and the Tirolitinae out of *Tirolites*, and both were thought to have come from *Xenodiscus* or some related genus. This subdivision of the family is, then, not merely a convenient arrangement but an attempt at a phylogenic classification. All the later work of Diener, Waagen, and others has substantiated the classification in most essentials, although some of the details must be modified.

The writer has studied the ontogeny of *Danubites, Ceratites, Arpadites*, and *Clionites*, of the Dinaritinae and has found the young stages to be like *Paratirolites*, so it becomes probable that this is the ultimate family radicle of both divisions of the Ceratitidae. The parent form of *Paratirolites* must have been *Xenodiscus* and ultimately *Lecanites*, which differs only very slightly from the earlier species of *Dinarites* and *Danubites*. *Lecanites* was probably derived from *Paralecanites* of the Permian and Lower Triassic, through which the Ceratitidae were probably derived from the Prolecanitidae of the Carboniferous. By the Prolecanitidae the writer does not mean the phylum or suborder as the term has been used by Karpinsky and Haug but the group of *Prolecanites*.

At the time Mojsisovics selected *Xenodiscus* as the probable radicle of the Ceratitidae it was the only Permian ammonite genus known that could possibly have been the ancestral form. The later work of Diener and Waagen has shown that the characters of this genus and its kindred form *Xenaspis*, as known in the Lower Triassic, are too highly specialized for either one to have been the ultimate family radicle but that there are other similar but more primitive groups in the lower beds of the Triassic that may

[30] Waagen, W., op. cit. (Fossils from the Ceratite formation), p. 130, pl. 21, fig. 1.

[31] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 268, pl. 24, figs. 9, 10.

[32] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 395, 1893.

with more probability be regarded as the ancestors of the Ceratitidae.

No Ceratitidae are as yet known certainly below the Lower Triassic. *Lecanites* is now known in the Permian, and *Xenodiscus, Xenaspis, Hungarites,* and *Otoceras,* which must have developed out of *Lecanites,* are known in the upper Permian. Our knowledge of the ammonites of the Carboniferous is still very fragmentary, and until more discoveries are made all our classifications will stand on an insecure basis. At present the ontogeny of the principal genera is the only criterion, and that is uncertain, because of the imperfection of the material and its scarcity.

In America the Ceratitidae are represented in the Lower Triassic by *Danubites,* and *Tirolites.*

Genus TIROLITES Mojsisovics

1878. *Tirolites.* Mojsisovics, Dolomitriffe von Südtirol und Venetien, Wien, p. 43.
1879. *Tirolites.* Mojsisovics, Vorläufige kurze Uebersicht der Ammoniten-Gattungen der Mediterranen und Juvavischen Trias: K.-k. geol. Reichsanstalt Wien Verh., p. 138.
1882. *Tirolites.* Mojsisovics, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 64.
1893. *Tirolites.* Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 588.
1902. *Tirolites.* Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 324.
1903. *Tirolites.* Kittl, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 29.
1905. *Tirolites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 158.
1911. *Tirolites.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 250.

Type: "*Ceratites*" *idrianus* Hauer.[33]

Evolute, little embracing, robust, laterally compressed whorls, with wide, shallow umbilicus. Venter flattened and without central furrow or other sculpture. Sides ornamented with ribs, which end on the square abdominal shoulders in long spines. Body chamber short. Septa simple; external lobe divided by a shallow siphonal prominence; the two branches of this lobe are goniatitic. The lateral lobe is broad and shallow and may be weakly serrated, although in some forms it is goniatitic. An auxiliary lobe may be faintly indicated on the umbilical shoulder

This genus was regarded by Mojsisovics as the radicle of the Tirolitinae, subfamily of the Ceratitidae, including *Tirolites, Balatonites, Trachyceras,* and *Sirenites* as its chief representative. This view is no longer held, and the writer regards both *Tirolites* and *Dinarites* as degenerates rather than radicles.

Tirolites s. s. is characteristic of the Werfen beds of the Lower Triassic of the Mediterranean region and occurs in the Lower Triassic also in Idaho. In America it is represented by the subgenus *Metatirolites* Mojsisovics, which occurs in the Upper Triassic of California, and by one species of the Tirolites spinosi, in the Middle Triassic of California, and by several species closely allied to *Tirolites cassianus* in the *Tirolites* zone of the Lower Triassic of Idaho.

Tirolites harti Smith, n. sp.

Plate 57, Figures 9, 10

Shell rather large, evolute, widely umbilicate. Whorls with flanks sloping outwardly upward from the umbilicus, so that the widest part is at the ventral shoulders. Venter nearly flat but very gently arched. Surface with about 10 coarse spines to a revolution, situated on the ventral shoulder.

The height of the last whorl is somewhat greater than one-fourth of the diameter of the shell; the width is a little more than the height; the width of the umbilicus is somewhat less than half the diameter of the shell.

Tirolites harti has a considerable resemblance to *T. cassianus* Quenstedt as figured by Kittl[34] but has a broader whorl and fewer spines. It has a much closer resemblance to *T. haueri* Mojsisovics[35] but has the spines a little coarser and the whorl a trifle broader. However, Kittl[36] figures *T. haueri* as a broader and more robust species than the type description and figures show; he also states that Mojsisovics's figures are inaccurate, not being sufficiently broad and robust.

Better material will probably show that *Tirolites harti* is identical with *T. haueri,* but in default of that they must be kept separate for the present, as the material from the *Tirolites* zone of Idaho is rather too poor for the identification of interregional species.

Named in honor of James E. Hart.

Horizon and locality: Rather rare in the *Tirolites* zone of the Lower Triassic of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Tirolites pealei, T. knighti, Dalmatites attenuatus, Pentacrinus* (*Isocrinus*) *smithi, Pugnoides triassicus* Girty, and other forms.

Tirolites haueri is a diagnostic species for the *Tirolites* zone of the Werfen beds of the Balkan region.

[33] Hauer, F. von, Die Cephalopoden aus der Unteren Trias der Alpen: K. Akad. Wiss. Wien Sitzungsber., Band 52, p. 610, pl. 1, figs. 4, 5, 1865. Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 67, pl. 1, fig. 1, 1882.

[34] Kittl, Ernst, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 54, pl. 9, figs. 4-6, 1903.

[35] Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 71, pl. 3, figs. 2-4, 1882.

[36] Kittl, Ernst, op. cit., p. 56, pl. 9, figs. 8-13.

Tirolites illyricus Mojsisovics

Plate 49, Figures 12–16

1882. *Tirolites illyricus.* Mojsisovics, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 68, pl. 21, fig. 10.

1903. *Tirolites illyricus.* Kittl, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 48, pl. 8, figs. 3, 4, 6, 9.

Shell evolute, discoidal, little embracing, somewhat compressed laterally. Umbilicus wide, with abrupt shoulders; flanks flattened, ventral shoulders abruptly rounded, venter slightly arched. Ornamented with fine cross striae of growth, weak lateral folds, and strong spines on the ventral shoulders, about 10 to a revolution.

Tirolites illyricus is related to *T. harti* and *T. pealei*, of the *Tirolites* zone, but differs in its weaker sculpture, more compressed whorl, and less numerous spines.

Horizon and locality: *Tirolites illyricus* was first found in the Balkan region of the Mediterranean Province, where it is common in the Werfen *Tirolites* zone. It is very rare in the *Columbites* zone of the Lower Triassic of southeastern Idaho, at the mouth of Paris Canyon, 1 mile west of Paris; associated with *Columbites parisianus*, *C. spencei*, *Meekoceras pilatum*, *Ophiceras spencei*, and other forms.

Tirolites knighti Smith, n. sp.

Plate 57, Figures 1–4

Shell evolute, little embracing, with wide umbilicus and subrectangular whorls, a little higher than wide. Surface shows about 30 fine lateral ribs with ventral shoulder knots to a revolution. Septa ceratitic, with rounded saddles and serrated lobes, of which there are three—a very short divided ventral, a much longer lateral, and small auxiliary on the umbilical shoulder. Serrations could not be seen on the auxiliary, although they are probably present.

The height of the last whorl is two-sevenths of the diameter of the shell; the width is more than four-fifths of the height; the width of the umbilicus is somewhat less than half the diameter of the shell.

Tirolites knighti is very closely related to *T. cassianus* Quenstedt, as figured by Kittl,[37] but Kittl's figures are not like those of Mojsisovics,[38] being presumably based on better specimens. However, when the European authorities disagree as to specific characters, the writer does not care to identify American forms with them, especially as the American material is not sufficiently well preserved for such an attempt.

Horizon and locality: Rather rare in the Lower Triassic *Tirolites* zone in Paris Canyon, 1 mile west of Paris, Idaho; associated with *Tirolites harti*, *T. pealei*, *Dalmatites attenuatus*, *Pentacrinus* (*Isocrinus*) *smithi*, *Pugnoides triassicus* Girty, and other forms.

[37] Kittl, Ernst, op. cit. (Cephalopoden der oberen Werfener Schichten von Muć), p. 54, pl. 9, figs. 4–6.

[38] Mojsisovics, E. von, op. cit. (Die Cephalopoden der Mediterranen Triasprovinz), p. 70, pl. 2, figs. 4–8; pl. 81, fig. 3.

Tirolites pealei Smith, n. sp.

Plate 57, Figures 5–8

Form evolute, widely umbilicate, little embracing, with whorls higher than wide. Surface shows numerous lateral ribs and marginal spines, which are coarser and fewer in adolescence; at maturity the marginal spines are nearly obsolete, and the ribs become finer and more numerous.

The height of the last whorl is somewhat less than one-third of the diameter of the shell; the width is slightly greater than two-thirds of the height; the width of the umbilicus is a little less than half the diameter of the shell.

Tirolites pealei is related to *T. knighti* but is more compressed laterally. It has a much greater resemblance to *T. smiriagini* Auerbach, of the *Tirolites* beds of the Balkan region, as figured by Mojsisovics [39] and by Kittl,[40] differing from these descriptions and figures in no essential. But the material from the *Tirolites* zone of Idaho is hardly good enough for the identification of interregional species, and consequently they are separated until specimens can be found which would justify their union.

Named in honor of A. C. Peale.

Horizon and locality: Rather rare in the Lower Triassic *Tirolites* zone in Paris Canyon, 1 mile west of Paris, Idaho, associated with *Tirolites harti*, *T. knighti*, *Dalmatites attenuatus*, *Pentacrinus* (*Isocrinus*) *smithi*, *Pugnoides triassicus* Girty, and other forms.

Genus DANUBITES Mojsisovics

1893. *Danubites.* Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, pt. 2, p. 398.

1897. *Danubites.* Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 24.

1900. *Florianites.* Hyatt, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology (translated by C. R. Eastman), p. 558.

1902. *Danubites.* Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 323.

1905. *Danubites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 163.

1914. *Danubites.* Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 75.

Type: "*Celtites*" *floriani* Mojsisovics.[41]

[39] Mojsisovics, E. von, op. cit. (Die Cephalopoden der Mediterranen Triasprovinz), p. 73, pl. 81, figs. 1, 2.

[40] Kittl, Ernst, op. cit. (Die Cephalopoden der oberen Werfener Schichten von Muć), p. 63, pl. 11, fig. 6.

[41] Mojsisovics, E. von, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Abh., Band 10, p. 145, 1882.

Evolute, little embracing, robust whorls, slowly increasing in size; umbilicus very wide; shape of cross section subquadratic; body chamber short. Sculpture of the circumplicate type, consisting of simple, rarely bifurcating ribs, running straight from the umbilicus up the sides to the abdominal shoulders but invariably interrupted on the somewhat rounded venter. Occasionally there is a threadlike keel in the center of the siphonal area, but this is usually smooth and flattened.

Septa ceratitic, an external lobe, two lateral lobes, and an auxiliary lobe present. In one species the septa seem to remain through life in the goniatitic stage, and in others the auxiliary lobe remains entire, but usually all four are serrated.

Mojsisovics at first included the type species under his genus *Celtites*, which is characterized by goniatitic lobes and long body chamber. Afterward, when its characters became better known, he placed it under the group of Ceratites obsoleti, for which he established the subgenus *Danubites*, with this species as the type. But as this group is not derived from *Ceratites* and is probably not the ancestor of that genus, the writer prefers to consider it an independent genus.

Hyatt [42] took *Celtites floriani* as the type of a new genus, *Florianites*, having overlooked the fact that it was already used as the type of another genus.

This genus was once thought to be common in the Lower Triassic of India, Siberia, Idaho, and California and in the Middle Triassic of Siberia, Japan, and Nevada. Most of those species have since been assigned to other genera. *Danubites strongi* is the only form described from America that is left to *Danubites*, and that very doubtfully.

Danubites strongi Hyatt and Smith

Plate 9, Figures 4–10

1905. *Danubites strongi*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 165, pl. 9, figs. 4–10.

Evolute, robust, discoidal, somewhat compressed laterally, widely umbilicate. Whorls low and increasing slowly in height, covering about half the inner volution and indented by it to one-fifth of the height. The height of the whorl is a little more than one-third of the diameter of the shell. The umbilicus is shallow and wide, being nearly half the total diameter. The surface is ornamented only with coarse, rounded, straight radial ribs that start from the umbilical shoulders and run up the flanks to the rounded abdominal shoulders, where they become obsolete. The venter is highly arched, helmet shaped, and smooth.

The septa are ceratitic, the saddles are all rounded and entire, and the lobes are serrated. The ventral lobe is divided by a short siphonal saddle into two very short, narrow branches; the first lateral lobe is broader and longer, the second lateral about the size of the external, and there is a small shallow entire auxiliary on the umbilical shoulders. The body chamber seems to have been short, but no perfect specimens were found to illustrate this point.

Horizon and locality: Lower Triassic *Meekoceras* zone, *Owenites* subzone, of the Inyo Range, east side of Owens Valley, 1½ miles east of Union Springs and 3 miles east of Skinner's ranch, on the McAvoy trail leading over Union Wash to Salinas Valley, about 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Pseudosageceras multilobatum*, and many other forms characteristic of the Lower Triassic.

BELOCERATOIDEA

Family SAGECERATIDAE

Involute, laterally compressed, discoidal. Short body chamber; narrow venter, either flattened with angular margins or channeled or with central keel. Surface smooth or ornamented only with spiral ridges or low folds. Septa lanceolate, either dicranidian, prionidian, or ammonitic, but invariably with adventitious lobes.

This family probably connects with *Beloceras* Hyatt, of the Devonian, but the only intermediate genus yet known is *Prodromites* Smith and Weller,[43] from the Mississippian ("Lower Carboniferous") of America. In the Lower Triassic this family is represented by *Aspenites* Hyatt and Smith, *Sageceras* Mojsisovics, and *Pseudosageceras* Diener; so that many members of the family may be looked for in the Permian. In the Middle and Upper Triassic the chief member is *Sageceras*.

Genus ASPENITES Hyatt and Smith

1905. *Aspenites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 95.
1917. *Aspenites*. Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 172.
1922. *Aspenites*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 97.

Type: *Aspenites acutus* Hyatt and Smith.

Form compressed, involute, deeply embracing, discoidal; sides flattened, abdomen acute and surmounted by a keel, umbilicus closed. Surface ornamented with fine, strong radial folds.

Ventral lobe narrow and short, divided by a short siphonal notch; that is, one small adventitious lobe on each side; three laterals, which are larger than the others and distinctly serrated. Following these lobes

[42] Hyatt, Alpheus, Cephalopoda, in Zittel, K. A. von, Textbook of palaeontology, (translated by C. R. Eastman), p. 558, 1900.

[43] Smith, J. P., and Weller, Stuart, *Prodromites*, a new ammonite genus from the Lower Carboniferous: Jour. Geology, vol. 9, p. 255, 1901.

is a short auxiliary series of goniatitic lobes. The internal septa consist of a long antisiphonal lobe, two laterals, and a long series of internal auxiliaries, all serrated. The length of the body chamber is unknown.

Aspenites resembles *Clypites* Waagen but differs from that genus in the simpler lobes and in the possession of a keel. It shows also a certain resemblance to *Prodromites* Smith and Weller from the Mississippian but is entirely too simple to have been a descendant of that highly specialized genus. Its form and septa suggest a derivation from *Timanites* of the Devonian.

Aspenites is known at present from the Lower Triassic *Meekoceras* zone of southeastern Idaho and of the Inyo Range, Inyo County, Calif.; and from the *Owenites* zone of Timor. Three species have been found—*A. acutus*, *A. obtusus*, and *A. laevis*.

Aspenites acutus Hyatt and Smith

Plate 2, Figures 9–13; Plate 3, Figures 1–5; Plate 30, Figures 1–26; Plate 60, Figures 4–6

1905. *Aspenites acutus.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 96, pl. 2, figs. 9–13; pl. 3, figs. 1–5.

1917. *Aspenites acutus.* Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 172.

1922. *Aspenites layeriformis.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 97, pl. 155, figs. 6–8, and text fig. 7.

Form discoidal, involute, deeply embracing, laterally compressed. Whorls high and narrow, with flattened sides, and acute venter. Umbilicus closed. The height of the last whorl is nearly three-fifths of the total diameter of the shell; its width is somewhat more than one-third of its height, and it is indented to about three-eighths of its height by the inner volution.

The surface is nearly smooth but ornamented with fine radial folds, visible on the cast, stronger near the umbilicus, and becoming obsolete high upon the flanks.

The septa are lanceolate, consisting of an adventitious series, a lateral, and an auxiliary series. The saddles are all entire and rounded; the lobes of the adventitious and of the auxiliary series are simple and pointed, whereas the laterals are serrated. The external lobe consists of a short bifid ventral, flanked by a single longer and pointed adventitious lobe on each side. The first lateral is short and slightly serrated, the second is longer and broader, the third short like the first but broader. The auxiliary series consists of two or three short-pointed lobes with broadly rounded saddles.

The form and the septa suggest a derivation from *Timanites* Mojsisovics of the Devonian, as described by Holzapfel.[45] *Aspenites* differs from *Timanites* in the development of the adventitious series and the serration of the laterals, but its young stages are remarkably like the mature forms of the Devonian genus. *Timanites* is placed by some writers in the Prolecanitidae, by others in the Primordialidae, but its true position will probably be found to be along with *Beloceras*, as an offshoot from the Primordialidae.

Horizon and locality: *Aspenites acutus* was found by Alpheus Hyatt in the Lower Triassic *Meekoceras* zone in Wood Canyon, near Soda Springs, Idaho, and by J. P. Smith in the *Owenites* subzone of the *Meekoceras* zone in Union Wash, near Union Spring, in the Inyo Range, about 15 miles southeast of Independence, Inyo County, Calif. *Aspenites layeriformis* Welter[46] can be at most only a variety of *A. acutus.* This form was described by Welter from the *Owenites* zone of Timor, in very much the same association as in America.

Aspenites laevis Welter

Plate 28, Figures 28–33

1922. *Aspenites laevis.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 99, pl. 155, figs. 4, 5, and text fig. 8.

Involute, laterally compressed, narrowly umbilicate, with gently convex flanks and high, narrow, sharp venter, with high ventral keel. Surface nearly smooth. Septa with entire saddles and long tongue-shaped lobes, mostly serrated. There is a series of four adventitious lobes, reducing in size toward the siphon; two laterals, of which the outer is much the larger; and a long series of auxiliaries.

Aspenites laevis is closely related to *A. acutus*, differing in the higher ventral keel and much more complicated septa.

Horizon and locality: Very rare in the *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs. It was first described from the *Owenites* zone of the Lower Triassic of Timor, in the East Indies, in very much the same association as in Idaho.

Aspenites obtusus Smith, n. sp.

Plate 31, Figures 8–10

Form laterally compressed, high-whorled, involute, with closed umbilicus, flat sides, and narrow, blunt venter, rounded and without keels or furrow. Surface nearly smooth, with faint undulations and fine growth lines. Septa with rounded entire saddles and serrated lobes. The adventitious series is short, consisting of two small lobes; the first lateral is broad and shallow; the second lateral much smaller; the auxiliary

[45] Holzapfel, E., Die Cephalopoden des Domanik im südlichen Timan: Com. géol. [St.-Pétersbourg] Mém., vol. 12, No. 3, 1899.

[46] Welter, O. A., Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 97, pl. 155, figs. 6–8, and text fig. 7, 1922

series consists of a row of hardly differentiated rudimentary lobes.

Aspenites obtusus differs from *A. acutus* in its more robust form, blunt venter, and simpler septa.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone, of locality 5, 1 mile east of Hot Springs, at the north end of Bear Lake, Bear Lake County, Idaho; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Pseudosageceras multilobatum, Juvenites dieneri, J. kraffti, Cordillerites angulatus, Parananites aspenensis, Thermalites thermarum, Lanceolites compactus,* and many other species characteristic of this horizon.

Genus PSEUDOSAGECERAS Diener

1895. *Pseudosageceras.* Diener, Triadische Cephalopoden. faunen der ostsibirischen Küstenprovinz: Com. géol- [St.-Pétersbourg] Mém., vol. 14, p. 28, No. 3.

1902. *Pseudosageceras.* Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 659.

1905. *Pseudosageceras.* Noetling, Untersuchungen ueber den Bau der Lobenlinie von *Pseudosageceras multilobatum* Noetling: Palaeontographica, Band 51, pp. 155–260.

1905. *Pseudosageceras.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 98.

1908. *Pseudosageceras.* Arthaber, Ueber die Entdeckung von Untertrias in Albanien: Geol. Gesell. Wien Mitt., Band 1, p. 279.

1909. *Pseudosageceras.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 145.

1911. *Pseudosageceras.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 201.

1917. *Pseudosageceras.* Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 173.

1922. *Pseudosageceras.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 94.

1929. *Pseudosageceras.* Mathews, The lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 3.

Type: *Pseudosageceras* sp. indet. Diener.[47]

Shell compressed, involute, discoidal, deeply embracing, umbilicus closed, sides flattened; venter narrow and angular, with a low, sharp keel surmounting the venter. Surface smooth on all the species now known in Asia, Europe, and America. Septa consisting of numerous long and narrow lobes and saddles; the saddles are all entire, and the lobes all divided; near the venter there is a series of shorter adventitious lobes, chiefly bifid, and on the flanks a series of several laterals, chiefly trifid but with secondary divisions. Below the chief laterals is a series of bifid auxiliaries outside the umbilicus.

This genus resembles *Sageceras* Mojsisovics but has more complex septa and can not possibly be the ancestor of it, for in *Sageceras* the lobes are invariably bifid, the trifid stage never being reached. A near relative and possible ancestor of *Pseudosageceras* may be found in *Prodromites* Smith and Weller,[48] from the Mississippian ("Lower Carboniferous"), which may be a connecting link with *Beloceras* Hyatt, of the Devonian, for *Prodromites* has the same involute, compressed, acute form, and the numerous serrated lobes with a long auxiliary series, but it has not developed the typical adventitious lobes characteristic of *Beloceras* and *Pseudosageceras*. A more probable link between *Beloceras* and *Pseudosageceras* is *Acrocanites* Schindewolf,[49] type *A. multilobatus* Schindewolf, from the *Pericyclus* zone of the lower Carboniferous of Germany. This form is discussed below under the specific description, in which is also given a discussion of the phylogeny of *Pseudosageceras*, based on the ontogeny of the type species.

Pseudosageceras is known from the Lower Triassic of Ussuri Bay, in eastern Siberia; from the Lower Triassic of India, and from the corresponding *Meekoceras* zone of the Aspen Ridge in southeastern Idaho and the Inyo Range in California; also from the *Anasibirites* subzone of Utah and from the *Columbites* zone of Albania and of Idaho.

Frech assumes that two geologic horizons are represented in the *Proptychites* beds of Ussuri Bay and that *Ussuria* and *Pseudosageceras* came out of Permian strata, whereas *Meekoceras* came out of Lower Triassic beds. This assumption is, however, unlikely, for the writer has found both *Ussuria* and *Pseudosageceras* in the Aspen Ridge of Idaho, associated with *Meekoceras gracilitatis* and numerous other species of *Meekoceras* and other forms equally characteristic of the Lower Triassic. But it is extremely probable that both genera will eventually be found in the Permian, for the stocks to which they belong are already well differentiated in the Carboniferous.

Pseudosageceras multilobatum Noetling

Plate 4, Figures 1–3; Plate 5, Figures 1–6; Plate 25, Figures 7–16; Plate 60, Figure 32; Plate 63, Figures 1–6

1905. *Pseudosageceras multilobatum.* Noetling, Untersuchungen ueber den Bau der Lobenlinie von *Pseudosageceras multilobatum* Noetling: Palaeontographica, Band 51, pp. 183 et seq.

1905. *Pseudosageceras intermontanum.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 99, pl. 4, figs. 1–3; pl. 5, figs. 1–6; pl. 63, figs. 1, 2.

1906. *Pseudosageceras multilobatum.* Frech, in Noetling, Die asiatische Trias: Lethaea geognostica, Teil 2, Das Mesozoicum, Band 1, Trias, pl. 25, figs. 1a–b; pl. 26, figs. 3a–b.

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[47] Diener, Carl, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 28, pl. 1, fig. 8, 1895.

[48] Smith, J. P., and Weller, Stuart, op. cit., p. 257.

[49] Schindewolf, O. H., Ueber eine Unterkarbonfauna aus Ostthüringen: Senckenbergiana, Band 4, Heft 1, 2, p. 15, 1922.

1909. *Pseudosageceras multilobatum.* Krafft and Diener, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 145, pl. 21, fig. 5.

1911. *Pseudosageceras multilobatum.* Wanner, Triascephalopoden von Timor und Rotti: Neues Jahrb., Beilage-Band 32, p. 181, pl. 7, fig. 4.

1922. *Pseudosageceras multilobatum.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 94, text fig. 3.

1929. *Pseudosageceras intermontanum.* Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 3, pl. 1, figs. 18–22.

Not 1908. *Pseudosageceras multilobatum.* Arthaber, Ueber die Entdeckung von Untertrias in Albanien: Geol. Gesell. Wien Mitt., Band 1, p. 279, pl. 12, figs. 3a–c.

Shell compressed, involute, discoidal, deeply embracing, with closed umbilicus and flattened sides, with gentle convex curve up to the venter, which is narrow, with small furrow and two fine bordering keels. On this furrow rests a central keel, which, however, is usually broken off.

Septa consisting of numerous lanceolate lobes and saddles, the saddles all entire and the lobes mostly divided. Next to the venter is a series of four adventitious lobes on each side of the short undivided ventral, of which the first is short and undivided, the second longer and bifid, the third bifid, with a secondary notch on the upper prong, the fourth unsymmetrically bifid, with notches on both prongs; then follows a series of two principal lateral lobes, of which the first is unsymmetrically trifid, all the prongs being indented, and a second deeply and unsymmetrically bifid. After the principal lateral lobes follows a series of six irregular auxiliaries, of which the first and third are bifid and the others apparently entire. This septation is more complex than on Diener's type species but is of the same general character. Also Diener's specimen was very imperfect but if better preserved might have shown these same characters, so that the two are certainly congeneric.

The length of the body chamber is unknown, as all the specimens were septate, but imperfect individuals 115 millimeters in diameter have been found.

Dimensions of a specimen from the Lower Triassic Meekoceras zone of Wood Canyon, near Soda Springs, Idaho

	Millimeters
Diameter	93
Height of last whorl	56
Height of last whorl from the preceding	33
Breadth of last whorl	19
Involution	23
Width of umbilicus	2

The whorl is indented to nearly half its height by the inner coil, and the greatest breadth lies just opposite this point.

Horizon and locality: Lower Triassic *Meekoceras* zone of Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, southeastern Idaho; and the *Owenites* subzone of the same zone on Union Wash, 3 miles east of Skinner's ranch, near the old McAvoy trail from Owens Valley over the Inyo Range to Saline Valley, Inyo County, Calif. In both Idaho and California it is associated with *Meekoceras gracilitatis* White, *M.* (*Koninckites*) *mushbachanum* White, and many other species common to the two beds, enough to make certain the approximate correlation of the *Meekoceras* zone in California and Idaho. It was also found by R. S. Spence in the *Columbites* zone, 1 mile west of Paris, Bear Lake County, Idaho, associated with *Columbites parisianus* Hyatt and Smith, *Ophiceras jacksoni* Hyatt and Smith, *Ophiceras spencei* Hyatt and Smith, *Celtites ursensis* Smith, *Meekoceras pilatum* Hyatt and Smith, and other forms. It was also found in the *Anasibirites* subzone of Fort Douglas, Utah, as described by A. A. L. Mathews.

Pseudosageceras multilobatum is one of the most widely distributed and characteristic of Lower Triassic ammonites, occurring in the middle part of the Lower Triassic of the Salt Range, the Himalayas, on Timor, on Madagascar, in Idaho, California, and Nevada. It is essentially characteristic of what is called *Flemingites* beds in the Salt Range, *Hedenstroemia* beds in the Himalayas, and *Pseudosageceras multilobatum* subzone of the *Meekoceras* zone in Idaho, all of the same age and with virtually the same fauna. This is one of the most definite interregional zones known in the Triassic or in any other part of the geologic column and is of great importance in the correlation of faunas in Asia and America.

The American form was in press as "*Pseudosageceras multilobatum*" when the writer was informed by a letter from Noetling that he was about to publish a species under that name. As it was certain that Noetling's paper would appear first and extremely improbable that the two species would be more than congeneric, the writer at once changed the name of the American form to "*P. intermontanum.*" However, on receipt of Noetling's monograph, and after the publication of "The Triassic cephalopod genera of America," the writer was by no means certain that the change in name was justified. Still later, on receipt of excellent material of typical specimens of *Pseudosageceras multilobatum* from Timor, and on collecting more and better specimens of the American form from Idaho, the writer was convinced of the identity of the Asiatic and the American forms. Hence the older name is restored.

It is by no means certain that all of Noetling's figured specimens really should be kept under *Pseudosageceras multilobatum*, as the variation is so great. It seems possible to the writer that Noetling may even have included some specimens of *Hedenstroemia*. It is also quite possible that the two specimens figured by the writer on Plate 63, Figures 1–6, may belong to another species, as the rest of the fauna in the *Columbites* zone of Idaho is so different from that of the *Meekoceras* zone, from which the other specimens came. But they were well within the variation limits established by Noetling, and they have been left as named by Hyatt and Smith until the discovery of further material could settle their true identity.

Noetling published no observations on the ontogeny of his species, nor has anyone else, up to the present, but it has generally been assigned to what was formerly called the Pinacoceratidae. Arthaber[50] has later formulated an elaborate classification of this group, assigning *Pseudosageceras* to his group Beloceratea. In this the writer agrees with him, in part, in regarding *Pseudosageceras* and *Sageceras* as derivatives of the Devonian *Beloceras*. Young specimens of *Pseudosageceras multilobatum*, at a diameter of 5.5 millimeters, are almost perfect replicas of *Beloceras*, in the compressed high whorl, in the involution, and in the possession of well-developed adventitious and auxiliary lobes. They bear a close resemblance to the young of *Sageceras gabbi* at about the same size. In the present work the young stages of *P. multilobatum* are shown in Plate 25, Figures 10 to 14; the young of *Sageceras gabbi* are shown in Plate 45, Figures 16 and 17.

Diener[51] denies the relationship of *Pseudosageceras* to *Beloceras* and derives it from the Meekoceratidae. However, the writer figures in the present work the young of nearly all the genera of Meekoceratidae, and none will be found in any way resembling the young stages of either *Pseudosageceras* or *Sageceras*. On the contrary, they all resemble *Lecanites* and later *Xenodiscus*, the ceratitoid kinship being manifest in all.

The peculiar and characteristic beloceran young of *Pseudosageceras*, *Sageceras*, and *Aspenites* set them aside entirely from the typical Prolecanitidae.

A Carboniferous genus, *Acrocanites* Schindewolf,[52] is here suggested as an intermediary between the Devonian *Beloceras* and the Triassic *Pseudosageceras* and *Sageceras*. The genus *Prodromites* Smith and Weller,[53] though doubtless a descendant of *Beloceras*, is too highly specialized and premature to be this intermediary, but for many years it was the only possible member of the Beloceratea known from the entire Carboniferous. The septum of *Acrocanites* shown in Plate 44, Figure 9, is copied from Schindewolf's paper, cited above. The genus has not yet been fully studied, so far as the writer knows, and it has been wrongly assigned to the stock of *Prolecanites*. It should be looked for in European and American collections of Carboniferous fossils, as it furnishes a very much needed link in the series. Schindewolf's figure shows definite resemblance to the adult of *Beloceras* and strong suggestions of the young of *Pseudosageceras* and *Sageceras*. In all these forms the possession of adventitious and auxiliary lobes at at an early stage is positive.

Schmidt[54] cites *Acrocanites multilobatus* Schindewolf as a *Beloceras*-like form, too high up in the geologic column and with characters too unlike the *Prolecanites* stock to be attached to them. Nothing else has yet been published about this very interesting form, which may prove to be a veritable "missing link" partly recovered.

[50] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 177, 1911.

[51] Diener, Carl, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 173, 1917.

[52] Schindewolf, O. H., Ueber eine Unterkarbonfauna aus Ostthüringen: Senckenbergiana, Band 4, Heft 1, 2, p. 15, fig. 2d, 1922.

[53] Smith, J. P., The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, p. 34, 1903.

Superfamily DIMORPHOCERATOIDEA

Family HAUERITIDAE

Genus LANCEOLITES Hyatt and Smith

1905. *Lanceolites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 113.

1917. *Lanceolites*. Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 176.

Type: *Lanceolites compactus* Hyatt and Smith, Lower Triassic *Meekoceras* zone.

Form compact, laterally compressed, sides flattened, venter flattened, with sharp shoulder angles. Involute, deeply embracing, closed umbilicus. In youth the flat venter has a broad, shallow furrow, but this disappears at maturity. The form is thus seen to be exactly similar to that of *Cordillerites*, but the septa would distinguish the two genera at once. In *Lanceolites* the septa are complex, digitate, and lanceolate. There is a short adventitious series of simple lobes, two laterals, of which the first is deeply digitate and the second less so, and a series of tongue-shaped auxiliaries. The saddles are divided as well as the lobes. The septa suggest some relationship with *Cordillerites*, but that genus, though it has lanceolate septa, still has a more complex plan for its lobes. They may be parallel developments from kindred stocks.

Lanceolites is known only from the *Meekoceras* zone of the Lower Triassic in the Aspen Ridge of southeast Idaho, in eastern Nevada, and from the same horizon in the Inyo Range, eastern California, where the species described below were found.

[54] Schmidt, H., Die carbonischen Goniatiten Deutschlands: Preuss. geol. Landesanstalt Jahrb., Band 45, p. 543, 1925.

Lanceolites compactus Hyatt and Smith

Plate 4, Figures 4–10; Plate 5, Figures 7–9; Plate 21, Figures 21–23; Plate 28, Figures 17–20; Plate 40, Figures 9–11; Plate 60, Figure 10

1905. *Lanceolites compactus.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 113, pl. 4, figs. 4–10; pl. 5, figs. 7–9; pl. 78, figs. 9–11.

1927. *Lanceolites compactus.* Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 72, pl. 21, figs. 21–23.

Form involute, discoidal, laterally compressed. Whorl deeply embracing and deeply indented by the inner volution. Umbilicus completely closed. Sides of whorl flattened, gently convex, abdominal shoulders angular, venter narrow, flat, or even slightly depressed below the shoulder angles. The height of the last whorl is two-thirds of the diameter of the shell, and the breadth is half the height. The width of the venter is one-third of the greatest thickness of the shell, which occurs just above the umbilical shoulders.

The surface is nearly smooth, no ribs or spines being visible, but there are faint radial folds visible on the cast. The shell is not preserved on any specimen found. Length of body chamber unknown.

The septa are complex, with lanceolate digitation of the lobes. The external lobe is divided by a narrow siphonal saddle into two broad digitate branches. The first lateral lobe is broad and deep, with long linguiform digitations. The second lateral lobe is narrower and shallow, also digitate. There is an auxiliary series of several tonguelike small lobes above the umbilicus.

The form of this species is exactly like that of *Cordillerites angulatus*, but the septa show fundamental differences. The septa in the young stages show some resemblance to *Dimorphoceras*. In early youth, at the diameters of 4.5 and 5.5 millimeters (as shown on pl. 28, figs. 17–20), the shell and septa are remarkably like the Devonian and lower Carboniferous genus *Aphyllites* Mojsisovics. In adolescence, at the diameter of 8 millimeters (as shown on pl. 20, figs. 21–23), the septa have become more complex, with the lanceolate division of the large lateral lobe beginning. This stage corresponds to some unknown Permian genus distantly resembling and distantly related to *Thalassoceras*, not a derivative of *Dimorphoceras* but from some kindred form. The young of *Fremontites ashleyi* Hyatt and Smith,[55] of the Upper Triassic of California, are almost exactly like this stage of *Lanceolites*. *Fremontites* is a typical member of the Haueritidae, and this is very good evidence that this family is derived from *Lanceolites* or from some form very like it.

Horizon and locality: Rare in the Lower Triassic *Meekoceras* zone (*Pseudosageceras multilobatum* subzone) of southeastern Idaho, at locality 1, 5 miles southeast of Grays Lake; locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; also in the *Owenites* subzone of the *Meekoceras* zone at Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif. In Idaho it was associated with *Meekoceras gracilitatis*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Pseudosageceras multilobatum*, *Ussuria waageni*, and other forms. In California it was associated with *Meekoceras gracilitatis*, *Sturia compressa*, *Inyoites oweni*, *Owenites koeneni*, *Anasibirites noetlingi*, and other forms.

[55] Smith, J. P., Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 74, pl. 63, figs. 13–15, 1927.

Lanceolites bicarinatus Smith, n. sp.

Plate 55, Figures 1–2

High-whorled, involute, deeply embracing, laterally compressed. Umbilicus closed, venter narrow, with shallow ventral furrow, and distinct marginal keels.

Septa linguiform, but with both lobes and saddles slightly digitate. There is a short adventitious series consisting of small tongue-shaped lobes, a large principal lateral deeply divided by secondary lobes, with a smaller second lateral, and a short auxiliary series.

Lanceolites bicarinatus is rather closely related to *L. compactus* but differs in the greater compression of the whorl and the more complex septa. Both species have a considerable resemblance to the Upper Triassic *Fremontites*, and either one might be the ancestor of the Haueritidae.

Horizon and locality: Rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of Union Wash, 1½ miles east of Union Spring, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif., and at the same horizon at the Phelan ranch, Elko County, 70 miles south of Wells, and on the east side of the Ruby Range, Nev.; associated with *Meekoceras gracilitatis*, *Inyoites oweni*, *Owenites koeneni*, *Anasibirites desertorum*, *Pseudosageceras multilobatum*, *Aspenites acutus*, *Juvenites dieneri*, and other forms.

Family THALASSOCERATIDAE

Form involute, with laterally compressed, high-arched whorls and narrow, rounded venter. Surface smooth, or ornamented with spiral striae. Septa ammonitic, but in the more primitive forms the saddles are entire, although the digitations run high up on the sides of the saddles.

In this family are included *Thalassoceras* Gemmellaro, *Ussuria* Diener, and *Sturia* Mojsisovics. The two former genera are commonly accepted as standing in genetic connection and as having been derived from the Carboniferous genus *Dimorphoceras*. *Sturia* has hitherto been assigned to the Ptychitidae, but a species has been found in the Lower Triassic of California that seems to connect *Ussuria* with it, and this necessitates classing both with the Thalassoceratidae, with which they are clearly more closely allied than with the Ptychitidae.

Thalassoceras is known from the Permian of the Mediterranean region, Texas and Timor; *Ussuria* only from the Lower Triassic of Siberia, India, and Idaho; and *Sturia* only from the Lower Triassic of California and from the Middle and Upper Triassic of the Alpine province and the Middle Triassic of the Himalayas.

Genus USSURIA Diener

1895. *Ussuria.* Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 23.
1902. *Ussuria.* Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 659.
1905. *Ussuria.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 88.
1917. *Ussuria.* Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 166.
1922. *Ussuria.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 100.

Type: *Ussuria iwanowi* Diener.[56]

Compressed, involute, deeply embracing, whorls increasing rapidly in height. Umbilical shoulders broadly rounded, sides gently convex up to the narrow and rounded venter. Umbilicus narrow and deep. Surface without ribs or constrictions but provided with fine spiral striae (seen on specimens from California).

Septa, both lobes and saddles ammonitic, digitate, and highly specialized. The external lobe is divided by a broad digitate siphonal saddle, and each side of the lobe is deeply trifid, with secondary indentations on the prongs. There are two or three principal lateral lobes, wide, deep, and deeply digitate; the auxiliaries, of which there are three or more, are smaller but also digitate. The internal lobes have not been observed in detail, but broken whorls show that there is a long, narrow antisiphonal lobe, flanked by a pair of laterals on each side.

Diener considers this genus as a descendant of *Thalassoceras* Gemmellaro,[57] which has somewhat simpler, though ammonitic septa, in which there are two digitate lateral lobes and a single simple auxiliary. *Thalassoceras* has a depressed subglobose form, with the whorls usually broader than high, whereas the adults of *Ussuria* are high-whorled and compressed. But the young of the latter genus are robust and subglobose, resembling *Thalassoceras* both in form and septa, and the still younger stages are like *Dimorphoceras*. These observations have been made only on an *Ussuria waageni* Hyatt and Smith from the *Meekoceras* zone of Idaho, no young stages of *Sturia compressa* Hyatt and Smith having been seen. *Thalassoceras* is supposed to have been derived from *Dimorphoceras*, based on the resemblance of the adults and on Gemmellaro's observations on its ontogeny.

Ussuria bears a certain resemblance to *Sturia* Mojsisovics, commonly assigned to the Ptychitidae, in its compressed form, spiral striae, and complex septa, and a relationship between the two genera is by no means unlikely, in spite of the difference in complexity of the septa.

Hyatt classed *Ussuria* in a new family, the Ussuritidae, under the suborder Phylloceratida, but this was before any observations had been made on the ontogeny of the genus or any species of it was known except the Siberian forms.

Ussuria is known at present in the Lower Triassic *Proptychites* beds of Ussuri Bay in eastern Siberia, in the *Meekoceras* zone of the Aspen Ridge in southeast Idaho, and in beds at the same horizon on Timor, in all three places associated with *Meekoceras*, *Pseudosageceras*, *Ophiceras*, and *Xenodiscus*, with closely allied species.

Ussuria occidentalis Smith, n. sp.

Plate 27, Figures 8–12

Form involute, high-whorled, laterally compressed. Sides flattened, venter rather narrowly rounded. Umbilicus nearly closed. Septa ammonitic, with digitate lobes, and crenulate saddles. There are a principal external lobe, rather long and narrow, a short adventitious lobe, a large external lobe, and several auxiliaries, decreasing in size and complexity toward the umbilicus.

Dimensions of type specimen of Ussuria occidentalis

	Millimeters	Ratio
Diameter	84	100
Height of last whorl	55	65
Height of last whorl from the preceding	33	40
Width of last whorl	21	25
Involution	22	26
Width of umbilicus	3	3

Ussuria occidentalis is very closely related to *U. waageni* Hyatt and Smith, with which it is associated. It differs from that species in its greater lateral compression, higher whorl and more rapid increase in height, narrower umbilicus, and slightly simpler septa. The saddles are somewhat more club-shaped, with broader tops and greater constriction at the base; the external lobe is also not so narrow as that on *U. waageni*.

These two species differ from the Asiatic typical forms in the possession of a well-marked adventitious lobe.

[56] Diener, Carl, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 27, pl. 3, fig. 5, 1895.

[57] Gemmellaro, G. G., La fauna dei calcari con Fusulina della valle del Fiume Sosio nella provincia di Palermo, p. 69, 1887.

Horizon and locality: *Ussuria occidentalis* is rare in the Lower Triassic *Pseudosageceras multilobatum* subzone of the *Meekoceras* zone (equivalent of the *Hedenstroemia* or *Flemingites* zone of India), at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, southeastern Idaho. It was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Paranannites aspenensis*, *Pseudosageceras multilobatum*, *Lanceolites compactus*, *Cordillerites angulatus*, and many other species characteristic of this horizon.

Ussuria waageni Hyatt and Smith

Plate 21, Figures 24–40; Plate 42, Figures 1–8; Plate 60, Figures 15–20; Plate 65, Figures 1–5; Plate 66, Figures 1–12; Plate 67, Figures 1, 2

1905. *Ussuria waageni*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 90, pl. 65, figs. 1–5; pl. 66, figs. 1–12; pl. 67, figs. 1, 2; pl. 85, figs. 1–8.

1927. *Ussuria waageni*. Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, pl. 21, figs. 24–40.

Discoidal, involute, laterally compressed. Whorls high and increasing rapidly in height, deeply embracing, and deeply indented by the inner whorls. Sides flattened, with narrow rounded venter and no marked umbilical shoulders. The umbilicus is very narrow, being somewhat less than one-tenth of the entire diameter of the shell. The height of the last whorl is more than half the diameter of the shell, the width slightly more than half the height of the whorl, and it is indented to nearly one-seventh of its height by the inner whorl.

Proportions of shell of Ussuria waageni at maturity

Diameter	100
Height of last whorl	56
Height of last whorl from the preceding	43
Width of last whorl	29
Involution	13
Width of umbilicus	8

The greatest width of the whorl lies at a point about halfway up the flanks, some distance above the contact with the inner volution. The surface is nearly smooth, showing neither ribs nor constrictions but faint radial folds and striae of growth.

The septa are very complex, consisting of a rather small external lobe divided by a siphonal saddle, a small first lateral lobe, larger second lateral, and smaller third lateral, besides a long series of auxiliaries, decreasing in size and complexity toward the umbilicus. The external and the lateral lobes are deeply digitate, whereas the auxiliaries are much simpler in form. The saddles are all narrower than the lobes and somewhat phylloid.

These septa are more complex than those of *Ussuria schamarae* Diener and *U. iwanowi* Diener, from Siberia, but show that this species is congeneric with them. It must also be taken into account that the Idaho species is very large and that the Siberian species may have reached the same complexity of septation if such large specimens of them had been found.

The foregoing description applies only to the mature shell, for the young stages differ very much from the adult. An unusually good series of young stages was obtained, and as they show clearly the phylogeny of the genus they have been fully illustrated. The mature shell was found up to a diameter of 150 millimeters fully septate, and the complete shell must have been nearly 300 millimeters in diameter.

The smallest stage obtained has a diameter of 5.5 millimeters, is evolute, little embracing, with low, broadly rounded whorls, with simple goniatitic septa. The form and septa correspond to the Carboniferous genus *Dimorphoceras*. The change from glyphioceran septa to those characteristic of *Dimorphoceras* may be observed on the outer volution of this specimen, which is figured on Plate 42, Figures 5–8. For comparison with this the septa of *Dimorphoceras gilbertsoni* Phillips and *D. atratum* Goldfuss, of the Carboniferous, are figured on Plate 42, Figures 11 and 12.

At the diameter of 11 millimeters the shell shows a transition from *Dimorphoceras* to *Thalassoceras*. In the beginning of the digitation of the lobes the whorl becomes higher at this stage but not yet flattened as at maturity. This stage is figured on Plate 42, Figures 1–4. For comparison with it, the septa of *Thalassoceras gemmellaroi* Karpinsky and *T. phillipsi* Gemmellaro are figured on Plate 42, Figures 9 and 10.

At the diameter of 13 millimeters the form and septa are more like the highly specialized species of *Thalassoceras* known from the Permian; this stage is figured in Plate 66, Figures 10–12.

At the diameter of 17 millimeters the shell and septa show a transition from *Thalassoceras* to *Ussuria* in the flattening of the sides, increased height of whorl, greater complexity of lobes, and pronounced development of the auxiliary lobes. This stage is shown in Plate 66, Figures 7–9.

At the diameter of 30 millimeters the stage of development of the septa agrees with that of *Ussuria schamarae* Diener and *U. iwanowi* Diener, from the Lower Triassic of Siberia. It is possible, however, that the species described by Diener may have been based on young individuals. This stage of *Ussuria waageni* is figured in Plate 66, Figures 4–6.

At the diameter of 35 millimeters the shell and septa already show the most significant characters of maturity but are not yet so complex as in the larger specimens. This is shown in Plate 66, Figures 1–3.

The fully mature shell is figured in Plate 65, Figures 1–5, and Plate 67, Figures 1 and 2. The septa of *Ussuria iwanowi* Diener, from the Lower Triassic of

Siberia, are figured for comparison in Plate 66, Figure 25.

The development of *Ussuria waageni* is remarkable, in that we can trace the species in its ontogeny through stages corresponding successively to some gephyroceran form of the Devonian; then through the stage corresponding to the simpler species of *Dimorphoceras* in the Mississippian; then to the more complex species of *Neodimorphoceras* of the "Coal Measures"; then to the simpler species of *Thalassoceras* of the lower Permian or Artinsk stage; then to the more complex *Thalassoceras* of the upper Permian; and lastly through gradually increasing complexity into *Ussuria*. The stages come in the exact order of the geologic sequence of mature genera, so that the agreement of phylogeny and ontogeny is perfect.

Of course this is what we should expect in Lower Triassic species, for the time of the *Meekoceras* fauna is not greatly removed from that of the Permian faunas of Sicily and the Artinsk stage, nor yet very remote from even the Carboniferous. But such close correlation of individual development and geologic history is rare, even in Lower Triassic species, and especially in such complex forms, where the adult differs so markedly from the young.

Ussuria waageni Hyatt and Smith differs from *U. iwanowi* Diener and *U. schamarae* Diener in the greater complexity of its septa but agrees with them in the general plan of lobes and saddles. It agrees in general with *Sturia compressa* Hyatt and Smith, from the Lower Triassic *Meekoceras* zone of California, but differs from that species in the more robust whorl in all stages observed. The saddles in both the American species are more digitate than in the Asiatic forms, and the subdivision of the lobes is more complex. It has been suggested by Frech[58] that the Siberian species of *Ussuria* did not occur in the Lower Triassic, as Diener supposed, but in the Permian. It is certain, however, that the Siberian as well as the American species of this genus belong to the Lower Triassic, and that their greater simplicity of development is due to their occurrence at a lower horizon of the Triassic.

Horizon and locality: *Ussuria waageni* is rather common in the *Meekoceras* zone of the Lower Triassic, at the head of Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, southeastern Idaho. It was associated with *Meekoceras gracilitatis* White, *M. mushbachanum* White, *Pseudosageceras multilobatum* Noetling, *Flemingites russelli* Hyatt and Smith, *Hedenstroemia kossmati* Hyatt and Smith, *Ophiceras dieneri* Hyatt and Smith, *Paranannites aspenensis* Hyatt and Smith, *Cordillerites angulatus* Hyatt and Smith, *Aspidites*, and many other forms characteristic of this horizon.

[58] Frech, Fritz, Die Dyas: Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 659, 1902.

Genus STURIA Mojsisovics

1882. *Sturia.* Mojsisovics, Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 240.
1892. *Sturia.* Hauer, Beiträge zur Kenntniss der Cephalopoden aus der Trias von Bosnien: K. Akad. Wiss. Wien Denkschr., Band 59, p. 283.
1895. *Sturia.* Diener, Cephalopoda of the Muschelkalk: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 2, p. 113.
1902. *Sturia.* Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Supplement-Heft, p. 309.
1910. *Sturia.* Renz, Triadische Faunen der Argolis: Palaeontographica, Band 58, p. 24.
1914. *Sturia.* Welter, Die Obertriadischen Ammoniten und Nautiloiden von Timor: Palaeontologie von Timor, Lief. 1, p. 198.

Robust, involute, laterally compressed, deeply embracing, narrowly umbilicate, high whorled. Surface without ribs or constrictions but with sharp spiral lines. Septa ammonitic, deeply digitate, with ground plan of lobes and saddles pyramid shaped. There are a divided ventral lobe, a large first lateral, a smaller second lateral, and a series of several auxiliaries, decreasing regularly in size toward the umbilicus. Inner septa unknown. Length of body chamber less than a revolution.

Sturia is supposed to be related to the Thalassoceratidae, but its real kinship is unknown, for its development has not been worked out. The septal plan is somewhat like that of *Procarnites* Arthaber, but intimate relationship with that genus is improbable. The external form and spiral lines have some resemblance to *Cladiscites* Mojsisovics, but the plans of the septa of the two genera have no resemblance.

Sturia is essentially characteristic of the Middle Triassic but occurs also in the Upper Triassic, and two species have been found in the *Owenites* subzone of the Lower Triassic *Meekoceras* zone of California, *Sturia compressa* Hyatt and Smith, and *S. woodini* Smith.

Sturia compressa Hyatt and Smith

Plate 3, Figures 6–11

1905. *Ussuria compressa.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 89, pl. 3, figs. 6–11.

Form compressed, involute, discoidal; whorls deeply embracing and increasing rapidly in height, the outer whorl being indented to one-fourth of its height by the inner. Umbilicus closed, umbilical shoulders broadly rounded. Sides gently convex, with greatest breadth opposite the top of the inner volution. Venter rounded but very narrow. The whole form is thus seen to be lenticular, with the greatest thickness of the lens exactly in the middle, and one-third of the diameter.

The surface of the cast is perfectly smooth, devoid of ribs, constrictions, or other ornamentation; but in a few places the outer shell was preserved, adhering to the cast, and on this were observed fine spiral lines like those on the shell of other species of *Sturia*.

The septa are very complex, both lobes and saddles being thoroughly ammonitic, much more complex than those of *Ussuria schamarae* Diener and *U. iwanowi* Diener. The ventral lobe is divided by a broad, siphonal saddle, which in turn is broken up by several small, short digitations, almost becoming adventitious lobes; the two lateral lobes are deeply digitate, the first being much more complex than the second. The auxiliary series consists of four or five small lobes, scarcely individualized, and inclined backward to the umbilical margin. The internal septa could not be observed in detail, but broken whorls showed a large antisiphonal lobe, flanked by a pair of principal internal laterals on each side.

Sturia compressa has more compressed whorls than either of the Siberian species and also greater complexity of the septa and can not belong to the same genus with them.

Dimensions of the type specimen of Sturia compressa

	Millimeters
Diameter	66
Height of last whorl	45
Height of last whorl from the preceding	35
Width of last whorl	20
Involution	10
Width of umbilicus	0

This specimen was chambered throughout, and the species probably grew to twice this diameter.

Horizon and locality: In the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of Union Wash, near Union Spring, about 15 miles southeast of Independence, Inyo County, Calif., collected by J. P. Smith.

Sturia woodini Smith, n. sp.

Plate 51, Figures 5, 6

Form robust, involute, laterally compressed, narrowly umbilicate. Venter gently rounded. Umbilicus shallow and entirely without umbilical shoulders, so that the slope of each succeeding whorl coincides with that of the preceding one, giving a uniform slope to the center of the umbilicus. Surface ornamented with fine strong spiral lines.

The outer whorl embraces four-fifths of the inner and is indented to one-third of its height. The height of the last whorl is half the total diameter of the shell, and the width is two-fifths of the height. The width of the umbilicus is one-eighth of the diameter of the shell.

Sturia woodini is related to *S. compressa* Hyatt and Smith, with which it is associated, but differs in its more robust and less compressed whorl, broader venter, and stronger spiral lines.

Septa unknown, but the similarity to *Sturia compressa* makes the generic reference rather certain.

Named in memory of Doctor Woodin, in recognition of his hospitality and assistance.

Horizon and locality: Very rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of Union Wash, 1½ miles east of Union Spring, 15 miles southeast of Independence, Inyo County, Calif.; associated with *Owenites koeneni*, *Inyoites oweni*, *Lanceolites compactus*, *Meekoceras gracilitatis*, *Aspenites acutus*, *Anasibirites noetlingi*, and many other species characteristic of the higher part of the *Meekoceras* zone.

PRONORITOIDEA

Family PRONORITIDAE

Under this head the writer groups all forms closely allied with *Pronorites;* these are characterized by compressed whorls, little sculpture of the shell, rather short body chambers, and lanceolate septa, with pronounced development of the auxiliary and little development of the adventitious series of lobes. Karpinsky [59] has given almost a monograph of this family and has traced the ontogeny of several Paleozoic genera, so that a comparison of later forms is easy, and the relations between phylogeny and ontogeny are clear. This is one of the few families in which we can trace with certainty a series of forms, leading up from those with simple goniatitic lobes to those with complex ammonitic septa and in which in the ontogeny of each genus we can find its family history repeated in abridged form.

This family includes *Pronorites* Mojsisovics, *Uddenites* Boese, *Sicanites* Gemmellaro, *Propinacoceras* Gemmellaro, *Medlicottia* Waagen, *Sundaites* Haniel, of the Paleozoic, and *Cordillerites* Hyatt and Smith and *Albanites* Arthaber of the Lower Triassic; *Medlicottia* (*Episageceras*) also occurs in the Lower Triassic of India and Timor. Karpinsky has shown that *Pronorites* in its development can be traced back to *Prolecanites;* that *Sicanites*, *Propinacoceras*, and *Medlicottia* all show in their ontogeny their origin in *Pronorites*. In this paper the writer describes the ontogeny of *Cordillerites*, which genus goes through stages corresponding in succession to *Prolecanites*, *Pronorites*, and *Cordillerites*. The American representative of the Triassic Pronoritidae is so primitive in its stage of evolution that it appears to be rather a little-modified survivor of Permian type than a characteristic Lower Triassic ammonite.

Diener [60] has described, from the Middle Triassic of the Alps, a genus *Arthaberites*, which apparently is closely allied with *Cordillerites*, on account of its tri-

[59] Karpinsky, A., Ueber die Ammoneen der Artinsk-Stufe: Acad. imp. sci. St., Pétersbourg Mém., 7th ser., vol. 37, No. 2, 1889.

[60] Diener, Carl, Die Triadische Cephalopoden-Fauna der Schiechlinghöhe bei Hallstatt: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 13, p. 17, pl. 2, fig. 4 a–c, 1901.

partite external lobe and the lanceolate characters of its lobes and saddles. It differs from the rest of the Triassic members of the Pronoritidae in the minor development of the adventitious series. This is the only genus above the Lower Triassic that is thought to represent the stock of *Pronorites*.

Genus CORDILLERITES Hyatt and Smith

1905. *Cordillerites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 109.
1917. *Cordillerites*. Diener, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 175.
1929. *Cordillerites*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 3.

Type: *Cordillerites angulatus* Hyatt and Smith, Lower Triassic.

This genus is compressed, involute, deeply embracing, robust, with flattened sides, flat angular venter, and narrow umbilicus. The only surface sculpture visible on the casts consists of faint radial folds and striae of growth. The septa are lanceolate, with rounded saddles, and lobes partly serrated. The external or siphonal lobe is tripartite, as in *Pronorites*. There is a short series of lanceolate simple or bifid adventitious lobes, a series of laterals that are partly bifid and partly trifid, and a long series of auxiliaries, of which those nearest the umbilicus are undivided. The general plan of the septa is very like that of *Pseudosageceras*, but the lobes are not nearly so complex nor so numerous. There is a closer resemblance to *Arthaberites* Diener,[61] but the lobes of *Arthaberites* are uniformly trifid, and are of simpler plan than those of *Cordillerites*.

An equally close resemblance exists with *Prodromites* Smith and Weller, of the Mississippian ("Lower Carboniferous"), but *Cordillerites* has a flattened venter and no keel, and the general plan of the septa, though superficially similar, in noteworthy details is quite dissimilar.

The ontogeny of the only known species of *Cordillerites* shows clearly the origin of the genus. The earliest observed stage resembles *Prolecanites*, having a somewhat compressed moderately involute form, with an undivided ventral lobe and two or more lanceolate lateral lobes. After this follows a stage in which the ventral lobe becomes tripartite, corresponding to *Paraprolecanites*. The outline of the whorl then becomes subquadrangular, and the first lateral lobe becomes bifid, corresponding to *Pronorites*. Shortly after this, the first lateral lobe becomes tripartite, still corresponding to *Pronorites*, as some species of that genus have this character. Then the second lateral lobe becomes bifid, and the form is transitional from *Pronorites* toward *Cordillerites*. Next, the first lateral saddle becomes indented, the beginning of the adventitious series, which develops with great rapidity, though not reaching the number of the auxiliaries, which began earlier; that is, with the *Pronorites* stage.

The large tripartite lateral lobe of *Cordillerites* corresponds to the bifid or tripartite lateral of *Pronorites;* the adventitious lobes are made by subdivision of the first lateral saddle and at maturity may number as many as three. The second lateral lobe at maturity is tripartite and just before maturity is bifid. The third lateral lobe becomes bifid at maturity and before maturity is undivided. The auxiliaries decrease in size and complexity toward the umbilicus, as they do in all genera of the Pronoritidae.

This development shows the intimate kinship of *Cordillerites* with *Medlicottia*, from which it differs only in the form of the external lobe, the exaggerated development of the lanceolate adventitious lobes, and the tripartite laterals. *Medlicottia* in its ontogeny goes through stages corresponding successively to *Prolecanites*, *Paraprolecanites*, and *Pronorites*, somewhat as does *Cordillerites* but diverges in the peculiar development of the siphonal lobe and the external saddle.

Cordillerites is known only from the Lower Triassic *Meekoceras* zone of the Aspen Ridge, in southeast Idaho, where it is represented by a single species.

Diener [62] declines to accept *Cordillerites* as a member of the Pronoritidae but would place it either with *Hedenstroemia* or with *Pseudosageceras*. If it belongs with *Hedenstroemia*, it is a member of the Meekoceratidae and should show young like *Xenodiscus*. If it belongs to *Pseudosageceras* it should show young like *Beloceras*. But it does neither. Its young are compact, involute, subquadratic, with a very early appearance of division and complication of the lobes, utterly unlike any Xenodiscidae, though not quite like any known species of *Pronorites*. The resemblance is somewhat greater to *Pseudosageceras*, but that genus in its youth shows the long series of multiplicate serial lobes, with early development of both adventitious and auxiliary lobes, utterly foreign alike to the Pronoritidae and to descendants of the Xenodiscidae.

The genus *Uddenites*, described by Böse,[63] after the observations of Diener and the writer, shows a descendant of *Pronorites*, tending toward *Medlicottia*. Arthaber's genus *Albanites*,[64] which he later withdrew and renamed "*Pronorites*," is another example of the same sort of thing. There are probably many as yet unknown genera of the *Pronorites* stock which will help us to fill out the gaps suggested by ontogenetic studies. In the meantime we need not feel com-

[61] Diener, Carl, op. cit. (Die Triadische Cephalopoden-Fauna der Schiechlinghöhe bei Hallstatt), p. 17, pl. 2, figs. 4 a–c.

[62] Diener, Carl, Ueber Ammoniten mit Adventivloben: K. Akad. Wiss. Wien Denkschr., Band 93, p. 175, 1917.

[63] Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, west Texas: Texas Univ. Bull. 1762, p. 55, 1917.

[64] Arthaber, G. von, Ueber neue Funde in der Trias von Albanien: Geol. Gesell. Wien Mitt., Band 2, p. 232, 1909; Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 204, 1911.

pelled to throw all these somewhat doubtful forms into the too generous and receptive Meekoceratidae.

Cordillerites angulatus Hyatt and Smith

Plate 2, Figures 1–8; Plate 42, Figures 14–20; Plate 60, Figure 14; Plate 68, Figures 1–10; Plate 71, Figures 1–6

1905. *Cordillerites angulatus*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 110, pl. 2, figs. 1–8; pl. 68, figs. 1–10; pl. 71, figs. 1–6; pl. 85, figs. 14–20.

Form compressed, involute, discoidal, deeply embracing, the outer whorl being indented to one-third of its height by the preceding whorl. Umbilicus closed. Sides with rather abrupt umbilical shoulders, and gentle convex curve up to the abdominal shoulder angles. Venter flat and rather broad, with abdominal furrow in youth, which disappears in age. Surface ornamentation consisting of obscure radial folds and striae of growth. The length of the body chamber is unknown.

Septa lanceolate, with rounded saddles, and tongue-shaped lobes, mostly either bifid or trifid. The ventral lobe is rather short and tripartite. Near the abdominal shoulders is a series of three adventitious lobes, increasing in size away from the venter; the first of these is undivided, the second and third bifid. The third adventitious lobe is very large, deeply bifid, and occurs well down on the flanks; from its size and position it might well be called a lateral lobe if it were not a secondary development out of the external saddle. Its nature as an adventitious lobe would not even be suspected if one could not trace its gradual growth from a mere notch in the external saddle.

The true lateral lobes number two; the first is regularly and deeply tripartite, and longer and broader than the third adventitious lobe; the second is irregularly tripartite, with the prong nearest the venter longer than the other two, which are separated only by a shallow notch.

After this follows a long series of auxiliary lobes, growing smaller toward the umbilicus; the first three are distinctly bifid, the two others are apparently simple. The details of the internal septa could not be seen, but there is a long antisiphonal lobe, flanked by at least five internal laterals.

In its ontogeny *Cordillerites angulatus* shows its history and derivation from *Pronorites*. In the youngest stage seen, at a diameter of 2.5 millimeters, the whorl is moderately involute, rounded and somewhat compressed laterally. The septa consist of an undivided ventral lobe and two laterals. This stage corresponds to *Prolecanites* of the Devonian and Carboniferous.

At a quarter of a revolution farther on, at a diameter of 3.5 millimeters, the ventral lobe begins to divide and becomes indistinctly tripartite, and at the same time a third lobe is added outside of the umbilicus.

At a diameter of 4 millimeters, two septa farther on and about one-eighth of a revolution more, the first lateral lobe begins to divide. This is the beginning of the *Pronorites* stage, and the likeness is made greater by the accompanying development of the auxiliary series.

A quarter of a revolution farther on, at a diameter of 5.5 millimeters, the second lateral lobe becomes bifid, and the first is distinctly tripartite. *Pronorites* never had this character, but a descendant of that genus, *Sicanites*, of the Permian, did have it. This stage may therefore be said to be transitional from *Pronorites* to a genus somewhat like *Sicanites*. It lacks, however, a character that was distinctive of *Sicanites*, the division or notching of the external saddle.

At the diameter of about 7 millimeters the notching of the external saddle and the development of the adventitious series of lobes begin. Even then this stage can not be said to correspond with *Sicanites*, for the parallelism is obscured by the earlier inheritance in the larva of the tripartite principal lateral lobe, a character that *Sicanites* never acquired. This merely means that we have occurring simultaneously in this stage of growth some characters that were characteristic of *Sicanites*, along with others that were characteristic of kinsmen of that genus.

The *Sicanites*-like stage of growth is very short, just as was the life of that genus in the geologic succession, and very soon it is obscured by the appearance of characters that belonged to the mature stage. This follows naturally from the unequal acceleration of characters in inheritance.

When the adolescent stage is well advanced there is a single adventitious lobe, but this is soon followed by the appearance of a second smaller lobe nearer the venter, by further division of the external saddle. The first adventitious lobe by this time has become bifid, and the second soon becomes so.

At a diameter of 10 millimeters the septa resemble *Sicanites*, and at 12 millimeters they resemble those of the more primitive species of *Propinacoceras*, in the development of two distinct adventitious lobes.

At the diameter of 17 millimeters the first adventitious lobe is divided, the second still simple, and the third is just beginning to form. No change has taken place in the first lateral lobe, but the second has become tripartite instead of bifid, and the first auxiliary has become bifid. The other auxiliaries remain simple, as they do through life. At this stage there is a simultaneous occurrenceof characters that belonged to *Propinacoceras* and *Cordillerites*.

The only advance to be made now is the development of the third adventitious lobe by a further division of the external saddle. This takes place at the diameter of 30 millimeters, and the species has attained its full generic characters, although not yet mature size

It is easy to trace this development because the first lateral lobe is constant from the *Pronorites* stage until maturity, and the new elements are added and changes introduced into the lobe on both sides of it. The adventitious lobes are of simple character, and progress but little beyond the development attained in *Sicanites* and *Propinacoceras*. The same thing is true of the auxiliary series. The advance over those two genera is made chiefly in the prominence and special development of the two lateral lobes.

Pronorites, of the Carboniferous, progressed up to the stage shown on Plate 71, Figures 7 and 8, and stopped. *Sicanites*, of the lower Permian, went through the *Pronorites* stage and began the formation of the adventitious series by indentation of the external saddle. *Propinacoceras*, of the Permian, went through all the stages of *Pronorites* and *Uddenites* and advanced beyond them in the formation of two distinct adventitious lobes in the same way. *Cordillerites* in the Lower Triassic went through the stages corresponding to *Pronorites* and later to unknown genera resembling somewhat *Propinacoceras*, and it went beyond them in the further development of the adventitious series and in the greater complexity of the first and second lateral lobes.

The septa of these forms, showing their gradual advance, are figured in Plate 71. In the development of *Cordillerites* we see a species going through in its ontogeny all the stages gone through by its Paleozoic ancestors and in the same succession as did the genetic series of mature forms.

Horizon and locality: *Cordillerites angulatus* is not uncommon in the Lower Triassic *Meekoceras* zone of Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, southeastern Idaho. It was accompanied by *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Lanceolites compactus*, *Pseudosageceras multilobatum*, *Aspenites acutus*, *Paranannites aspenensis*, and other species.

Cordillerites compressus Mathews

Plate 79, Figures 3, 4

1929. *Cordillerites compressus*. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, p. 3, pl. 1, figs. 15–17.

The following description is taken from Mathews's paper:

Form extremely involute, discoidal, highly compressed laterally; whorls increasing rapidly in height, completely embracing, and greatly indented by the penultimate volution. Sides nearly flat and sloping from the greatest width of the shell which is at the umbilical shoulder to the ventral shoulder forming a sharp wedge in cross section. Umbilicus is closed. Umbilical shoulder is almost indistinguishable. Inner wall sloping at an angle of about 8° with the side of the preceding whorl. The height of the last whorl is over three times its greatest thickness and five-eighths its diameter. It is indented to over two-fifths its height by the penultimate volution and conceals this volution. The distance across the preceding volution from suture to suture is less than one-half its involution. The venter is flat and narrow, forming square shoulders with the side walls. The shell is very thin and smooth. The living chamber is unknown.

The sutures are lanceolate, with sharply rounded to slightly angular saddles and tongue-shaped lobes, mostly bifid with one medial lateral trifid. The ventral saddle is very simple, with two slight lobate irregularities. The first lateral adventitious lobe is short, narrow, and simple and is situated at the ventral shoulder; the second lateral is slightly notched; the third and fourth are forked, with the latter being the larger. The first lateral lobe, which is medial on the side wall, is tripartite. It is well developed, much longer than any of the others, and distinctly different. The second lateral lobe is bipartite with each of the prongs bifid, so that there are four denticulations present. The central notch is nearly three times as deep as the lateral notches. The first auxiliary is bifid, which is followed by a series of lobes decreasing in size. There are 10 auxiliaries in all.

This species differs from *Cordillerites angulatus* Hyatt and Smith by being greatly compressed, with narrow venter and with the second lateral lobe bifid with each lateral prong notched.

Horizon and locality: Found only in the upper *Anasibirites* beds, Pinecrest formation, Baffle Ridge, Fort Douglas Military Reservation, Utah.

Clan GASTRIOCERATEA

Superfamily ARCESTOIDEA

Forms with long body chamber, smooth subglobose whorls, and septa either goniatitic, ceratitic, or ammonitic, of the brachyphyllic type. The Arcestoidea seem to be derived from the gastrioceran branch of the Glyphioceratidae, probably from *Adrianites* or *Agathiceras*. Under this group belong the Cyclolobidae, Arcestidae, Cladiscitidae, and Ptychitidae.

Family CYCLOLOBIDAE

Genus PROSPHINGITES Mojsisovics

1886. *Prosphingites*. Mojsisovics, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 64.

1905. *Prosphingites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 72.

Type: *Prosphingites czekanowskii* Mojsisovics.[65]

Subglobose, laterally compressed, with helmet-shaped whorls and highly arched venter. Umbilicus deep and showing the inner volutions.

Surface smooth, except the cross striae of growth.

Septa consisting of an external and two lateral serrated lobes, and a fourth lobe, goniatitic in character, on the umbilical border. Internal lobes consisting of a long, serrated antisiphonal and two or more narrow laterals on each side.

Horizon and locality: *Prosphingites* is known only in the Lower Triassic and up to the present only from

[65] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 64, pl. 15, figs. 10–12, 1886.

the Arctic-Pacific regions. A single species has been found in the Lower Triassic of California.

Prosphingites austini Hyatt and Smith

Plate 7, Figures 1–4

1905. *Prosphingites austini*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 72, pl. 7, figs. 1–4.

Shell subglobose, rather involute, with helmet-shaped whorls, impressed to about half their height by the inner coils. Surface smooth, except for the periodic constrictions or varices that occur to the number of six or eight to a volution. External septa consisting of a divided antisiphonal lobe, and two principal laterals, all serrated, and a third lateral or auxiliary, goniatitic. The external lobe is narrow, and the first and second laterals are broad and shallow. The saddles are entire, rounded, and broader than the lobes. The internal lobes consist of a short antisiphonal, flanked by three laterals.

Named in honor of Mr. S. W. Austin.

Horizon and locality: In the Lower Triassic *Meekoceras* zone on Union Wash, 3 miles east of Skinner's ranch, Inyo Range, Inyo County, Calif.

Family PTYCHITIDAE

The Ptychitidae are represented by the subfamily Nannitinae, with *Nannites*, *Paranannites*, and *Paraganides*, and by the subfamily Ptychitinae, with *Ptychites* and *Proptychites*. The Nannitinae are largely confined to the Lower Triassic, whereas of the Ptychitinae *Proptychites* is confined to the Lower Triassic and *Ptychites* is characteristic of the Middle Triassic.

Subfamily NANNITINAE

Involute, robust, subglobose; body chamber short; surface nearly smooth but ornamented with periodic constrictions. Septa goniatitic or weakly ceratitic. Found throughout the Triassic.

This subfamily is composed of *Paraganides* Hyatt and Smith, *Nannites* Mojsisovics, and *Paranannites* Hyatt and Smith, all represented in the American Triassic.

Genus PARANANNITES Hyatt and Smith

1905. *Paranannites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 80.

1911. *Paranannites*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 220.

Type: *Paranannites aspenensis* Hyatt and Smith.

Form subglobose, laterally compressed, sides convex, venter broadly rounded. Umbilicus narrow; whorls involute, deeply embracing.

Surface nearly smooth or ornamented only with radial folds or constrictions.

Septa ceratitic, lobes partly serrated, saddles all rounded and entire. The external lobe is divided by a small siphonal notch into two short branches. The lateral lobe is broad and serrated; the small auxiliary is serrated on the type species. The internal septa are goniatitic, and consist of a rather long antisiphonal lobe flanked by a pair of laterals on each side.

The form and surface ornamentation are exactly like those of *Juvenites*, from which *Paranannites* can be distinguished only by its ceratitic septa. It is probably an intermediate form between *Juvenites* and the true Ptychitidae.

Paranannites is known at present only from the Lower Triassic *Meekoceras* zone of southeast Idaho, where several species of it occur, together with *Juvenites*, *Meekoceras*, *Flemingites*, *Pseudosageceras*, *Ophiceras*, and other genera characteristic of the Lower Triassic.

Paranannites aspenensis Hyatt and Smith

Plate 8, Figures 1–15; Plate 73, Figures 1–30

1905. *Paranannites aspenensis*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 81, pl. 8, figs. 1–15, pl. 73, figs. 1–30.

Form robust, involute, somewhat compressed laterally. Whorl highly arched, with flattened sides and rather broadly rounded venter. Abdominal shoulders indistinct. The umbilicus is very narrow, and the whorl is deeply embracing and deeply indented by the inner volution. The height of the whorl is half of the total diameter of the shell; the breadth is slightly less than the height; the indentation is somewhat more than half the height. The width of the umbilicus is about one-eighth of the diameter of the shell.

The surface is nearly smooth but has faint cross striae of growth visible only on the shell, which is rarely preserved. These striae become later on weak folds, giving a sculpture like that of the Glyphioceratidae. There are also a few constrictions, which are visible on the cast.

The septa are ceratitic but comparatively simple. The external lobe is divided by a siphonal notch into two narrow branches with serrated ends. The lateral lobe is broad and deep, with four or five serrations; the auxiliary is similar but smaller and also serrated. The antisiphonal lobe is long and narrow, not divided, and is flanked on each side by a pair of similar smaller internal laterals.

In the young stages this species is a typical *Juvenites*, the serration of the lobes beginning at the diameter of 5 millimeters. In the *Juvenites* stage the varices are much more numerous, and the form is more robust than in later life.

Horizon and locality: In the Lower Triassic *Meekoceras* zone of the Aspen Ridge, Wood Canyon, southeastern Idaho, about 9 miles east of Soda Springs.

Paranannites columbianus Smith, n. sp.

Plate 32, Figures 11–25

Shell small, high whorled, involute, laterally compressed, with narrow but open umbilicus, rounded flanks, and high helmet-shaped venter. Surface with very numerous close-set constrictions.

Septa ceratitic, with rounded entire saddles and sharply serrated lobes, of which there are a divided external, large lateral, small auxiliary, and a divided antisiphonal, flanked by two internal laterals.

Paranannites columbianus is closely related to *P. aspenensis* but differs in its more robust whorl, wider umbilicus, and stronger sculpture. It has no close resemblance to any other known species of this widely distributed genus.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 1, 5 miles east of Grays Lake; locality 3, head of Wood Canyon, 9 miles east of Soda Springs; and locality 5, 1 mile east of Hot Springs, at the north end of Bear Lake; associated with *Meekoceras gracilitatis, Flemingites russelli, Hedenstroemia kossmati, Cordillerites angulatus, Lanceolites compactus, Aspenites acutus,* and other forms.

Paranannites compressus Smith, n. sp.

Plate 31, Figures 19–21

Shell small, involute, laterally compressed, with flattened sides, narrow venter with subangular ventral shoulders, and narrow umbilicus. Surface shows weak constrictions.

Septa ceratitic, with rounded entire saddles and serrated lobes, as in all members of the genus.

Paranannites compressus differs from *P. aspenensis* in its smaller size, higher and more compressed whorls, flattened narrow venter and weaker sculpture. It differs from *P. pertenuis* in its thicker whorls and broader venter.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, southeastern Idaho; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Aspenites acutus, Pseudosageceras multilobatum, Cordillerites angulatus, Lanceolites compactus, Clypeoceras muthianum, Xenodiscus intermontanus, Lecanites arnoldi,* and other forms.

Paranannites pertenuis Smith, n. sp.

Plate 31, Figures 13–15

Shell small, involute, laterally compressed, with high subrectangular whorl, flattened sides, abrupt ventral shoulders, and somewhat flattened venter. Septa ceratitic, with rounded entire saddles, and three external serrated lobes. Length of body chamber unknown. Surface with numerous folds and several weak constrictions.

Paranannites pertenuis is closely related to *P. compressus* but differs in its greater lateral compression and stronger sculpture. It is not nearly related to any other known species of this widely distributed genus.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Aspenites acutus, Cordillerites angulatus, Lanceolites compactus, Ussuria waageni, Pseudosageceras multilobatum,* and other forms.

Subfamily PTYCHITINAE

Subglobose, laterally compressed, involute forms, with short body chamber, and surface ornamented only with obscure folds. Septa either ceratitic or ammonitic. Venter rarely acute, forming a sort of keel, more commonly arched.

All members of this group go through a *Nannites* stage of growth in their youth, but the separation from the parent stock must have taken place in Paleozoic time, for typical members of the Ptychitinae are present in the Lower Triassic of Asia and America.

This subfamily is represented in the American Triassic by three genera—*Owenites* Hyatt and Smith, known in the Lower Triassic of California, and in Timor; *Proptychites* Waagen, known in America only from the Lower Triassic of California but common in the same series in Siberia and India, rare in the Middle Triassic of the Alpine province; and *Ptychites,* characteristic of the Middle Triassic in America, Asia, and Europe; and probably by a fourth genus, *Proteusites* Hauer, common in the Middle Triassic of the Balkan Peninsula and rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of California.

Genus OWENITES Hyatt and Smith

1905. *Owenites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 82.

1922. *Owenites.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 151.

Type: *Owenites koeneni* Hyatt and Smith.

Body chamber long, comprising the last volution. Form lenticular, involute, deeply embracing, with closed umbilicus, rounded sides, and acute venter without any real keel or shoulder angles.

Surface smooth or ornamented with radial folds, occasionally with bundled ribs, which run straight up the sides and become obsolete on the venter.

Septa ceratitic, the saddles mostly rounded, the lobes serrated. The siphonal saddle may occasionally be digitate but is generally entire. There are no adventitious lobes. The external and the two principal laterals are similar, usually short and rather wide. Some species have a third lateral before the auxiliary series, which is composed of two or more denticulations, becoming with age independent auxiliaries but never serrated. The internal lobes and saddles are also very numerous. This genus resembles *Hungarites* but differs in lacking the abdominal shoulder angles and in having the young globose and involute, with *Nannites* form and septa. It is therefore classed in the Ptychitidae as a descendant of *Nannites*. The young also possess rather strong radial ribs and constrictions, wholly unlike the young stages of any of the true Ceratitoidea. Toula[66] has described from the lower Muschelkalk of Asia Minor some species which he assigned to *Hungarites* but which are said to have globose young. In form and septa they resemble *Owenites*, and it is quite possible that this genus has lasted into the Middle Triassic in that region.

Owenites has a strong external resemblance to *Dalmatites* Kittl,[67] which that author assigned to the Hungaritidae, but the European genus differs from the American in lacking the auxiliary lobes. Kittl regarded *Dalmatites* as nearly related to the radicle of the Hungaritidae, whereas the ontogeny of *Owenites* shows that it does not belong to the Hungaritidae and that it is rather closely related to definite members of the Ptychitidae.

Owenites is known at present from the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of the Inyo Range, Inyo County, Calif., where several species have been found, besides *Owenites koeneni;* it is also fairly common and characteristic of the Lower Triassic *Owenites* zone of Timor, in the East Indies.

Owenites carpenteri Smith, n. sp.

Plate 54, Figures 31–34

Shell small, involute, laterally compressed, with closed umbilicus, flattened sides, and blunt subangular venter. Surface ornamented with rather strong bundled radial ribs. Septa ceratitic, with an external divided lobe, larger first lateral, smaller second lateral, and short series of several small auxiliaries. The siphonal saddle that divides the external lobe shows a tendency to form adventitious lobes, as is frequently seen in members of the Meekoceratidae. But the young of this species are like *Juvenites* with gastrioceran septa and with well-defined ribs and constrictions, and it must be assigned to the Ptychitidae.

Owenites carpenteri is not closely related to any other known members of the genus, differing from all in the bluntness of the venter and in the stronger sculpture.

Named in honor of Philip P. Carpenter, who after 60 years still exerts a lasting and wholesome influence on the study of American paleontology.

Horizon and locality: Rather rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, of Union Wash, Inyo Mountains, Inyo County, Calif., about 15 miles southeast of Independence; associated with *Meekoceras gracilitatis, Owenites koeneni, Lecanites arnoldi, Xenodiscus waageni, Anasibirites desertorum, A. noetlingi, Lanceolites compactus, Pseudosageceras multilobatum, Inyoites oweni*, and other forms.

Owenites egrediens Welter

Plate 52, Figure 6–8

1922. *Owenites egrediens*. Welter, Die Ammoniten des Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 151, pl. 168, figs. 22–29, and text figs. 14–18.

Form robust, lenticular, with narrow egredient umbilicus and arched whorls, curving to the steep, roof-shaped venter. Surface with very fine curved striae of growth, and nearly obsolete folds. Septa ceratitic, with rounded entire saddles and four external serrated lobes, of which the fourth, next to the umbilicus, is broken up into a short auxiliary series.

Until the diameter of 20 millimeters is reached the umbilicus is closed and at this stage begins to egress, the egression being more pronounced in age.

Owenites egrediens is rather closely related to *O. koeneni*, differing in its more robust shell, greater egression of the whorl, and simpler septa.

Horizon and locality: *Owenites egrediens* was first found in the Lower Triassic *Owenites* zone of Timor; it is rather rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Meekoceras gracilitatis, Owenites koeneni, Lanceolites bicarinatus, Pseudosageceras multilobatum, Sturia compressa, Juvenites dieneri*, and other forms.

Owenites koeneni Hyatt and Smith

Plate 10, Figures 1–22

1905. *Owenites koeneni*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 83, pl. 10, figs. 1–22.

Form involute, laterally compressed, lenticular. Whorl deeply embracing and deeply indented by the inner volutions; sides flattened-convex, curving without abdominal shoulders to the acute venter. There is no keel, but the abdomen grows gradually narrower until it resembles a keel. Umbilicus narrow, growing wider with age. The height of the last whorl is half the total diameter, and the indentation or involution is

[66] Toula, F., Eine Muschelkalkfauna am Golfe von Ismid in Kleinasien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 10, Heft 4, p. 176, 1896.

[67] Kittl, Ernst, Die Cephalopoden der oberen Werfener Schichten von Muć in Dalmatien: K.-k. geol. Reichsanstalt Wien Abh., Band 20, Heft 1, p. 72, 1903.

half the height. The width of the whorl is three-fifths of the height. The width of the umbilicus is about one-sixth of the total diameter.

The surface of the shell and of the cast is smooth at maturity, being destitute of ribs, constrictions, or other ornamentation.

The septa are ceratitic, the saddles are all rounded and entire, the lobes all serrated. The external lobe is divided by a siphonal notch or saddle into two short branches; the first lateral is similar but larger; the second lateral is similar to the first but only two-thirds of its size. First auxiliary bifid, each of the small divisions being serrated; second auxiliary undivided but serrated. Antisiphonal lobe narrow and undivided, flanked by five internal lobes on each side.

In the young stages the whorl is rounded, robust, with rounded venter, constrictions, and radial ribs. In this stage it resembles *Juvenites* in form and the simple septa. The venter becomes acute at the diameter of about 6 millimeters; the constrictions cease and the ribs become less distinct at 8 millimeters, and the septa cease to be goniatitic and become serrated at about 10 millimeters. From this stage onward no change in development takes place, except in the widening of the umbilicus at maturity.

Owenites koeneni resembles *Hungarites* but differs externally from that genus in its merely sharpened venter, without abdominal shoulder angles. The inner volutions, however, show still greater differences, being involute and rounded, like *Juvenites*, the radicle of the Ptychitidae, instead of evolute and discoidal, like the young of the Ceratitoidea.

The only species with which *Owenites koeneni* may be compared is *O. egrediens* of the same fauna, from which it differs in greater involution, more compressed form, and more complex septa.

Horizon and locality: *Owenites koeneni* was found by J. P. Smith in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of the Inyo Range, 1½ miles east of Union Spring, on the old McAvoy trail across to Saline Valley, about 15 miles southeast of Independence, Inyo County, Calif.

Owenites zitteli Smith, n. sp.

Plate 52, Figures 1–5

Form involute, narrowly umbilicate, sides flattened, sloping rather abruptly to the umbilicus and very gently to the high, narrow venter, which is extended in a rather sharp keel. Surface at maturity nearly smooth, except for the fine growth lines. Septa ceratitic, with the divided ventral lobe narrow, tongue-shaped, and longer than the first lateral; there is also a smaller second lateral and a long series of auxiliaries. The ventral saddle shows on the siphonal side a small notch that resembles an incipient adventitious lobe.

Body chamber at least a revolution long.

Owenites zitteli resembles *O. koeneni*, the genotype, but differs in its greater compression, higher whorl, sharper keel, and more complicated septa. Its young stages are like those of *O. koeneni*, with gastrioceran septa, ribs, and constrictions.

Named in memory of Karl A. von Zittel.

Horizon and locality: Rare in the Lower Triassic *Ownites* subzone of the *Meekoceras* zone, of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Lecanites arnoldi*, *Xenodiscus waageni*, *Anasibirites desertorum*, *A. noetlingi*, *Lanceolites compactus*, *Sturia compressa*, *Pseudosageceras multilobatum*, *Inyoites oweni*, and other forms.

Genus PROPTYCHITES Waagen

1892. *Proptychites*. Waagen, India Geol. Survey Rec., vol. 25, p. 183.

1892. *Proptychites*. Waagen, K.-k. geol. Reichsanstalt Wien Jahrb., Band 42, p. 379.

1895. *Proptychites*. Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 162.

1895. *Proptychites*. Diener, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, p. 31.

1897. *Proptychites*. Diener, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 70.

1902. *Aspidites* (part). Frech, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637.

1905. *Proptychites*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 84.

1911. *Proptychites*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 221.

Type: "*Ceratites*" *lawrencianus* De Koninck,[68] from the Lower Triassic of the Salt Range.

Form thickly lenticular, robust, with narrow umbilicus, flattened sides, and broadly rounded venter. Surface smooth or ornamented with faint radial folds. Septa distinctly ceratitic, the saddles long, narrow, and rounded, the lobes usually broader and serrated. There is usually an external lobe divided by a rather deep siphonal saddle, two principal laterals, and an auxiliary series, which may consist of a single ceratitic lobe or a series of denticulations, some of which may become individualized into secondary lobes. The internal septa consist of an antisiphonal lobe, with a single lateral.

Mojsisovics[69] classes *Proptychites lawrencianus* under *Meekoceras*, whereas Griesbach classes it with *Ptychites*. But the young of *Proptychites* are said to be invariably globose, of the *Nannites* type, and the mature forms

[68] De Koninck, L. G., Descriptions of some fossils from India: Geol. Soc. London Quart. Jour., vol. 19, p. 14, pl. 6, fig. 3, 1863.

[69] Mojsisovics, E. von, Arktische Triasfaunen: Acad. imp. sci. St.-Pétersbourg Mém., 7th ser., vol. 33, No. 6, p. 79, 1886.

invariably have ceratitic septa—characters which distinguish *Proptychites* from those two genera. Waagen considers this genus the ancestor of *Ptychites*, although he knew of no transitional forms between the two.

Frech [70] proposes to drop the genus *Proptychites* and to assign all the species of this group to *Aspidites*. The writer is of the opinion that this view is probably correct, but a further study of the ontogeny of the two genera would be necessary before such a reference could be decisive. Waagen was of the opinion that *Proptychites* was an ancestral form of the Ptychitidae, but Frech believes that this family was not differentiated before the Middle Triassic. Mojsisovics, Diener, and the writer, however, agree in regarding *Nannites* as the ancestor of *Ptychites*.

Proptychites is almost exclusively confined to the Lower Triassic, being found at that horizon in the Salt Range and the Himalayas in India, at Ussuri Bay in eastern Siberia, and in the *Owenites* subzone of the *Meekoceras* zone of Inyo County, Calif. *Proptychites walcotti* is the only species known to occur in America.

Proptychites walcotti Hyatt and Smith

Plate 19, Figures 1–7; Plate 52, Figures 18–20

1905. *Proptychites walcotti.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 85, pl. 19, figs. 1–7.

Robust, involute, deeply embracing, laterally compressed, abdomen rounded so that there are no shoulders. Outer whorl twice as high as broad, embracing about half the inner and being indented to about one-fourth the height by it. Umbilicus narrow, only about one-sixth of the diameter. Umbilical shoulders abrupt, almost angular.

Surface smooth, so far as known.

Septa ceratitic, with rounded, entire, and constricted saddles and serrated lobes. External lobe divided into two very broad branches by a broad, digitate siphonal saddle; the first lateral lobe is twice as long as the external and serrated not only on the ends but also more than halfway up its sides; second lateral about the size of the external; auxiliary series, consisting of four or five denticulations forming a broad lobe, somewhat after the manner of *Clypeoceras* (*Aspidites*) but perfectly regular. Internal septa not seen in detail but consisting of a large antisiphonal and one smaller lateral. The form and septa greatly resemble those of "*Paranorites*" *ambiensis* Waagen [71] but differ in being more robust, having narrower umbilicus, and having fewer denticulations on the auxiliary series. This species might well be assigned to *Paranorites*, but that genus is probably based merely on a highly specialized form of *Proptychites*. The present species also resembles somewhat *Proptychites khoorensis* Waagen [72] but has the septa much more specialized, as the ventral saddle is digitate and the serrations are not confined to the ends of the lobes. This sort of digitation of the lobes and the bases of the saddles is quite common in *Proptychites* but does not seem to be transitional to *Ptychites*. The writer has not yet had the opportunity to study the complete ontogeny of this genus but is of the opinion that it will turn out to be a member of the Meekoceratidae, which it so greatly resembles that even Mojsisovics has not been able to draw a line between them. It seems to be more nearly related to *Clypeoceras* than to any other member of the group and may be the ancestral form of that genus.

Horizon and locality: *Proptychites walcotti* was found by J. P. Smith in the *Owenites* subzone of the Lower Triassic *Meekoceras* zone of Union Wash, Inyo Range, east side of Owens Valley, about 15 miles southeast of Independence, Inyo County, Calif., associated with *Meekoceras gracilitatis* White and *M.* (*Koninckites*) *mushbachanum* White.

Genus PROTEUSITES Hauer

1887. *Proteusites.* Hauer, Die Cephalopoden des bosnischen Muschelkalkes von Han Bulog bei Sarajevo: K. Akad. Wiss. Wien Denkschr., Band 54, p. 27.

1892. *Proteusites.* Hauer, Beiträge zur Kenntniss der Cephalopoden aus der Trias von Bosnien, I: K. Akad. Wiss. Wien Denkschr., Band 59, p. 267.

1905. *Proteites.* Diener, Entwurf einer Systematik der Ceratitiden des Muschelkalkes: Akad. Wiss. Wien Sitzungsber., Band 114, p. 797.

1915. *Proteites.* Diener, Fossilium Catalogus, pt. 8, Cephalopoda Triadica, p. 233.

Type: *Proteusites kellneri* Hauer [73] from the Middle Triassic of the Balkan Peninsula.

Form robust, subrotund, with rather wide umbilicus and rounded whorls. Surface with umbilical ribs and nodes prolonged up the flanks. Some species show spiral lines on the shell. Septa ceratitic on the type but slightly ammonitic on some species. Length of body chamber unknown.

This genus was assigned by F. von Hauer to the Ceratitidae, but its form and sculpture point certainly to a derivation from the Glyphioceratidae and to kinship with either the Tropitidae or the Ptychitidae, probably the latter.

Horizon and locality: Common in the Middle Triassic of the Balkan Pennisula; rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone of Inyo County, Calif.

Proteusites rotundus Smith, n. sp.

Plate 53, Figures 5–8

Shell of moderate size, robust, subrotund, somewhat evolute, little embracing; with helmet-shaped whorls,

[70] Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 4, p. 637, 1902.

[71] Waagen, W., Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 158, pl. 22, fig. 1, 1895.

[72] Idem, p. 176, pl. 20, fig. 4.

[73] Hauer, F. von, Die Cephalopoden des bosnischen Muschelkalkes von Han Bulog bei Sarajevo: K. Akad. Wiss. Wien Denkschr., Band 54, p. 27, pl. 7, figs. 1–4, 1887.

rounded and broad. Surface with strong, straight umbilical ribs, running more than halfway up the flanks, and crossed by fine, strong transverse striae. Septa ceratitic, with entire saddles and four external serrated lobes. No spiral striae are visible on the specimens at hand, but they would hardly be preserved.

The height of the last whorl is two-fifths of the diameter of the shell; the width is more than three-fourths of the height; the width of the umbilicus is more than one-third of the diameter of the shell.

Proteusites rotundus is not nearly related to any of the Middle Triassic members of the genus, the only ones known up to this time.

Horizon and locality: Rare in the Lower Triassic *Owenites* subzone of the *Meekoceras* zone, in Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif.; associated with *Meekoceras gracilitatis*, *Owenites koeneni*, *Inyoites oweni*, *Lanceolites bicarinatus*, *Aspenites acutus*, *Pseudosageceras multilobatum*, *Anasibirites desertorum*, *A. noetlingi*, and other forms.

TROPITOIDEA

Forms with long body chamber, ammonitic, rarely goniatitic, simple septa, strong sculpture, either lateral ribs, or spines, or ventral keel. The young are involute and subglobose, resembling in form and septa the Carboniferous family Glyphioceratidae. Under this group are included the Haloritidae, Tropitidae, and Celtitidae.

Family CELTITIDAE

Whorls evolute, slender, rounded or subquadratic in cross section, little embracing and little indented by the inner whorls.

Surface ornamented with umbilical or lateral ribs that usually become obsolete on the flanks, commonly also with weak spiral lines. The inner whorls often show varices or constrictions. The septa are simple, being either goniatitic or weakly serrated. The body chamber is long, more than a revolution in length. The young stages of all members of this family resemble *Gastrioceras* of the Carboniferous, from which group the Celtitidae no doubt descended.

Celtites has usually been regarded as the radicle of the Tropitidae, but the writer is of the opinion that, although it is nearly related to the ancestral stock of *Tropites*, it should rather be regarded as a lateral branch, degenerate in character. The earlier species of *Celtites* may have been connecting links between *Gastrioceras* and *Columbites*, but the species found in the higher horizons of the Triassic are merely little-modified survivors.

Hyatt and Smith [74] placed the Celtitidae under the Ceratitoidea, but this was done because of the inclusion of *Xenodiscus* in the family. It is pretty generally agreed now that *Xenodiscus* is allied to the group of *Meekoceras* and *Ceratites* and has no kinship with the true Celtitidae.

The Celtitidae, in the restricted sense, are represented in America by *Celtites* and *Columbites* in the Lower and Middle Triassic. *Tropigastrites* Smith might also be included in the family, but its more complex septa and its high acute venter show greater affinity to the Tropitidae and afford a connecting link between *Columbites* and *Tropites*.

Hauer has described, from the Middle Triassic of Bosnia, the genus *Proteusites*,[75] with which also the group of "*Ceratites*" *decrescens* Hauer may be united. This group is characterized by robust form, wide umbilicus, semilunar cross section, strong lateral ribs, many constrictions, ceratitic or brachyphyllic septa, and semiglobose young. These forms certainly do not belong to the Ceratitoidea but are descendants of the stock of Glyphioceratidae. Philippi [76] is inclined to unite *Proteusites* and its kindred with the Arcestidae, but the strong sculpture in youth as well as age would forbid this. All the characters of *Proteusites* remind one strongly of *Columbites*, and this is especially true of *Proteusites striatus* Hauer,[77] which agrees with *Columbites* in the lateral ribs, evolute whorl, and spiral lines on the shell and differs only in its more numerous lobes and brachyphyllic saddles. The writer is of the opinion that *Proteusites* is a little-modified descendant of *Columbites* and a parallel development with *Tropigastrites*. *Celtites* and *Columbites* are not found below the Triassic.

Genus CELTITES Mojsisovics

1882. *Celtites*. Mojsisovics, Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 145.

1892. *Celtites*. Hauer, Beiträge zur Kenntniss der Cephalopoden der Trias von Bosnien, I: K. Akad. Wiss. Wien Denkschr., Band 59, p. 273.

1893. *Celtites*. Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 346.

1905. *Celtites* (part). Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 125.

1911. *Celtites* (part). Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 266, 1911.

1914. *Celtites*. Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 34.

[74] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 121, 1905.

[75] Hauer, F. von, Die Cephalopoden des bosnischen Muschelkalkes von Han Bulog bei Sarajevo: K. Akad. Wiss. Wien Denkschr., Band 54, p. 27, 1887.

[76] Philippi, E., Die Ceratiten des oberen deutschen Muschelkalkes: Palaeont. Abh. (Dames & Koken), new ser., Band 4, p. 438, 1901.

[77] Hauer, F. von, Beiträge zur Kenntniss der Cephalopoden aus der Trias von Bosnien, I: K. Akad. Wiss. Wien Denkschr., Band 59, p. 263, pl. 4, figs. 1a-c, 1892.

Not 1895. *Celtites.* Waagen, Fossils from the Ceratite formation: India Geol. Survey Mem., Palaeontologia Indica, 13th ser., Salt Range fossils, vol. 2, p. 69.
Not 1906. *Celtites.* Koken, in Noetling, Die asiatische Trias: Lethaea geognostica, Teil 2, Das Mesozoicum, Band 1, Trias, pl. 22 and explanation of plate.

Type: "*Trachyceras*" *epolense* Mojsisovics.[78]

Whorls evolute, little embracing, low, increasing very slowly in height. Cross section quadratic, sides flattened, abdominal shoulders abruptly rounded, venter flattened. Sides ornamented with simple straight ribs that become obsolete at the shoulders. Fine spiral lines appear on the venters of some species, and occasionally the sculpture crosses the venter in old age. Body chamber long. Septa goniatitic. Ventral lobe generally divided but in some specimens undivided. There are usually two laterals and an auxiliary. Antisiphonal lobe divided.

Celtites ranges from the bottom to the top of the Triassic. In America it has been found in the Middle Triassic of the West Humboldt Range of Nevada, two species having been described from that place. Several species occur in the Lower Triassic of southeast Idaho.

Celtites apostolicus Smith, n. sp.

Plate 48, Figures 1–10

Shell small, evolute, widely umbilicate; whorls with subquadratic section, higher than wide, very slender, and increasing very slowly in size. Surface with weak constrictions curving forward in a broad sinus on the venter; also with very fine spiral lines. In youth these are weak umbilical nodes, becoming obsolete with age. Septa goniatitic, with divided ventral lobe, larger lateral, small auxiliary; narrow antisiphonal lobe, with small internal lateral.

Celtites apostolicus is very closely related to *C. ursensis*, with which it is associated, differing only in the higher and more slender whorl. It agrees perfectly with that species in its long body chamber, almost obsolete sculpture and gastrioceran septation. It, too, is little modified from the ancestral *Gastrioceras* from which it must have sprung.

Horizon and locality: Rather common in the Lower Triassic *Columbites* zone of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Meekoceras pilatum, Columbites parisianus, C. spencei, Ophiceras spencei, Pseudharpoceras idahoense, Celtites planovolvis, C. ursensis*, and other forms.

Celtites planovolvis Smith, n. sp.

Plate 48, Figures 11–20

Shell small, evolute, widely umbilicate; whorls low and flattened, wider than high, with broad subquadratic section, subangular shoulders, narrow flanks and flattened venter. Surface with very weak constrictions and fine spiral lines, stronger in youth, becoming almost obsolete with age. Septa goniatitic, with divided ventral lobe, larger lateral, small auxiliary and tongue-shaped antisiphonal, flanked by a small lateral.

Dimensions of a large specimen of Celtites planovolvis

	Millimeters
Diameter	33
Height of last whorl	7.5
Height of last whorl from the preceding	6
Width of last whorl	9.5
Width of umbilicus	19.5

Celtites planovolvis is closely related to *C. ursensis*, from which it differs in its lower and broader whorl; from *C. apostolicus* it differs in the same characters but to a much greater degree. It is not nearly related to any other known species of *Celtites*, but its form, sculpture, and septation suggest a very decided kinship with the ancestral *Gastrioceras* or *Paragastrioceras*.

Horizon and locality: Rather rare in the Lower Triassic *Columbites* zone of Paris Canyon, 1 mile west of Paris, Idaho; associated with *Meekoceras pilatum, Columbites parisianus, C. spencei, Ophiceras spencei, Pseudharpoceras idahoense. Celtites ursensis, C. apostolicus*, and other forms.

Celtites ursensis Smith, n. sp.

Plate 47, Figures 11–23

Shell small, evolute, widely umbilicate; whorls subquadratic in section, with flattened sides, gently arched venter, and subangular ventral and umbilical shoulders, slightly higher than wide; little embracing, and increasing very slowly in height. Surface with weak lateral folds and constrictions that curve forward on the flanks and become nearly obsolete on the venter; also faint spiral lines on the shell and the cast. Septa goniatitic, with a ventral lobe divided into two narrow branches, a larger lateral, small auxiliary on the umbilical slope, and a longer bifid antisiphonal lobe flanked by a small internal lateral.

Length of body chamber greater than a revolution.

Dimensions of a large specimen of Celtites ursensis

	Millimeters
Diameter	42
Height of last whorl	10
Height of last whorl from the preceding	9
Width of last whorl	9
Width of umbilicus	25

Celtites ursensis is closely related to *C. planovolvis* of the same fauna but differs in its narrower and higher whorl; from *C. apostolicus*, also of the same fauna, it differs in its broader and squarer whorl. *C. ursensis* has some remote kinship with *C. polygyratus* Smith, of the Middle Triassic of Nevada, but differs in its more robust whorl and weaker sculpture.

[78] Mojsisovics, E. von, Die Dolomitriffe von Südtirol und Venetien, p. 57, 1878; Die Cephalopoden der Mediterranen Triasprovinz: K.-k. geol. Reichsanstalt Wien Abh., Band 10, p. 149, pl. 29, figs. 1, 2; pl. 38, fig. 13, 1882.

Horizon and locality: Rather common in the Lower Triassic *Columbites* zone, Paris Canyon, 1 mile west of Paris, Idaho; associated with *Columbites parisianus*, *C. spencei*, *Meekoceras pilatum*, *Ophiceras spencei*, *Pseudharpoceras idahoense*, *Celtites apostolicus*, *C. planovolvis*, etc.

Genus COLUMBITES Hyatt and Smith

1905. *Columbites.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 50.
1908. *Columbites.* Arthaber, Ueber die Entdeckung von Unter Trias in Albanien und ihre faunistische Bewertung: Geol. Gesell. Wien Mitt., Band 1, p. 276.
1911. *Columbites.* Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 260.
1914. *Columbites.* Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 36.
Not 1922. *Columbites.* Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 150.

Type: *Columbites parisianus* Hyatt and Smith.

Form evolute, discoidal; whorls little embracing and little impressed by the inner volutions, low and increasing slowly in height. Cross section helmet shaped. Umbilicus wide. Body chamber at least one revolution in length. Surface ornamented with lateral ribs, spiral striae, and many constrictions.

Septa consisting of a divided ventral lobe, a principal lateral lobe, and an auxiliary. Internal septa consisting of a narrow antisiphonal lobe flanked by a similar lateral on each side. The divided ventral lobe and the principal lateral are slightly serrated, the other lobes and all the saddles are goniatitic, except the auxiliary lateral lobe, which is occasionally serrated.

In adolescence the whorl is trapezoidal in shape and is much broader and more depressed than at maturity. At this stage the septa are goniatitic, and all the characters resemble *Gastrioceras* of the Carboniferous, from which genus *Columbites* seems to have originated, and it is probably a connecting link between the Tropitidae of the Triassic and the Glyphioceratidae of the Carboniferous.

For a long time *Celtites* has been regarded by some paleontologists as the ancestor of the Tropitidae, in spite of the fact that no certain members of the Tropitidae were known to have young stages resembling *Celtites*. This was because the ontogeny of the Tropitidae points to an evolute ancestor with long body chamber and lateral ribs and destitute of keel and abdominal furrows. *Columbites* meets these requirements and is like the young stages of the more primitive members of the Tropitidae, whereas *Celtites* is somewhat retrograde and almost too primitive to be the radicle.

Columbites is apparently tending directly toward the Tropitidae. In its youth it is decidedly like *Gastrioceras* and *Paragastrioceras* and in adolescence takes on the serration of the lobes. The development of two species of this genus has been fully described by the writer,[79] and the young stages of *C. parisianus* Hyatt and Smith and of *C. spencei* Smith fully figured, with detailed comparisons with *Gastrioceras*. Arthaber [80] has described from Albania several species of *Columbites* that appear to approach more nearly to *Tropites* than the American species do, in spite of the somewhat adverse opinion of that author. At that time Arthaber could not know of the intergradation of *Columbites* and *Tropigastrites*, which was not published until 1914 and was consequently inaccessible to him for several years.

The writer does not mean to assert that any known species of *Columbites* in either the American or the Albanian fauna was the ancestor of *Tropites* but that something like a *Columbites* certainly was.

Columbites is chiefly characteristic of the lower Triassic *Columbites* zone of Idaho and Albania, but some retarded species are found in the middle Triassic of Nevada. It has been assumed by Mojsisovics [81] that the Tropitidae developed out of *Gastrioceras*, of the Carboniferous, in spite of the enormous gap that existed from Permian to Upper Triassic. It was supposed that *Paraceltites*, of the Permian, and *Isculites*, of the Middle Triassic, partly filled the gap, but the former genus is now assigned to Xenodiscidae and the latter to Haloritidae. The writer [82] has described several species of *Columbites* from the Lower Triassic of Idaho.

Arthaber [83] recognized *Columbites* as a common member of the Lower Triassic fauna of Albania, and along with it he described the genus *Protropites*,[84] which in his opinion has even greater right than *Columbites* to be considered the radicle of the Tropitidae. It is certainly true that the late larval stages of *Tropites subbullatus*, *Paratropites sellai*, and *Discotropites sandlingensis*, as figured by the writer [85] six years before the publication of Arthaber's work, resemble greatly the adults of *Protropites*. The writer accepts *Protropites*

[79] The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 51, 1905; The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, pp. 36, 37, 1914.

[80] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, pp. 260-264, 1911.

[81] Mojsisovics, E. von, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 7, 1893.

[82] Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 50, 1905; The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 36, 1914.

[83] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 261.

[84] Idem, p. 255.

[85] Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, 1905. (*Paratropites sellai*, pl. 31, figs. 14-33; *Discotropites sandlingensis*, pl. 36, figs. 1-9; *Tropites subbullatus*, pl. 79, figs. 1-6.)

as an ancestral form but considers it a possible link between *Columbites* and *Tropigastrites*.

Columbites was first described by Hyatt and Smith from the *Columbites* zone, upper part of Lower Triassic, of the Wasatch Mountains, in southeastern Idaho. In this fauna it is represented by *Columbites consanguineus* Smith, *C. ligatus* Smith, *C. minimus* Smith, *C. ornatus* Smith, *C. parisianus* Hyatt and Smith, and *C. spencei* Smith.

In the Albanian fauna, at the same horizon, *Columbites* is represented by *C. dusmani* Arthaber, *C. europaeus* Arthaber, *C. mirditensis* Arthaber, and *C. perrini-smithi* Arthaber, all apparently more specialized than the American type.

The writer [86] has also recognized somewhat doubtfully two Middle Triassic species of this genus—*Columbites humboldtensis* Smith and *C. plicatulus* Smith. No other authentic species of the genus are known.

Columbites consanguineus Smith, n. sp.

Plate 46, Figures 1–13

Shell large, robust, discoidal, widely umbilicate, little embracing. Whorls higher than wide, with abruptly rounded umbilical shoulders, flattened flanks, gently rounded ventral shoulders, and rounded venter. Ornamented with rather coarse umbilical ribs that thin out on the flanks, curve gently forward and cross the venter without interruption. Up to a diameter of 37 millimeters the sculpture is coarse, and then becomes finer, though never obsolete. There are also very fine spiral lines visible on the outer shell, as on all American species of *Columbites*. Septa ceratitic, with rounded saddles, serrated ventral and lateral lobe, and goniatitic auxiliary. The antisiphonal lobe is flanked by a rather long internal lateral.

The height of the last whorl is somewhat less than one-third of the diameter of the shell, the width is two-thirds of the height; the width of the umbilicus is about two-fifths of the diameter of the shell.

Columbites consanguineus is very closely related to *C. spencei*, differing in its greater lateral compression, higher whorl, and somewhat weaker sculpture, also in the reduction of the coarse umbilical ribs at a much smaller size. It is also related to *C. parisianus* but is much more robust than that species, has stronger sculpture through life, and is more narrowly umbilicate. In youth, up to a diameter of about 20 millimeters, the two species are indistinguishable, but from then on *C. consanguineus* diverges rapidly from its kinsman, becoming at maturity much more like *C. spencei*.

Horizon and locality: Rare in the Lower Triassic *Columbites* zone of Paris Canyon, 1 mile west of Paris, southeastern Idaho; associated with *Columbites parisianus*, *C. spencei*, *C. ligatus*, *C. ornatus*, *Meekoceras micromphalus*, *M. pilatum*, *M. curticostatum*, *Pseudosageceras multilobatum*, and other forms.

Columbites ligatus Smith, n. sp.

Plate 47, Figures 1–8

Shell evolute, discoidal, little embracing, somewhat compressed laterally. Whorls trapezoidal in section, with abrupt umbilical shoulders, flattened sides, and bluntly rounded ventral shoulders, with broad, nearly flat venter. Ornamented with strong umbilical ribs that curve forward up the flanks and continue across the venter, forming a broad sinus. Parallel with these ribs are numerous shallow constrictions that also cross the venter. On the outer shell are fine spiral lines, as on all members of *Columbites*. Septa ceratitic, with entire saddles and serrated lobes; the ventral lobe is divided into two rather short, narrow branches; the first lateral is large and strongly serrated; the second lateral or auxiliary is small, narrow, and unserrated. The internal, antisiphonal lobe is long, narrow, and bifid, flanked by a shorter interior lateral. Body chamber more than a revolution in length.

In early youth the shell is decidedly gastrioceran in shape, ornamentation and septa, having broad trapezoidal section, coarse umbilical knots; strong constrictions, and goniatitic gastrioceran septa.

The height of the last whorl is one-third of the diameter of the shell, the width is more than three-fourths of the height, the width of the umbilicus is slightly less than half the diameter of the shell. These dimensions apply only to the mature shell, for in youth the whorl is wider than high.

Columbites ligatus is closely related to *C. spencei* but differs in being somewhat more slender and in the stronger sculpture, which persists through life. It differs in the same way from *C. parisianus* but to a greater degree. It is not closely related to any of the Albanian species of this genus, which is known at present only in America and in Albania.

In some respects *Columbites ligatus* shows its gas trioceran ancestry more decidedly than any other species of the group. It also stands out as further removed from its near kinsmen with which it is associated.

Horizon and locality: Rare in the *Columbites* zone of the Lower Triassic of southeastern Idaho, at Paris Canyon, 1 mile west of Paris; associated with *Columbites parisianus*, *C. spencei*, *Ophiceras spencei*, *O. jacksoni*, *Pseudharpoceras idahoense*, *Pseudosageceras multilobatum* Noetling, *Meekoceras pilatum*, *M. curticostatum*, and other forms.

Columbites minimus Smith, n. sp.

Plate 47, Figures 9, 10

Shell small, evolute, widely umbilicate, with trapezoidal whorls and gently rounded venter. Surface in

[86] Smith, J. P., The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, pp. 36–37, 1914.

youth with strong umbilical ribs, and in age with fine ribs, folds, and constrictions crossing the venter.

Columbites minimus is evidently a dwarf of the vigorous stock, not merely the young of some unknown species; it is certainly not like the young of any known species. It shows the beginning of the phenomenon of retardation and degeneration, which later will play such a significant part in this stock.

Horizon and locality: Very rare in the Lower Triassic *Columbites* zone in Paris Canyon, 1 mile west of Paris, Idaho; associated with *Columbites parisianus*, *C. spencei*, *Meekoceras pilatum*, *Ophiceras spencei*, *O. jacksoni*, *Pseudharpoceras idahoense*, and other forms.

Columbites ornatus Smith, n. sp.

Plate 46, Figures 14–21

Evolute, discoidal, widely umbilicate, little embracing; whorls low, helmet shaped, somewhat trapezoidal, with abrupt umbilical shoulders, rounded flanks, broadly rounded ventral shoulders, and arched venter. Ornamented with numerous fine umbilical ribs that extend across the flanks, becoming finer on the venter but persisting throughout life; also with faint constrictions that become obsolete with age. Surface of the shell with fine spiral lines, becoming obsolete at maturity. The young shells are broader and more gastrioceran, but even then the umbilical ribs are never coarse. Septa ceratitic, with rounded entire saddles and three external lobes, of which the ventral and the lateral are strongly serrated and the short auxiliary is goniatitic.

The height of the last whorl is less than one-third of the diameter of the shell, the width is three-fourths of the height, and the width of the umbilicus is less than half the diameter of the shell.

Columbites ornatus is most nearly related to *C. parisianus*, from which it is distinguished by its greater slenderness, its much finer and sharper sculpture, and the persistence of this sculpture through life. The young stages are even more slender and graceful and lack the coarse gastrioceran umbilical ribs of *C. parisianus* and *C. spencei*.

Horizon and locality: Rare in the Lower Triassic *Columbites* zone of southeastern Idaho, at Paris Canyon, 1 mile west of Paris; associated with *Columbites parisianus*, *C. spencei*, *Ophiceras spencei*, *O. jacksoni*, *Meekoceras pilatum*, *M. curticostatum*, *Pseudosageceras multilobatum*, and other forms.

Columbites parisianus Hyatt and Smith

Plate 1, Figures 9–14; Plate 61, Figures 1–21; Plate 72, Figures 1–24

1905. *Columbites parisianus*. Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 51, pl. 1, figs. 9–14; pl. 61, figs. 1–21; pl. 72, figs. 1–24.

This species is the type of *Columbites* Hyatt and Smith.

Form evolute, discoidal, laterally compressed. Whorls little embracing and little indented by the inner volutions. Cross section high helmet shaped, the width being about two-thirds of the height of the whorl. The sides are convex, curving without marked shoulders to the rounded venter. The indentation is shallow, being less than one-fourth of the height of the whorl. The outer whorl embraces about three-eighths of the inner. The height of the whorl is somewhat less than one-third of the entire diameter of the shell.

The umbilicus is broad and shallow, being about three-eighths of the entire diameter of the shell.

At maturity the sculpture is weak, consisting of low umbilical folds, which extend up the sides and occasionally across the venter, being much weaker on the ventral portion of the whorl. These folds curve sharply forward on the flanks, forming a broad sinus on the venter. Parallel with them are numerous weak varices, which are distinct on the cast but scarcely visible on the outer shell. The surface of the shell is ornamented with fine cross striae of growth, parallel with the folds, and weaker spiral striae.

The body chamber was seen on several specimens to be at least a complete revolution in length, and the sculpture persists on the body whorl as well as on the chambered portion of the shell.

The septa consist of a ventral lobe divided by a deep saddle into two narrow branches, a principal lateral lobe in the middle of the flank, and a short, narrow auxiliary on the umbilical shoulder. There are also a narrow antisiphonal lobe and a single small internal lateral. The ventral lobe, the principal lateral, and the auxiliary are slightly serrated, and the internal lobes are goniatitic. All the saddles are rounded and entire.

The foregoing description applies only to the mature shell; for up to the diameter of 20 millimeters the whorl is low and trapezoidal in cross section, sloping outwardly to the angular ventral shoulders, where the umbilical ribs end in knots. At this stage the sculpture is almost obsolete on the venter, but the varices are more strongly marked than at maturity. The spiral striae are also very distinct, and the septa are all goniatitic. Up to the diameter of 15 millimeters the shape, ornamentation, and septa are exactly like those of *Gastrioceras* of the Carboniferous, from which genus *Columbites* appears to have been derived by increasing the involution and height of the whorl and by the slight serration of the ventral and lateral lobes. This transition is just such as one would expect to find in the upper Permian or the lowest Triassic, and the beds in which *Columbites* was found are in the Lower Triassic, but that they belong to the Mesozoic is shown by the association of *Meekoceras*, *Prionolobus*, *Celtites*, and *Pseudosageceras*, of which the species are in part identical with forms from the *Meekoceras* zone, which lies below the *Columbites* zone.

Columbites parisianus resembles externally *Danubites strongi* Hyatt and Smith but differs from that species in its stronger sculpture, especially in the young whorls, in its varices, longer body chamber, and in lacking a third lateral lobe. The young stages of the two genera are so unlike that they must belong to different stocks, in spite of their convergence in appearance at maturity.

Horizon and locality: *Columbites parisianus* was found by Mr. R. S. Spence in the Lower Triassic *Columbites* zone, 1 mile west of Paris, Bear Lake County, southeastern Idaho, associated with *Pseudosageceras multilobatum*, *Ophiceras jacksoni*, *Meekoceras pilatum*, *Ophiceras spencei*, *Celtites ursensis*, several other species of *Columbites*, and a few other forms. This bed lies above the beds with *Meekoceras gracilitatis*, which crop out near by, but it still belongs to the Lower Triassic and is the probable equivalent of the Olenek horizon of northern Siberia.

Columbites spencei Smith

Plate 77, Figures 1–21; Plate 78, Figures 1–16

1914. *Columbites spencei*. Smith, The Middle Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, p. 36, pl. 70, figs. 1–16; pl. 71, figs. 1–16.

Form evolute, discoidal, robust. Whorls helmet shaped, slightly higher than wide, embracing half of the inner whorl and indented by it to one-sixth of the height. Flanks and venter rounded, without ventral shoulders at the junction. Umbilical shoulders hardly developed, umbilicus wide and shallow, being half the diameter of the shell. The surface is ornamented at maturity with rather weak lateral ribs that swing forward on the venter in a strong sinus and with weak constrictions at distant and irregular intervals. There are also weak spiral lines on the shell. The body chamber is more than a revolution in length. The septa are ceratitic, the saddles being entire, the ventral lobe divided and slightly serrated, the lateral lobe distinctly serrated, and the auxiliary either goniatitic or slightly serrated. Of the inner lobes the antisiphonal is bifid, and it is flanked by a simple lateral.

Up to a diameter of 10 millimeters this species is a typical *Gastrioceras*, having simple gastrioceran lobes, trapezoidal cross section, coarse umbilical ribs, and strong constrictions. At about 10 millimeters the septa become slightly serrated, but the gastrioceran form and sculpture persist until a diameter of about 35 millimeters is reached, when the whorl becomes higher and more compressed laterally. The shoulders become obsolete, and the umbilical ribs become weaker and extend across the venter. These stages are figured on Plates 77 and 78.

Columbites spencei greatly resembles *C. parisianus* Hyatt and Smith[87] but differs from that species in the more robust form, stronger sculpture, and the persistence of the gastrioceran stage much later in life.

The specific name was given in honor of Mr. R. S. Spence, the discoverer of this fauna and a pioneer collector of Triassic fossils.

This species should have been the type of *Columbites*, instead of *C. parisianus*, for it is much more distinctive and characteristic, but the material illustrating it was obtained after the descriptions and illustrations of *C. parisianus* were completed and ready for publication.

Horizon and locality: Rather common in the Lower Triassic *Columbites* zone, Paris Canyon, a mile west of Paris, Idaho; associated with *Columbites parisianus*, *Ophiceras spencei*, *O. jacksoni*, *Meekoceras pilatum*, *Pseudosageceras multilobatum*, *Pseudharpoceras idahoense*, and other forms.

Family HALORITIDAE

Subglobose, involute genera, with lateral ribs, commonly crossing the venter, and in some groups with spines or knots on the ribs. No keels nor ventral furrows are known in this group, but the interruption of the ribs on the venter in some specimens gives the appearance of a furrow.

The septa are ammonitic, dolichophyllic, or ceratitic. The young of this family resemble the Glyphioceratidae and more especially the genus *Pericyclus* Mojsisovics, of the Carboniferous.

This family was formerly classed by Mojsisovics under the Tropitidae, but it did not come from the main stock, being rather a parallel development from the same Carboniferous radicle but probably from different branches of the same family.

The Haloritidae are known chiefly from the Upper Triassic, in the Karnic and Noric stages, in the Alpine Province, the Himalayas, and western America. They are represented in America by *Leconteiceras* Smith, *Sagenites* Mojsisovics, *Halorites* Mojsisovics, *Metasibirites* Mojsisovics, *Juvavites* Mojsisovics, and *Gonionotites* Gemmellaro, all confined to the Upper Triassic. They are sparingly represented in the Lower Triassic by *Juvenites* Smith, *Thermalites* Smith, and *Prenkites* Arthaber; also in the Middle Triassic by *Isculites* Mojsisovics.

Genus JUVENITES Smith

1927. *Juvenites*. Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 23.

Type: *Juvenites kraffti* Smith.

[87] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 51, pl. 1, figs. 9–14; pl. 61, figs. 1–21; pl. 62, figs. 1–24, 1905.

Form robust, moderately involute, widely umbilicate, cross sections trapezoidal. Surface with numerous close-set periodic constrictions. Body chamber long. Septa simple, goniatitic, with divided ventral lobe and two simple laterals.

Juvenites includes the primitive Lower Triassic forms that have hitherto been classed under the arrested and reversionary *Nannites—Nannites dieneri* Hyatt and Smith, *Nannites medius* Krafft, *Nannites herberti* Diener, *Nannites? hindostanus* Diener.

So far as known, this genus is confined to the Lower Triassic of western America and the Indian region, in which horizon it is represented by several species. It forms a connecting link between *Gastrioceras* of the group of *G. globulosum* and the Ptychitidae and probably also the Haloritidae. It is quite Paleozoic in aspect, little removed in characters and in time from the ancestral group, still progressive, or at most slightly retarded. The true *Nannites*, of the Middle Triassic is decidedly reversionary and can hardly be congeneric with the Lower Triassic species.

Juvenites dieneri Hyatt and Smith

Plate 7, Figures 5–25; Plate 32, Figures 1–1c

1905. *Nannites dieneri.* Hyatt and Smith, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 79, pl. 7, figs. 5–25.

Form subglobose, involute, deeply embracing; whorls depressed, helmet shaped, wider than high, indented more than half the height by the preceding whorl. Breadth of whorl slightly greater than its height, 9 : 7. Umbilicus narrow, deep, one-fifth of the total diameter of the shell. Venter broadly rounded. Umbilical shoulders abrupt and umbilical slope steep. Body chamber long, comprising about the last volution.

Surface nearly smooth in youth but marked with varices and constrictions that become more numerous as the shell grows older, until there are as many as 10 to a revolution. Between the principal constrictions and varices intervene minor cross ribs, and the entire shell is ornamented with fine radial striae, like those in the Glyphioceratidae.

Septa goniatitic; external lobe divided by a small siphonal notch into two sharp-pointed lobes; lateral lobe broader and not so deep; shallow auxiliary on the umbilical slope. The two lateral saddles are broadly rounded. The internal antisiphonal lobe is narrow and short, the lateral is similar, and there is a smaller auxiliary inside of the umbilical suture. The internal saddles are broadly rounded.

This species is most nearly related to *Juvenites? hindostanus* Diener [88] but differs from the Indian species in being broader and having fewer constrictions of the shell. The divisions of the ventral lobe are also somewhat sharper. The constrictions are as distinctly marked on the shell as on the cast, whereas on *J. hindostanus* they are visible chiefly on the cast.

These differences would be considered by the writer not to have a greater than varietal significance if Diener had not used even smaller differences to separate his *Juvenites herberti* from *J.? hindostanus.* But in small shells with few distinctive characters, those marks that are seen should be accorded greater significance in classification than those on shells with many characters.

This species grew to the diameter of at least 24 millimeters.

Dimensions of a symmetrical specimen of Juvenites dieneri

	Millimeters
Diameter	13. 5
Height of whorl	7
Height of last whorl from the preceding	3
Width of last whorl	9
Width of umbilicus	2. 75
Involution	4

Horizon and locality: *Juvenites dieneri* is common in the Lower Triassic *Meekoceras* zone of Union Wash, about 1½ miles east of Union Spring, Inyo Range, east side of Owens Valley, about 15 miles southeast of Independence, Inyo County, Calif.

Juvenites kraffti Smith

Plate 21, Figures 1–10

1927. *Juvenites kraffti.* Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 23, pl. 21, figs. 1–10.

Form broad, widely umbilicate, with low crescentic cross section. Surface with very numerous close-pressed folds, giving an imbricated appearance. Body chamber long. Septa simple, goniatitic, with divided ventral and two laterals.

Closely related to *Juvenites dieneri* Hyatt and Smith [89] of the Lower Triassic but broader, less involute, more strongly sculptured, and more decidedly gastrioceran in appearance.

Horizon and locality: Lower Triassic *Meekoceras* zone at locality 5, 1 mile east of Hot Springs, north end of Bear Lake, southeastern Idaho; also at locality 1, 5 miles east of Grays Lake; also at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs. It is confined to the zone of *Pseudosageceras multilobatum* and associated with *Meekoceras gracilitatis, M. mushbachanum, Flemingites russelli, Hedenstroemia kossmati, Aspenites acutus, Cordillerites angulatus, Lanceolites compactus, Ussuria waageni, Xenodiscus intermontanus, Lecanites arnoldi,* and other forms.

[88] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 68, pl. 7, figs. 3, 12, 1897.

[89] Hyatt, Alpheus, and Smith, J. P., The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, p. 79, pl. 7, figs. 5–25, 1905.

Juvenites sanctorum Smith, n. sp.

Plate 31, Figures 22–30

Shell small, laterally compressed, with flattened sides, and broadly arched venter; narrowly umbilicate, involute and deeply impressed by the inner whorl. Surface with numerous shallow constrictions, giving a strong sculpture to the surface of the shell and the cast.

Septa goniatitic, with small external lobe, longer lateral, and small auxiliary on the umbilical border.

Dimensions of the type specimen of Juvenites sanctorum

	Millimeters
Diameter	13. 5
Height of last whorl	6. 0
Height of last whorl from the preceding	3. 5
Width of last whorl	6. 0
Width of umbilicus	2. 5

Juvenites sanctorum is closely related to "*Nannites*" *medius* Krafft and Diener, of the Lower Triassic of India, differing only in its somewhat stronger sculpture. It is also related to *J. septentrionalis*, from which it differs in its greater involution, compression of the whorl, and weaker sculpture.

Horizon and locality: Rather rare in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Cordillerites angulatus*, *Lanceolites compactus*, and other forms.

Juvenites septentrionalis Smith, n. sp.

Plate 31, Figures 31–40

Shell small, robust, rather evolute, with broad semiangular whorls and wide umbilicus. Surface with very numerous close-set constrictions, showing on both shell and cast. Body chamber long, more than a revolution. Septa goniatitic, with short, narrow external lobe divided into two branches, a larger lateral, small auxiliary on the umbilical shoulder; and a divided long, narrow antisiphonal lobe, flanked by a short internal lateral.

Juvenites septentrionalis is very similar to "*Nannites*" *hindostanus* Diener [90] but differs from the Indian species in its slightly wider umbilicus, somewhat more compressed whorl, and stronger sculpture.

Krafft [91] makes the statement that delicate denticulations may be seen on the type specimen of "*Nannites*" *hindostanus* and on other specimens from the same region. This alone would prevent identification of the American with the Indian species, for on the numerous specimens of *Juvenites septentrionalis* the septa are distinctly goniatitic.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of southeastern Idaho, at localities 1, 2, 3, 4, and 5, associated with *Meekoceras gracilitatis*, *Flemingites russelli*, *Cordillerites angulatus*, *Lanceolites compactus*, *Hedenstroemia kossmati*, *Aspenites acutus*, *Pseudosageceras multilobatum*, and other forms.

[90] Diener, Carl, Cephalopoda of the Lower Trias: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., Himalayan fossils, vol. 2, pt. 1, p. 68, pl. 7, figs. 3a–b, 1897.

[91] Krafft, A. von, and Diener, Carl, Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans: India Geol. Survey Mem., Palaeontologia Indica, 15th ser., vol. 6, Mem. 1, p. 141, 1909.

Genus PRENKITES Arthaber

1911. *Prenkites*. Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Band 24, p. 258.

1922. *Prenkites*. Welter, Die Ammoniten der Unteren Trias von Timor: Palaeontologie von Timor, Lief. 11, Abh. 19, p. 150.

Form evolute, robust, depressed, widely umbilicate, little embracing. Whorls low and broad, flanks reduced to little or nothing. Body chamber long.

Septa ceratitic, with rounded entire saddles and serrated lobes, of which there are only three visible externally, the short ventral, the relatively enormous lateral, and a small auxiliary.

Prenkites differs from *Isculites* in the ceratitic instead of slightly ammonitic lobes and in the very depressed instead of the highly arched whorl. It differs from *Thermalites* in the greater simplicity of the septa and in the more exaggerated gastrioceran shape of the whorls.

The type of *Prenkites* is *P. malsorensis* Arthaber, [92] from the Lower Triassic *Columbites* beds of Albania. It is represented in America by a single species, which is described below.

Prenkites depressus Smith, n. sp.

Plate 31, Figures 16–18

Form evolute, broadly umbilicate, depressed, broad, little embracing, and little indented by the inner whorl. Flanks exceedingly narrow, being merely the meeting of the abrupt ventral shoulder with the umbilical slope.

Surface nearly smooth, without ribs or constrictions. Septa distinctly serrated, with rounded saddles, and with a small ventral, very large lateral lobe, and a small auxiliary just visible on the umbilical border. Body chamber apparently long but uncertain.

Prenkites depressus has some resemblance to *Thermalites thermarum* but differs in the greater evolution, wider umbilicus, weaker sculpture, and flattened whorl. It is more nearly related to *Prenkites malsorensis* Arthaber [93] but differs in the less pronounced

[92] Arthaber, G. von, Die Trias von Albanien: Beitr. Paläontologie Oesterr. Ungarns u. des Orients, Band 24, p. 258, pl. 22, figs. 17–19, 1911.

[93] Idem.

flattening of the whorl, and entirely in the faunal association.

Horizon and locality: Very rare in the Lower Triassic *Meekoceras* zone of southeast Idaho, at locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; associated with *Meekoceras gracilitatis*, *Flemingites russelli*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Pseudosageceras multilobatum*, and other forms.

Genus THERMALITES Smith

1927. *Thermalites*. Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 24.

1911. *Isculites* (part). Arthaber, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, vol. 24, p. 259.

Not 1893. *Isculites*. Mojsisovics, Die Cephalopoden der Hallstätter Kalke: K.-k. geol. Reichsanstalt Wien Abh., Band 6, Hälfte 2, p. 64.

Type: *Thermalites thermarum* Smith.[94]

Form robust, subspherical, with broad subtrapezoidal whorls, wide umbilicus. Surface with numerous constrictions and folds. Body chamber long. Septa with entire saddles and slightly serrated lobes of simple pattern.

This genus is transitional from *Juvenites* to the Haloritidae, differing from the former only in the serration of the lobes and from the latter only in the rudimentary sculpture and the very primitive septa.

Thermalites should probably include "*Isculites*" *originis* Arthaber,[95] which is certainly not a member of *Isculites* and which is closely related to *Thermalites thermarum*.

This genus is confined to the Lower Triassic of western America, and, somewhat doubtfully, Albania; it is probably ancestral to the true *Isculites* of the *Columbites* zone of the Lower Triassic and of the Middle Triassic.

[94] Smith, J. P., Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 24, 1927.

[95] Arthaber, G. von, op. cit. (Die Trias von Albanien), p. 259, pl. 23, figs. 1-10.

Thermalites thermarum Smith

Plate 21, Figures 11–20

1927. *Thermalites thermarum*. Smith, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, p. 24, pl. 21, figs. 11–20.

Form robust, with highly arched, helmet-shaped, deeply embracing whorls and subtrapezoidal, moderately wide umbilicus. Surface with numerous strong constrictions, which become nearly obsolete with age and are replaced by rather weak folds. Septa with rounded entire saddles and serrated lobes. The external septa consist of a divided ventral lobe and two laterals; the internal septa consist of a divided antisiphonal and two laterals, all slightly serrated. The body chamber is more than one revolution in length. The height of the last whorl is nearly half the total diameter of the shell, and the width is one and a half times the height. The whorl is rather deeply embracing and is indented to half its height by the inner whorl. The width of the umbilicus is one-third of the diameter of the shell.

Thermalites thermarum differs from "*Isculites*" *originis* Arthaber in being more trapezoidal and in having stronger sculpture. It is almost certainly congeneric with that species, and neither can belong to *Isculites*. It has also a very close resemblance to *Juvenites kraffti* Smith, differing only in the serration of the lobes, the form, sculpture, and ground plan of the septa being the same in both species. In both species the shell is ornamented with very fine cross striae of growth and both lack suggestion of spiral lines, so common on descendants of the gastrioceran stock.

Horizon and locality: Rather common in the Lower Triassic *Meekoceras* zone of Aspen Ridge, Wood Canyon, locality 1, 9 miles east of Soda Springs; and at locality 5, 1 mile east of Hot Springs, north end of Bear Lake, southeastern Idaho. It was associated with *Meekoceras gracilitatis*, *M. mushbachanum*, *Flemingites russelli*, *F. aplanatus*, *F. cirratus*, *Hedenstroemia kossmati*, *Cordillerites angulatus*, *Lanceolites compactus*, *Ussuria waageni*, *Aspenites acutus*, *Pseudosageceras multilobatum*, and other forms.

PLATES

PLATE 1

FIGURES 1–3. *Flemingites russelli* Hyatt and Smith (p. 53).

1–3. Side and front views and septum.

From Lower Triassic *Meekoceras* zone, 9 miles northeast of Wood Canyon, Aspen Ridge, Idaho. Collection of United States National Museum.

FIGURES 4–8. *Hedenstroemia (Clypites) tenuis* Hyatt and Smith (p. 79).

4–6. Side and rear views and septum.

7, 8. A young specimen of the same species, showing the *Ambites* stage of growth; diameter 9 millimeters. This species may prove to be merely the young of *Hedenstroemia kossmati* Hyatt and Smith.

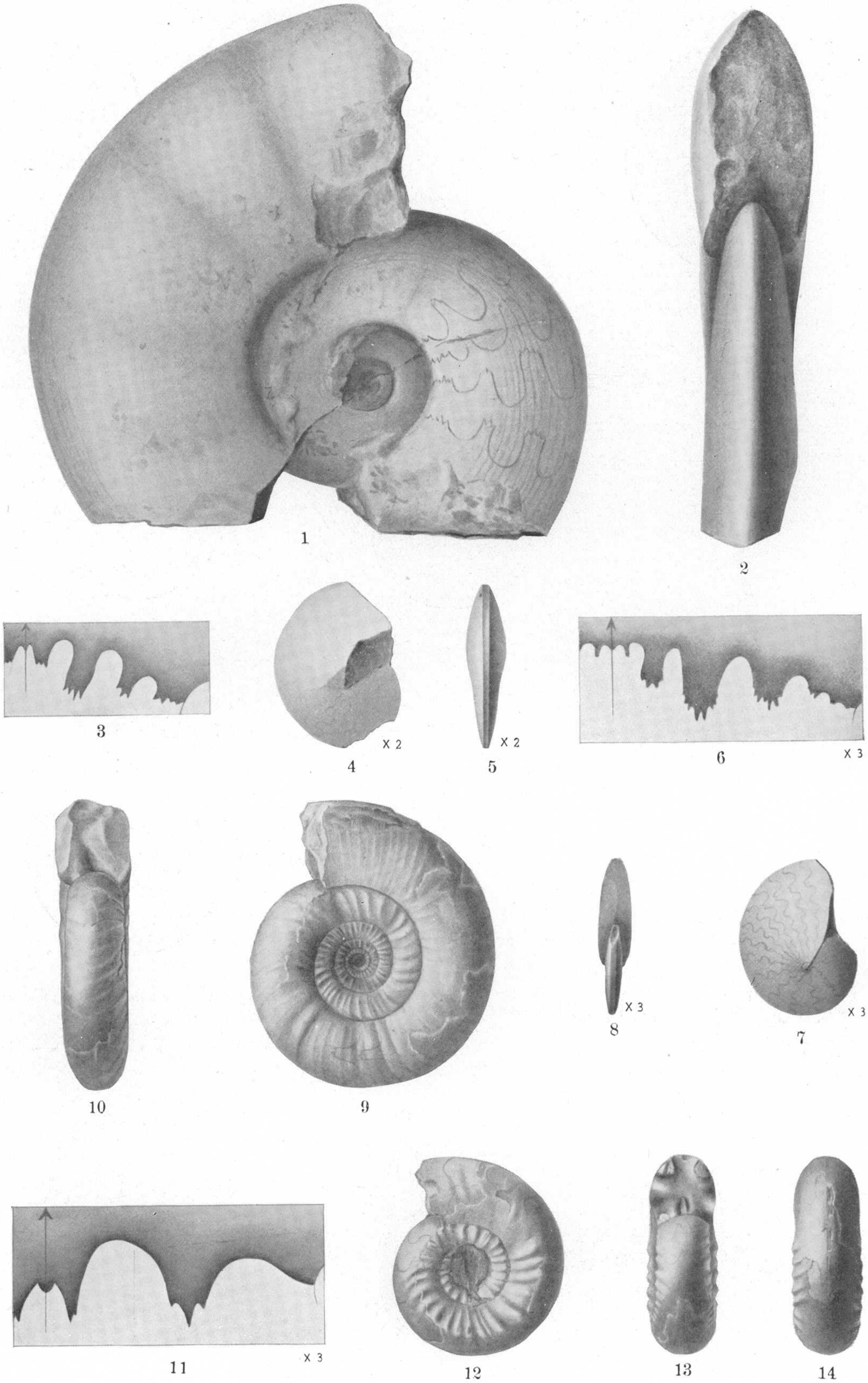
From Lower Triassic *Meekoceras* zone, 9 miles east of Wood Canyon, Aspen Ridge, Idaho. Collection of United States National Museum.

FIGURES 9–14. *Columbites parisianus* Hyatt and Smith (p. 107).

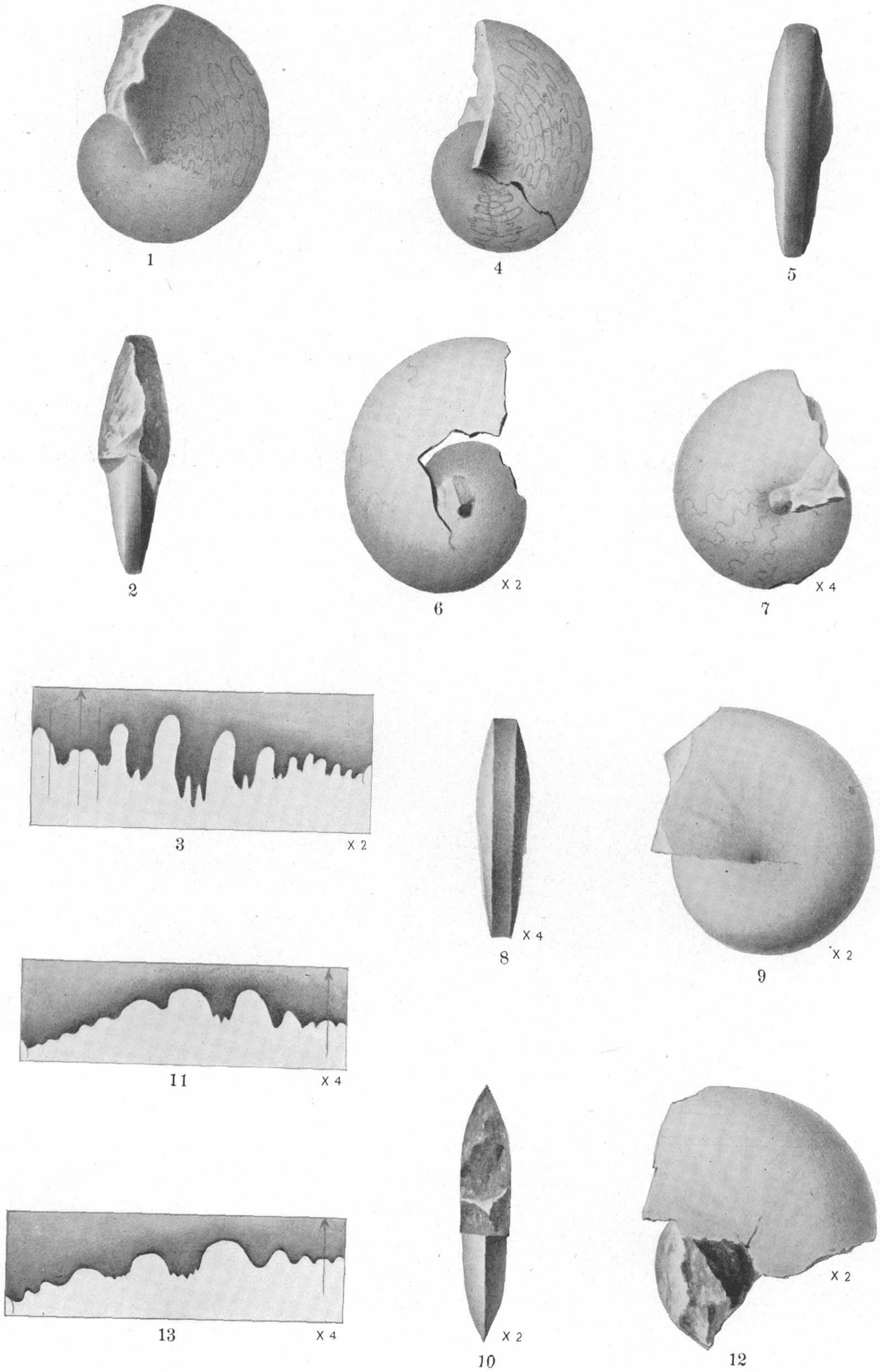
9–11. Left side and front views and septum of type specimen.

12–14. Left side, front, and rear views of an adolescent specimen; diameter 33 millimeters.

From Lower Triassic *Columbites* zone, 1 mile west of Paris, southeastern Idaho. Collection of United States National Museum.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 2

FIGURES 1–8. *Cordillerites angulatus* Hyatt and Smith (p. 96).

1–3. Side and front views and septum.

4, 5. Side and rear view of another specimen.

7, 8. Side view and septum of an adolescent specimen. *Sicanites* stage; diameter of 7 millimeters.

6. Side view of an adolescent specimen, showing transition from *Sicanites* to *Cordillerites*.

FIGURES 9–13. *Aspenites acutus* Hyatt and Smith (p. 86).

9–11. Side and front views and septum of an immature specimen.

12, 13. Left side view and septum of a larger specimen.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, Idaho. Collection of United States National Museum.

PLATE 3

FIGURES 1–5. *Aspenites acutus* Hyatt and Smith (p. 86).

1, 2. Side and front views of the type specimen.

3. Side view of a larger specimen, showing the septa.

4, 5. Side and rear views of a young specimen; diameter 4.5 millimeters.

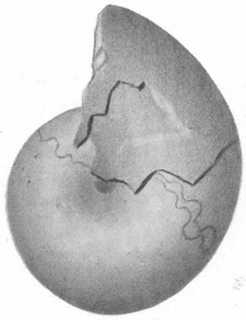
FIGURES 6–11. *Sturia compressa* Hyatt and Smith (p. 93).

6, 7. Side and front view of the type specimen.

8, 9. Septa drawn from both sides of another specimen.

10, 11. Side view and septum of a smaller specimen.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.



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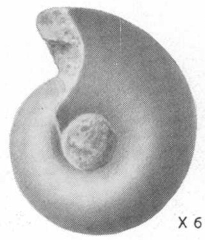

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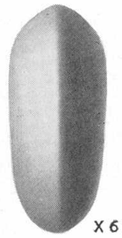

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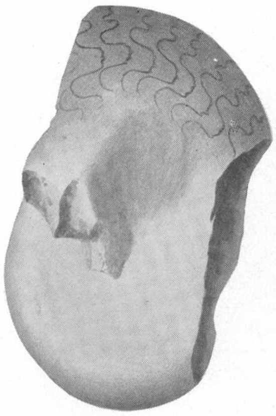

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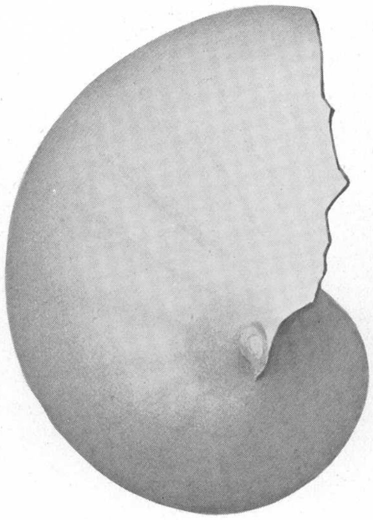

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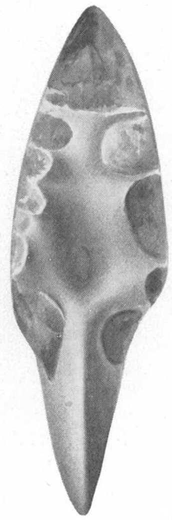

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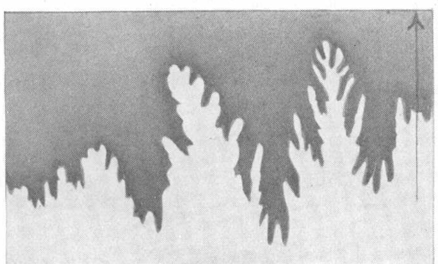

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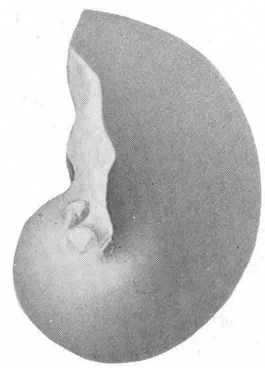

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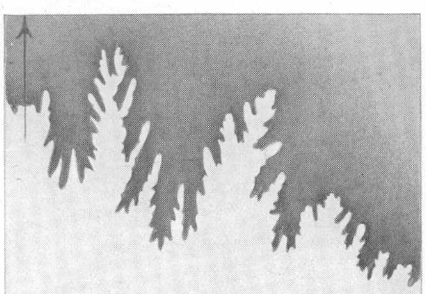

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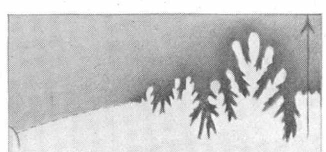

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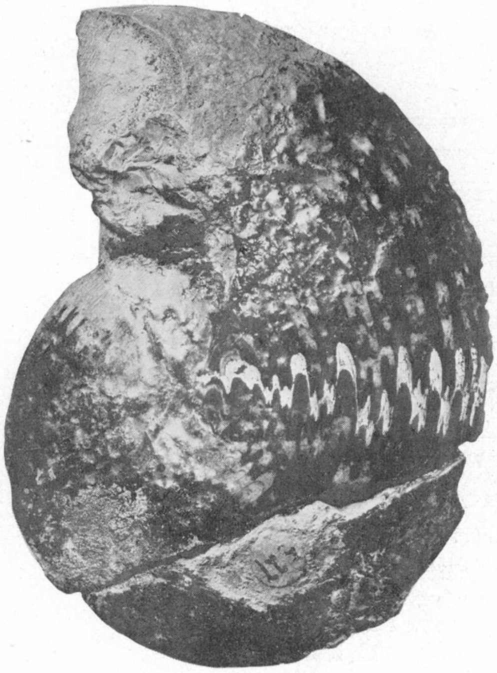
LOWER TRIASSIC AMMONOIDS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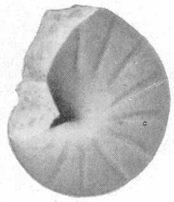
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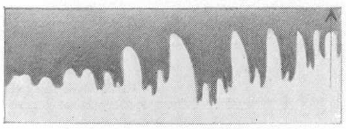
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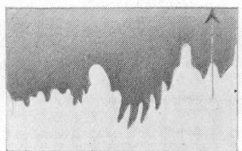
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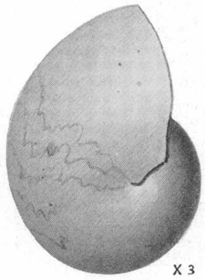
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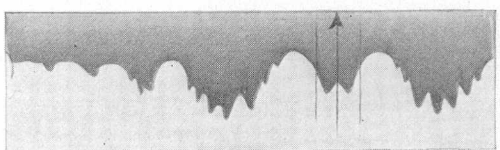
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LOWER TRIASSIC AMMONOIDS

PLATE 4

FIGURES 1–3. *Pseudosageceras multilobatum* Noetling (p. 87). Side and front views and septum of the type specimen.

FIGURES 4–10. *Lanceolites compactus* Hyatt and Smith (p. 90).

4–6. Side and rear views and septum.

7. Septum of another specimen.

8–10. Side and front views and septum of a young specimen; diameter 12 millimeters.

All the specimens of *Lanceolites compactus* figured in this plate are immature and have not yet acquired the lanceolate type of septa which is characteristic of maturity in this genus. The mature stage is shown in Plate 40, Figures 9–11.

All specimens figured came from Lower Triassic *Meekoceras* zone, Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, Idaho. Collection of United States National Museum.

PLATE 5

FIGURES 1–6. *Pseudosageceras multilobatum* Noetling (p. 87).

1, 2. Side and front views of a large specimen.

3, 4. Side view and septum of a smaller specimen.

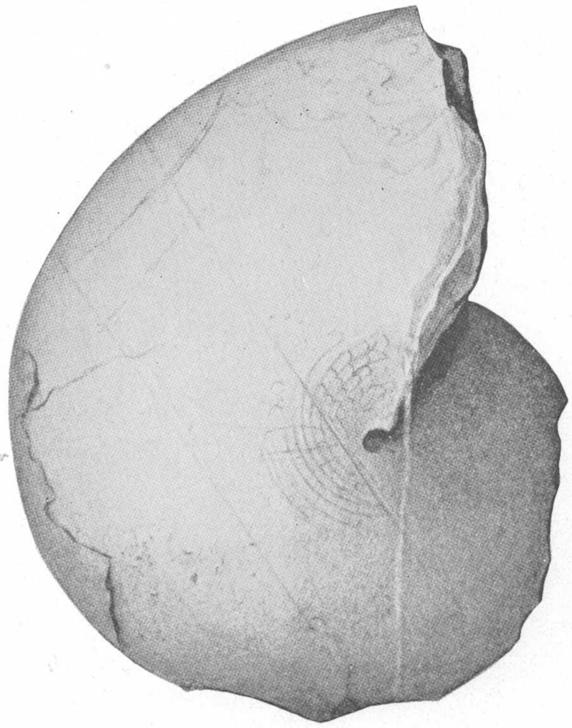
5, 6. View of ventral keel.

FIGURES 7–9. *Lanceolites compactus* Hyatt and Smith (p. 90).

7, 8. Side view and septum considerably modified by weathering.

9. Septum from a small specimen. Details of septum not quite correct and greatly modified by weathering.

The specimens shown in this plate are immature and have not yet acquired the lanceolate type of septum that characterizes maturity. The mature stage is shown on Plate 40, Figures 9–11. All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.



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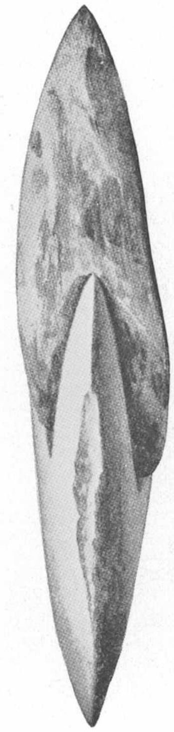

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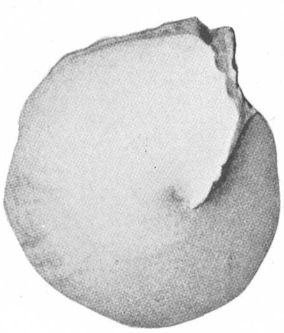

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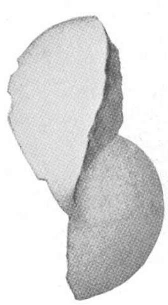

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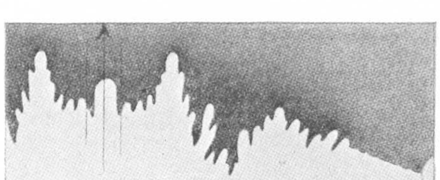

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LOWER TRIASSIC AMMONOIDS

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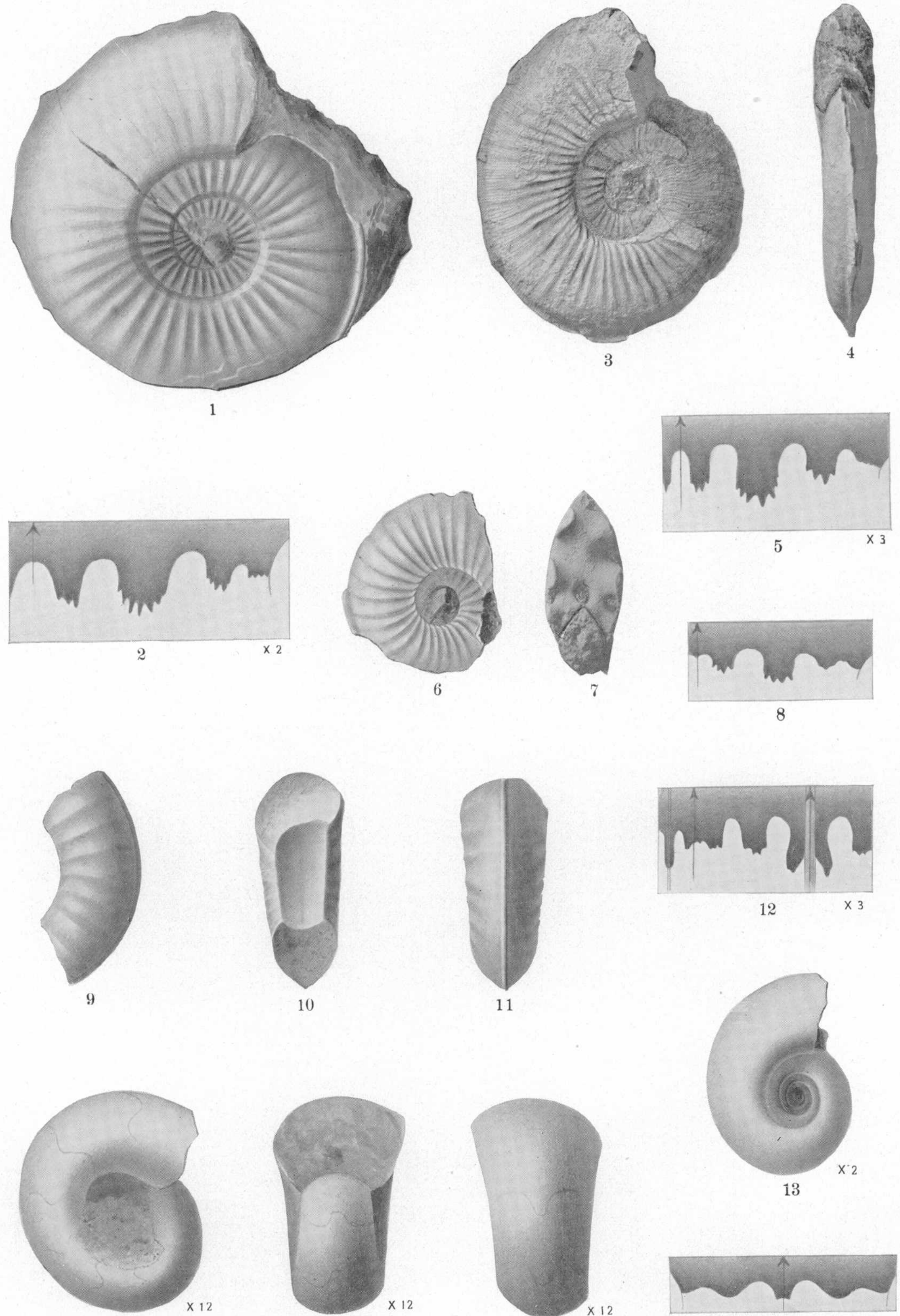


LOWER TRIASSIC AMMONOIDS

PLATE 6

FIGURES 1–16. *Inyoites oweni* Hyatt and Smith (p. 80).

1. Side view.
2. Septum drawn from a specimen of the same size as Figure 1.
3, 4. Side and front views of a smaller specimen.
5. Septum from a smaller specimen; diameter about 25 millimeters.
6. Side view of small specimen.
7, 8. Front view and septum of a fragment of the whorl.
9–11. Side, front, and rear views of a fragment of whorl of young specimen; diameter about 15 millimeters.
12. Septum, external and internal, from the same specimen.
13. Side view of young specimen.
14–16. Side, front, and rear views and septum of larval specimen; diameter 2.5 millimeters.

From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

PLATE 7

FIGURES 1–4. *Prosphingites austini* Hyatt and Smith (p. 98). Side, front, and rear views and septum of the type specimen.

FIGURES 5–25. *Juvenites dieneri* Hyatt and Smith (p. 109).

5, 6. Side and rear views.

7–9. Side and front views and septum.

10–13. Side, front, and rear views and septum of the type specimen.

14. Inside view of part of the body chamber broken from the specimen shown in Figures 10–13.

15–18. Side, front, and rear views and septum of an adolescent specimen; diameter 9.5 millimeters.

19–21. Side, front, and rear views of an adolescent specimen, showing the shell.

22–25. Side, front, and rear views and septum of a larval specimen having a diameter of 2.6 millimeters.

FIGURES 26–33. *Xenodiscus marcoui* Hyatt and Smith (p. 47).

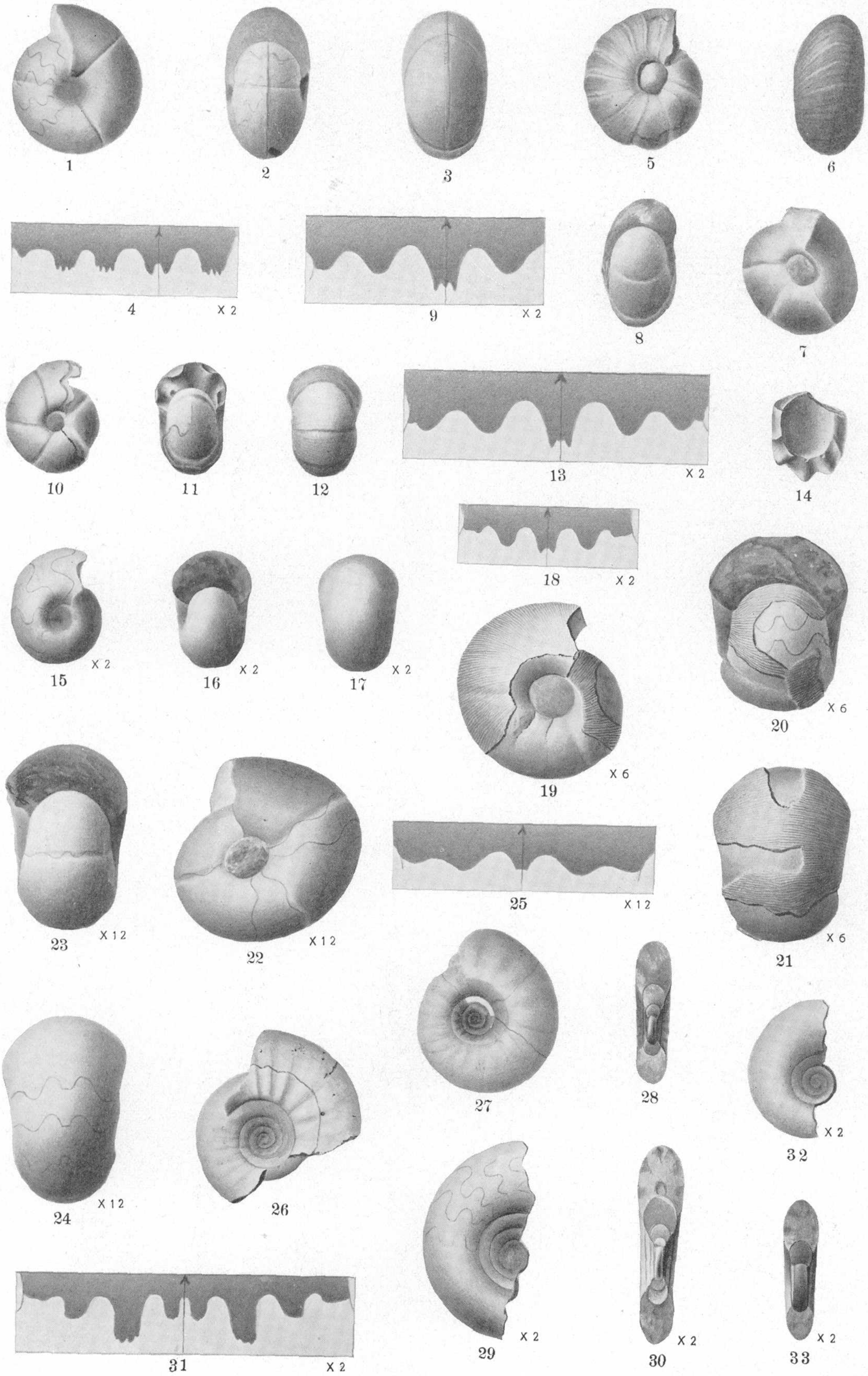
26. Side view.

27, 28. Side view and cross section of a broken whorl.

29–31. Side view, cross section, and septum.

32, 33. Side and front views of an adolescent specimen.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.



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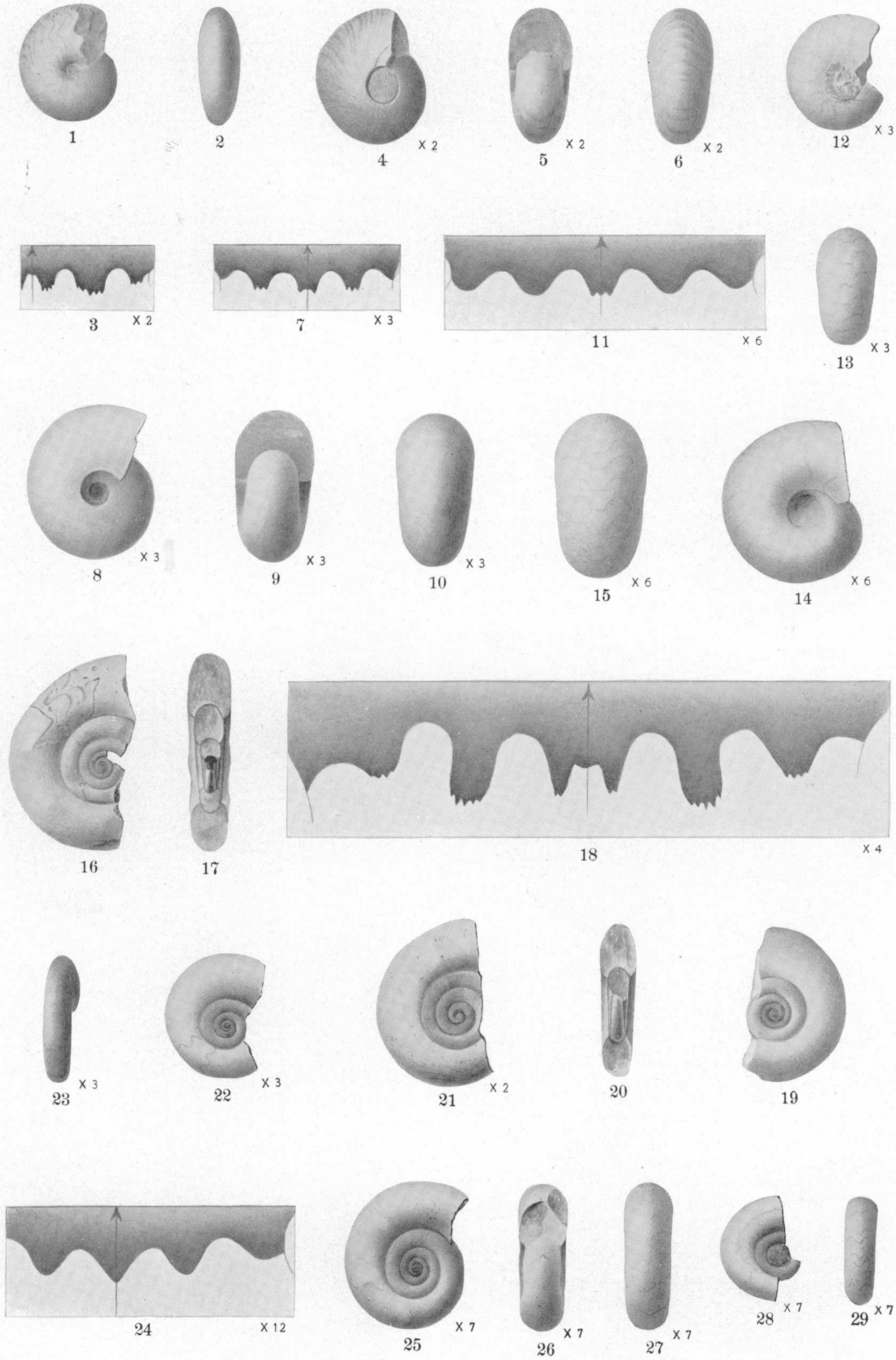


LOWER TRIASSIC AMMONOIDS

PLATE 8

FIGURES 1–15. *Paranannites aspenensis* Hyatt and Smith (p. 98).

1–3. Side and rear views and septum of a specimen of which the outline has been partly restored, as shown in the shading.

4–6. Side, front, and rear views.

7. Septum of the same specimen.

8–10. Side, front, and rear view of an adolescent specimen.

11. Septum from specimen shown in Figures 8–10.

12, 13. Side and rear views of an adolescent specimen; diameter 6 millimeters.

14, 15. Side and rear views of a specimen showing the transition from *Aganides* to *Nannites;* diameter 4 millimeters.

FIGURES 16–29. *Ophiceras dieneri* Hyatt and Smith (p. 48).

16–18. Side and front views and septum of the type specimen.

19, 20. Side and front views of a smaller specimen.

21. Side view of an adolescent specimen.

22, 23. Side and rear views of a specimen; diameter 5.5 millimeters.

24. Septum of the same specimen.

25–27. Side, front, and rear views of young specimen; diameter 3.5 millimeters.

28, 29. Side and rear views of larval specimen; diameter 2.5 millimeters.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, Idaho. Collection of United States National Museum.

PLATE 9

FIGURES 1–3. *Anasibirites noetlingi* Hyatt and Smith (p. 74). Side, front, and rear views.

FIGURES 4–10. *Danubites strongi* Hyatt and Smith (p. 85).

4–6. Side and front views and septum of the type specimen.

7, 8. Side and end views of a fragment of the body chamber, showing the normal shape of the cross section.

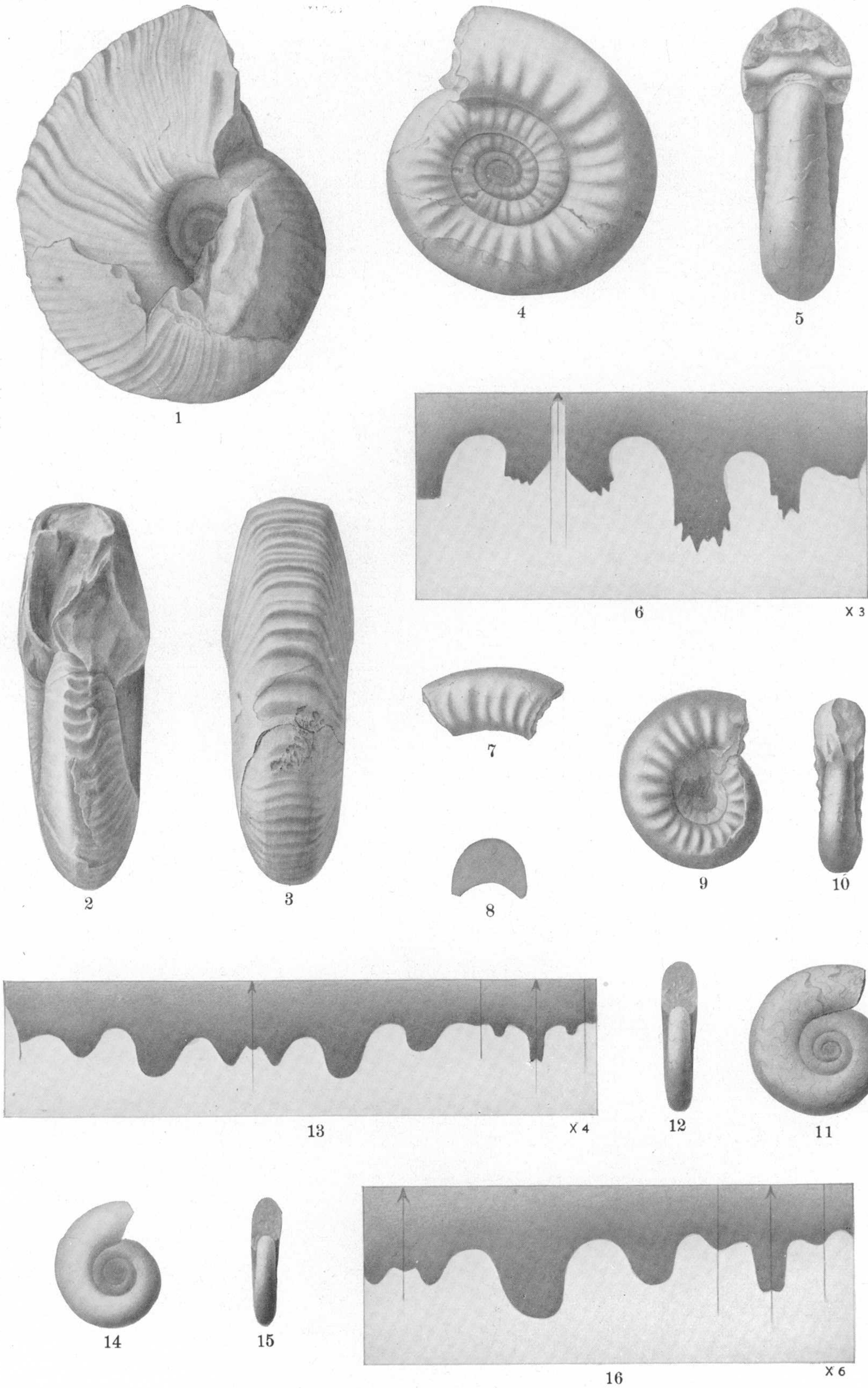
9, 10. Side and front views of a smaller specimen.

FIGURES 11–16. *Lecanites knechti* Hyatt and Smith (p. 41).

11–13. Side and front views and septum of the type specimen.

14–16. Side and front views and septum of a smaller specimen.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.



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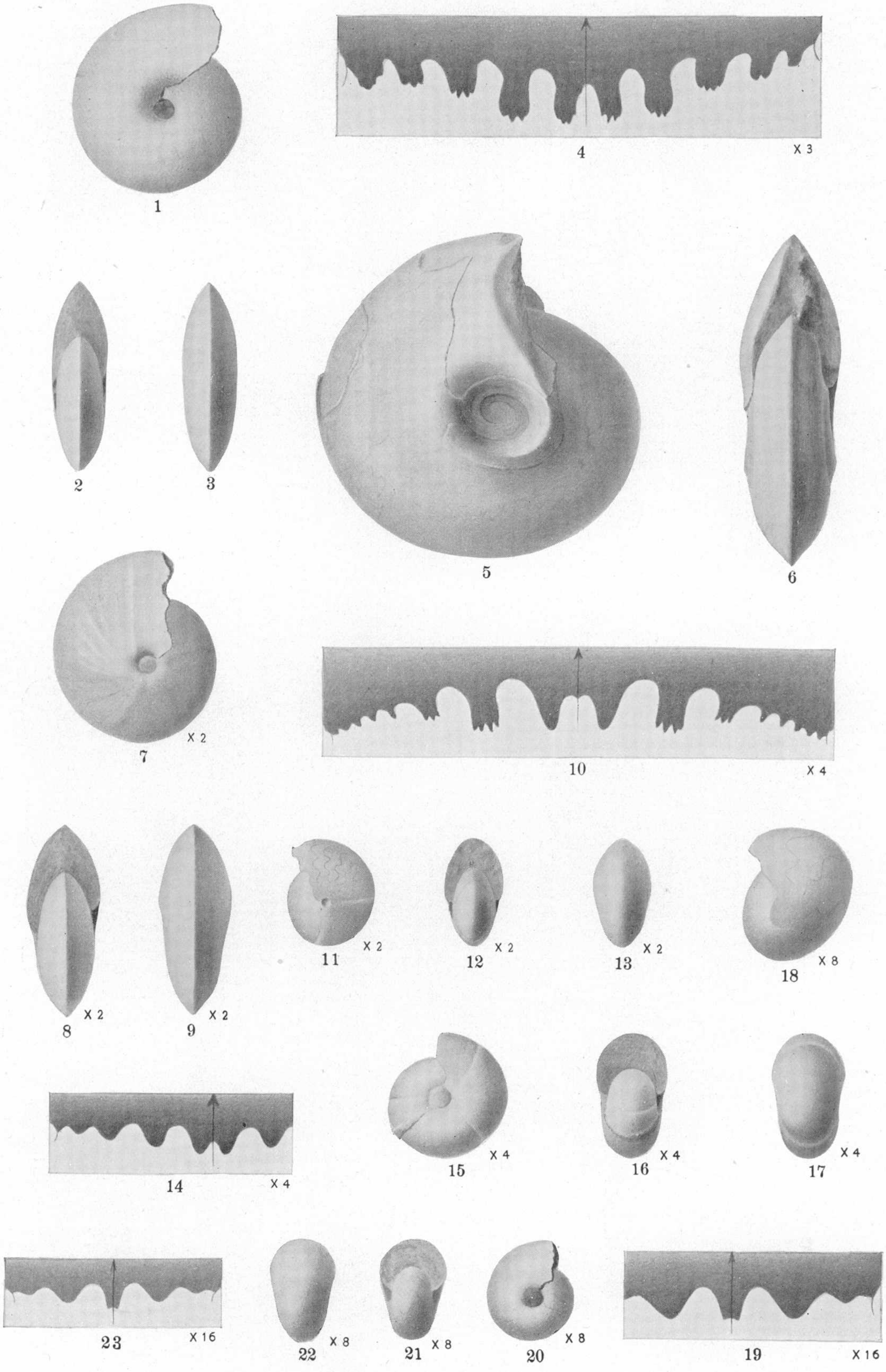


LOWER TRIASSIC AMMONOIDS

PLATE 10

FIGURES 1–23. *Owenites koeneni* Hyatt and Smith (p. 100).

1–4. Side, front, and rear views and septum of the type specimen.

5, 6. Side and front views of a specimen showing only the body chamber in the last volution.

7–10. Side, front, and rear views and septum of adolescent specimen, showing the transition from goniatite to ceratitic stage; diameter 15 millimeters.

11–13. Side, front, and rear views of an adolescent specimen, showing only the goniatite stage; diameter 9 millimeters.

14. Septum from the same specimen.

15–17. Side, front, and rear views of small adolescent specimen; diameter 5 millimeters.

18, 19. Left side and septum of larval specimen, showing *Nannites* stage; diameter 2.4 millimeters.

20–23. Side, front, and rear views and septum of larval shell showing the *Nannites* stage; diameter 1.9 millimeters.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

PLATE 11

FIGURES 1–14. *Flemingites aplanatus* White (p. 52).

1–3. Side and front views and septum of White's type specimen. (U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, pl. 31, figs. 1a, 1b, and 1d, 1880.)

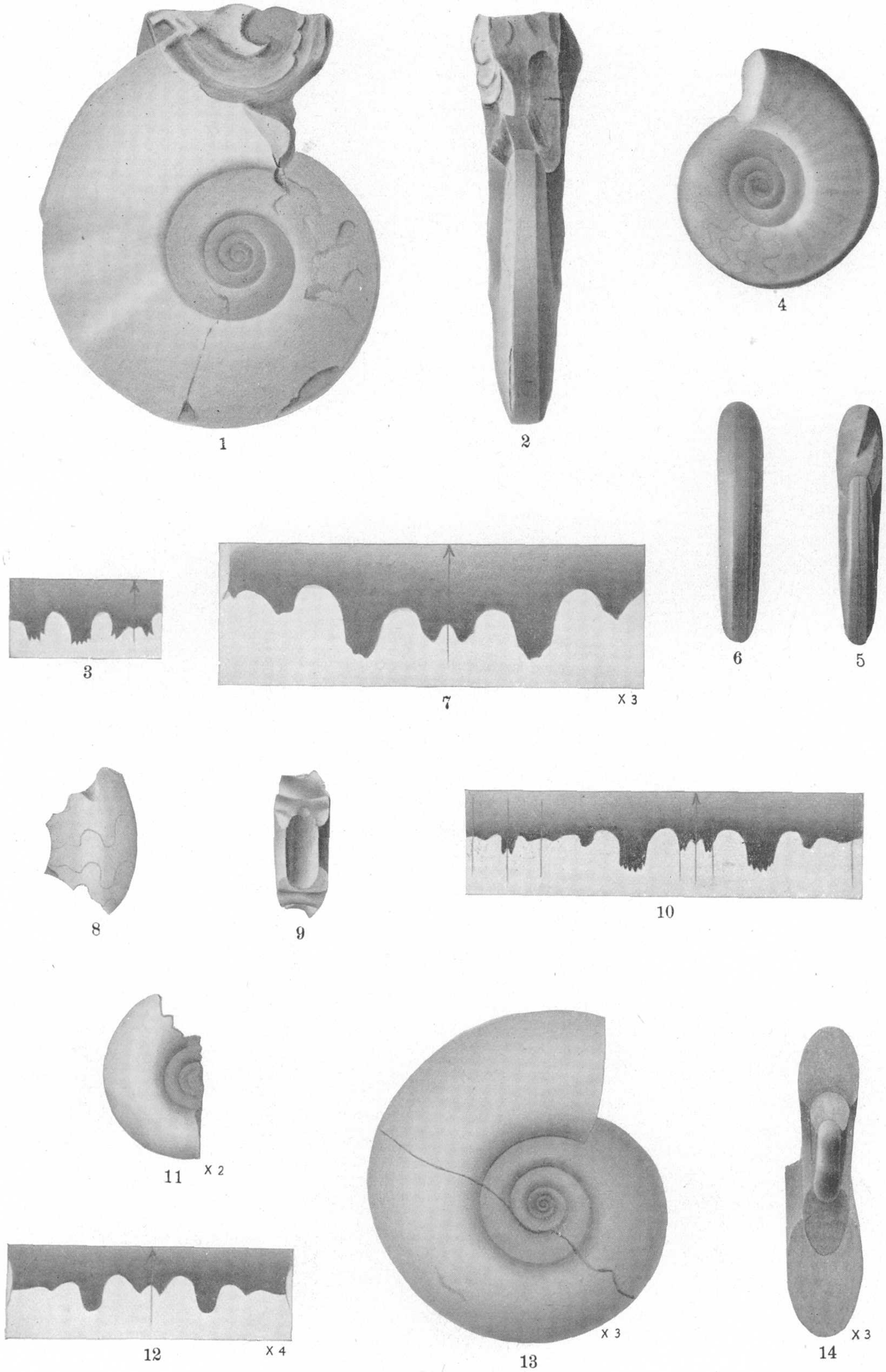
4–7. Side, front, and rear views and septum of an adult specimen.

8–10. Side and front views and septum of a fragment of the chambered shell.

11, 12. Side view and septum of an adolescent specimen, showing the *Lecanites* stage.

13, 14. Side and cross section.

From Lower Triassic *Meekoceras* zone, southeastern Idaho. Specimen shown in Figures 1–3 from locality 2 of White, 50 miles north of the Utah line and about 18 miles west of the Wyoming line; specimen shown in Figures 4–14 from Wood Canyon, 9 miles east of Soda Springs, Aspen Mountains, Idaho. Collection of United States National Museum.



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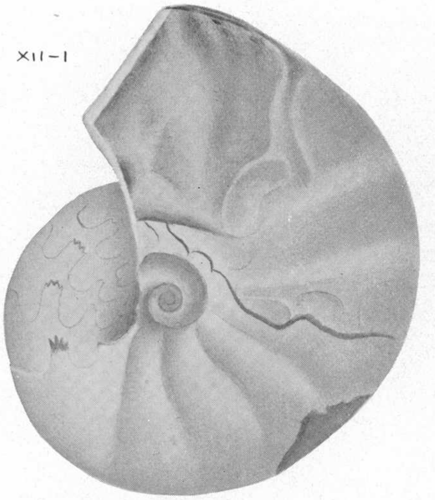
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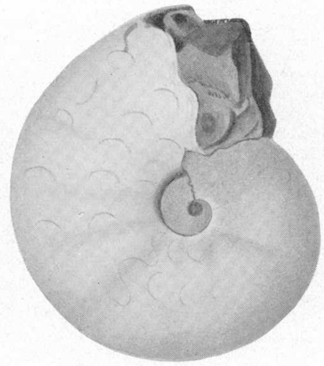
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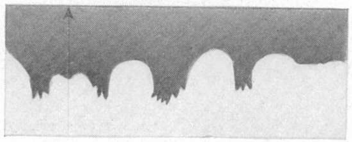
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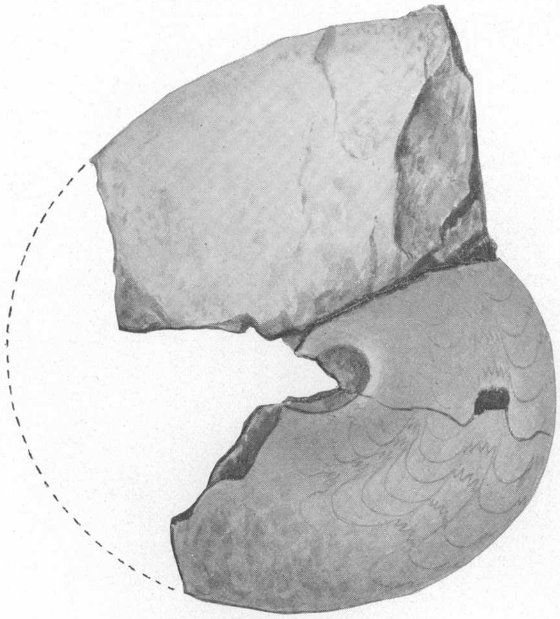
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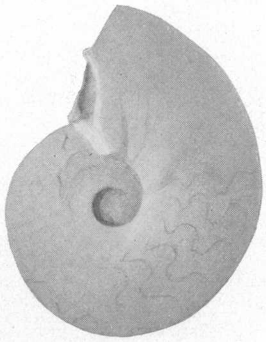
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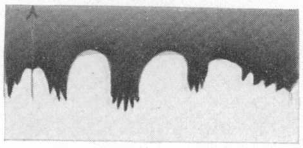
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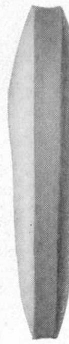
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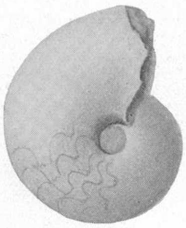
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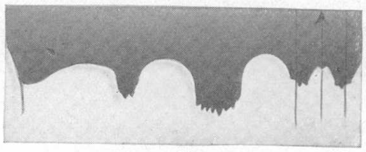
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LOWER TRIASSIC AMMONOIDS

PLATE 12

FIGURES 1–13. *Meekoceras gracilitatis* White (p. 57).

1. Side view of White's type specimen. (Copied from pl. 31, fig. 2a, of White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1.)

2, 3. Side and front views of a smaller specimen. (Copied from White's pl. 31, figs. 2b, 2c.)

4. Septum of a larger specimen. (Copied from White's pl. 31, fig. 2d.)

5, 6. Side view and septum of a large specimen.

7–10. Side, front, and rear views and septum of a smaller specimen.

11–13. Side, front, and rear.

From Lower Triassic *Meekoceras* zone, southeastern Idaho. Specimens shown in Figures 1–4 from locality 1 of White, 65 miles north of the Utah line and 18 miles west of Wyoming; specimens shown in Figures 5–13 from Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, Idaho. Collection of United States National Museum.

PLATE 13

Figures 1–18. *Meekoceras gracilitatis* White (p. 57).

1. Broken specimen showing cross section of the whorls (locality 1 of White).

2–4. Side and front views and septum; diameter 14.5 millimeters.

5. Side view of the adolescent specimen, showing the end of the goniatite stage; diameter 12 millimeters.

6, 7. Side and front views; diameter 5.5 millimeters.

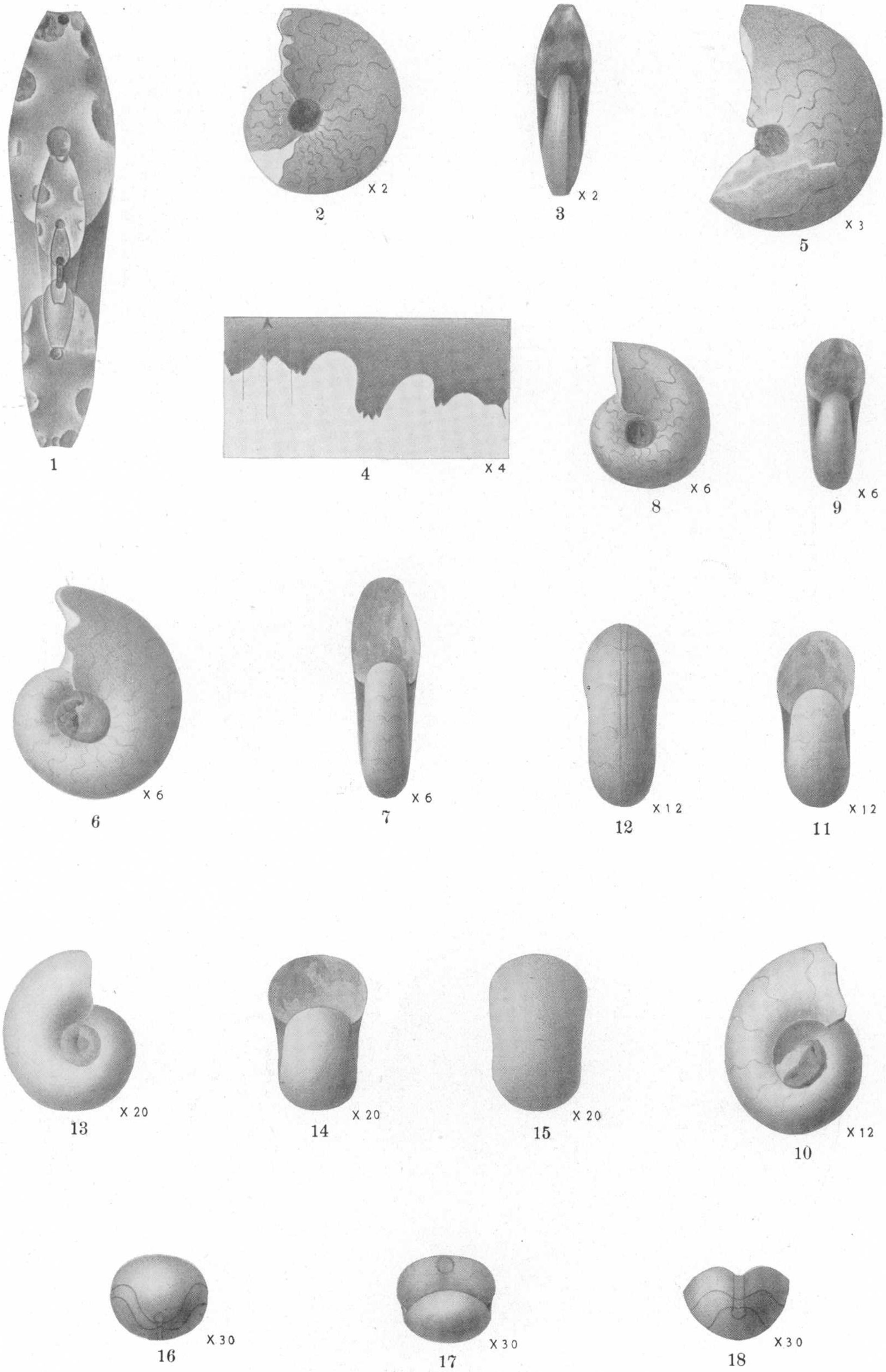
8, 9. Side and front views; diameter 4.5 millimeters.

10–12. Side, front, and rear views; diameter 2.56 millimeters.

13–15. Side, front, and rear views of larval specimens; diameter 1.32 millimeters.

16–18. Front and top views; protoconch with two chambers attached; diameter 0.6 millimeter.

From Lower Triassic *Meekoceras* zone, Wood Canyon, 9 miles east of Soda Springs, Aspen Ridge, Idaho. Collection of United States National Museum.



LOWER TRIASSIC AMMONOIDS

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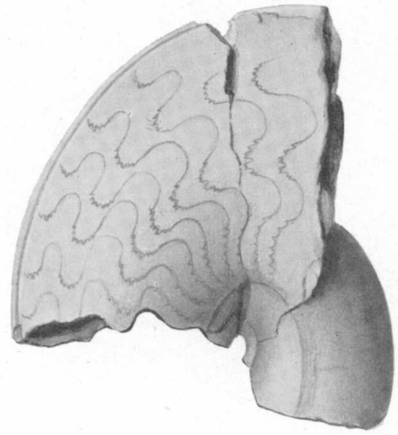
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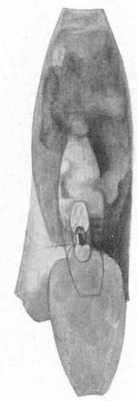
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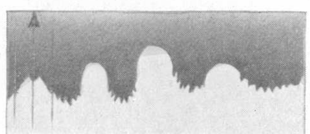
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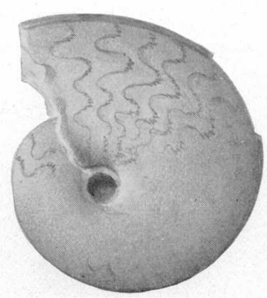
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LOWER TRIASSIC AMMONOIDS

PLATE 14

FIGURES 1–8. *Meekoceras gracilitatis* White (p. 57).

1–3. Side and rear views and septum of a broken specimen, showing cross section of the younger whorls.

4, 5. Side and front views of a smaller specimen.

6. Side view of a large specimen, showing the increasing evolution of the old whorl.

7, 8. Side and front views of an adolescent specimen.

From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Mountains, Inyo County, Calif. Collection of United States National Museum.

PLATE 15

FIGURES 1–9. *Meekoceras* (*Koninckites*) *mushbachanum* White (p. 61).

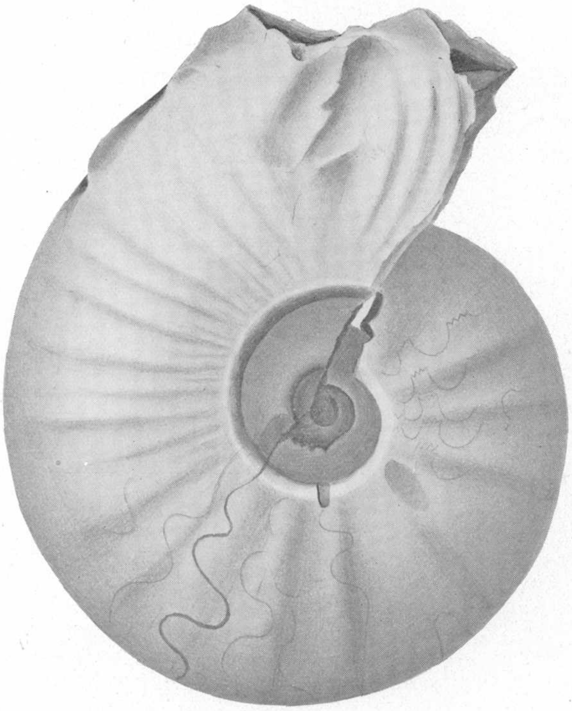
1–3. Side and front views and cross section of White's type specimen, after his Plate 31, Figures 1a, 1b, 1c.

4. Septum from a larger specimen, after White's Plate 31, Figure 1d.

5–7. Side and rear views and septum of a smaller specimen.

8, 9. Side view and septum of an adolescent specimen.

From Lower Triassic *Meekoceras* zone, Aspen Ridge, Idaho. Specimens shown in Figures 1–4 from locality 1 of White, 65 miles north of the Utah line and 18 miles west of the Wyoming line; specimens shown in Figures 5–9 from Wood Canyon, 9 miles east of Soda Springs. Collection of United States National Museum.



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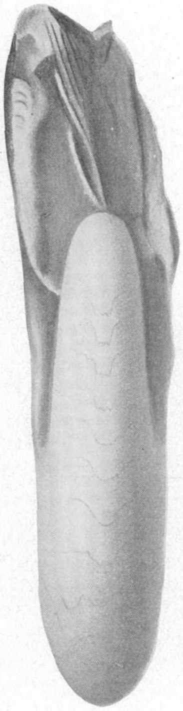

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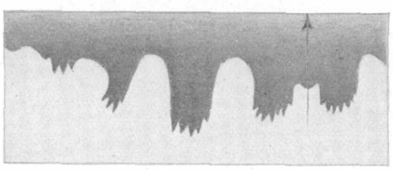

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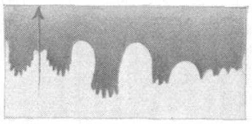

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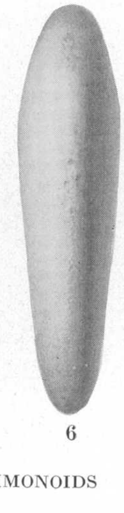

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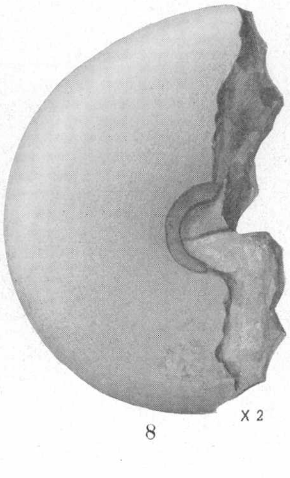

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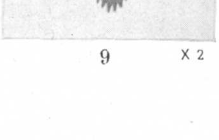

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LOWER TRIASSIC AMMONOIDS

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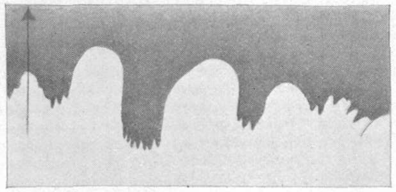

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LOWER TRIASSIC AMMONOIDS

PLATE 16

FIGURES 1–3. *Meekoceras (Koninckites) mushbachanum* White (p. 61). Side views and septum of a large specimen, showing the characteristic septum and shape of the whorl.

From Lower Triassic *Meekoceras* zone, southeastern Idaho, locality 1 of White, 65 miles north of the Utah line and 18 miles west of the Wyoming line. Collection of United States National Museum.

PLATE 17

FIGURES 1–12. *Clypeoceras hooveri* Hyatt and Smith (p. 63).

1–3. Side and rear views and septum of the type specimen. (Fig. 3, septum not correct in detail.)

4–6. Side and front views and septum of an adolescent specimen.

7, 8. Side and front views of a small specimen showing the *Meekoceras* stage.

9. Septum of the same specimen.

10–12. Side and front views and septum of an adolescent specimen, showing the *Lecanites* stage, broken out of a larger specimen. From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

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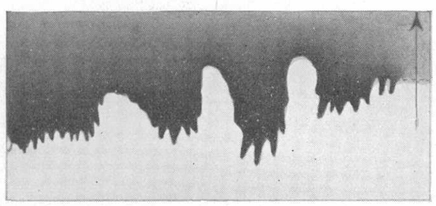

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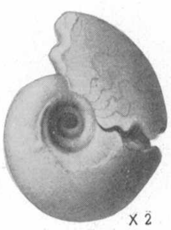

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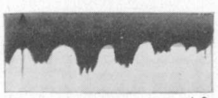

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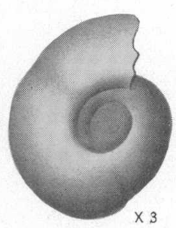

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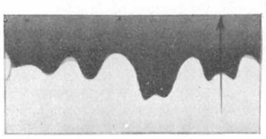
11 X 3



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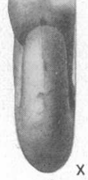

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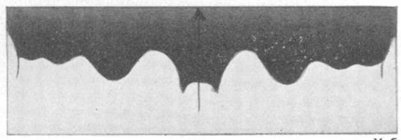
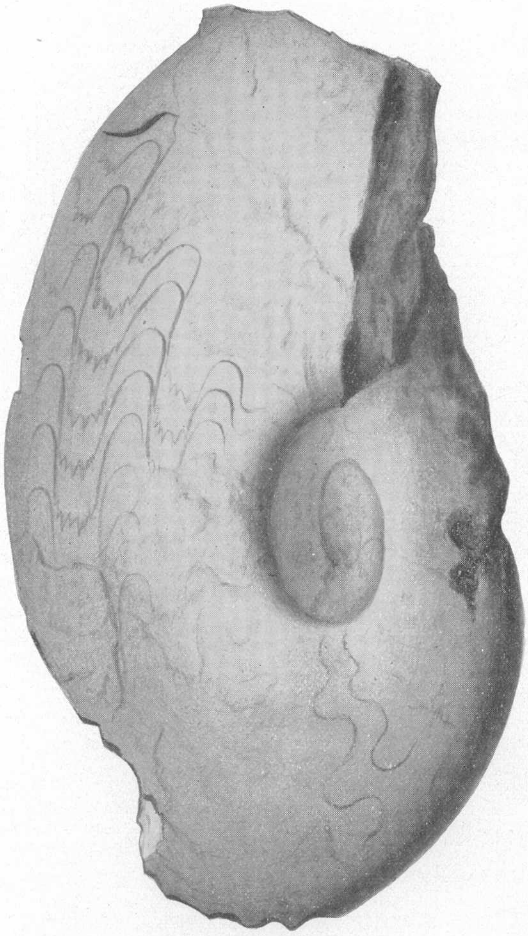


12 X 6

LOWER TRIASSIC AMMONOIDS



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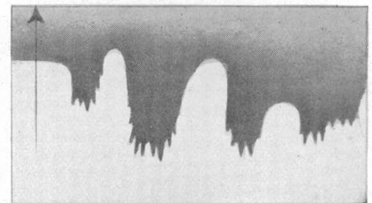

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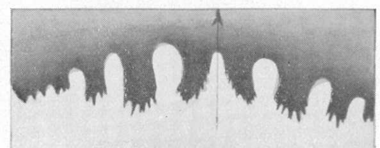

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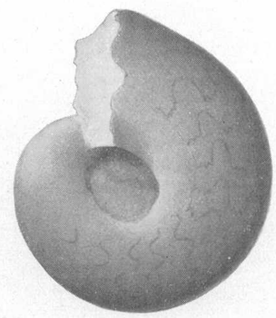

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7

LOWER TRIASSIC AMMONOIDS

PLATE 18

FIGURES 1–7. *Meekoceras* (*Koninckites*) *mushbachanum* White (p. 61).

1, 2. Side view and septum of a large specimen.

3–5. Side and rear views and septum of a smaller specimen.

6, 7. Side and front views of an immature specimen.

From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

PLATE 19

FIGURES 1–7. *Proptychites walcotti* Hyatt and Smith (p. 102).

1–3. Side and front views and septum of the type specimen.

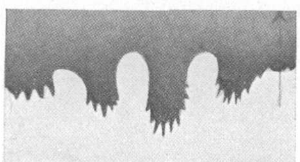
4–6. Side and front views and septum of a small specimen (broken out of the shell shown in fig. 7); diameter 10 millimeters.

7. Side view of a large shell out of which was broken the small specimen shown in Figures 4–6.

From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

1

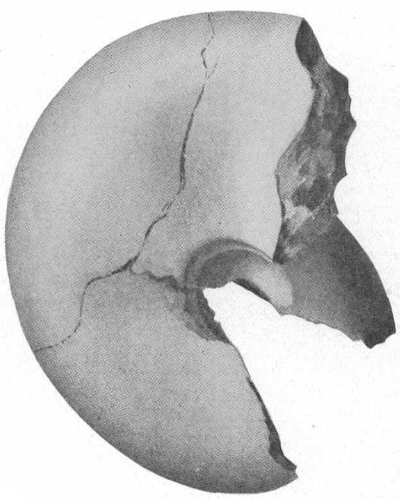
2



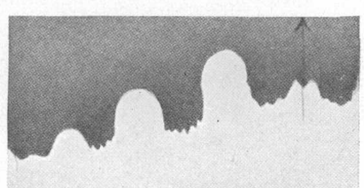
3

5 X 3

4 X 3



7



6 X 6

LOWER TRIASSIC AMMONOIDS

LOWER TRIASSIC AMMONOIDS

PLATE 20

Flemingites cirratus (White) (p. 53). Side view.

Lower Triassic *Meekoceras* zone, Rohner's ranch, 1 mile west of Paris, Idaho. Collection of United States Geological Survey.

PLATE 21

FIGURES 1–10. *Juvenites kraffti* Smith (p. 109).

1–3. Type.

4–6. Same specimen with half of the whorl removed.

7. Old-age form, showing sculpture and septum.

8–10. Adolescent stage; diameter 5 millimeters.

FIGURES 11–20. *Thermalites thermarum* Smith (p. 111).

11–14. Type.

15. Septum of another specimen.

16–18. Adult specimen, showing typical sculpture.

19, 20. Early mature stage; diameter 10 millimeters.

FIGURES 21–23. *Lanceolites compactus* Hyatt and Smith (p. 90). Adolescent stage; diameter 8 millimeters.

FIGURES 24–40. *Ussuria waageni* Hyatt and Smith (p. 92).

24–26. Larval stage, corresponding to *Manticoceras;* diameter 1.8 millimeters.

27–29. Larval stage, transitional from *Manticoceras* to *Dimorphoceras;* diameter 4.4 millimeters.

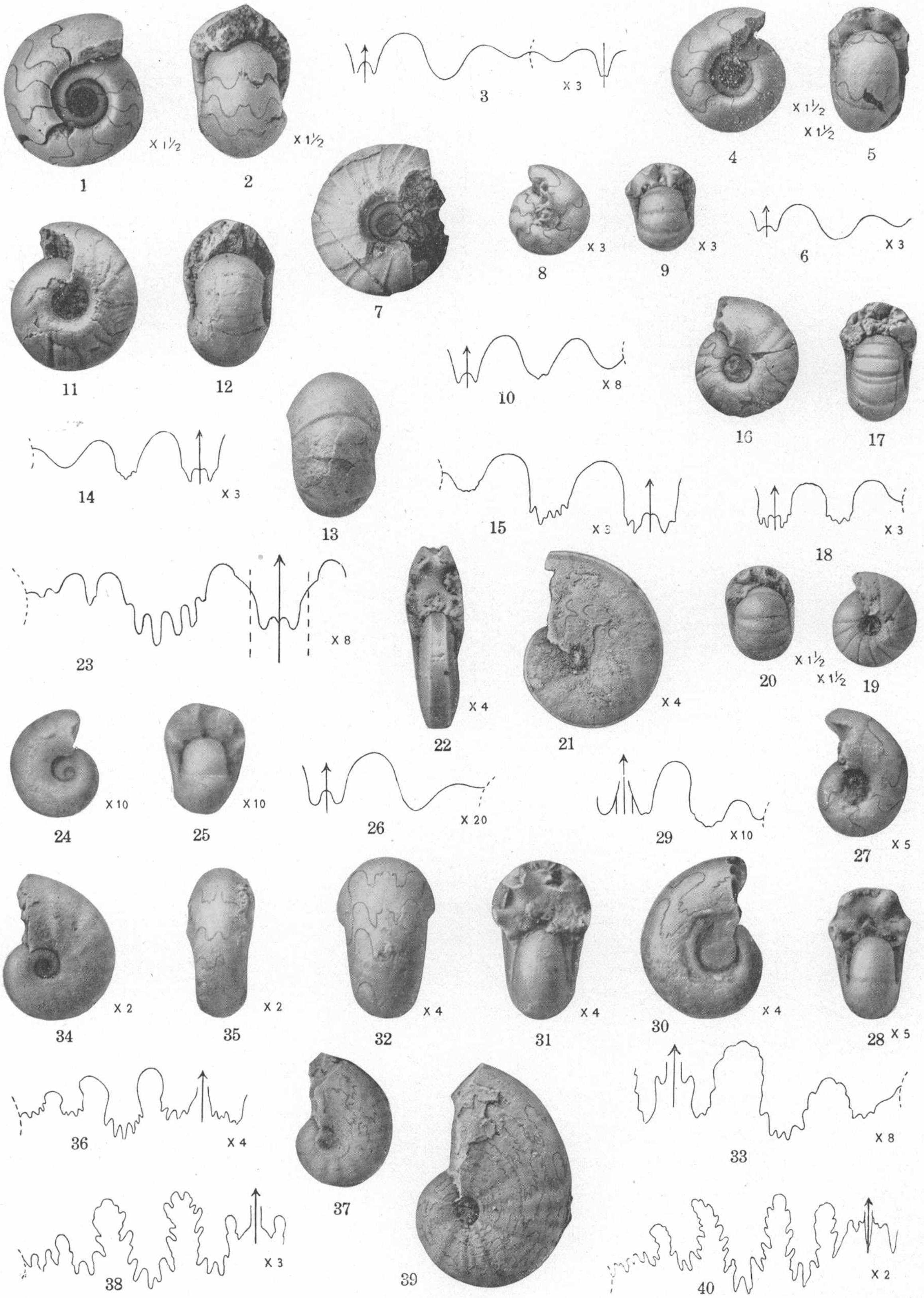
30–33. Early adolescent stage, transitional from *Dimorphoceras* to *Thalassoceras;* diameter 6.5 millimeters.

34–36. Adolescent stage, diameter 12 millimeters; resembling *Thalassoceras.*

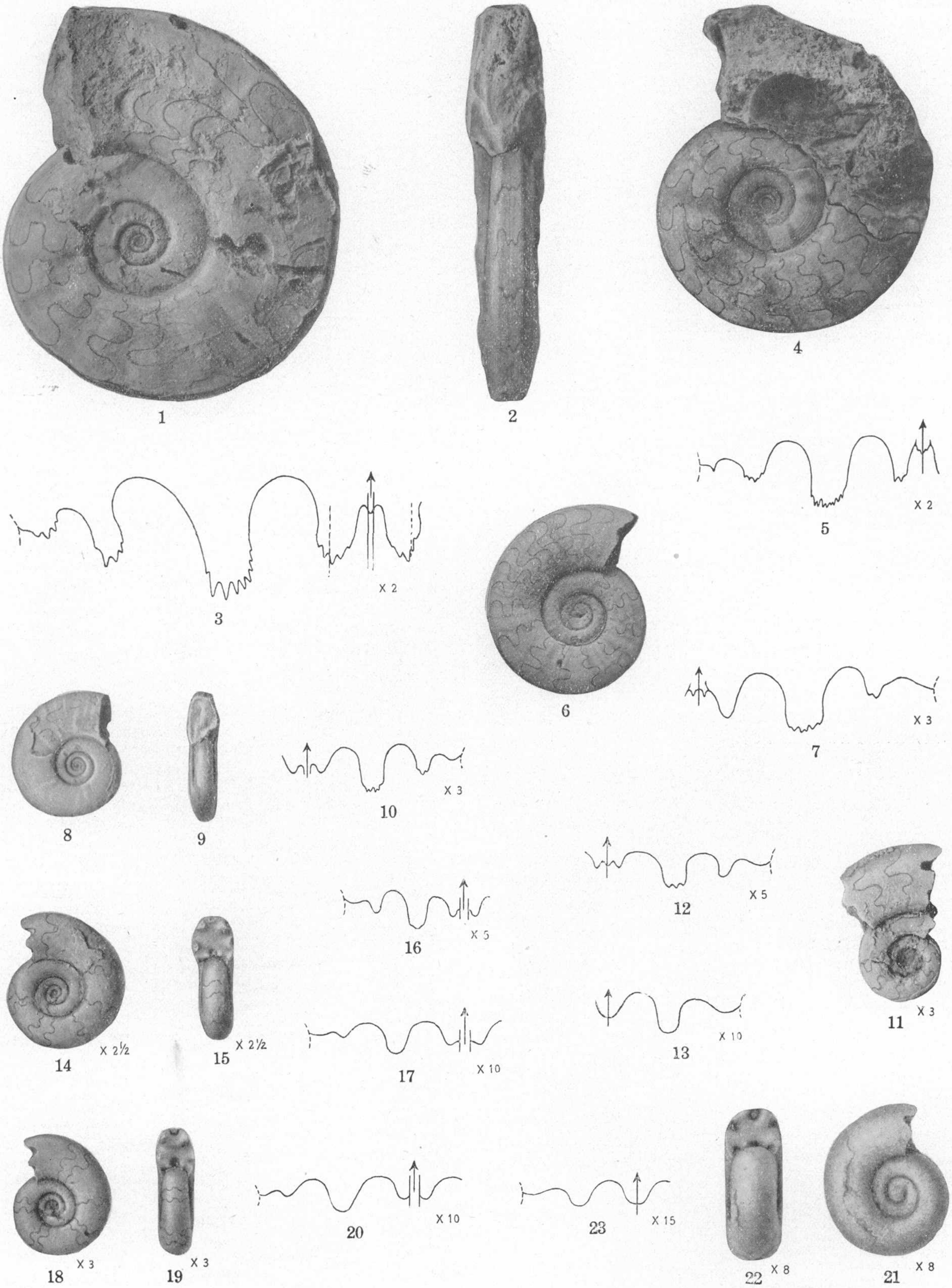
37, 38. Early mature stage, showing beginning of adventitious lobes.

39, 40. Early mature stage, showing adventitious lobes.

All specimens figured in this plate came from the Lower Triassic *Meekoceras* zone of southeastern Idaho. Collection of United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 22

FIGURES 1–23. *Flemingites aplanatus* White (p. 51).

1, 2. Adult specimen, side and front views.
3. Septum of the same specimen.
4. Early mature stage, side view.
5. Septum of the same specimen.
6. Early mature stage, diameter 34 millimeters.
7. Septum of the same specimen.
8, 9. Late adolescent stage, diameter 27 millimeters, transitional from *Xenodiscus* to *Flemingites*.
10. Septum of the same specimen.
11. Larval stage at diameter 6 millimeters corresponding to *Lecanites*, included in broken specimen of diameter 13 millimeters corresponding to *Xenodiscus*.
12. Septum of the same specimen at diameter 12 millimeters.
13. Septum of the same specimen at diameter 5 millimeters.
14, 15. Larval stage, diameter 10 millimeters, corresponding to *Xenodiscus*, showing transition from *Lecanites* at 7 millimeters diameter.
16. Septum of the same specimen, *Xenodiscus* stage, diameter 10 millimeters.
17. Septum of the same specimen, *Lecanites* stage, diameter 6 millimeters.
18, 19. Larval stage, diameter 7 millimeters, corresponding to *Lecanites*, showing transition from *Prolecanites*.
20. Septum of the same specimen.
21, 22. Early larval stage, diameter 3 millimeters, transitional from *Gephyroceras* to *Prolecanites*.
23. Septum of the same specimen.

The original of Figure 1 came from locality 3, Wood Canyon, 9 miles east of Soda Springs, Idaho; the originals of Figures 4 and 8 from locality 2, head of Slug Creek, 14 miles east of Hot Springs, Idaho; the original of Figure 6 from locality 1, 1 mile east of Grays Lake, Idaho; the originals of Figures 11, 14, 18, and 21 from locality 1, 5 miles east of Grays Lake. They were collected from the Lower Triassic *Meekoceras* zone by J. P. Smith and are in the collection of the United States Geological Survey.

PLATE 23

FIGURES 1–5. *Flemingites russelli* Hyatt and Smith var. *gracilis* Smith (p. 53).

1, 2. Type.

3. Septum of the same specimen.

4, 5. Adolescent specimen.

FIGURES 6–11. *Flemingites aspenensis* Smith, n. sp. (p. 52).

6, 7. Type.

8. Septum of the type.

9, 10. Adolescent stage, transitional from *Lecanites* to *Xenodiscus*, diameter 13 millimeters.

11. Septum of the same specimen.

FIGURES 12–17. *Xenodiscus waageni* Hyatt and Smith (p. 46).

12, 13. Type.

14. Septum of the same specimen.

15, 16. Larval stage, diameter 4 millimeters, corresponding to *Prolecanites*.

17. Septum of the same specimen.

FIGURES 18–26. *Flemingites bannockensis* Smith (p. 52).

18, 19. Type.

20. Septum of the type.

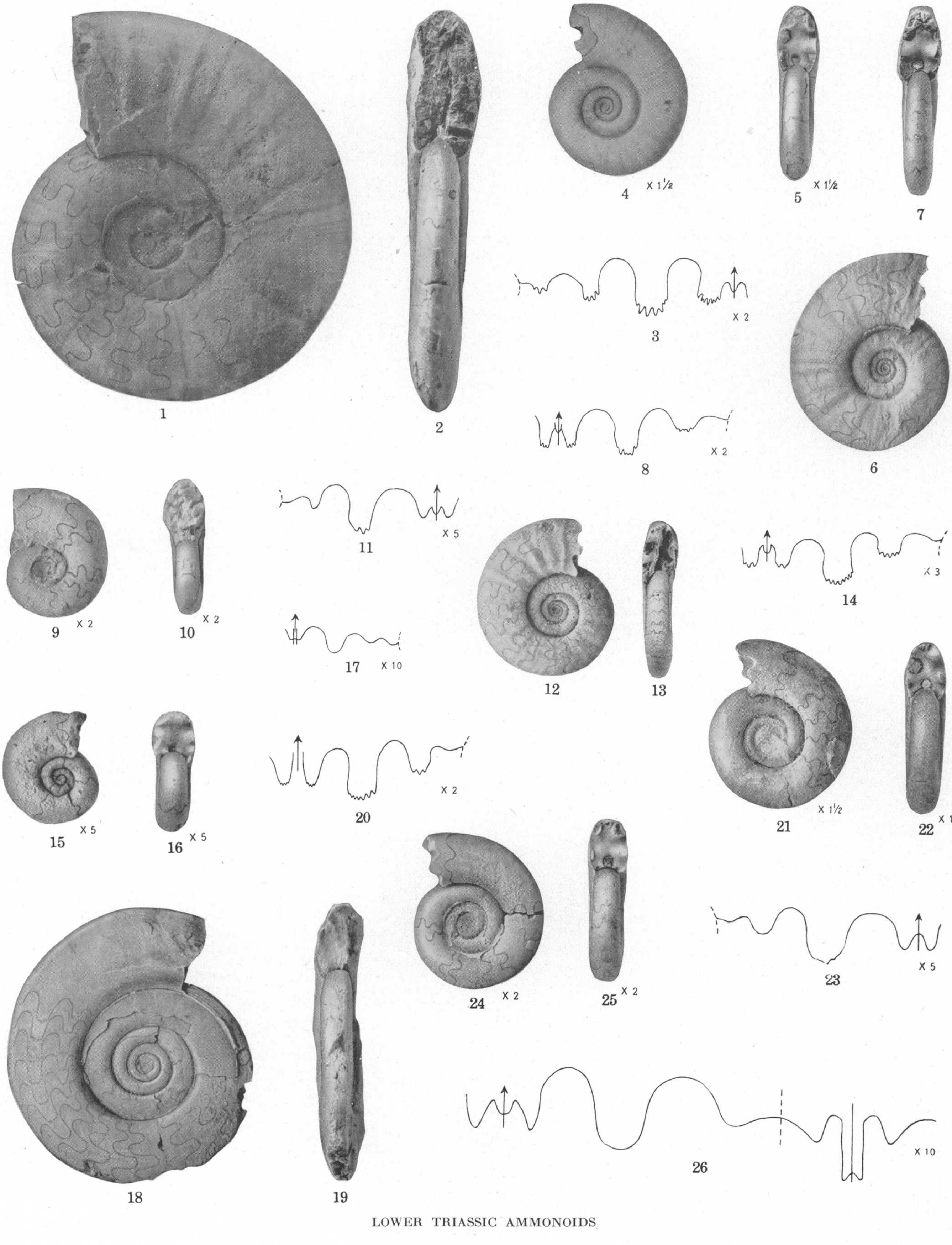
21, 22. Adolescent specimen, *Xenodiscus* stage, diameter 21 millimeters.

23. Septum of the same specimen.

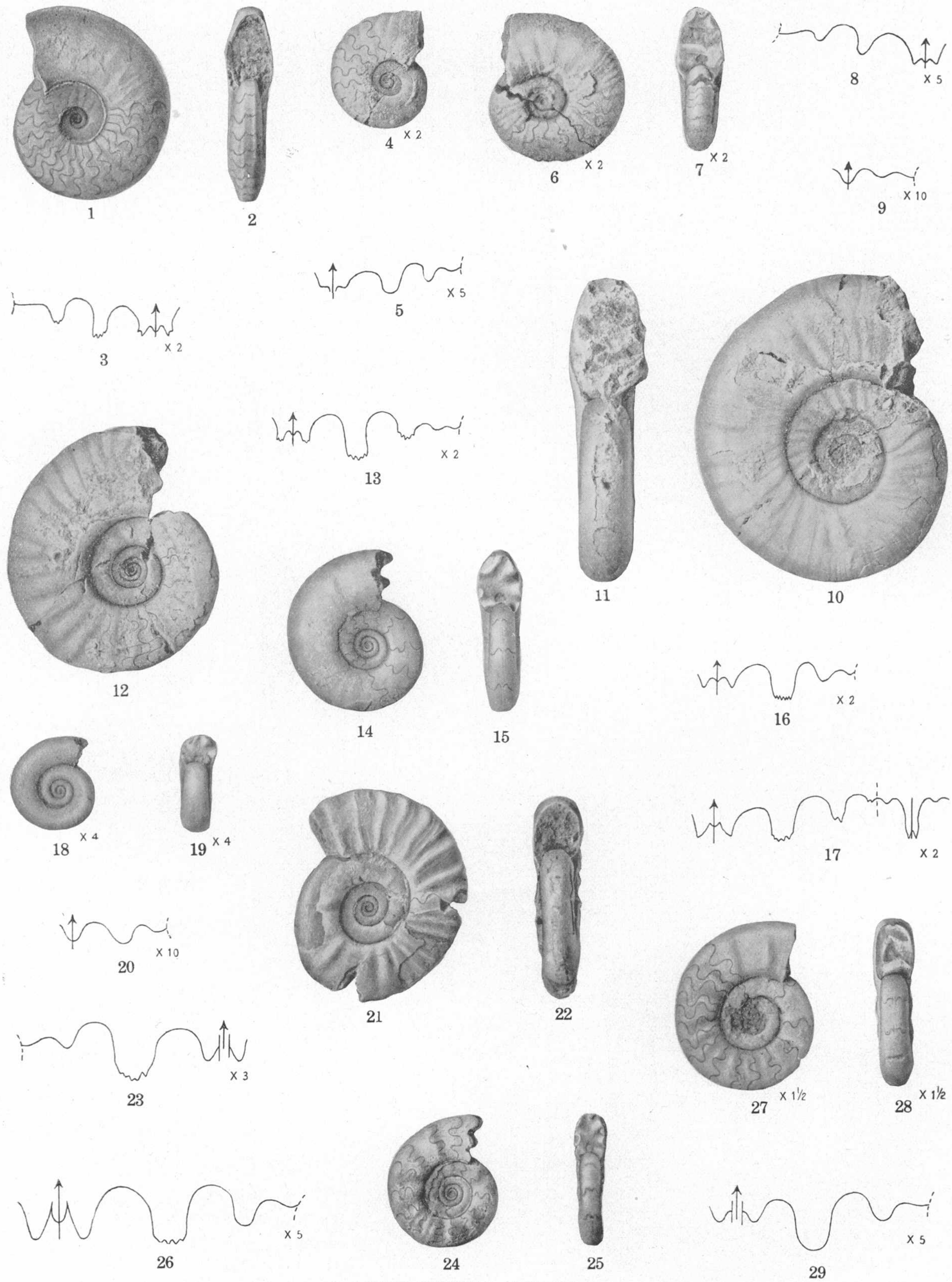
24, 25. Larval stage, corresponding to *Lecanites*, diameter 12 millimeters.

26. Septum of the same specimen.

The originals of Figures 1, 4, 18, 21, and 24 came from locality 2, head of Slug Creek, Aspen Mountains, 14 miles east of Soda Springs, Idaho; the originals of Figures 6, 9, 12, and 15 from locality 1, 5 miles southeast of Grays Lake, southeastern Idaho. They were collected from the Lower Triassic *Meekoceras* zone by J. P. Smith and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 24

FIGURES 1–9. *Xenodiscus gilberti* Smith, n. sp. (p. 43).
1, 2. Type.
3. Septum of the type.
4. Late larval stage, corresponding to *Lecanites*, diameter 10 millimeters.
5. Septum of the same specimen.
6, 7. Late larval stage.
8. Septum of the same specimen at diameter 12 millimeters.
9. Septum of the inner whorl of the same specimen, showing *Prolecanites* stage.

FIGURES 10–20. *Xenodiscus intermontanus* Smith, n. sp. (p. 44).
10, 11. Type.
12. Paratype. Side view.
13. Septum of paratype.
14, 15. Early mature stage.
16. Septum of the same specimen.
17. Septum of an older part of the same specimen.
18, 19. Larval stage, diameter 4 millimeters, corresponding to *Prolecanites*.
20. Septum of the same specimen.

FIGURES 21–29. *Xenodiscus cordilleranus* Smith, n. sp. (p. 43).
21, 22. Type.
23. Septum of the type.
24, 25. Adolescent specimen, beginning of *Xenodiscus* stage.
26. Septum of the same specimen.
27, 28. Late larval stage, diameter 19 millimeters, corresponding to *Lecanites*.
29. Septum of the same specimen.

The original of Figures 1, 4, 6, 12, 14, 18, 21 came from the Lower Triassic *Meekoceras* zone, locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, southeastern Idaho; the original of Figure 10 from the same horizon, locality 2, head of Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; the originals of Figures 24 and 27 from the same horizon, locality 1, 5 miles southeast of Grays Lake, southeastern Idaho. They were collected by J. P. Smith and are in the collection of the United States Geological Survey.

PLATE 25

FIGURES 1–3. *Xenodiscus toulai* Smith, n. sp. (p. 45).

1, 2. Type.

3. Septum of the type.

FIGURES 4–6. *Xenodiscus tarpeyi* Smith, n. sp. (p. 45).

4, 5. Type.

6. Septum of the type.

FIGURES 7–11. *Pseudosageceras multilobatum* Noetling (p. 87).

7, 8. Mature specimen.

9. Septum of the same specimen.

10, 11. Larval stage, diameter 12.5 millimeters, showing transition from *Beloceras*-like stage toward *Pseudosageceras*.

12. Septum of the same specimen at diameter 9 millimeters, showing beginning of *Pseudosageceras* stage.

13. Septum of the same specimen, diameter 8.5 millimeters.

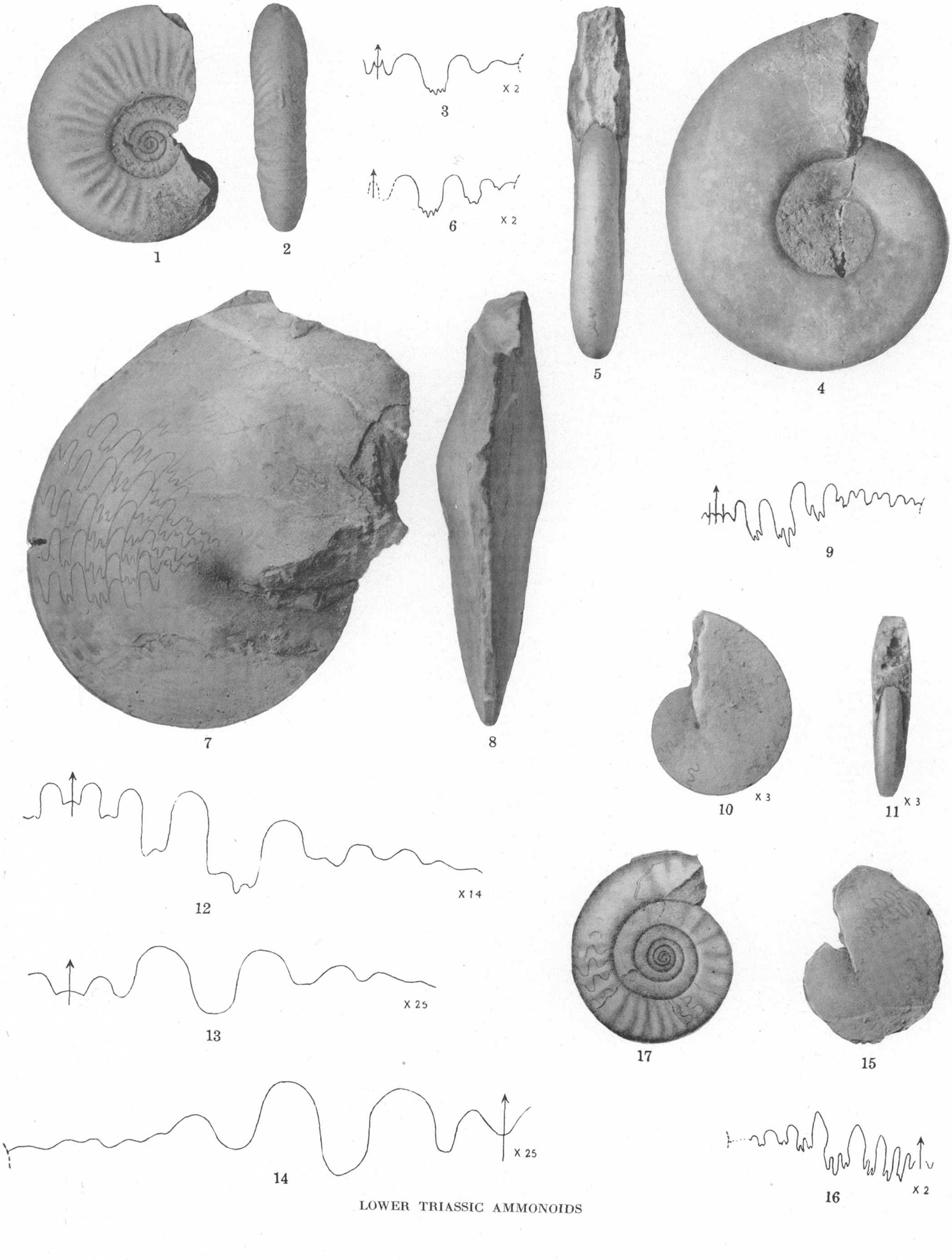
14. Septum of the same specimen, diameter 5.5 millimeters, showing resemblance to *Beloceras*.

15. Adolescent stage, diameter 38 millimeters, natural size.

16. Septum of the same specimen (× 2).

FIGURE 17. *Xenodiscus whiteanus* Waagen (p. 46). Type figure. (Copied from White, C. A., U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, pl. 31, fig. 1c [= "*Meekoceras aplanatum* White," part], locality 2, Slug Creek, southeastern Idaho.)

The originals of Figures 1, 4, and 10 came from the *Meekoceras* zone, at locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs, Idaho; the originals of Figures 7, 15, and 17 from the same horizon, at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs; they were collected by J. P. Smith and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS

LOWER TRIASSIC AMMONOIDS

PLATE 26

FIGURES 1–13. *Flemingites cirratus* (White) (p. 53).

1. Left side.
2, 3, 4. Left and front views and septum.
5, 6. Adolescent specimen, diameter 10.5 millimeters, left and front views.
7. Septum of the same specimen.
8. Septum of the same specimen at diameter 6 millimeters, showing *Lecanites* stage.
9. Larval stage, diameter 5 millimeters.
10. Septum of the same specimen at diameter 2.5 millimeters, *Paralecanites* stage.
11, 12. Early larval stage, diameter 1.5 millimeters, *Gephyroceras* stage.
13. Septum of the same specimen.

FIGURES 14–23. *Flemingites russelli* Hyatt and Smith (p. 53).

14. Adolescent stage, diameter 28 millimeters, showing *Flemingites* stage. With inner coil exposed, showing *Lecanites* stage, at diameter 7 millimeters.
15. Septum of the same specimen, *Flemingites* stage.
16. Septum of the same specimen at diameter 7 millimeters, *Lecanites* stage.
17, 18. *Xenodiscus* stage, diameter 11 millimeters, right side and front.
19. Septum of the same specimen.
20. Septum of the same specimen at diameter 6 millimeters, showing *Lecanites* stage.
21, 22. Larval stage, diameter 4½ millimeters, showing *Prolecanites* stage.
23. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, southeastern Idaho. The originals of Figures 1, 5, 9, 11, 14, and 17 came from locality 5, 1 mile east of Hot Spring, Bear Lake County, Idaho; the originals of Figures 2 and 21 from locality 9 of White, 5 miles east of Grays Lake and 1½ miles west of Williamsburg, Bannock County, Idaho. They were collected by J. P. Smith and are in the collection of the United States Geological Survey.

PLATE 27

FIGURES 1–7. *Clypeoceras muthianum* (Krafft) (p. 64).

1. Adult stage.
2. Septum of the same specimen.
3, 4. Early adult stage.
5. Septum of the same specimen.
6. Adolescent stage, diameter 20 millimeters.
7. Septum of the same specimen.

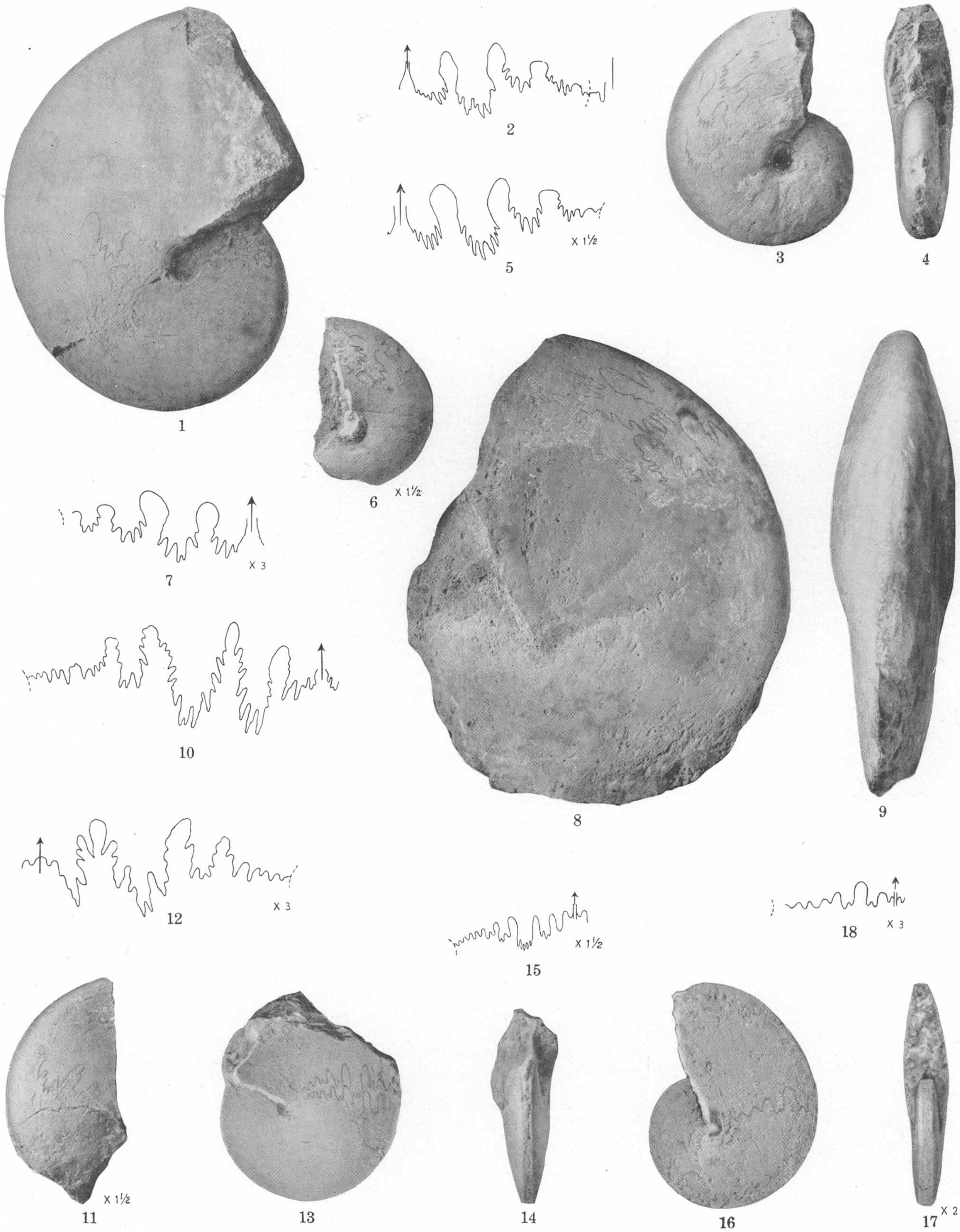
FIGURES 8–12. *Ussuria occidentalis* Smith, n. sp. (p. 91).

8, 9. Type.
10. Septum of the type.
11. Adolescent specimen, diameter 25 millimeters.
12. Septum of the same specimen.

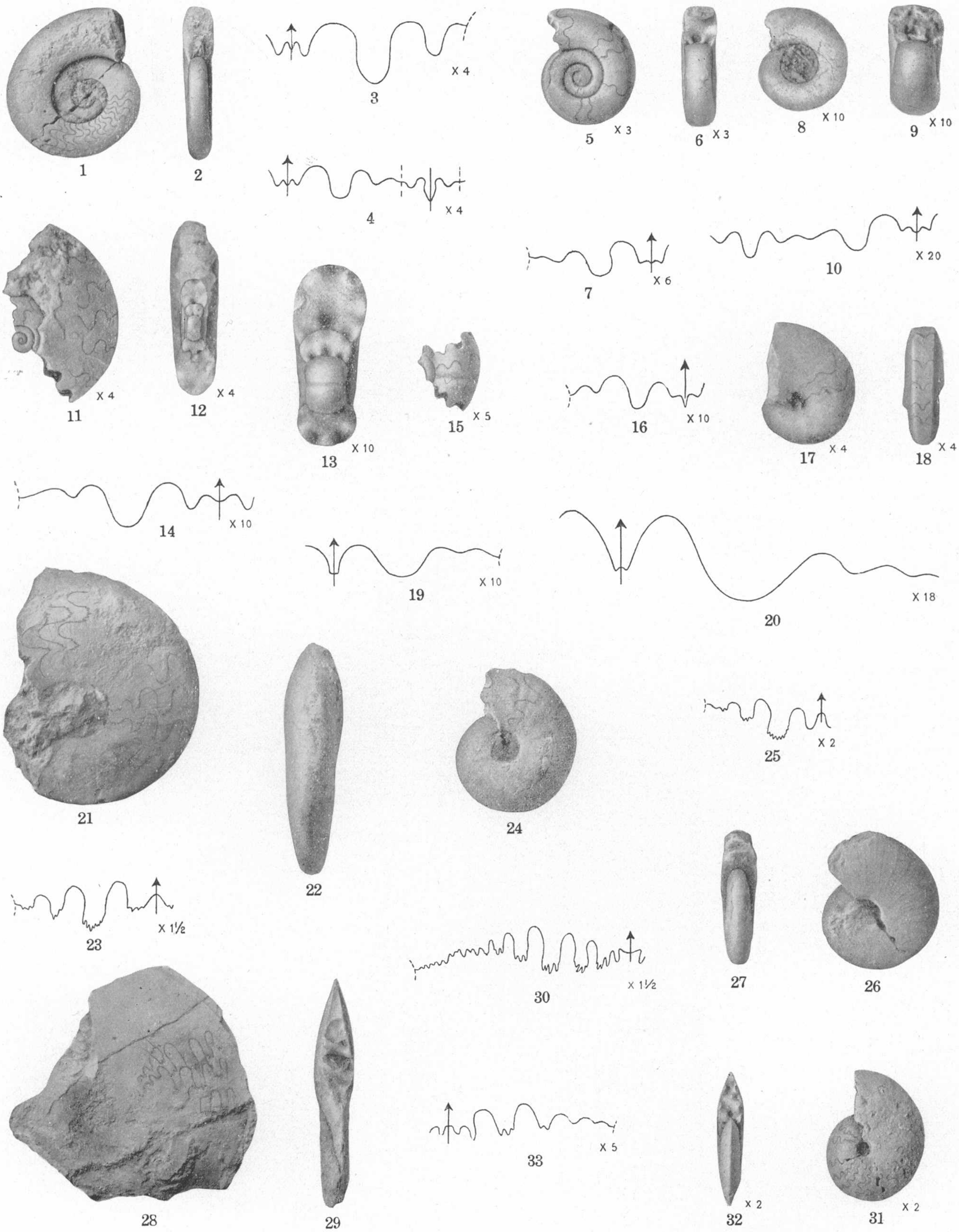
FIGURES 13–18. *Hedenstroemia hyatti* Smith, n. sp. (p. 78).

13, 14. Type.
15. Septum of the type.
16, 17. Adolescent specimen, diameter 20 millimeters.
18. Septum of same specimen.

The originals of Figures 1, 3, 6, 8, and 11 came from the Lower Triassic *Meekoceras* zone, locality 3, 9 miles east of Soda Springs, Aspen Mountains, southeastern Idaho; the original of Figure 13 from the same horizon, at locality 1, 5 miles southeast of Grays Lake, southeastern Idaho; the original of Figure 16 from the same horizon, at locality 2, Slug Creek, Aspen Mountains, 14 miles east of Soda Springs. They were collected by J. P. Smith and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 28

FIGURES 1–7. *Lecanites knechti* Hyatt and Smith (p. 41).
1, 2. Adult specimen.
3. Septum of the same specimen.
4. Septum of a smaller specimen.
5, 6. Larval stage, diameter 7 millimeters.
7. Septum of the same specimen.

FIGURES 8, 9. *Lecanites arnoldi* Hyatt and Smith (p. 41).
8, 9. Larval stage, diameter 1.75 millimeters, corresponding to *Prolecanites.*
10. Septum of the same specimen.

FIGURE 11–16. *Hedenstroemia kossmati* Hyatt and Smith (p. 78).
11, 12. Late larval stage, diameter 7.5 millimeters.
13. Inner coil of the same specimen.
14. Same specimen, septum at diameter 7 millimeters.
15. Broken coil of the same specimen at diameter 4 millimeters.
16. Septum of the same specimen.

FIGURES 17–20. *Lanceolites compactus* Hyatt and Smith (p. 90).
17–19. Larval stage, diameter 5.5 millimeters; shell and septum.
20. Septum of larval stage, diameter 4.5 millimeters.

FIGURES 21–27. *Meekoceras patelliforme* Smith, n. sp. (p. 58).
21, 22. Type,
23. Septum of the type.
24. Early mature stage.
25. Septum of the same specimen.
26, 27. Early mature stage, showing faint sculpture.

FIGURES 28–33. *Aspenites laevis* Welter (p. 86).
28, 29. Adult specimen.
30. Septum of the same specimen.
31, 32. Adolescent stage, diameter 17 millimeters.
33. Septum of the same specimen.

All specimens figured in this plate came from the Lower Triassic *Meekoceras* zone of southeastern Idaho. The originals of Figures 1, 8, 21, 24, 26, and 31 came from locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs; the originals of Figures 4 and 5 from locality 2, Slug Creek; the originals of Figures 11, 17, and 28 from locality 1, 5 miles east of Grays Lake. Collection of United States Geological Survey.

PLATE 29

FIGURES 1–8. *Dagnoceras haydeni* Smith, n. sp. (p. 66).

1–3. Type.

4, 5. Adolescent stage, diameter 14 millimeters.

6–8. Inside whorl of the same specimen, with one-third of a revolution removed. Shell, diameter 11.5 millimeters, and septum.

FIGURES 9–23. *Dagnoceras bonnevillense* Smith, n. sp. (p. 65).

9–11. Type.

12–14. Adult shell.

15–17. Transitional from larval to adolescent stage, diameter 11 millimeters; showing beginning of serration of septum, at diameter 7 millimeters.

18–20. Larval stage, diameter 5.5 millimeters, corresponding to *Lecanites*.

21–23. Larval stage, diameter 3 millimeters, transitional from *Prolecanites* to *Lecanites*.

FIGURES 24–37. *Dagnoceras pealei* Smith, n. sp. (p. 66).

24–26. Type.

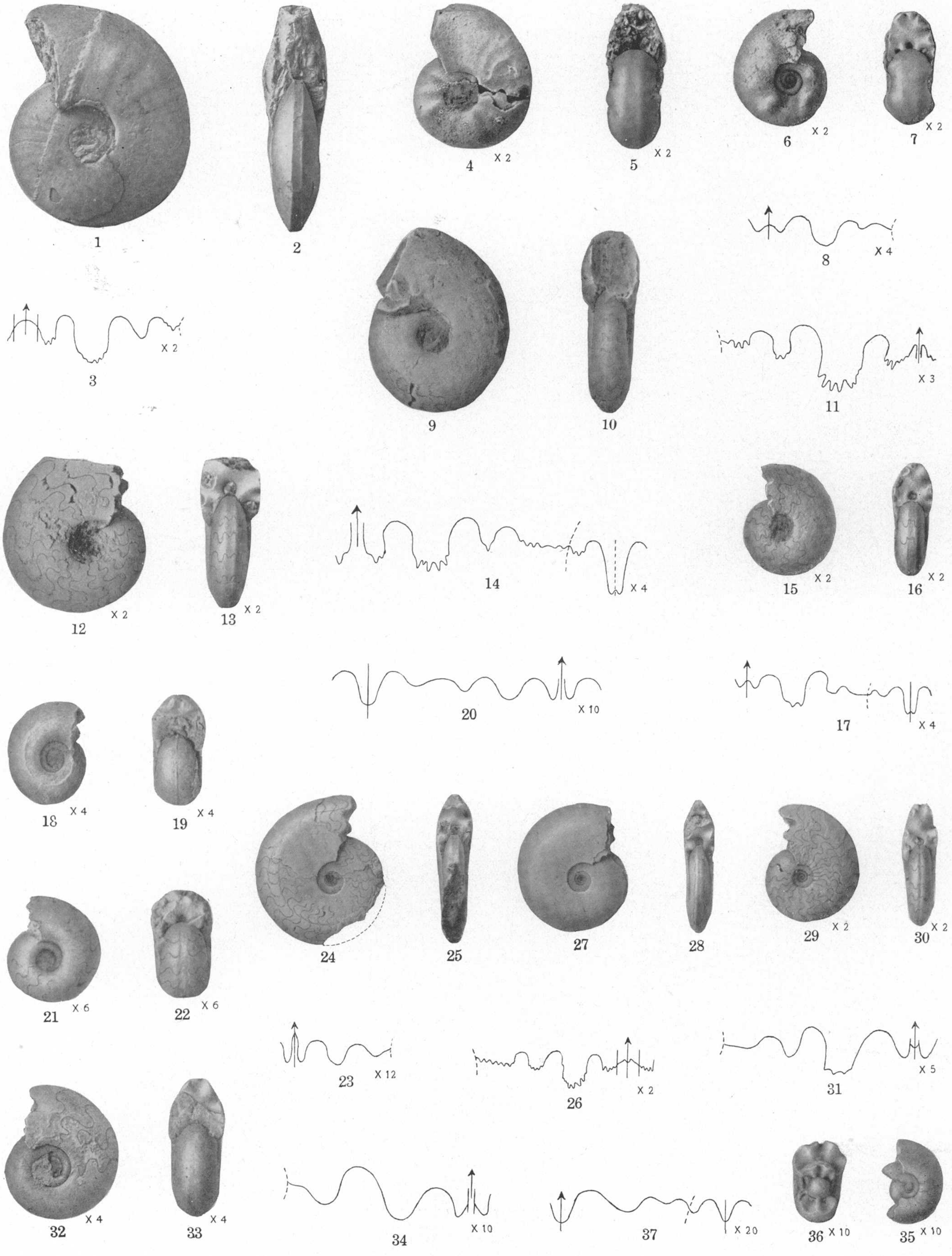
27, 28. Perfect specimen, with shell preserved.

29–31. Transitional from larval to adolescent stage, diameter 12 millimeters.

32–34. Larval stage, diameter 6 millimeters.

35–37. Larval stage, diameter 1.5 millimeters.

The originals of all figures on this plate came from the Lower Triassic *Meekoceras* zone of southeastern Idaho, collected by J. P. Smith; collection of United States Geological Survey; the originals of Figures 1, 4, 24, 27, 29, and 32 from locality 5, 1 mile east of Hot Spring, north end of Bear Lake; the originals of Figures 12, 15, 18, 21, and 35 from locality 1, 5 miles east of Grays Lake; the original of Figure 9 from locality 3, Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs.



LOWER TRIASSIC AMMONOIDS

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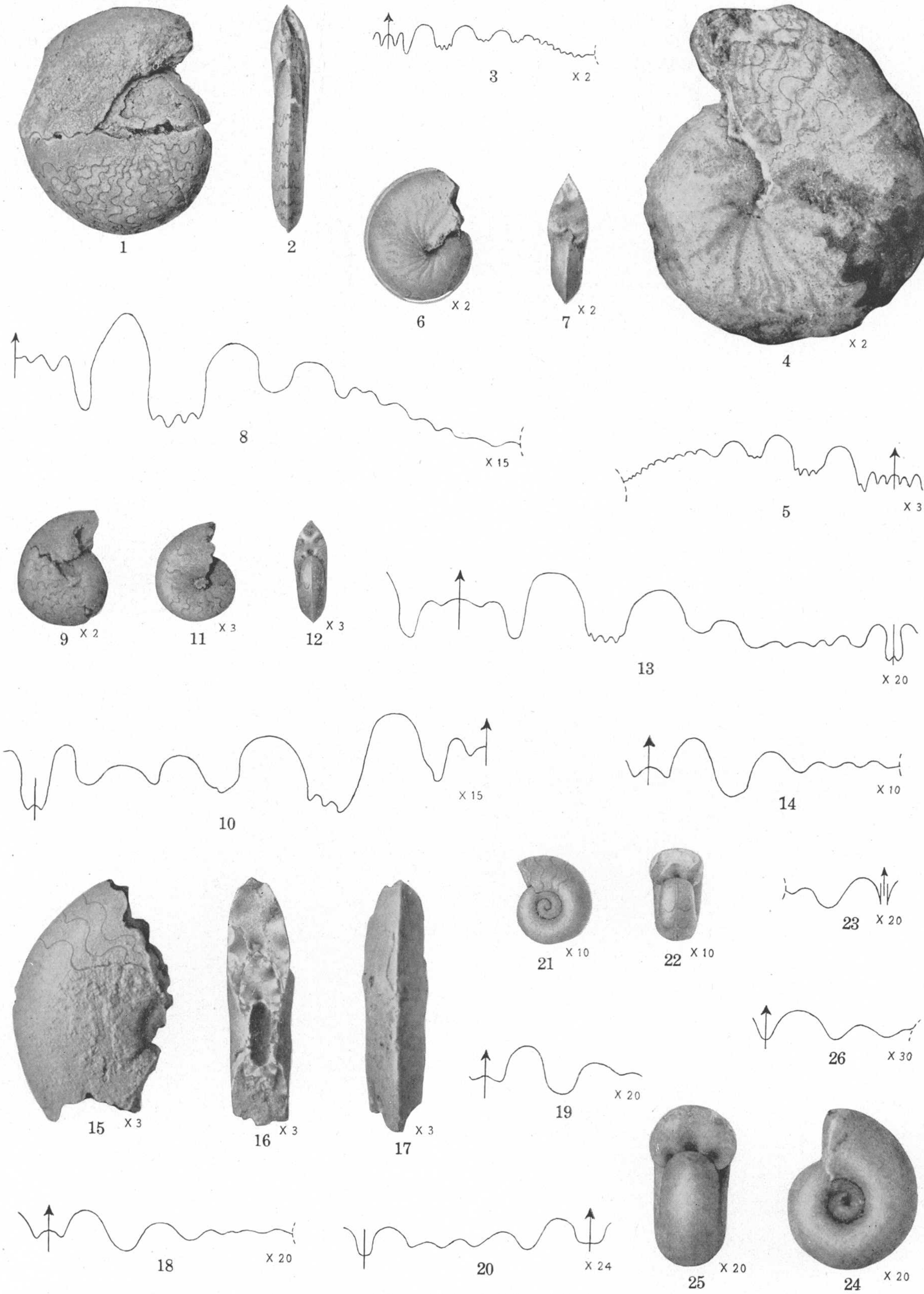


LOWER TRIASSIC AMMONOIDS

PLATE 30

FIGURES 1–26. *Aspenites acutus* Hyatt and Smith (p. 86).

1–3. Adult specimen.
4, 5. Adult specimen.
6, 7. Adolescent stage, diameter 11 millimeters.
8. Septum of another specimen, at diameter 10 millimeters.
9, 10. Shell at diameter 8.5 millimeters, and septum.
11–13. Shell at diameter 5.5 millimeters; septum at diameter 6.5 millimeters.
14. Septum at 5 millimeters.
15–18. Larval stage, diameter 4 millimeters.
19. Septum at diameter 2.75 millimeters.
20. Septum at diameter 2 millimeters.
21–23. Larval stage, diameter 1.5 millimeters.
24–26. Larval stage, diameter 0.85 millimeter.

The originals of all figures on this plate were collected by J. P. Smith in the *Meekoceras* zone, Lower Triassic, southeastern Idaho, and are in the collection of the United States Geological Survey. The originals of Figures 1, 4, and 20 came from locality 5, 1 mile east of Hot Spring; the originals of Figures 6, 8, 11, 21, and 24 from locality 1, 5 miles east of Grays Lake; the originals of Figures 9, 14, and 19 from locality 3, Wood Canyon, 9 miles east of Soda Springs.

PLATE 31

FIGURES 1–7. *Dagnoceras bridgesi* Smith, n. sp. (p. 65).
- 1–3. Type.
- 4–7. Larval stage, diameter 3 millimeters.

FIGURES 8–10. *Aspenites obtusus* Smith, n. sp. (p. 86). Type.

FIGURES 11, 12. *Anasibirites (Goniodiscus) typus* Waagen (p. 76).

FIGURES 13–15. *Paranannites pertenuis* Smith, n. sp. (p. 99). Type.

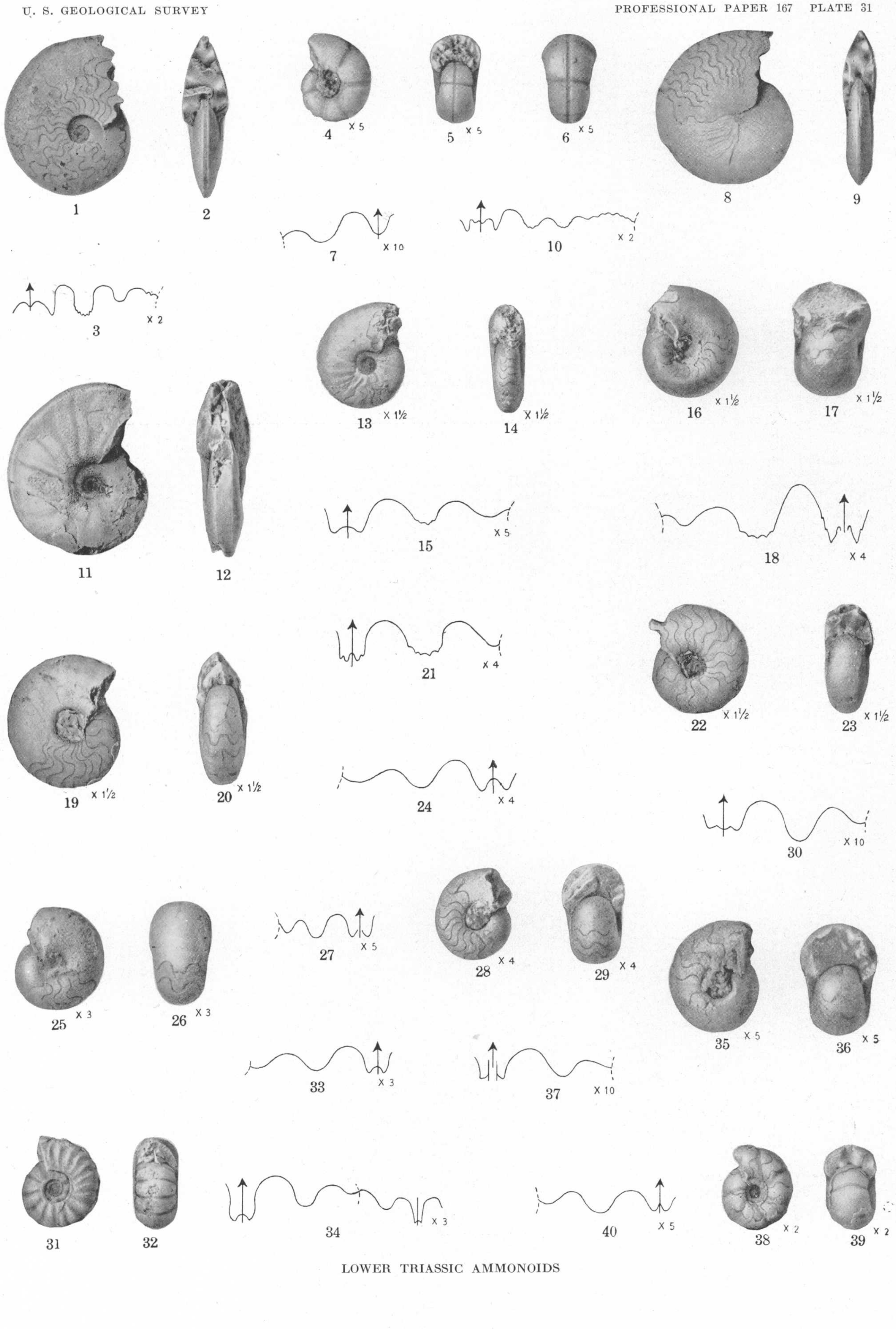
FIGURES 16–18. *Prenkites depressus* Smith, n. sp. (p. 110). Type.

FIGURES 19–21. *Paranannites compressus* Smith, n. sp. (p. 99). Type.

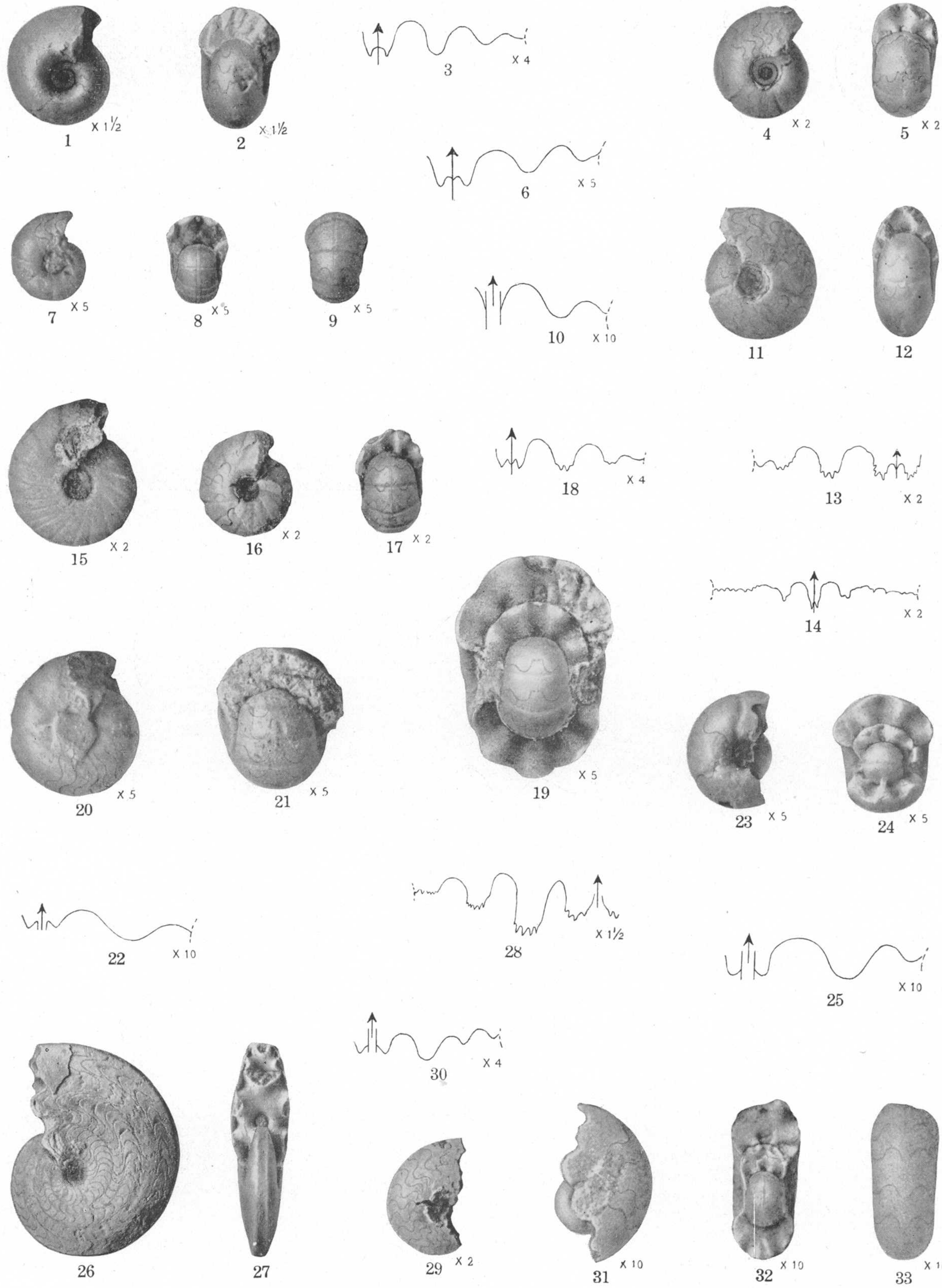
FIGURES 22–27. *Juvenites sanctorum* Smith, n. sp. (p. 110).
- 22–24. Type.
- 25–27. Adolescent stage, diameter 6.5 millimeters.
- 28–30. Larval stage, diameter 5 millimeters.

FIGURES 31–40. *Juvenites septentrionalis* Smith, n. sp. (p. 110).
- 31–33. Type.
- 34. Septum, outside and inside, of an adult specimen.
- 35–37. Larval stage, diameter 4 millimeters.
- 38–40. Adolescent stage, diameter 8 millimeters.

The originals of all figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone of southeastern Idaho; the originals of Figures 1, 31, 34, and 35 came from locality 2, Slug Creek, Aspen Mountains; the originals of Figures 4 and 13, from locality 3, Wood Canyon, Aspen Mountains; the originals of Figures 8, 16, 19, 22, 25, 28, and 38, from locality 5, 1 mile east of Hot Spring; the original of Figure 11 from locality 4, Rohner's ranch, 1 mile west of Paris. They are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 32

FIGURES 1–10. *Juvenites dieneri* Hyatt and Smith (p. 109).
1–3. Adult specimen.
4–6. Adolescent stage.
7–10. Transition from larval to adolescent stage, diameter 2.5 millimeters.

FIGURES 11–25. *Paranannites columbianus* Smith, n. sp. (p. 99).
11–13. Type.
14. Septum of another specimen, showing the inner lobes.
15. Early mature stage, showing the outer shell.
16–18. Early mature stage, diameter 13 millimeters.
19. Same specimen, broken across the center, diameter 6.5 millimeters, showing the inner whorl, larval stage.
20–22. Larval stage, diameter 4.5 millimeters.
23–25. Larval stage, diameter 3.5 millimeters.

FIGURES 26–30. *Meekoceras arthaberi* Smith, n. sp. (p. 56).
26–28. Type.
29, 30. Adolescent stage, diameter 9.5 millimeters, showing goniatite stage of development.
31–33. Larval stage, diameter 2.5 millimeters.

The originals of all figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone of southeastern Idaho and are in the collection of the United States Geological Survey. The originals of Figures 1, 4, 7, 14, 16, 23, 26, 29, and 31 came from locality 5, 1 mile east of Hot Spring; the originals of Figures 11 and 20 from locality 3, Wood Canyon, Aspen Mountains.

PLATE 33

FIGURES 1–14. *Meekoceras sylvanum* Smith, n. sp. (p. 59).

1–3. Type.

4. Septum, outer and inner, of another specimen.

5. Early mature stage.

7–9. Adolescent stage, diameter 17 millimeters.

10, 11. Adolescent stage, diameter 12 millimeters.

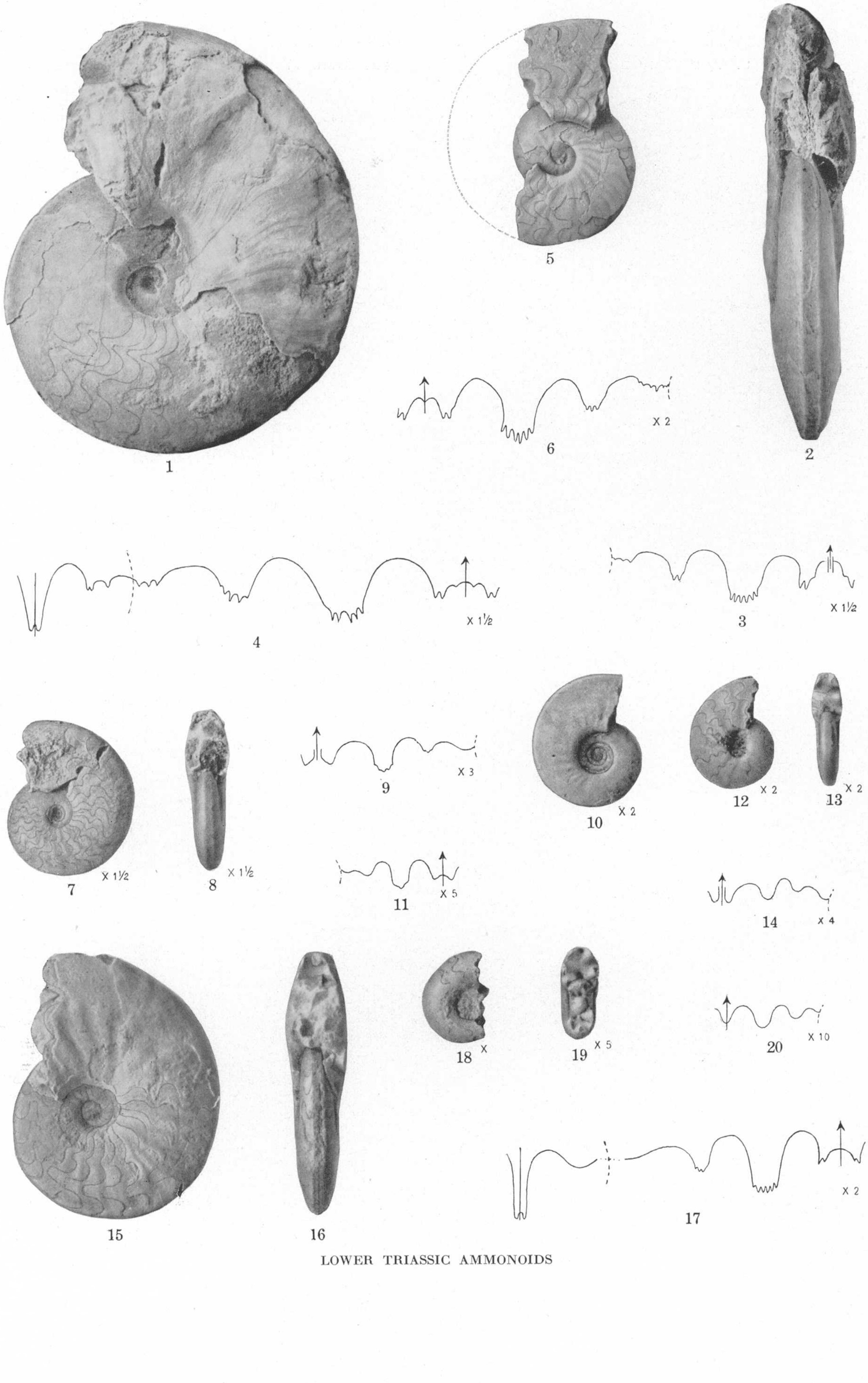
12–14. Adolescent stage, diameter 10 millimeters.

FIGURES 15–20. *Meekoceras cristatum* Smith, n. sp. (p. 56).

15–17. Adult shell.

18–20. Larval stage, diameter 3 millimeters.

The originals of all figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone of southeastern Idaho and are in the collection of the United States Geological Survey. The originals of Figures 1, 14, and 17 came from locality 1, 5 miles east of Grays Lake; the originals of Figures 4, 10, and 11 from locality 5, 1 mile east of Hot Springs, at the north end of Bear Lake; the originals of Figures 5 and 7 from locality 3, head of Wood Canyon, Aspen Mountains, 9 miles east of Soda Springs.



LOWER TRIASSIC AMMONOIDS


4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1


2

LOWER TRIASSIC AMMONOIDS

PLATE 34

FIGURES 1–6. *Meekoceras cristatum* Smith, n. sp. (p. 56).

1–3. Type.

4–6. Early adult stage.

The originals of the figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone in southeastern Idaho, at locality 5, 1 mile east of Hot Springs at the north end of Bear Lake. They are in the collection of the United States Geological Survey.

PLATE 35

FIGURES 1–3. *Meekoceras evansi* Smith, n. sp. (p. 60). Type.

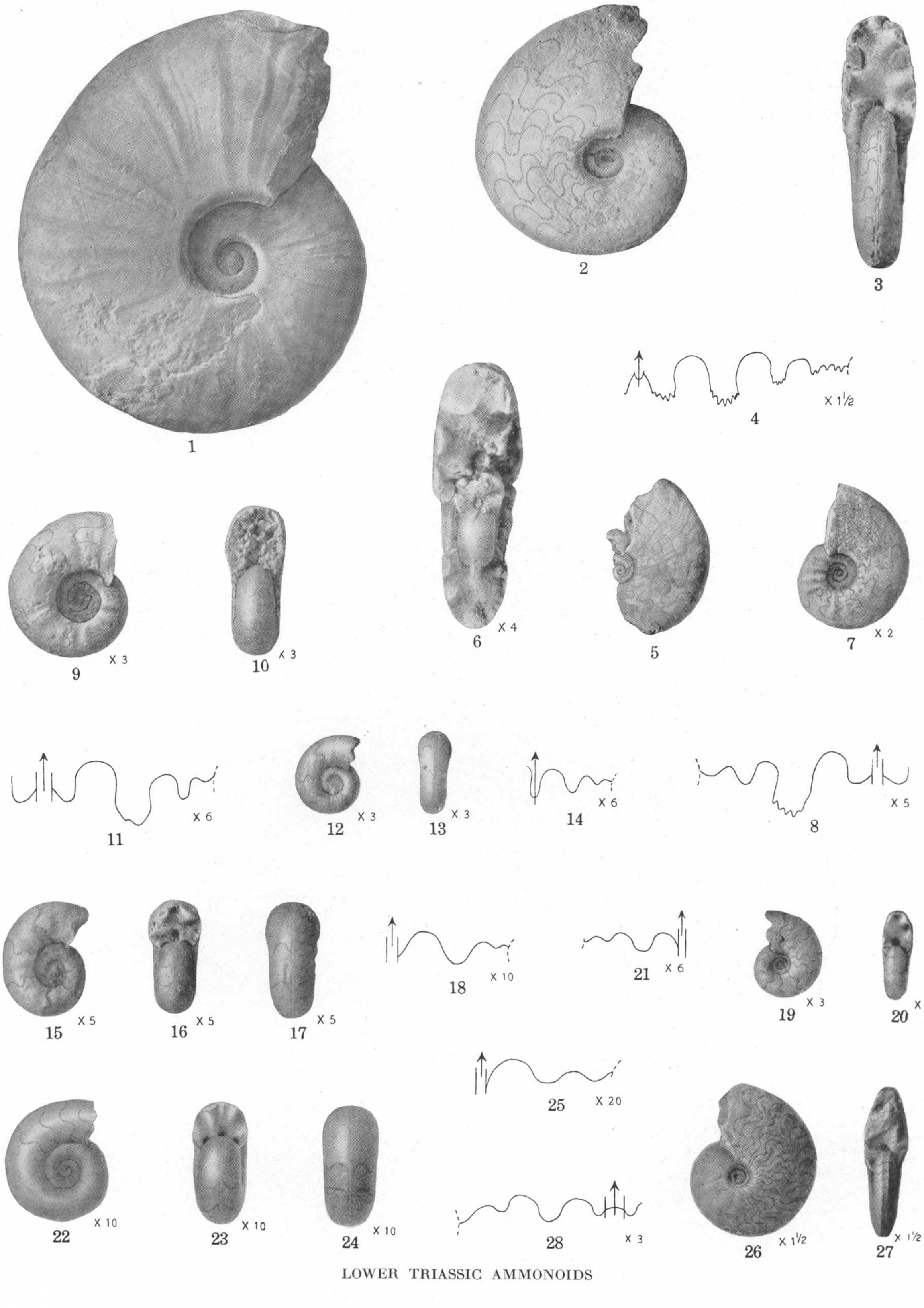
The original specimen was collected by J. P. Smith in the Lower Triassic *Meekoceras* zone, at locality 5, 1 mile east of Hot Springs, at the north end of Bear Lake, southeastern Idaho. It is in the collection of the United States Geological Survey.

3

2

1

LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 36

FIGURES 1–18. *Meekoceras evansi* Smith, n. sp. (p. 60).

1. Early mature stage, showing sculpture.

2–4. Early mature stage.

5, 6. Early mature stage, diameter 27 millimeters, broken so as to show the larval coil inside. Side view and front view of the interior coils.

7, 8. Adolescent stage, diameter 17 millimeters, showing transition from *Lecanites* to *Xenodiscus* at 6 millimeters, and from *Xenodiscus* to *Meekoceras* at 15 millimeters.

9–11. Adolescent stage, diameter 9 millimeters, showing transition from *Lecanites* to *Xenodiscus*.

12–14. Larval stage, transitional from *Prolecanites* to *Lecanites*, diameter 4.5 millimeters.

15–18. Larval stage, diameter 3.5 millimeters, corresponding to *Prolecanites*.

FIGURES 19–28. *Meekoceras gracilitatis* White (p. 57).

19–21. Larval stage, diameter 5 millimeters, corresponding to *Lecanites*.

22–25. Larval stage, diameter 2 millimeters, transitional to *Prolecanites*.

26–28. Adolescent stage, diameter 16 millimeters, showing transition from goniatitic to serrated stage at 13 millimeters.

The originals of all figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone, of southeastern Idaho and are in the collection of the United States Geological Survey. The originals of Figures 1, 2, 5, 7, 9, 12, 15, and 19 came from locality 1, 5 miles east of Grays Lake; the original of Figure 22 from locality 5, 1 mile east of Hot Springs, at north end of Bear Lake.

PLATE 37

FIGURES 1–7. *Meekoceras gracilitatis* White (p. 57).

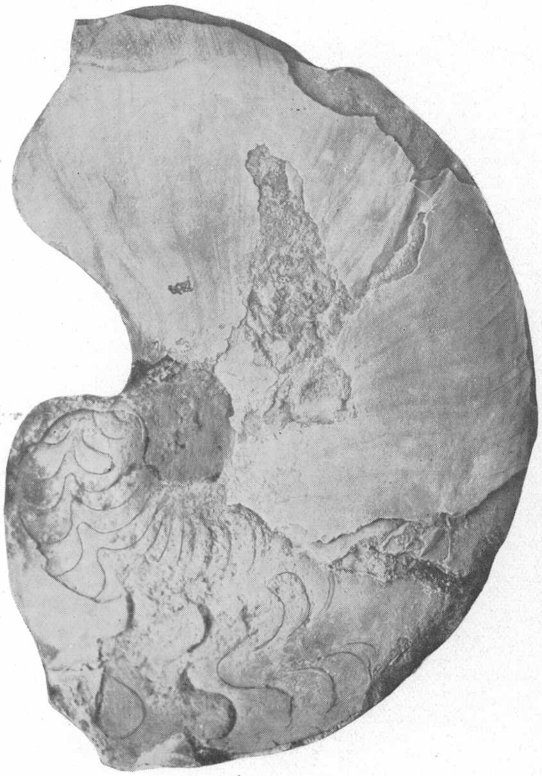
1. Aged specimen, showing aperture.

2, 3. Large specimen.

4. Perfect specimen showing sculpture of shell.

5–7. Early mature stage, broken so as to show the goniatite stage of the inner whorl; shell, septum of the outer whorl, and septum of the inner whorl, goniatite stage.

The specimens figured in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone of southeastern Idaho and are in the collection of the United States Geological Survey. The originals of Figures 1, 2, and 5 came from locality 1, 5 miles east of Grays Lake; the original of Figure 4 from locality 3, head of Wood Canyon, 9 miles east of Soda Springs.



1

2

7 X 5

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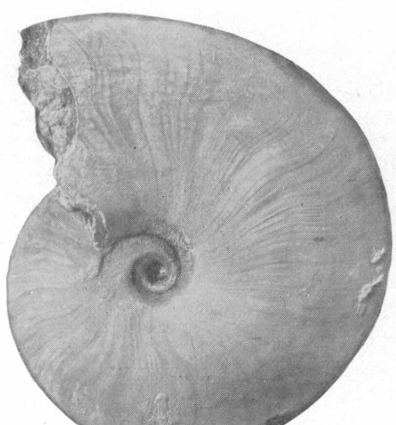
6



4

X 2

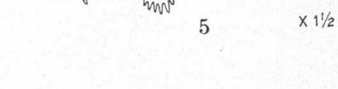
5

LOWER TRIASSIC AMMONOIDS

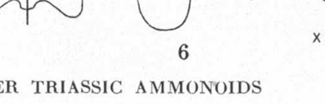
67664—32——13

1

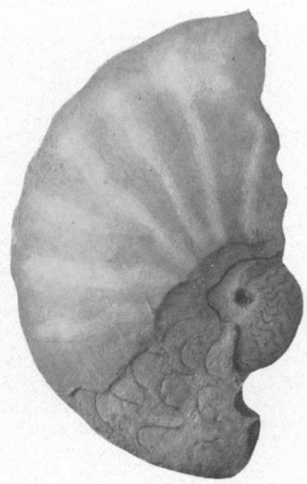
2



3 X 1½



5 X 1½



4

6 X 5

LOWER TRIASSIC AMMONOIDS

PLATE 38

FIGURE 1. *Meekoceras mushbachanum* White var. *corrugata* Smith, n. var. (p. 61). Type.

FIGURES 2–6. *Meekoceras gracilitatis* White (p. 57).

2, 3. Mature specimen with shell removed.

4–6. Mature shell broken so as to show the adolescent stage inside; shell, septum of mature stage, and septum of adolescent stage.

The originals of the figures in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone of southeastern Idaho and are in the collection of the United States Geological Survey; the originals of Figures 1 and 2 came from locality 5, 1 mile east of Hot Springs, north end of Bear Lake; the original of Figure 4 from locality 1, 5 miles east of Grays Lake.

PLATE 39

FIGURES 1, 2. *Flemingites aplanatus* (White) (p. 51). Side view and septum.

FIGURES 3–8. *Xenodiscus waageni* Hyatt and Smith (p. 46).

3, 4. Side and front views.

5. Septum of the same specimen.

6, 7. Smaller specimen.

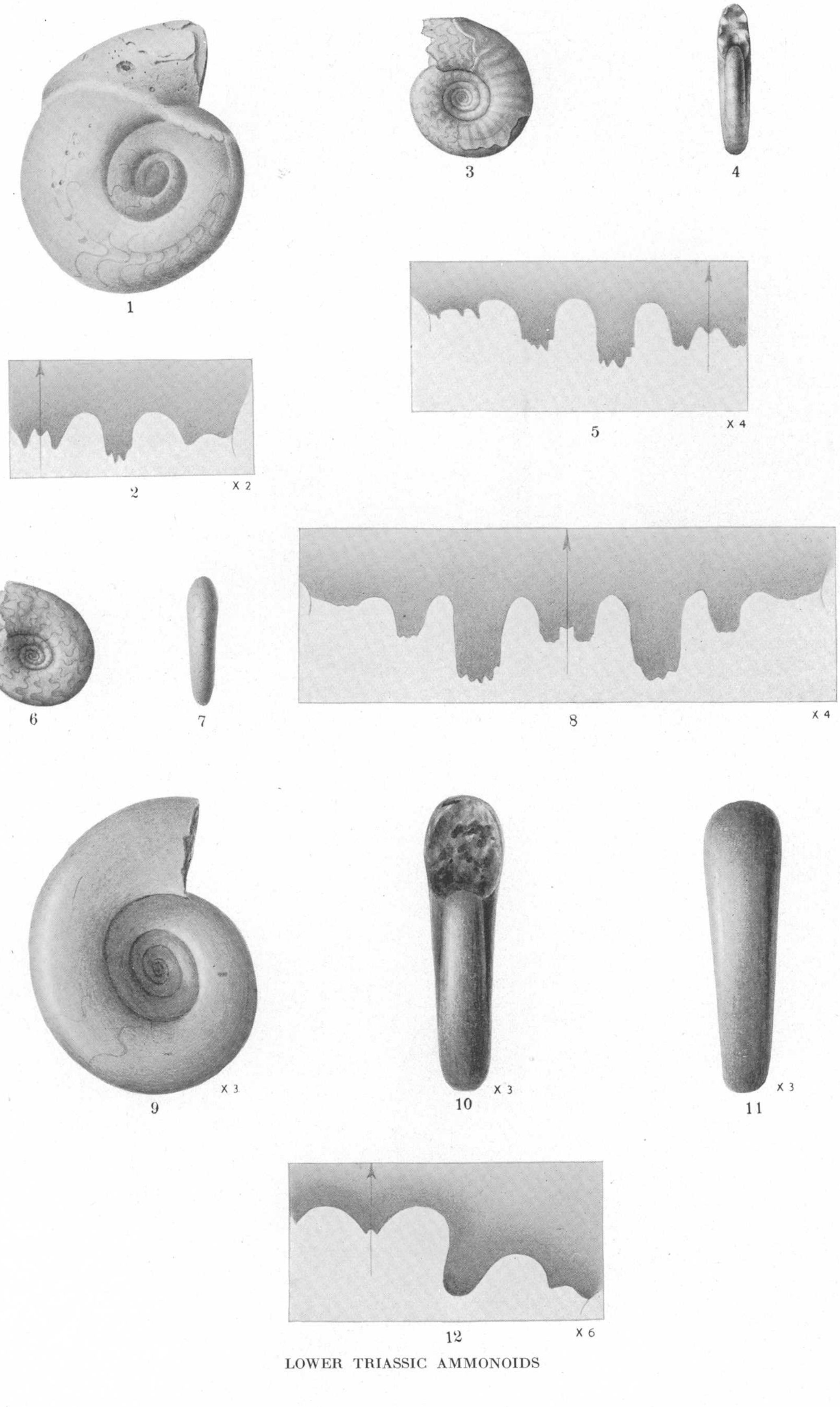
8. Septum of the same specimen.

FIGURES 9–12. *Lecanites* (*Paralecanites*) *arnoldi* Hyatt and Smith (p. 41).

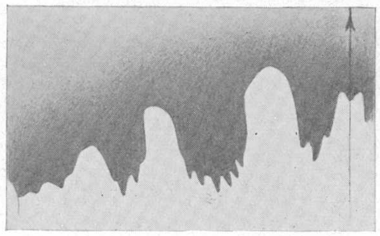
9–11. Adult stage.

12. Septum of the same specimen.

All specimens figured in this plate came from Lower Triassic *Meekoceras* zone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.



LOWER TRIASSIC AMMONOIDS



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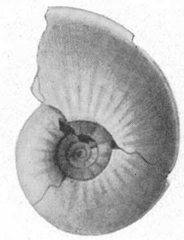

2

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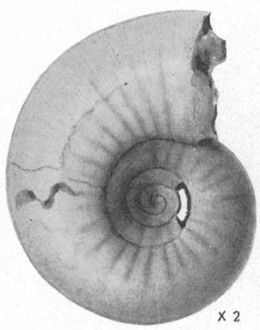
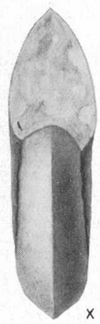
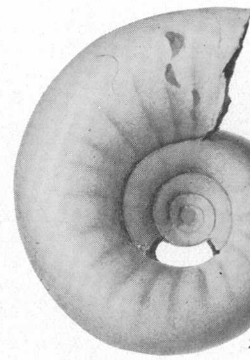


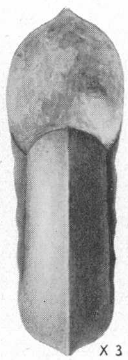
4 X 2



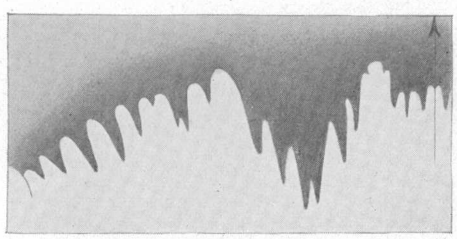
5 X 2



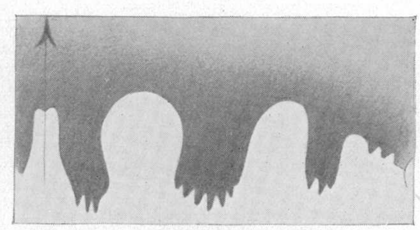
6 X 3



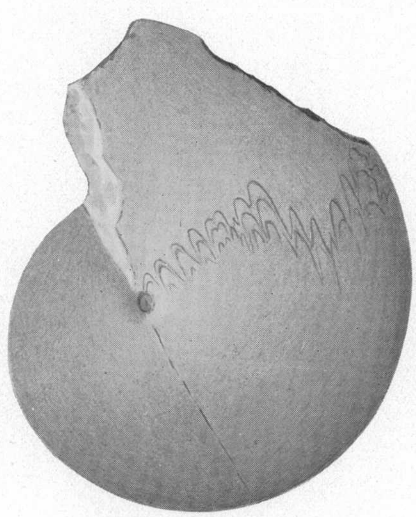
7 X 3



11 X 1½



8 X 6



9

10

LOWER TRIASSIC AMMONOIDS

PLATE 40

FIGURES 1–8. *Inyoites oweni* Hyatt and Smith (p. 80).

1. Septum of a young specimen; diameter 3 millimeters.
2, 3. Adolescent stage; diameter 33 millimeters.
4, 5. Above specimen, with one-third of a revolution removed, giving a diameter of 22 millimeters.
6, 7. The same specimen, with another third of a revolution removed, giving a diameter of 17 millimeters.
8. Septum of the same specimen.

FIGURES 9–11. *Lanceolites compactus* Hyatt and Smith (p. 90).

9, 10. Mature specimen; diameter 65 millimeters.
11. Septum of the same specimen.

All specimens figured in this plate came from Lower Triassic *Owenites* subzone of the *Meekoceras* zone, Union Wash, Inyo Range, Inyo County, Calif. Collection of United States National Museum.

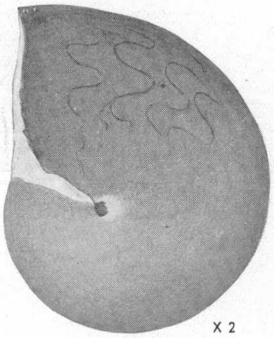
PLATE 41

FIGURES 1–10. *Hedenstroemia kossmati* Hyatt and Smith (p. 78).

1. Side view of an adult specimen.
2. Septum of the same specimen.
3–5. Adolescent stage; diameter 23 millimeters.
6. Septum of the same specimen.
7. Septum of another specimen; diameter 20 millimeters.
8–10. End of larval stage; diameter 5.5 millimeters.

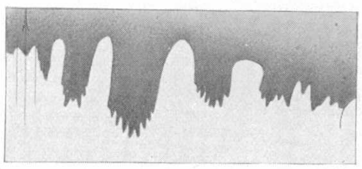
From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho. Collection of United States National Museum.

1



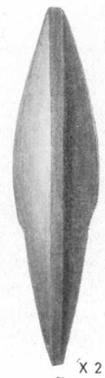
X 2

3

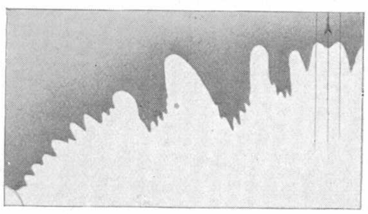


2 X 2

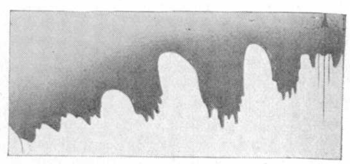
4 X 2



5 X 2

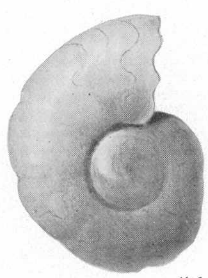


7 X 3



6 X 3

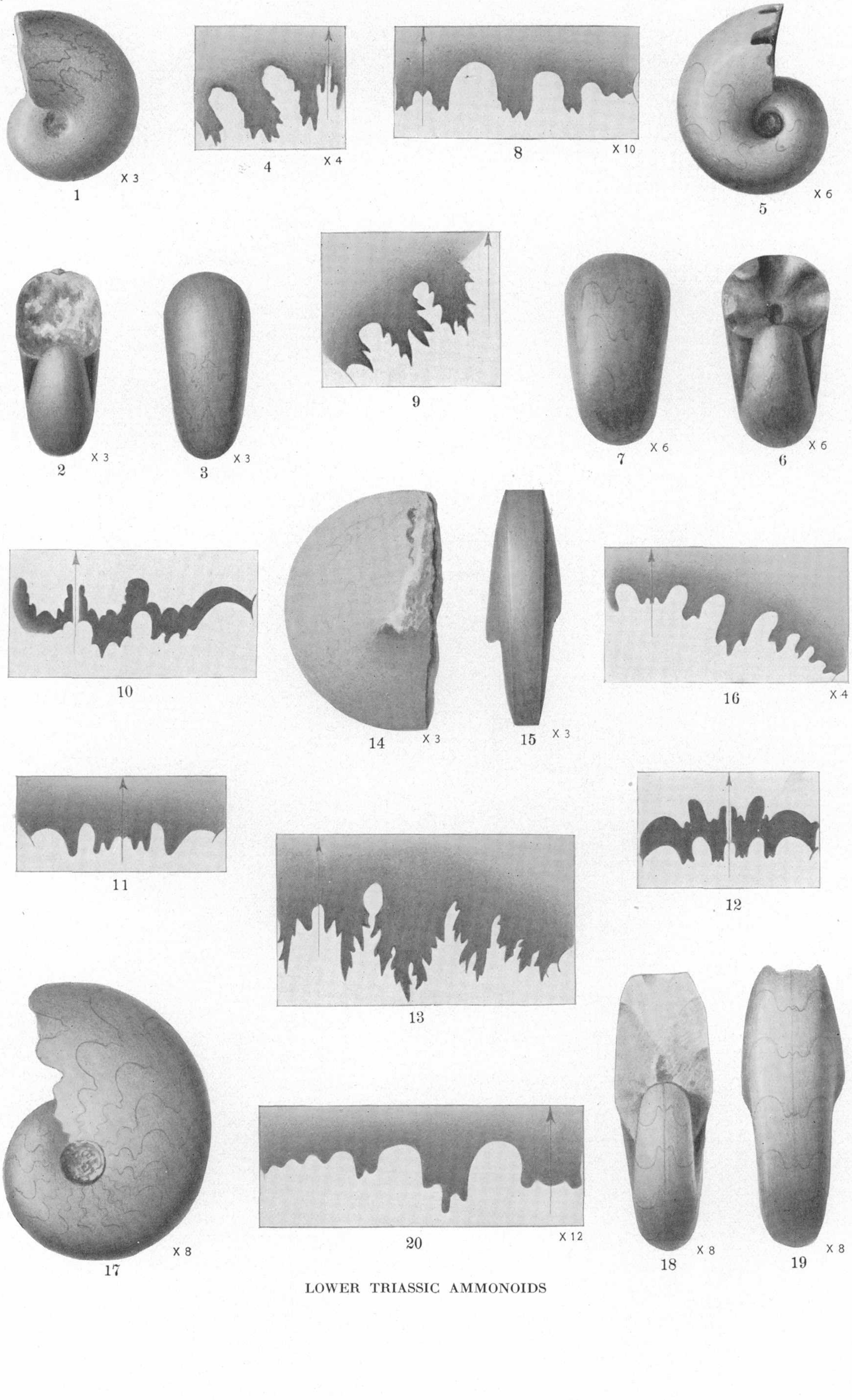
9 X 6



8 X 6

10 X 6

LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 42

FIGURES 1–8. *Ussuria waageni* Hyatt and Smith (p. 92).

1–3. Left side, front, and rear views, transition from *Dimorphoceras* to *Thalassoceras;* diameter 11 millimeters.

4. Septum of the same specimen.

5–7. Right side, front, and rear views, *Dimorphoceras* stage; diameter 5.5 millimeters.

8. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho. Collection of United States National Museum.

FIGURE 9. Septum of *Thalassoceras phillipsi* Gemmellaro (for comparison). (Copied from Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, fig. 8.)

FIGURE 10. Septum of *Thalassoceras gemmellaroi* Karpinsky (for comparison). (Copied from Karpinsky, A., Ammoneen der Artinsk Stufe, pl. 4, fig. 3c.)

FIGURE 11. Septum of *Dimorphoceras atratum* Goldfuss (for comparison). (Copied from Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 2, pl. 46b, fig. 11b.)

FIGURE 12. Septum of *Dimorphoceras gilbertsoni* Phillips (for comparison). (Copied from Foord and Crick, Catalogue of fossil Cephalopoda, British Museum, pt. 3, p. 221, fig. 105.)

FIGURE 13. Septum of *Ussuria iwanowi* Diener (for comparison). (Copied from Diener, Carl, Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz: Com. géol. [St.-Pétersbourg] Mém., vol. 14, No. 3, pl. 3, fig. 5, 1895.

FIGURES 14–20. *Cordillerites angulatus* Hyatt and Smith (p. 96).

14, 15. Adolescent stage; diameter 15 millimeters.

16. Septum of the same specimen.

17–19. Larval stage; diameter 6.5 millimeters.

20. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho. Collection of United States National Museum.

PLATE 43

FIGURES 1–3. *Gonioloboceras welleri* Smith (p. 24). Type, refigured. Cisco group (Pennsylvanian), Graham, Tex.

FIGURES 4–7. *Neodimorphoceras texanum* Smith (p. 23). Type, refigured. Cisco group (Pennsylvanian), Graham, Tex.

FIGURES 8–13. *Gastrioceras listeri* Martin (p. 24). Typical specimen, Middle Coal Measures, Manchester, England. Larval stages.

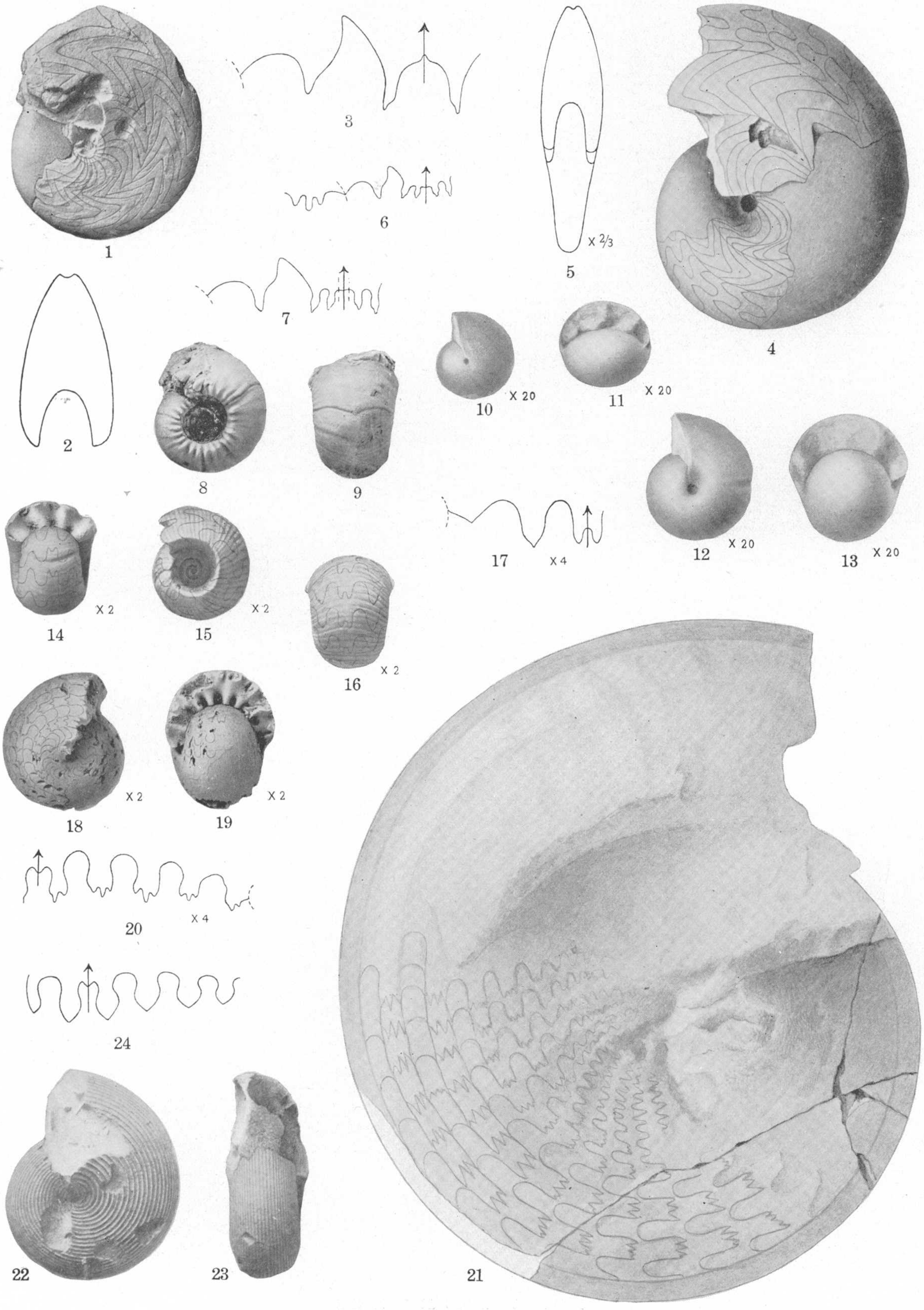
FIGURES 14–17. *Gastrioceras welleri* Smith (p. 24). Typical specimen, from the "Upper Coal Measures" (Pennsylvanian) at Howard, Kans.

FIGURES 18–20. *Marathonites ganti* Smith (p. 24). "Upper Coal Measures" (Pennsylvanian) at Howard, Kans.

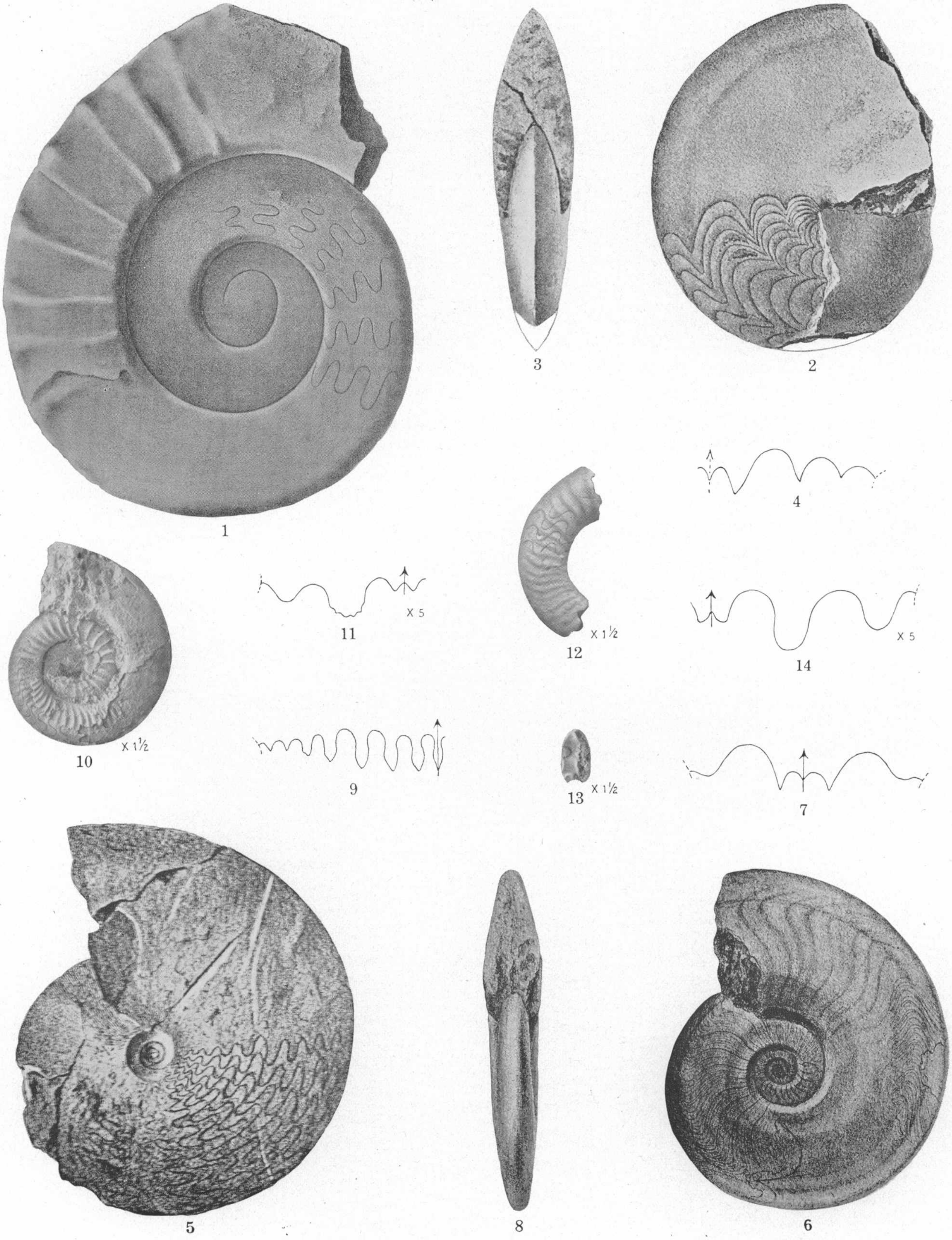
FIGURE 21. *Prodromites gorbyi* Miller (p. 24). Typical specimen. Chouteau limestone (Mississippian), Pettis County, Mo.

FIGURES 22–24. *Agathiceras ciscoense* Smith (p. 24). Type, refigured. Cisco group (Pennsylvanian), Graham, Young County, Tex.

Figures 1–7 and 21–24 are from U. S. Geol. Survey Mon. 42 (The Carboniferous ammonoids of America). These figures are introduced here for comparison with young stages of Triassic ammonites. This plate is reprinted from Plate 20, U. S. Geol. Survey Prof. Paper 141, 1927.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 44

FIGURE 1. *Prolecanites applanatus* Frech (p. 23). Lower Carboniferous, Krumberg, Germany. (After Holzapfel, E., Die Cephalopodenführenden Kalke des Unteren Carbon von Erdbach-Breitscheid bei Herborn: Paleont. Abh. (Dames & Kayser), n. F., Band 1, pl. 5, fig. 1.)

FIGURES 2–4. *Timanites acutus* Keyserling (p. 24). Upper Devonian, Timan, Russia. (After Holzapfel, E., Die Cephalopoden des Domanik im südlichen Timan: Com. géol. [St.-Pétersbourg] Mém., vol. 12, No. 3, pl. 7, figs. 6, 6b, 7.)

FIGURE 5. *Beloceras multilobatum* Beyrich (p. 24). Upper Devonian, Cabrières, France. (After Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 1, pl. 32a, fig. 9a.)

FIGURES 6–8. *Gephyroceras regale* Holzapfel (p. 23). Upper Devonian, Timan, Russia. (After Holzapfel, E., Die Cephalopoden des Domanik im südlichen Timan: Com. géol. [St.-Pétersbourg] Mém., vol. 12, No. 3, pl. 3, figs. 5, 5a, 5c.)

FIGURE 9. *Acrocanites multilobatus* Schindewolf (p. 89). Lower Carboniferous. (After Schindewolf, O. H., Ueber eine Unterkarbonfauna aus Ostthüringen: Senckenbergiana, vol. 4, Heft 1, 2, p. 15, fig. 2d.)

FIGURES 10–14. *Paracelltites multicostatus* Böse (p. 41).

10, 11. From Delaware Mountain formation, lower Permian, near Van Horn, Culberson County, Tex.

12–14. From Word formation, lower Permian, Nos. 17–34. Section N. 55° W. from Hess ranch house, near Marathon, Brewster County, Tex.

These Paleozoic species are introduced here for comparison with young stages of Triassic ammonites.

PLATE 45

FIGURES 1–3. *Aphyllites (Agoniatites) marcellensis* Hall (p. 23). Middle Devonian. (After a specimen in the Stanford collection.)

FIGURES 4, 5. *Pronorites timorensis* Haniel (p. 24). Lower Permian, Somohole, Timor. (After a specimen in the Stanford collection.)

FIGURES 6–8. *Gastrioceras (Paragastrioceras) zitteli* Gemmellaro (p. 24). Lower Permian, Sicily. (After Gemmellaro, G. G., La fauna dei calcari con Fusulina della Valle del Fiume Sosio nella Provincia di Palermo, pl. 6, figs. 21–23, 1887.)

FIGURES 9–11. *Adrianites timorensis* Boehm (p. 24). Middle Permian, Timor. (After Haniel, C., Die Cephalopoden der Dyas von Timor: Palaeontologie von Timor, Lief. 3, pl. 50, figs. 7a, 7b, 11.)

FIGURES 12–15. *Uddenites schucherti* Böse (p. 24).

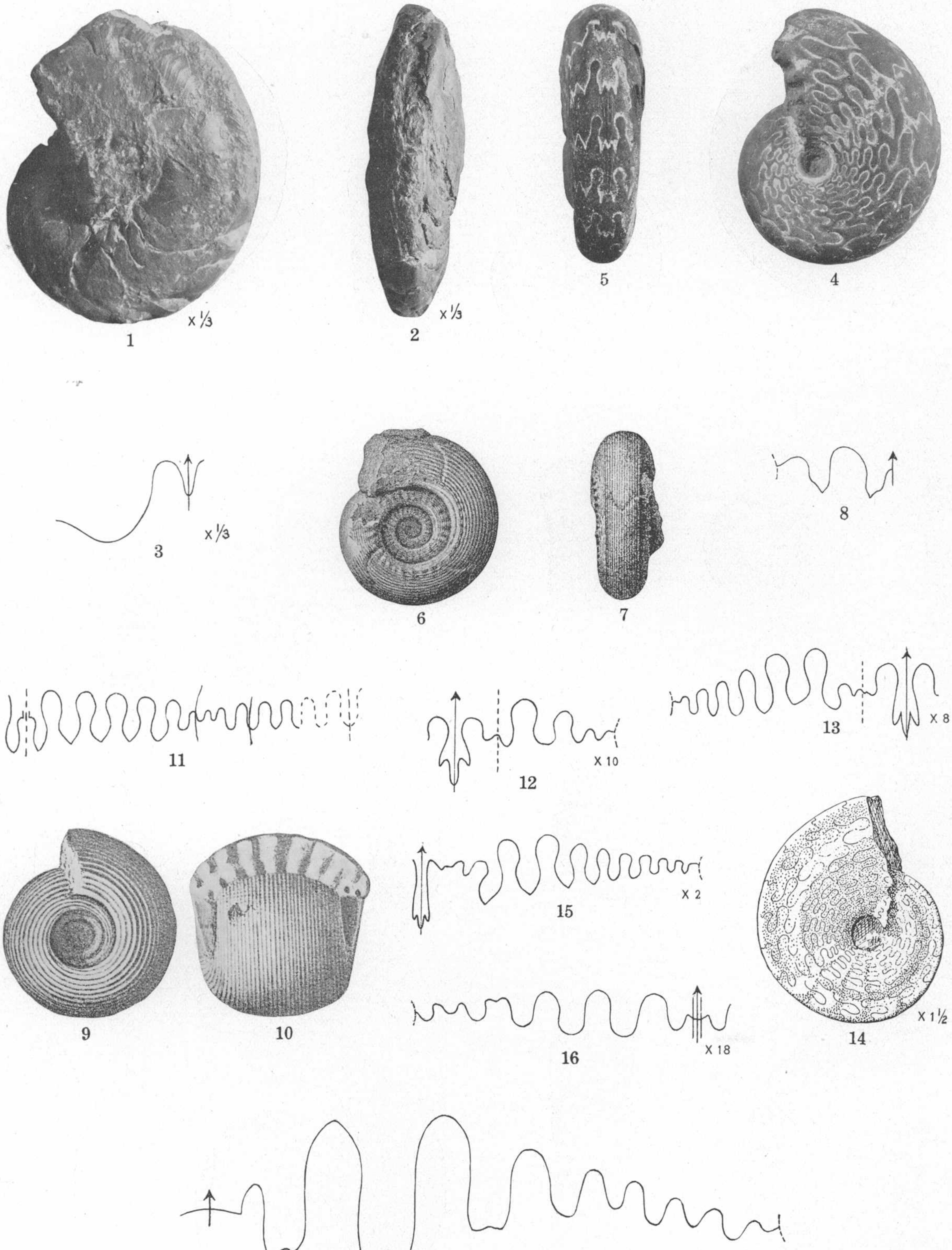
12, 13. Lower Permian, Wolfcamp formation, Glass Mountains, Tex. (After Smith, J. P., Am. Jour. Sci., 5th ser., vol. 17, p. 72, 1929.) 12, *Pronorites* stage; diameter 5.5 millimeters. 13, Transitional toward *Uddenites;* diameter 10 millimeters.

14, 15. Same locality and horizon as Figures 12 and 13. Adult shell and septum.

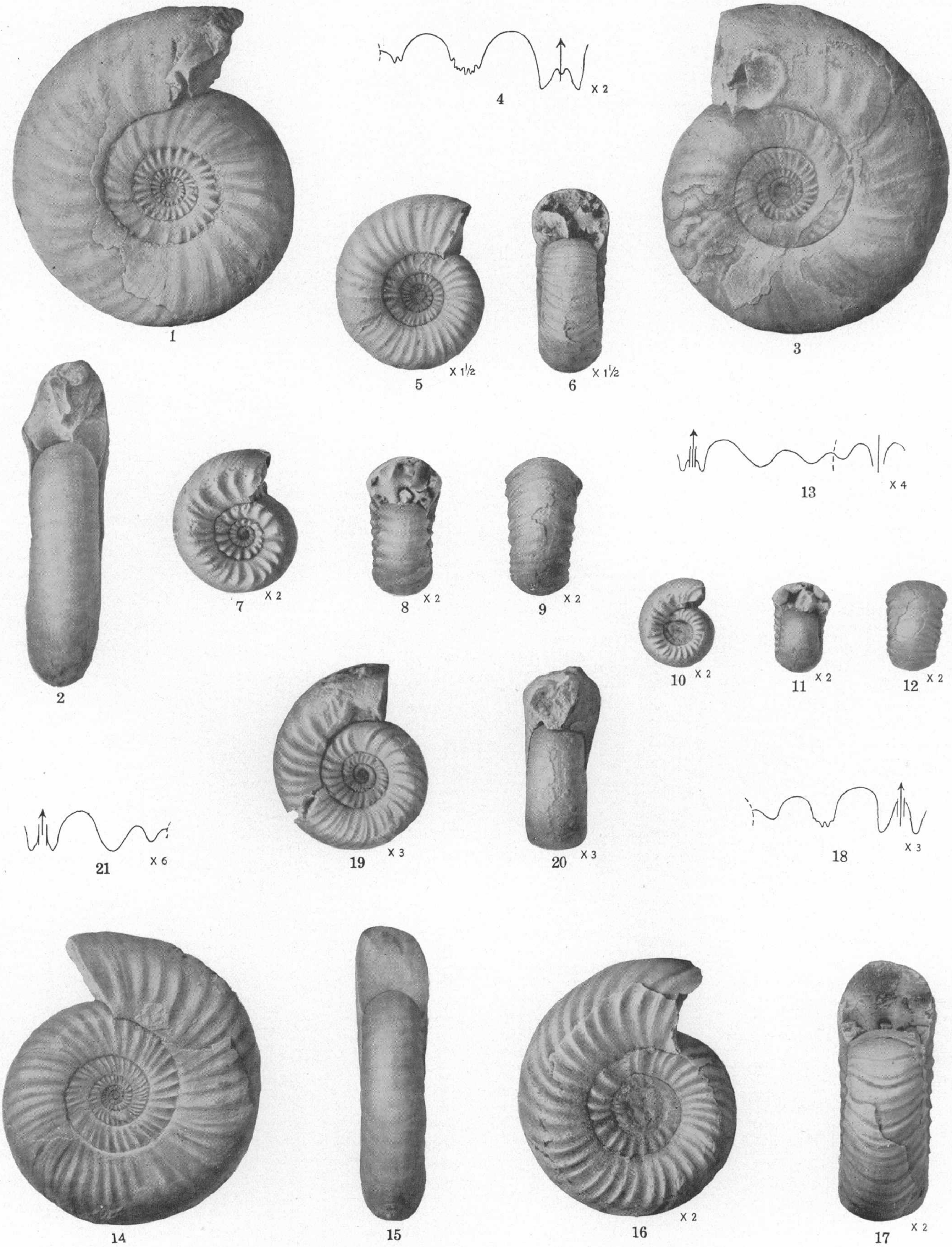
FIGURES 16, 17. *Sageceras gabbi* Mojsisovics (p. 89).

16. Septum. Middle Triassic, Fossil Hill, West Humboldt Range, Nev. Larval stage, diameter 45 millimeters.

17. Middle Triassic, same locality as specimen shown in Figure 16. Adolescent stage, diameter 7 millimeters.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 46

FIGURES 1–13. *Columbites consanguineus* Smith, n. sp. (p. 106).

1, 2. Type.

3, 4. Adult showing septum.

5, 6. Adolescent stage; diameter 28 millimeters.

7–9. Adolescent stage, diameter 13 millimeters, corresponding to *Paragastrioceras.*

10–13. Adolescent stage, diameter 8.5 millimeters, corresponding to *Gastrioceras.*

FIGURES 14–21. *Columbites ornatus* Smith, n. sp. (p. 107).

14, 15. Type.

16–18. Early mature stage, diameter 25 millimeters.

19–21. Adolescent stage, diameter 9 millimeters, corresponding to *Paragastrioceras.*

All specimens figured in this plate came from the Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho, and are in the collection of the United States Geological Survey.

PLATE 47

FIGURES 1–8. *Columbites ligatus* Smith, n. sp. (p. 106).

1–3. Type.

4, 5. Adult shell.

6–8. Adult shell.

FIGURES 9, 10. *Columbites minimus* Smith, n. sp. (p. 106). Type.

FIGURES 11–23. *Celtites ursensis* Smith, n. sp. (p. 104).

11, 12. Type.

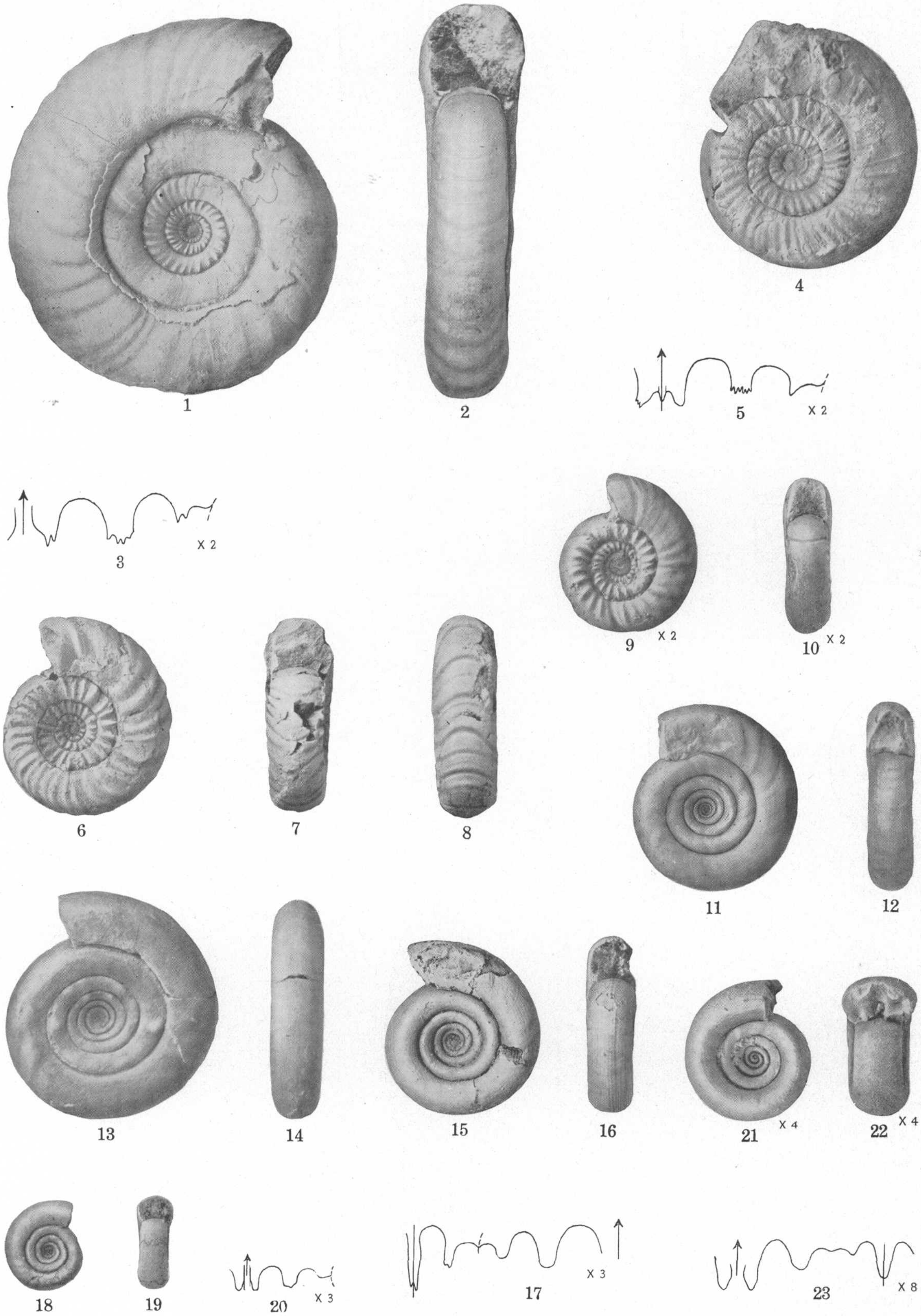
13, 14. Shell and spiral lines.

15–17. Adult shell, showing septum and surface sculpture.

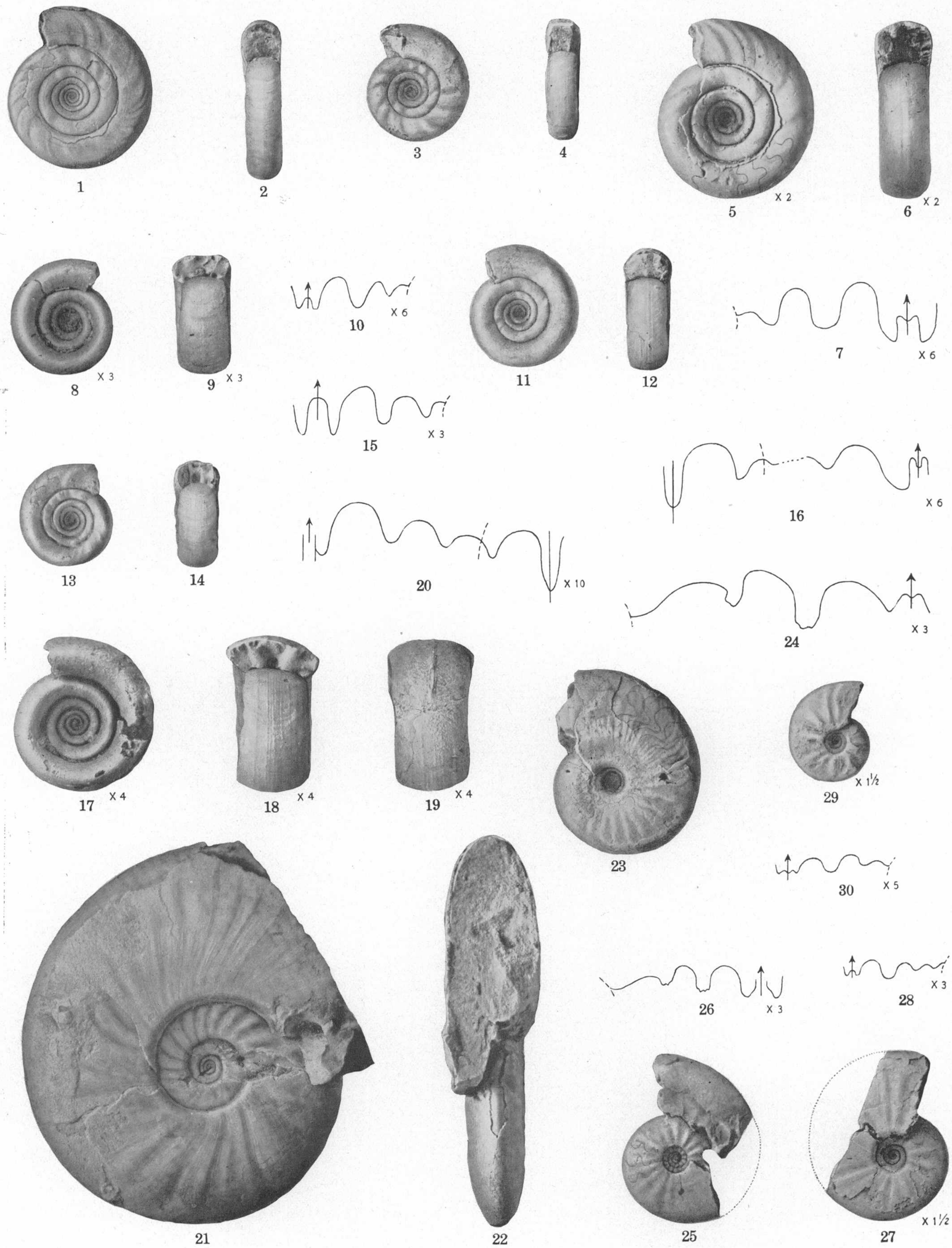
18–20. Adult shell.

21–23. Late larval stage, corresponding to *Paragastrioceras;* diameter 5.5 millimeters.

The originals of all figures on this plate came from the Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho, and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 48

FIGURES 1–10. *Celtites apostolicus* Smith, n. sp. (p. 104).

1, 2. Type.

3, 4. Shell and sculpture.

5–7. Shell, diameter 18 millimeters, and septum.

8–10. Adolescent stage, diameter 7 millimeters; corresponding to *Gastrioceras*.

FIGURES 11–20. *Celtites planovolvis* Smith, n. sp. (p. 104).

11, 12. Type.

13–15. Adult shell.

16. Septum from specimen at diameter 15 millimeters.

17–20. Adolescent stage, diameter 6.5 millimeters, corresponding to *Gastrioceras*.

FIGURES 21–30. *Meekoceras curticostatum* Smith, n. sp. (p. 56).

21, 22. Type.

23, 24. Adult shell.

25, 26. Adult shell.

27, 28. Adult shell.

29, 30. Shell and septum, showing transition from *Lecanites* to *Xenodiscus*.

The originals of all figures on this plate came from the Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho, and are in the collection of the United States Geological Survey.

PLATE 49

FIGURES 1–4. *Meekoceras sanctorum* Smith, n. sp. (p. 59).

1, 2. Type.

3, 4. Paratype, showing septum.

FIGURES 5–11. *Meekoceras micromphalus* Smith, n. sp. (p. 58).

5–8. Type.

9–11. Adolescent stage, diameter 17 millimeters.

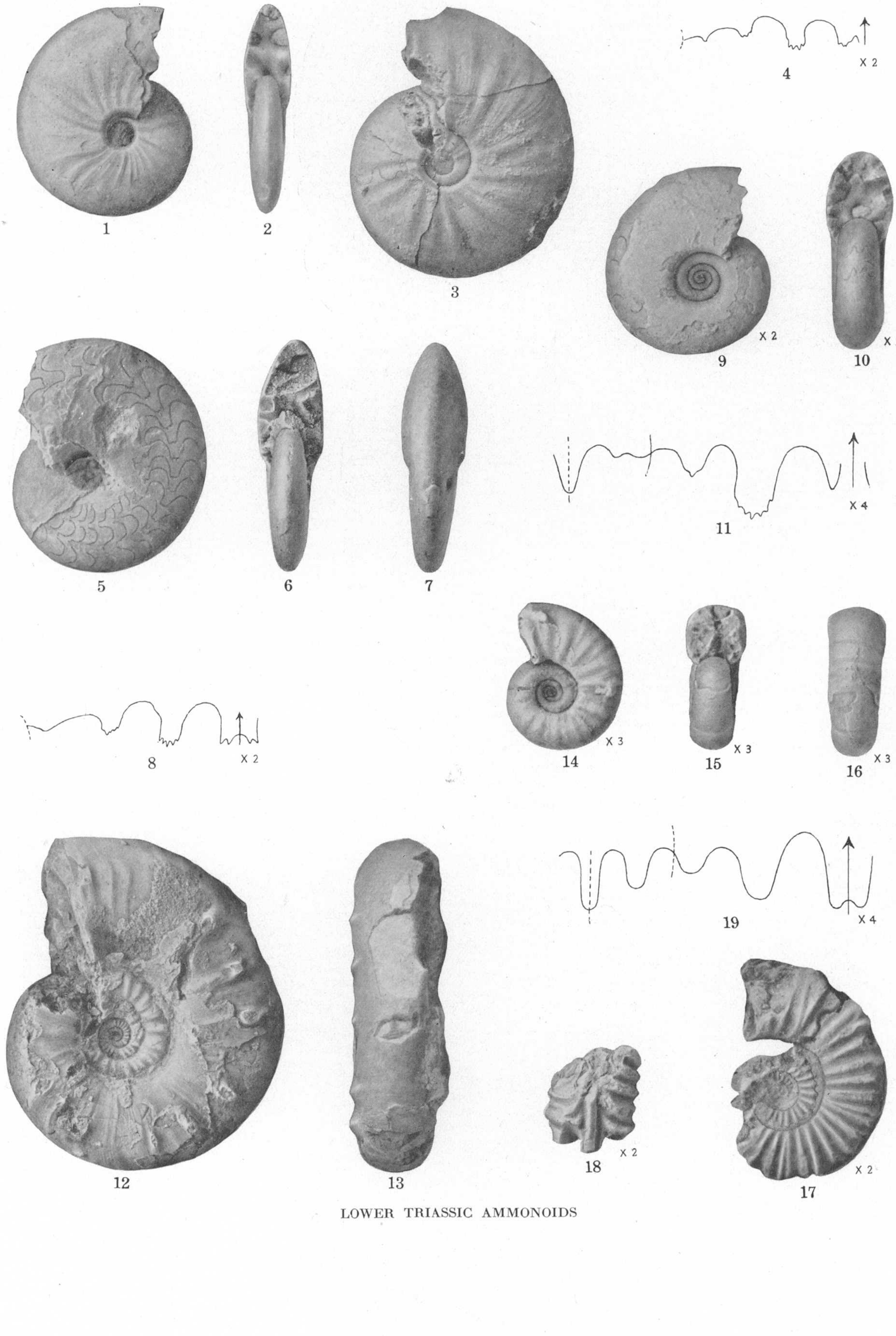
FIGURES 12–16. *Tirolites illyricus* Mojsisovics (p. 84).

12, 13. Adult shell.

14–16. Adolescent stage, diameter 9 millimeters, showing transition from *Xenodiscus* to *Paratirolites*.

FIGURES 17–19. *Pseudharpoceras idahoense* Smith, n. sp. (p. 81). Type.

The originals of all figures in this plate came from the Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho, and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS

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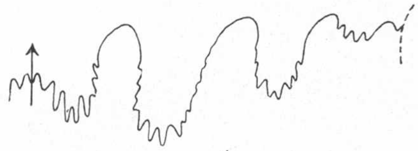

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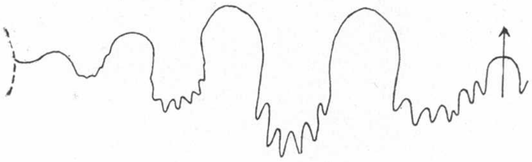


3

LOWER TRIASSIC AMMONOIDS

PLATE 50

FIGURES 1–4. *Meekoceras tuberculatum* Smith, n. sp. (p. 62).

1–3. Type.

4. Septum of another specimen.

The specimens figured in this plate came from the Lower Triassic *Meekoceras* zone, *Owenites* subzone, of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif. They were collected by J. P. Smith and are in the collection of the United States Geological Survey.

PLATE 51

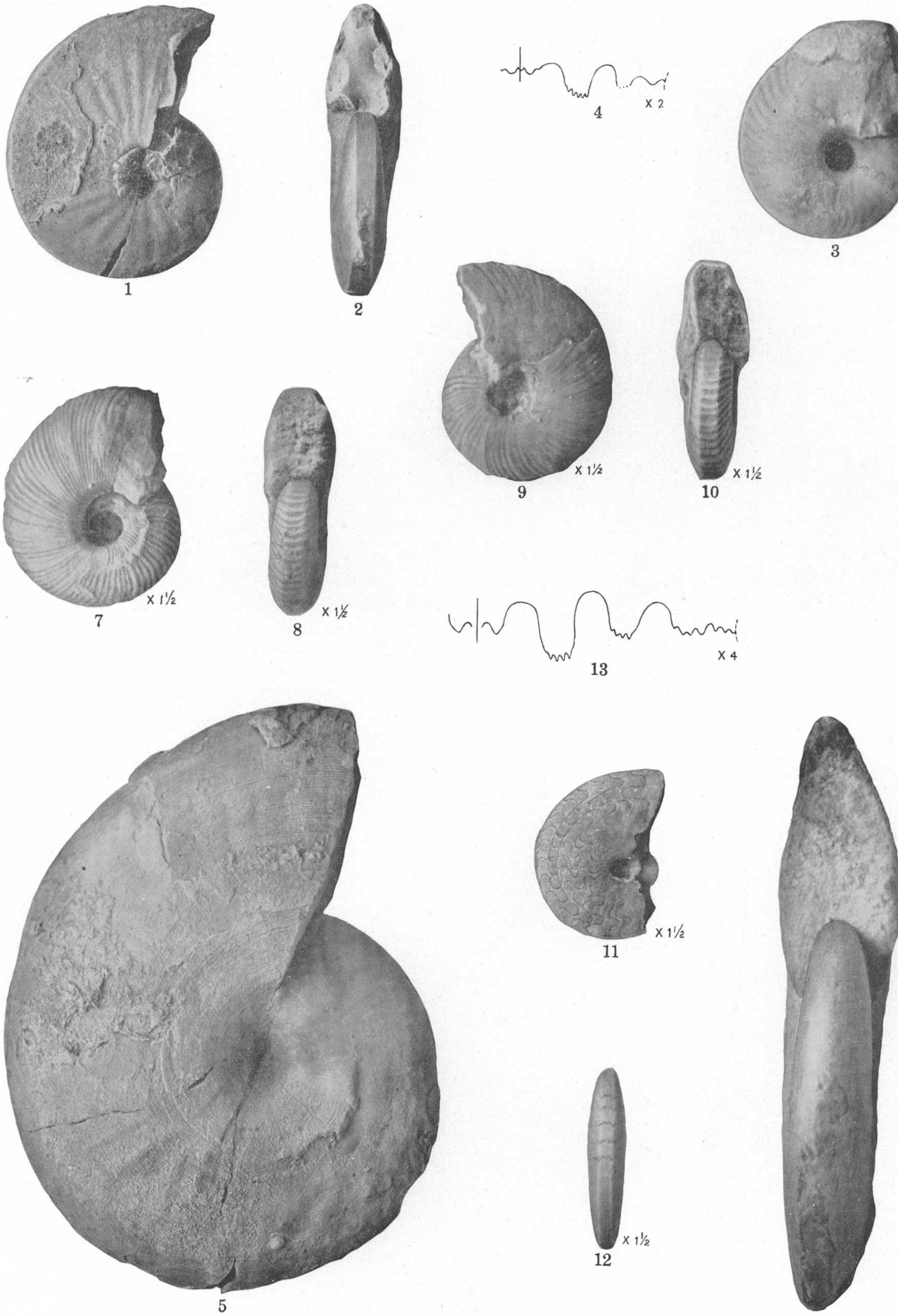
FIGURES 1–4. *Meekoceras radiosum* Waagen (p. 59).
- 1, 2. Adult shell.
- 3, 4. Adult shell.

FIGURES 5, 6. *Sturia woodini* Smith, n. sp. (p. 94). Type.

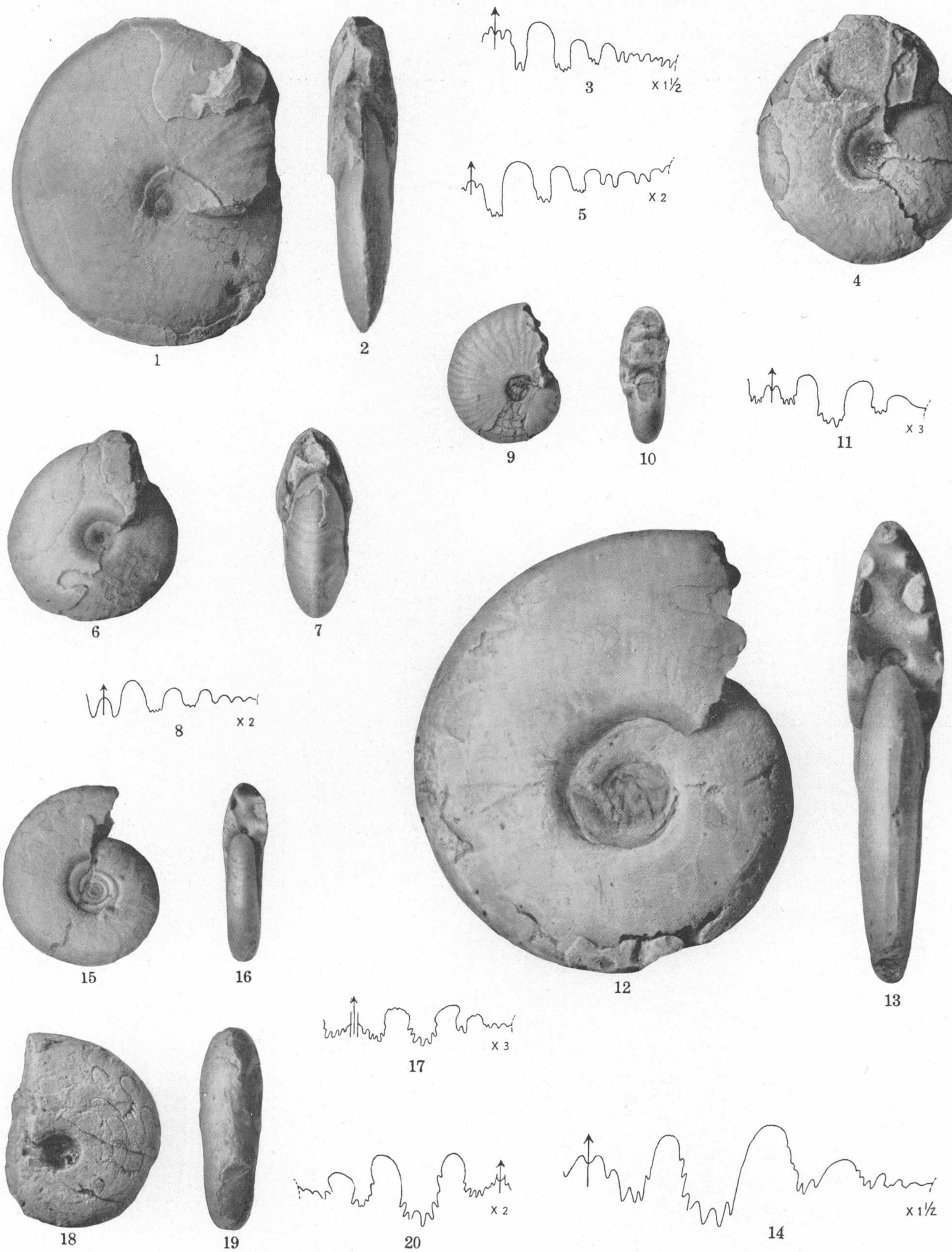
FIGURES 7–10. *Anasibirites desertorum* Smith, n. sp. (p. 71).
- 7, 8. Type.
- 9, 10. Adult shell.

FIGURES 11–13. *Clypeoceras pusillum* Smith, n. sp. (p. 64). Type.

All specimens figured in this plate came from the Lower Triassic *Meekoceras* zone, *Owenites* subzone, of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif. They were collected by J. P. Smith and are in the collection of the United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 52

FIGURES 1–5. *Owenites zitteli* Smith, n. sp. (p. 101).

1–3. Type.

4, 5. Adult shell.

FIGURES 6–8. *Owenites egrediens* Welter (p. 101). Adult specimen.

FIGURES 9–11. *Meekoceras patelliforme* Smith, n. sp. (p. 58). Adult stage.

FIGURES 12–17. *Meekoceras strongi* Smith, n. sp. (p. 62).

12–14. Type.

15–17. Adolescent stage.

FIGURES 18–20. *Proptychites walcotti* Hyatt and Smith (p. 102).

All specimens figured in this plate were collected by J. P. Smith in the *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif. Collection of United States National Museum.

PLATE 53

FIGURES 1. *Meekoceras* (*Koninckites*) *newberryi* Smith, n. sp. (p. 62).

1–3. Type.

4. Septum of another specimen.

FIGURES 5–8. *Proteusites rotundus* Smith, n. sp. (p. 102).

5, 6. Type.

7, 8. Another specimen.

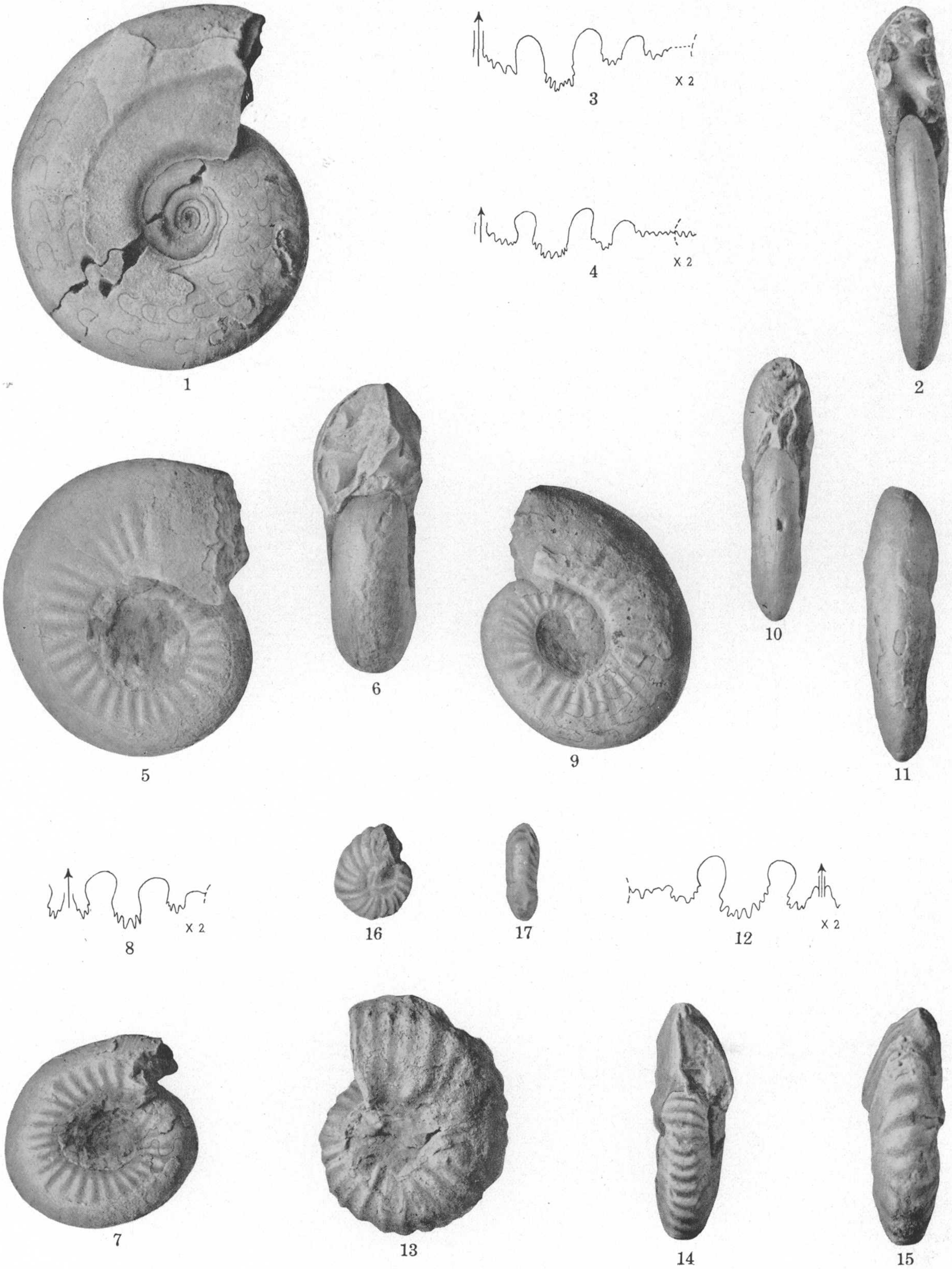
FIGURES 9–12. *Xenodiscus toulai* Smith, n. sp. (p. 45). Type.

FIGURES 13–17. *Anasibirites lindgreni* Smith, n. sp. (p. 73).

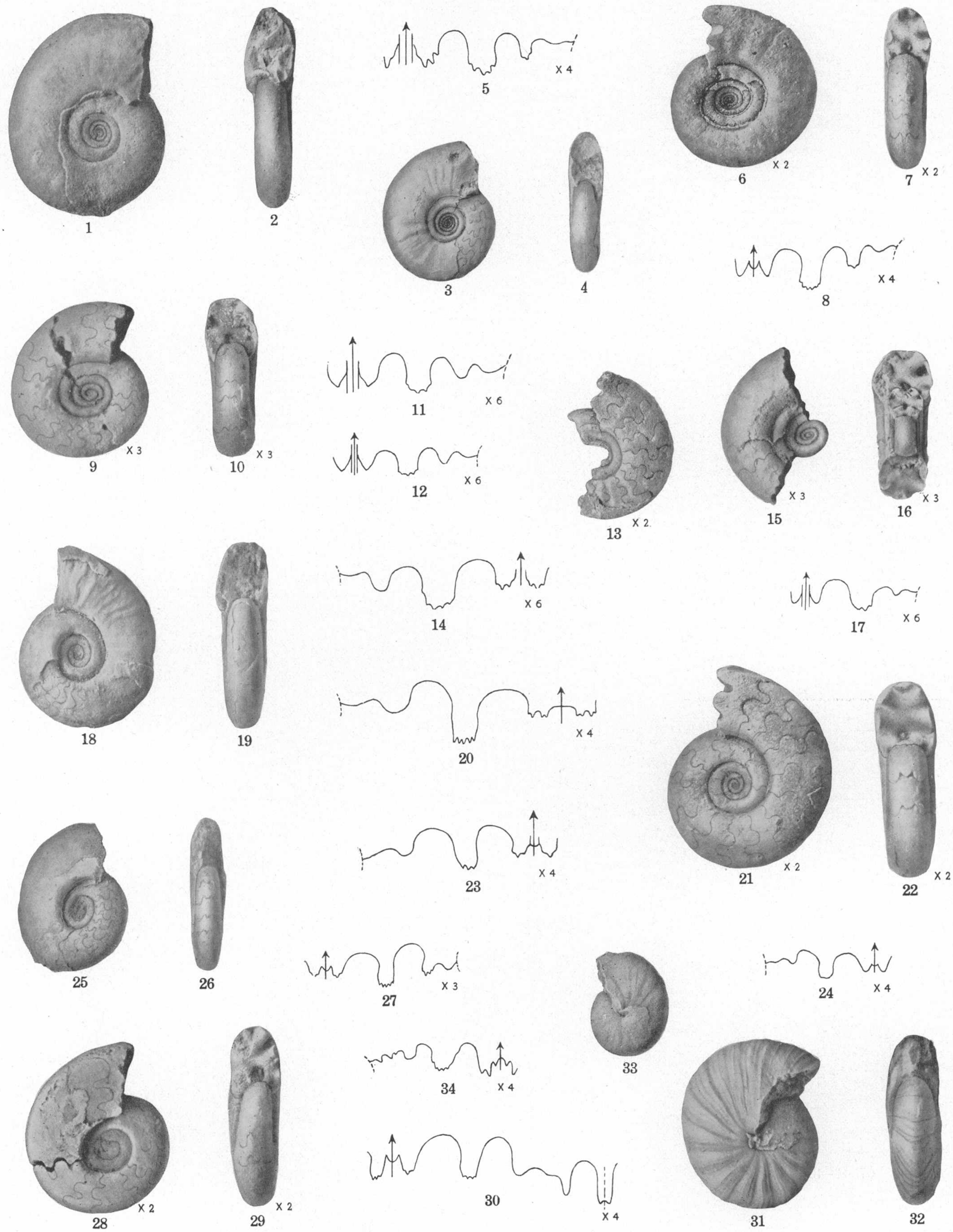
13–15. Type.

16, 17. Adolescent specimen.

All specimens figured in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif. Collection of United States National Museum.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 54.

FIGURES 1–17. *Ophiceras sakuntala* Diener (p. 50).

1, 2. Mature stage.

3–5. Younger shell.

6–8. *Xenodiscus* stage.

9–12. Transition from *Lecanites* to *Xenodiscus*, diameter 10 millimeters; 11, septum at diameter of 10 millimeters; 12, septum at diameter of 8 millimeters.

13, 14. *Xenodiscus* stage, diameter 9 millimeters.

15–17. Transition from *Prolecanites* through *Lecanites* to *Xenodiscus*.

FIGURES 18–24. *Ophiceras subquadratum* Smith, n. sp. (p. 50).

18–20. Type.

21–24. Adolescent stage, diameter 20 millimeters, showing transition from *Lecanites* through *Xenodiscus* to *Ophiceras*, 23 septum in *Ophiceras* stage, at diameter of 20 millimeters; 24, septum in *Lecanites* stage, diameter 9.5 millimeters.

FIGURES 25–30. *Ophiceras parvum* Smith, n. sp. (p. 49).

25–27. Type.

28–30. Adolescent stage, diameter 9 millimeters, corresponding to *Lecanites*.

FIGURES 31–34. *Owenites carpenteri* Smith, n. sp. (p. 100).

31, 32. Type.

33, 34. Shell; septum.

All specimens figured in this plate were collected by J. P. Smith, in the Lower Triassic *Meekoceras* zone, *Owenites* subzone, of Union Wash, Inyo Mountains, about 15 miles southeast of Independence, Inyo County, Calif. They are in the collection of the United States Geological Survey.

PLATE 55

FIGURES 1–13. *Lanceolites bicarinatus* Smith, n. sp. (p. 90).

1–3. Type.

4, 5. Adult shell.

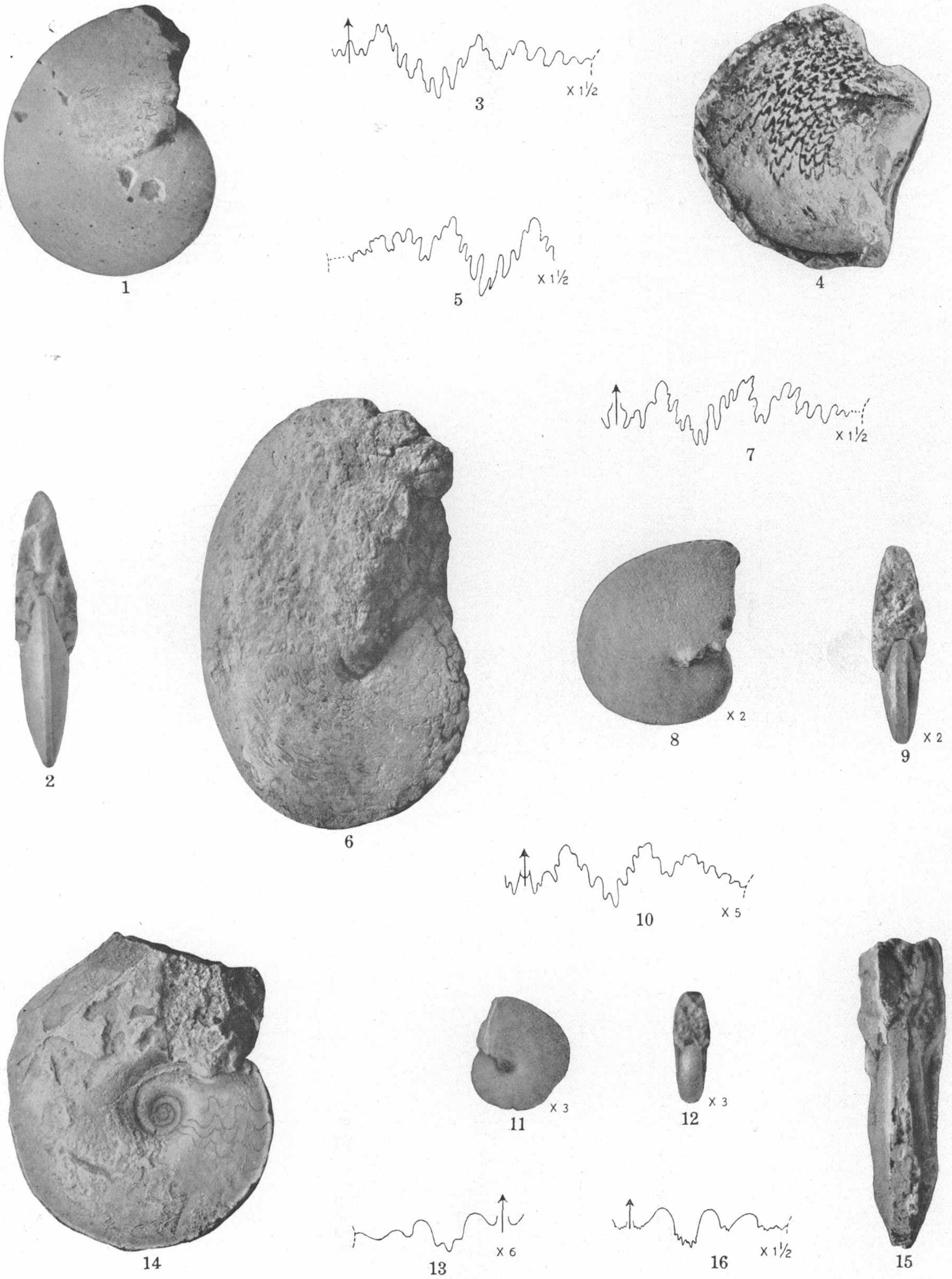
6, 7. Adult shell.

8–10. Adolescent stage.

11–13. Larval stage, diameter 6 millimeters, corresponding to *Aphyllites*.

FIGURES 14–16. *Meekoceras elkoense* Smith, n. sp. (p. 56). Type.

The specimens figured in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone, *Owenites* subzone. Originals of Figures 1–4 and 14–16 came from Phelan ranch, mouth of Cottonwood Canyon, east side of Ruby Range, about 70 miles south of Wells, Elko County, Nev. Originals of Figures 5–13 came from Union Wash, Inyo Mountains, 15 miles southeast of Independence, Inyo County, Calif. Collection of United States National Museum.



LOWER TRIASSIC AMMONOIDS

LOWER TRIASSIC AMMONOIDS

PLATE 56

FIGURES 1–5. *Xenodiscus nevadanus* Smith, n. sp. (p. 47).

1, 2. Type.

3, 4. Paratype.

5. Slab containing two large septate specimens.

FIGURES 6–12. *Xenodiscus nivalis* Diener (p. 44).

6, 7. Adult shell.

8, 9. Adult shell.

10–12. Adolescent stage.

FIGURES 13–18. *Ophiceras sakuntala* Diener (p. 50).

13–15. Adult shell.

16–18. Adult shell.

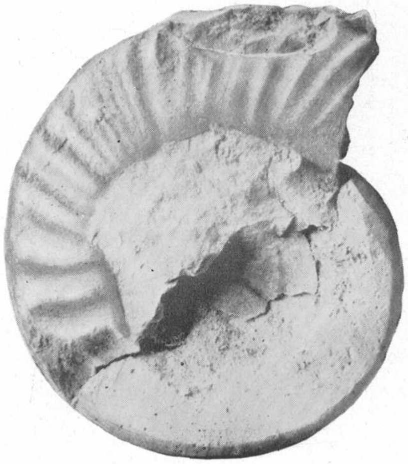
FIGURES 19, 20. *Anasibirites desertorum* Smith, n. sp. (p. 71).

All specimens figured in this plate were collected by J. P. Smith in the Lower Triassic *Meekoceras* zone, *Owenites* subzone. Originals of Figures 1–18 came from Phelan ranch, Cottonwood Canyon, east side of Ruby Range, 70 miles south of Wells, Elko County, Nev. Originals of Figures 19 and 20 came from Rohner ranch (locality 4), south side of Paris Canyon, 1 mile west of Paris, Idaho. Collection of United States National Museum.

PLATE 57

FIGURES 1–4. *Tirolites knighti* Smith, n. sp. (p. 84).
  1, 2. Type.
  3, 4. Paratype.
FIGURES 5–8. *Tirolites pealei* Smith, n. sp. (p. 84).
  5, 6. Type.
  7, 8. Another specimen.
FIGURES 9, 10. *Tirolites harti* Smith (p. 83). Type.
FIGURES 11–13. *Dalmatites attenuatus* Smith, n. sp. (p. 81). Type.

All specimens figured in this plate were collected by J. P. Smith in the Lower Triassic *Tirolites* zone, Paris Canyon, 1½ miles west of Paris, Idaho. Collection of United States National Museum.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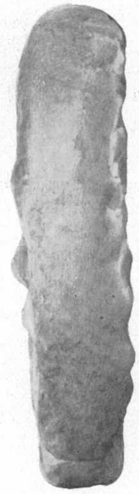
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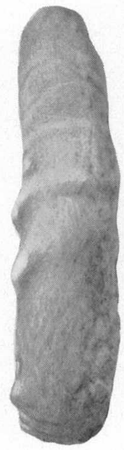
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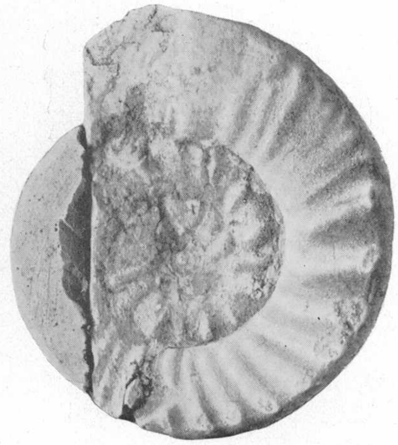
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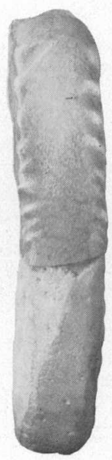
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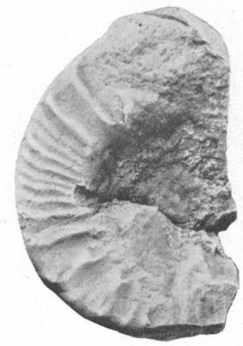
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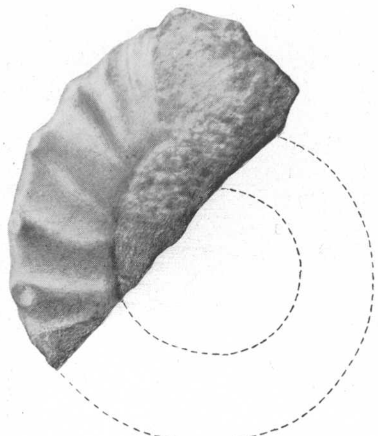
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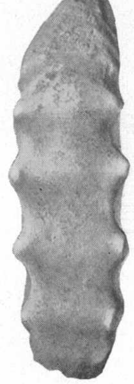
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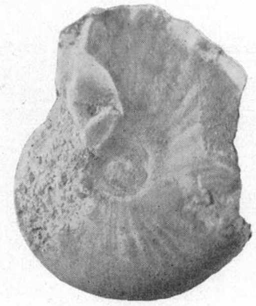
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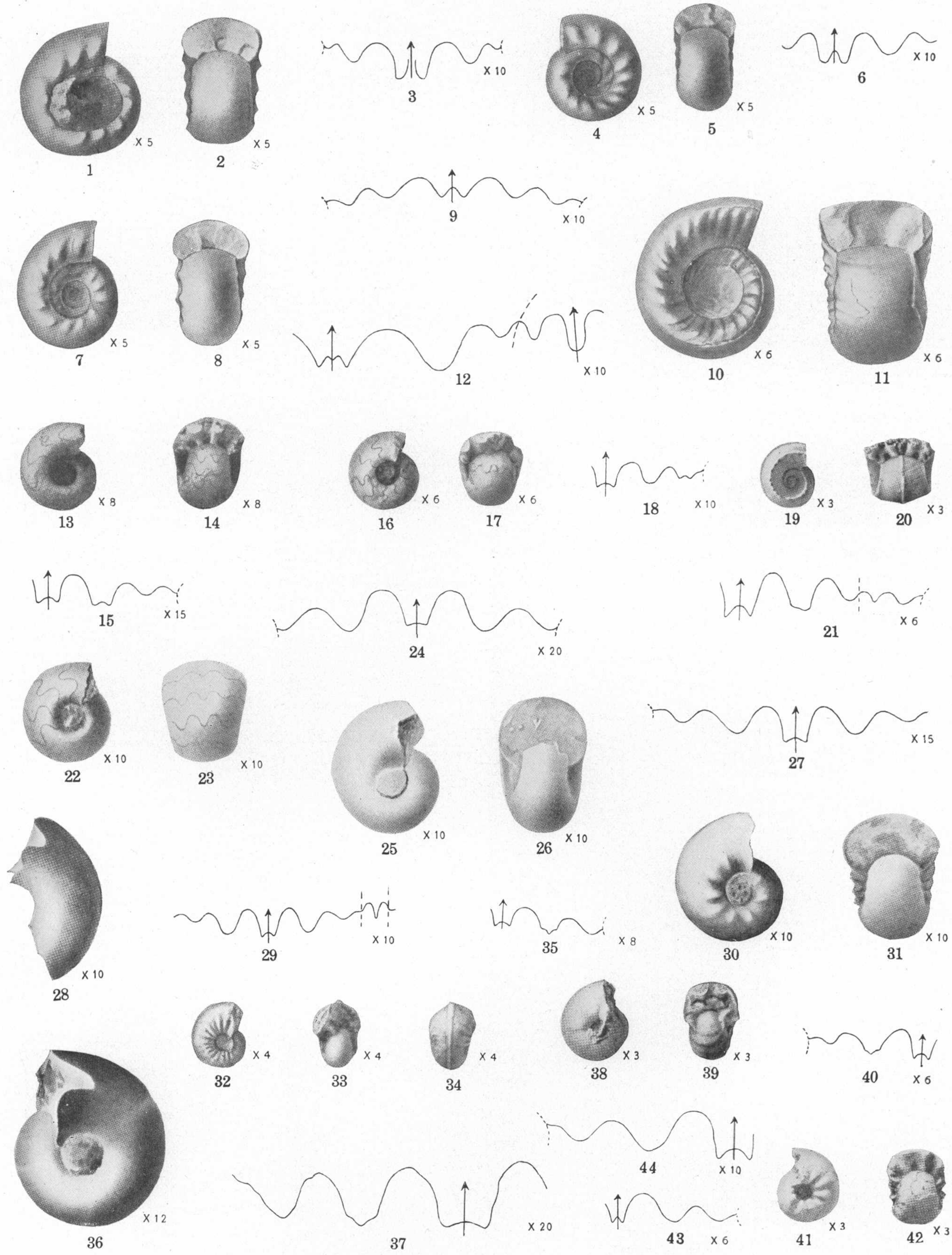
LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 58

RECAPITULATION OF GASTRIOCERAN STAGES OF GROWTH IN TRIASSIC GASTRIOCERATEA

FIGURES 1–3. *Tropigastrites trojanus* Smith (p. 22). Larval stage, diameter 4.5 millimeters. Middle Triassic, Nevada.
FIGURES 4–6. *Tropigastrites halli* Mojsisovics (p. 22). Larval stage, diameter 4 millimeters. Middle Triassic, Nevada.
FIGURES 7–9. *Tropigastrites lahontanus* Smith (p. 22). Larval stage, diameter 3.5 millimeters.
FIGURES 10–12. *Columbites spencei* Smith (p. 22). Larval stage, diameter 4.5 millimeters. Lower Triassic, Idaho.
FIGURES 13–15. *Tropites torquillus* Mojsisovics (p. 22). Larval stage, diameter 2 millimeters. Upper Triassic, California.
FIGURES 16–18. *Tropites welleri* Smith (p. 22). Larval stage, diameter 2.5 millimeters. Upper Triassic, California.
FIGURES 19–21. *Tropites occidentalis* Smith (p. 22). Larval stage, diameter 6 millimeters. Upper Triassic, California.
FIGURES 22–24. *Tropites subbullatus* Hauer (p. 22). Larval stage, diameter 1.83 millimeters. Upper Triassic, California.
FIGURES 25–27. *Paratropites sellai* Mojsisovics (p. 22). Larval stage, diameter 2.3 millimeters. Upper Triassic, California.
FIGURES 28–31. *Discotropites sandlingensis* Hauer (p. 22). Upper Triassic, California.
28, 29. Larval stage, diameter 3.2 millimeters.
30, 31. Larval stage, diameter 2.68 millimeters.
FIGURES 32–35. *Discotropites mojsvarensis* Smith (p. 22). Larval stage, diameter 3 millimeters. Upper Triassic, California.
FIGURES 36, 37. *Sagenites herbichi* Mojsisovics (p. 22). Larval stage, diameter 2.4 millimeters. Upper Triassic, California.
FIGURES 38–40. *Juvavites subintermittens* Hyatt and Smith (p. 22). Larval stage, diameter 5 millimeters. Upper Triassic, California.
FIGURES 41–43. *Metasibirites frechi* Hyatt and Smith (p. 22). Larval stage, diameter 4.5 millimeters. Upper Triassic, California.
FIGURE 44. *Juvavites brockensis* Smith (p. 22). Larval stage, diameter 5 millimeters.

The figures in this plate are introduced to show the similarity of larval stages of growth of Triassic ammonites to their Carboniferous predecessors and supposed ancestors. Figures 1–12 are from U. S. Geol. Survey Prof. Paper 83 (figs. 1–3, pl. 17; figs. 4–6, pl. 18; figs. 7–9, pl. 19; figs. 10–12, pl. 71). Figures 13–44 are from U. S. Geol. Survey Prof. Paper 141 (figs. 13–15, pl. 68; figs. 16–18, pl. 78; figs. 19–21, pl. 70; figs. 22–24, pl. 79; figs. 25–27, pl. 31; figs. 28–31, pl. 36; figs. 32–35, pl. 8; figs. 36, 37, pl. 28; figs. 38–40, pl. 16; figs. 41–43, pl. 60; fig. 44, pl. 16).

PLATE 59

RECAPITULATION OF ADRIANITES STAGES OF GROWTH IN THE AGATHICERATEA BRANCH OF TRIASSIC GASTRIOCERATEA

FIGURES 1–3. *Arcestes pacificus* Hyatt and Smith (p. 22). Upper Triassic, California.
1, 2. Larval stage, diameter 3 millimeters, transitional from *Adrianites* to *Marathonites*.
3. Larval stage, younger part of same specimen, diameter 2.0 millimeters, corresponding to *Adrianites*.

FIGURES 4–7. *Arcestes traski* Smith (p. 22). Upper Triassic, California.
4–6. Larval stage, diameter 3 millimeters.
7. Larval stage, younger part of same specimen, diameter 2.5 millimeters; showing transition from *Adrianites* to primitive *Marathonites*.

RECAPITULATION OF LECANITES AND PROLECANITES STAGES IN TRIASSIC CERATITOIDEA

FIGURES 8–10. *Lecanites arnoldi* Hyatt and Smith (p. 22). Larval stage, corresponding to *Prolecanites*, diameter 3.36 millimeters. Lower Triassic, Idaho.

FIGURES 11–16. *Xenodiscus bittneri* Hyatt and Smith (p. 22). Middle Triassic, California.
11–13. Larval stage, corresponding to *Prolecanites*, diameter 2.20 millimeters.
14–16. Larval stage, diameter 4 millimeters, corresponding to *Lecanites*.

FIGURES 17–21. *Meekoceras mushbachanum* White (p. 22). Lower Triassic, Idaho.
17, 18. Larval stage, corresponding to *Prolecanites*, diameter 4 millimeters.
19–21. Adolescent stage, corresponding to *Lecanites*, diameter 10 millimeters.

FIGURES 22–24. *Beyrichites rotelliformis* White (p. 22). Larval stage, diameter 3.4 millimeters, corresponding to *Lecanites*. Middle Triassic, Nevada.

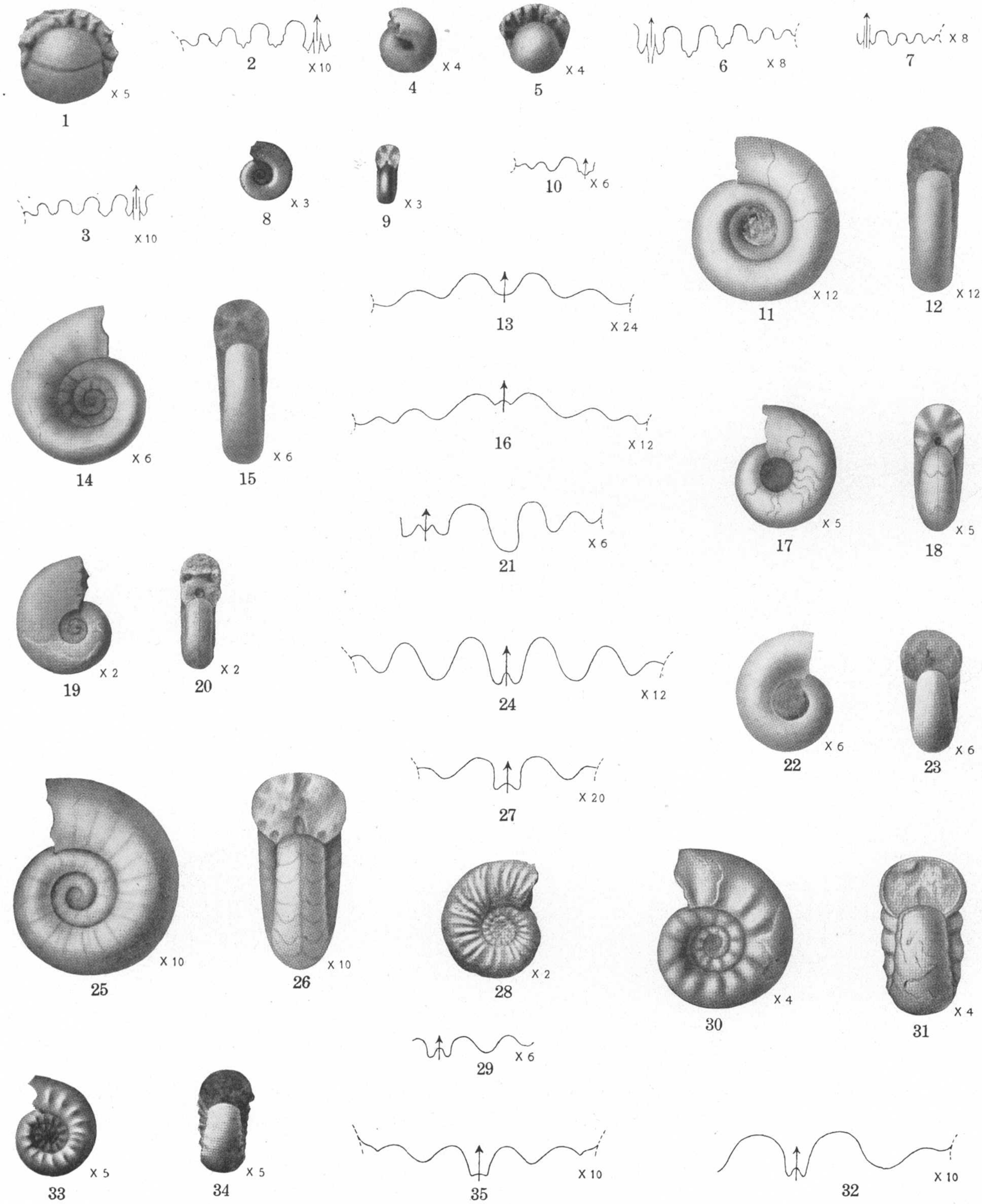
FIGURES 25–27. *Gymnoticeras blakei* Gabb (p. 22). Larval stage, diameter 3 millimeters, corresponding to *Lecanites*. Middle Triassic, Nevada.

FIGURES 28, 29. *Hollandites organi* Smith (p. 22). Adolescent stage, corresponding to *Lecanites*, diameter 11 millimeters. Middle Triassic, Nevada.

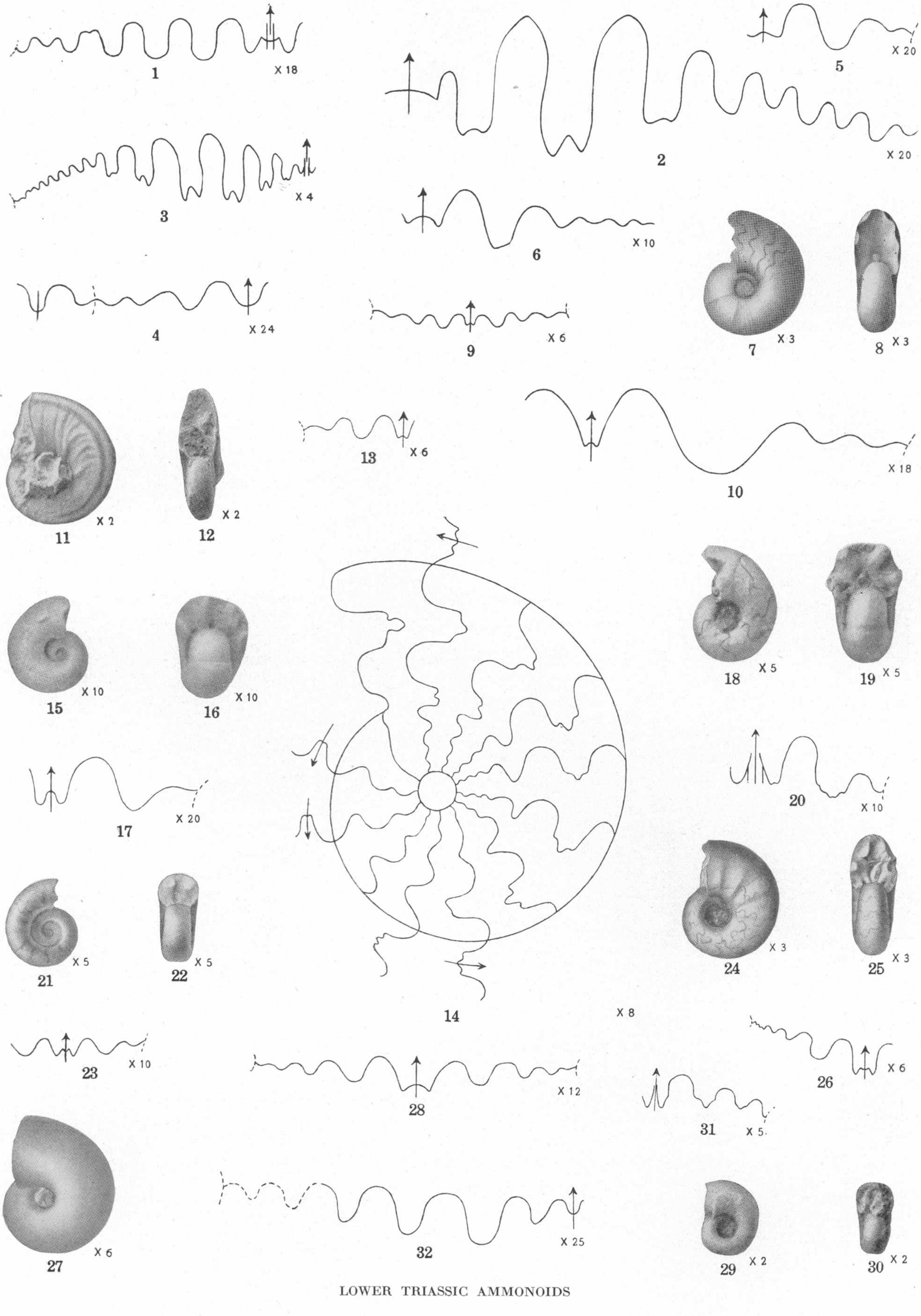
FIGURES 30–32. *Nevadites merriami* Smith (p. 22). Larval stage, corresponding to transition from *Lecanites* to primitive *Xenodiscus*, diameter 6.5 millimeters. Middle Triassic, Nevada.

FIGURES 33–35. *Arpadites gabbi* Hyatt and Smith (p. 22). Larval stage, diameter 3.46 millimeters; transitional from *Prolecanites* to *Lecanites*. Upper Triassic, California.

The figures in this plate are introduced for comparison of larval stages of Triassic ammonites with antecedent and supposedly ancestral Paleozoic or early genera. Figures 1–3, 4–7, 33–35, from U. S. Geol. Survey Prof. Paper 141, pls. 23, 22, 83; Figures 8–10 from U. S. Geol. Survey Prof. Paper 40, pl. 64; Figures 11–16, 17–21, 22–24, 25–27, 28–29, 30–32 from U. S. Geol. Survey Prof. Paper 83, pls, 2, 74, 8, 66, 55, 8.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 60

FIGURES 1–3. *Sageceras gabbi* Mojsisovics (p. 22). Middle Triassic, Nevada.

1. Larval stage, diameter 4.5 millimeters; transitional from *Gephyroceras* toward *Beloceras*.
2. Late larval stage, diameter 7 millimeters; transitional from *Beloceras* toward primitive *Sageceras*.
3. Adolescent stage, diameter 18 millimeters.

FIGURES 4–6. *Aspenites acutus* Hyatt and Smith (p. 22). Lower Triassic, Idaho.

4. Larval stage, transitional toward *Gephyroceras*, diameter 2 millimeters.
5. Larval stage, corresponding to *Gephyroceras*, diameter 2.75 millimeters.
6. Larval stage, corresponding to *Timanites*, diameter 5 millimeters.

FIGURES 7–9. *Dieneria arthaberi* Hyatt and Smith (p. 22). Larval stage, diameter 3.6 millimeters. Upper Triassic, Calif.

FIGURE 10. *Lanceolites compactus* Hyatt and Smith (p. 22). Larval stage, diameter 4.5 millimeters; corresponding to *Aphyllites*. Lower Triassic, Idaho.

FIGURES 11–13. *Fremontites ashleyi* Hyatt and Smith (p. 22). Larval stage, diameter 8 millimeters; corresponding to *Aphyllites*. Upper Triassic, California.

FIGURE 14. *Cordillerites angulatus* Hyatt and Smith (p. 22). Larval stage, showing development from the *Prolecanites* to the *Pronorites* stage, diameter 6.5 millimeters. Lower Triassic, Idaho.

FIGURES 15–20. *Ussuria waageni* Hyatt and Smith (p. 22). Lower Triassic, Idaho.

15–17. Larval stage, diameter 1.8 millimeters; corresponding to *Gephyroceras*.

18–20. Larval stage, diameter 4.4 millimeters; corresponding to *Dimorphoceras*.

FIGURES 21–23. *Eutomoceras laubei* Meek (p. 22). Larval stage, diameter 2.5 millimeters; corresponding to *Lecanites*. Middle Triassic, Nevada.

FIGURES 24–26. *Dalmatites parvus* Smith (p. 22). Larval stage, diameter 7 millimeters; corresponding to *Lecanites*. Middle Triassic, Nevada.

FIGURES 27, 28. *Longobardites nevadanus* Hyatt and Smith (p. 22). Larval stage, diameter 4 millimeters. Middle Triassic, Nevada.

FIGURES 29–31. *Discophyllites patens* Mojsisovics (p. 22). Larval stage, diameter 5 millimeters; septa drawn from same specimen at diameter of 2 millimeters, showing transition from goniatite stage to primitive *Xenodiscus*. Upper Triassic, California.

FIGURE 32. *Pseudosageceras multilobatum* Noetling (p. 22). Larval stage, diameter 5.5 millimeters; corresponding to *Beloceras*. Lower Triassic, Idaho.

The figures in this plate are introduced to show comparison of young stages of Triassic ammonites with Paleozoic antecedents and supposed ancestors. Figures 1, 2, 4–6, 10, and 32 are originals; Figure 14 is from U. S. Geol. Survey Prof. Paper 40, pl. 71; Figures 7–9, 11–13, 15–20, 29–31 from U. S. Geol. Survey Prof. Paper 141, pls. 81, 63, 21, 62; Figures 3, 21–23, 24–26, 27–28 from U. S. Geol. Survey Prof. Paper 83, pls. 12, 27, 30, 12.

PLATE 61

FIGURES 1–21. *Columbites parisianus* Hyatt and Smith (p. 107).

1. Mature specimen, showing the body chamber to be one revolution in length, also the obsolescence of sculpture at maturity.

2–4. Side and front views and septum, early maturity.

5–7. Side, front, and rear views, to show the sculpture on both shell and cast.

8, 9. Side and front views, end of adolescent stage; diameter 33 millimeters.

10. Front view, broken, showing the inner whorl; diameter 28 millimeters.

11, 12. Side and front views of whole specimen, adolescent stage; diameter 26 millimeters.

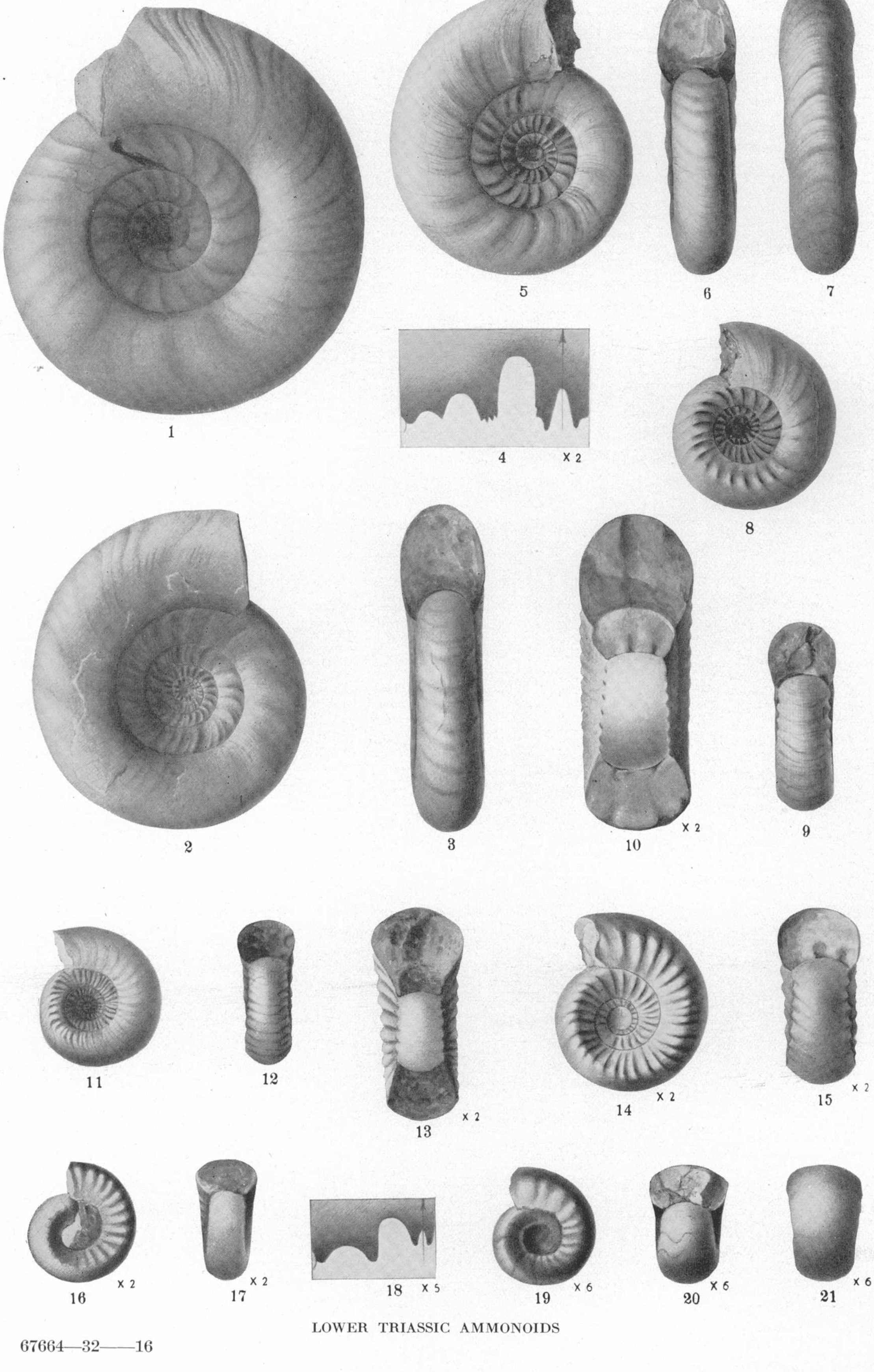
13. Front view of broken whorl of same specimen, showing the inner whorl.

14, 15. Side and front views, showing *Gastrioceras* stage of growth, adolescent stage, diameter 16 millimeters.

16–18. Side and front views and septa, early adolescent stage; diameter 10 millimeters.

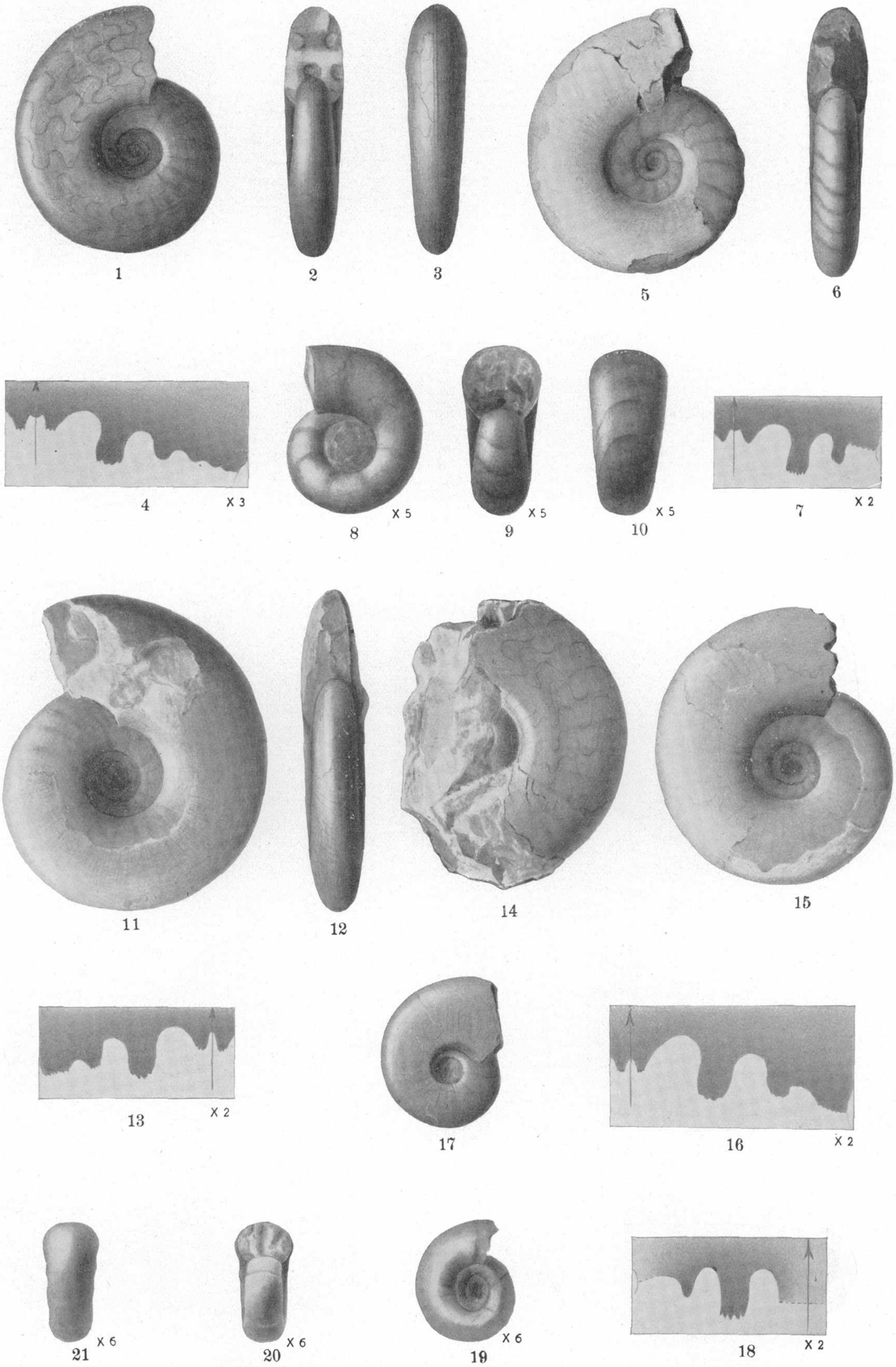
19–21. Side, front, and rear views, early adolescent stage; diameter 3.32 millimeters.

From Lower Triassic, *Columbites* zone, 1 mile west of Paris, Idaho (locality 1981, United States Geological Survey).



LOWER TRIASSIC AMMONOIDS

67664—32——16



LOWER TRIASSIC AMMONOIDS

PLATE 62

Figures 1–10. *Ophiceras spencei* Hyatt and Smith (p. 50).

1–4. Side, front, and rear views and septum. (The septa do not show the auxiliary lobes shown by mistake in the drawing.)

5–7. Side and front views and septum.

8–10. Side, front, and rear views, early adolescent stage; diameter 5.5 millimeters.

Figures 11–21. *Ophiceras jacksoni* Hyatt and Smith (p. 49).

11–13. Side and front views and septum of type specimen.

14. Side view.

15, 16. Side view and septum, adult stage.

17, 18. Side view and septum, end of adolescent stage; diameter 25 millimeters.

19–21. Side, front, and rear views, larval stage; diameter 3.2 millimeters.

All specimens figured in this plate from Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho. Collection of United States National Museum.

PLATE 63

FIGURES 1–6. *Pseudosageceras multilobatum* Noetling (p. 87).

1, 2. Side and front views.

4, 5. Side and rear views.

6. Septum of the same specimen.

FIGURES 7–13. *Meekoceras pilatum* Hyatt and Smith (p. 59).

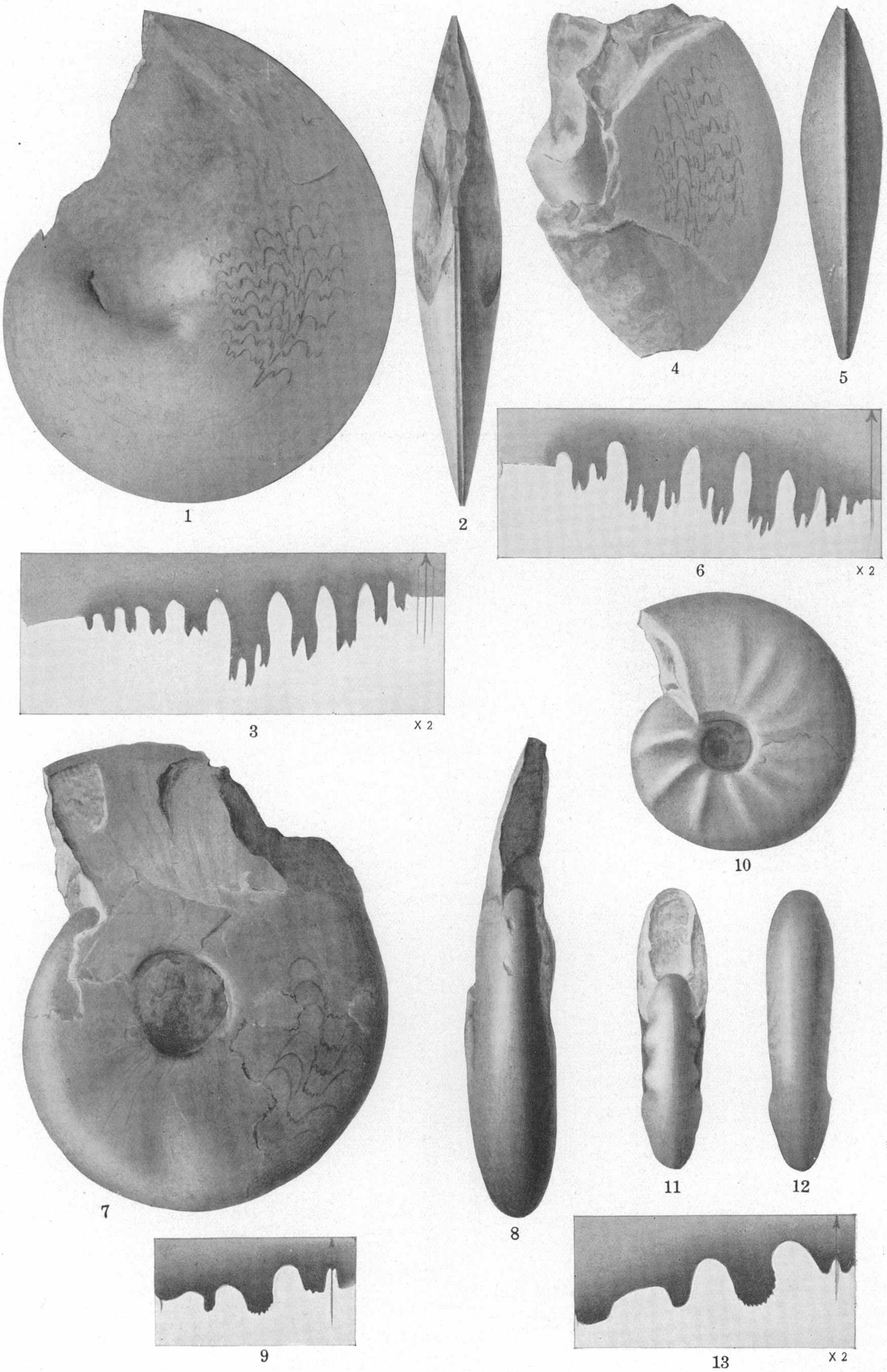
7, 8. Side and front views.

9. Septum of the same specimen.

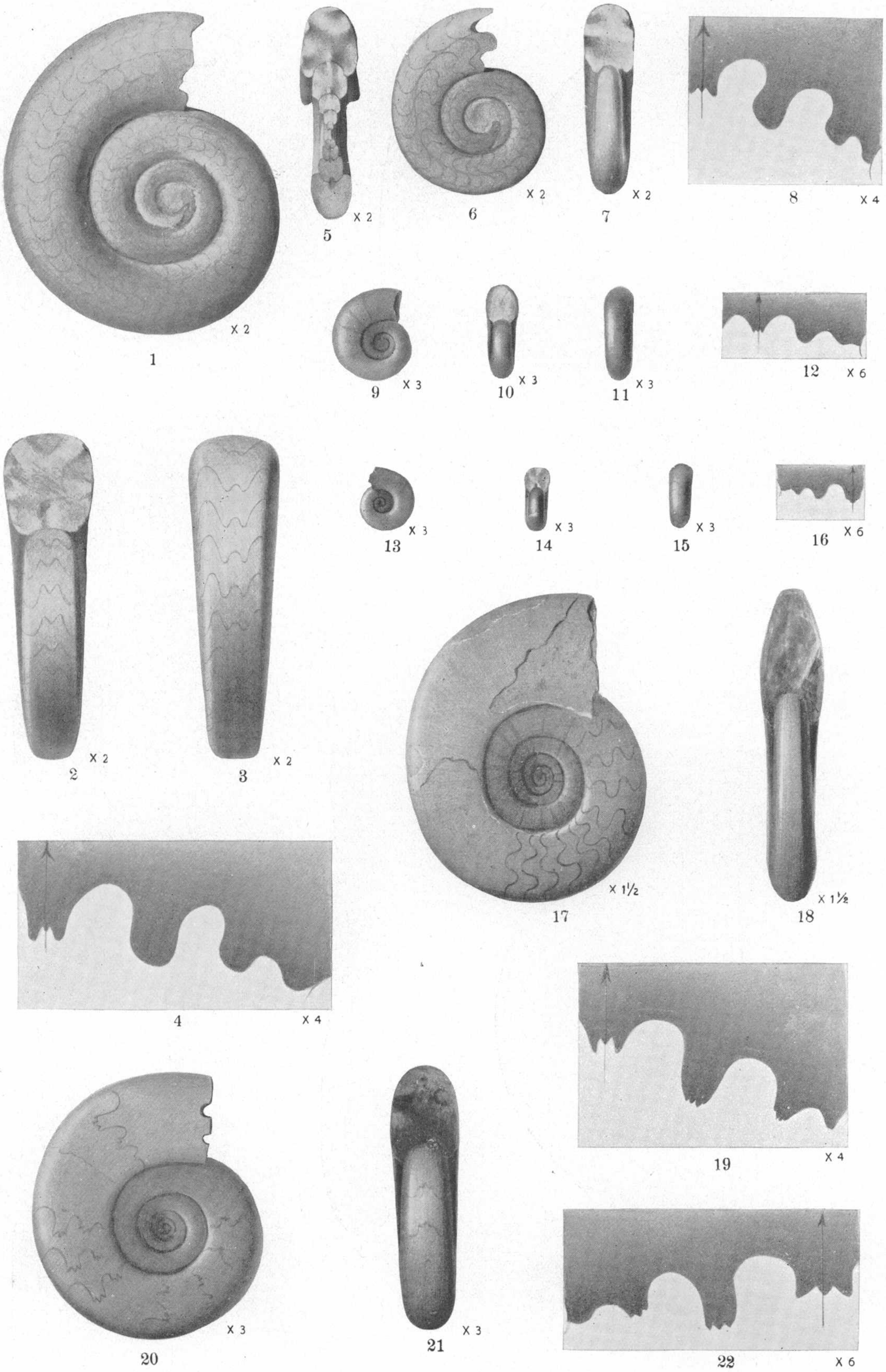
10–12. Side, front, and rear views of a smaller specimen.

13. Septum of the same specimen.

All specimens figured in this plate from Lower Triassic, *Columbites* zone, 1 mile west of Paris, Idaho. Locality 1981, United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 64

FIGURES 1–16. *Lecanites* (*Paralecanites*) *arnoldi* Hyatt and Smith (p. 41).

1–3. Right side, front, and rear views of type specimen.
4. Septum of the same specimen.
5. Cross section.
6, 7. Right side and front views, adolescent specimen; diameter 15 millimeters.
8. Septum of the same specimen.
9–11. Right side, front, and rear views, adolescent stage; diameter 5 millimeters.
12. Septum of the same specimen.
13–15. Left side, front, and rear views; diameter 3.36 millimeters.
16. Septum of the same specimen.

FIGURES 17–22. *Flemingites aplanatus* (White) (p. 51).

17, 18. Side and front views.
19. Septum of the same specimen.
20, 21. Side and front views, adolescent stage; diameter 14 millimeters.
22. Septum of the same specimen.

All specimens figured in this plate from Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.

PLATE 65

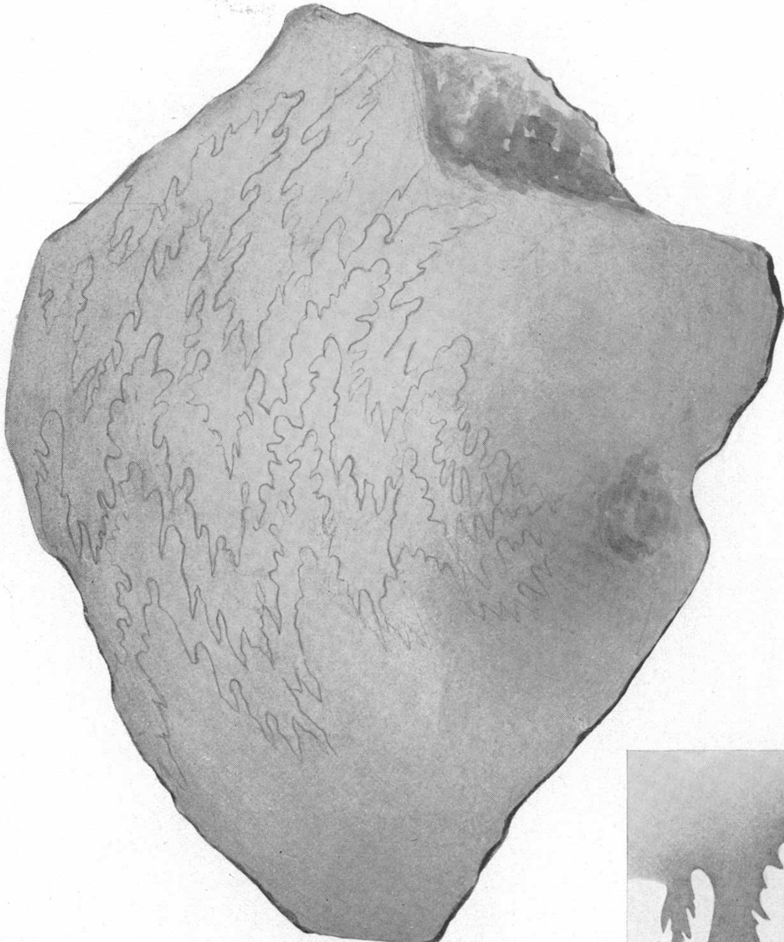
FIGURES 1–5. *Ussuria waageni* Hyatt and Smith (p. 92).

1. Side view of large specimen, showing the mature septa.
2. Septum of the same specimen.

3, 4. Side and front views of a younger specimen; diameter 75 millimeters.

5. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.



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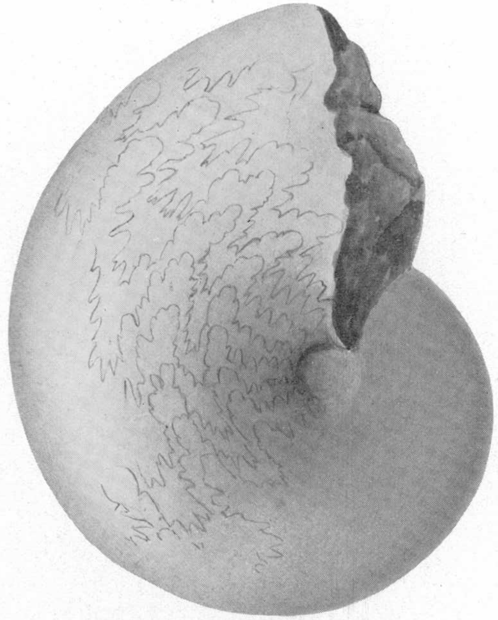

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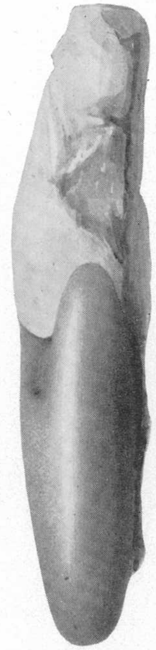

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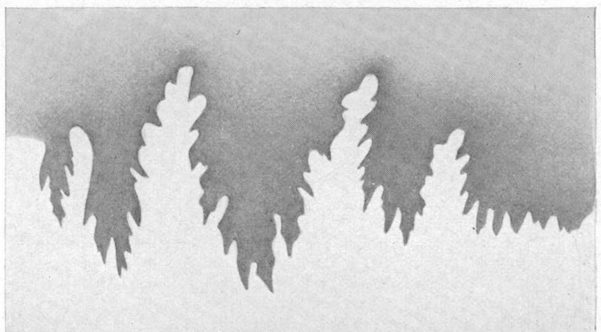

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LOWER TRIASSIC AMMONOIDS


X 2
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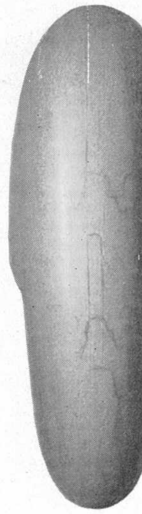
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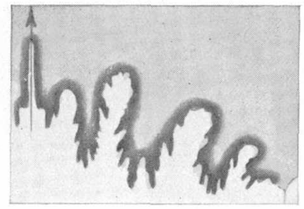
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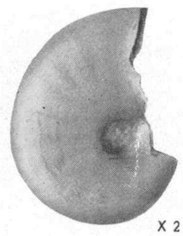
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X 2
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X 2
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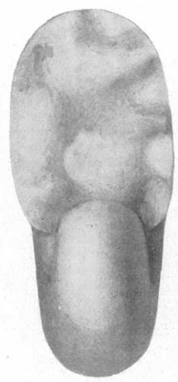
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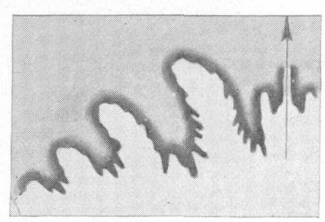
X 3
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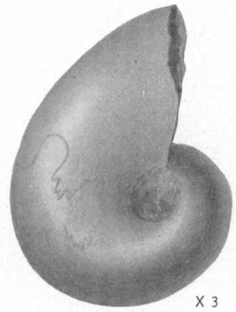
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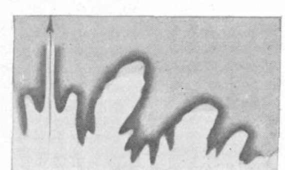
10


X 3
11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12

LOWER TRIASSIC AMMONOIDS

PLATE 66

FIGURES 1–12. *Ussuria waageni* Hyatt and Smith (p. 92).

1, 2. Right side and rear views, adolescent stage, showing the early *Ussuria* stage; diameter 35 millimeters.
3. Septum of the same specimen.
4, 5. Right side and front views, adolescent stage; diameter 30 millimeters.
6. Septum of the same specimen.
7, 8. Side and front views, adolescent stage, showing transition from *Thalassoceras* to *Ussuria;* diameter 17 millimeters.
9. Septum of the same specimen.
10, 11. Right side and front views, *Thalassoceras* stage; diameter 13 millimeters.
12. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.

PLATE 67

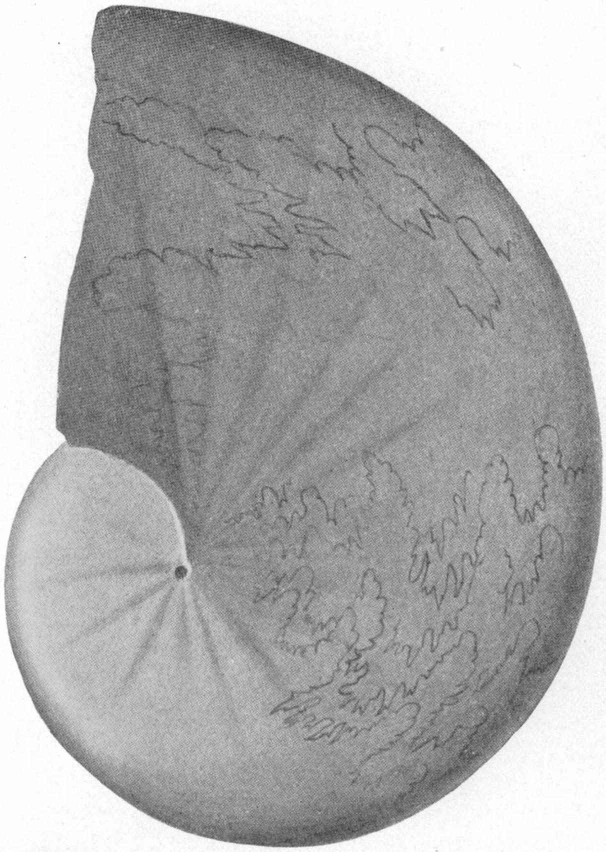
FIGURES 1, 2. *Ussuria waageni* Hyatt and Smith (p. 92). Side and front views of a large specimen with the details of the septa somewhat obliterated by weathering.

FIGURES 3–7. *Hedenstroemia kossmati* Hyatt and Smith (p. 78).

3–6. Left side, right side, front, and rear views of the type specimen.

7. Septum of the same specimen.

All specimens figured in this plate from Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.



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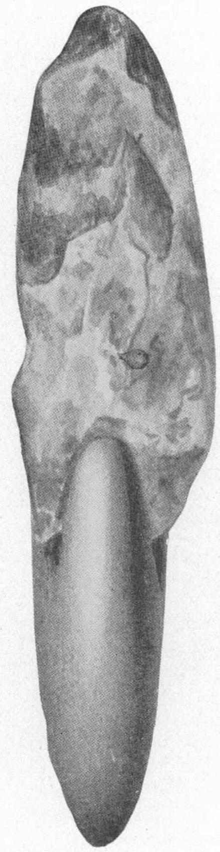

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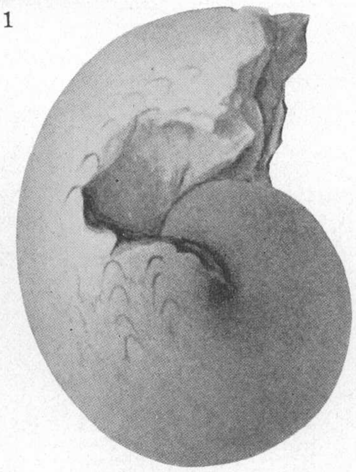

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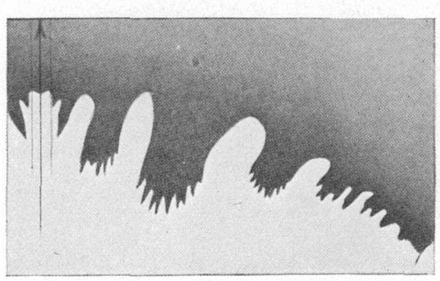
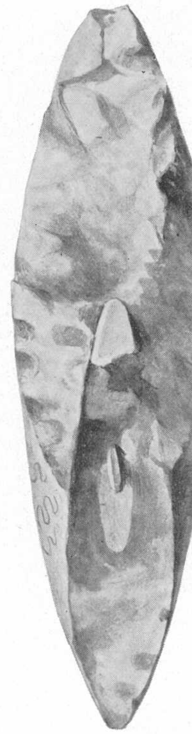


7 X 2

LOWER TRIASSIC AMMONOIDS

1



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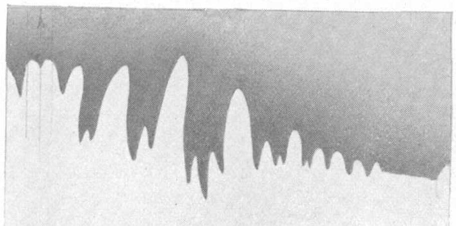

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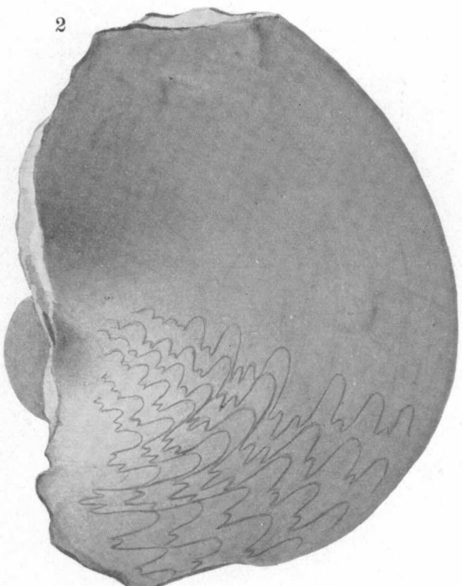

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8 X 2

9 X 2

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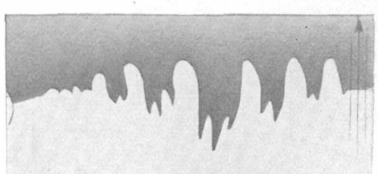


6

10 X 4

LOWER TRIASSIC AMMONOIDS

PLATE 68

FIGURES 1–10. *Cordillerites angulatus* Hyatt and Smith (p. 96).

1–3. Side and front views and septum of a very large specimen; diameter 95 millimeters.

4–6. Side, front, and septum of a smaller specimen; diameter 80 millimeters.

7. Side view of inner coil, inclosed in the same specimen; diameter about 20 millimeters.

8, 9. Right side and rear views, adolescent stage; diameter 25 millimeters.

10. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.

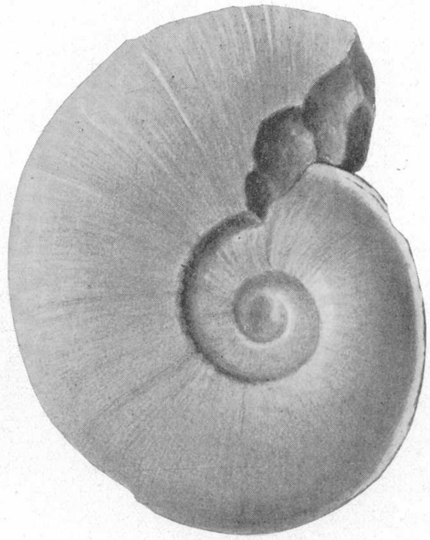
PLATE 69

FIGURES 1–9. *Inyoites oweni* Hyatt and Smith (p. 80).

1. Side view of large specimen showing the characteristic sculpture and the septa; diameter 90 millimeters.
2, 3. Side and front views; diameter 72 millimeters.
4–6. Left side, front, and rear views, adolescent specimen; diameter 36 millimeters.
7, 8. Left side and front views, adolescent stage; diameter 27 millimeters.
9. Septum of the same specimen.

From Lower Triassic *Meekoceras* zone, *Owenites* subzone, Union Canyon, 15 miles southeast of Independence, Inyo County, Calif.

1



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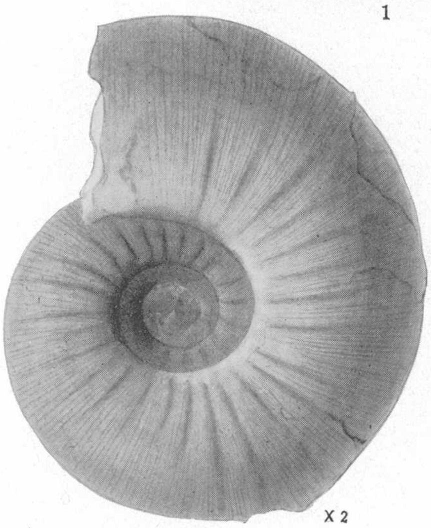

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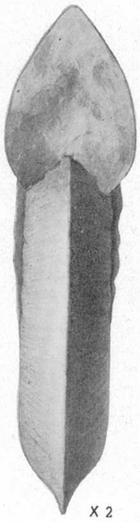

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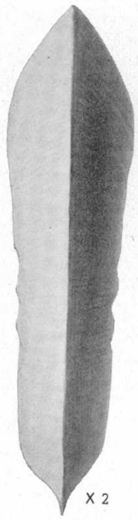

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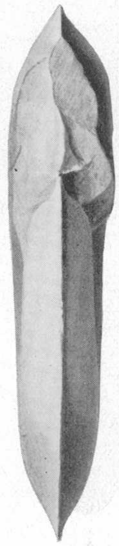

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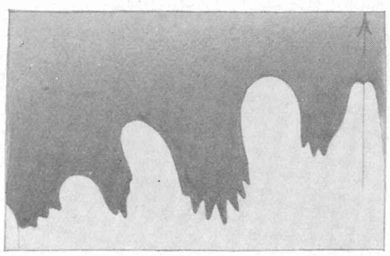

9 X 4

X 2

7

X 2

8

LOWER TRIASSIC AMMONOIDS

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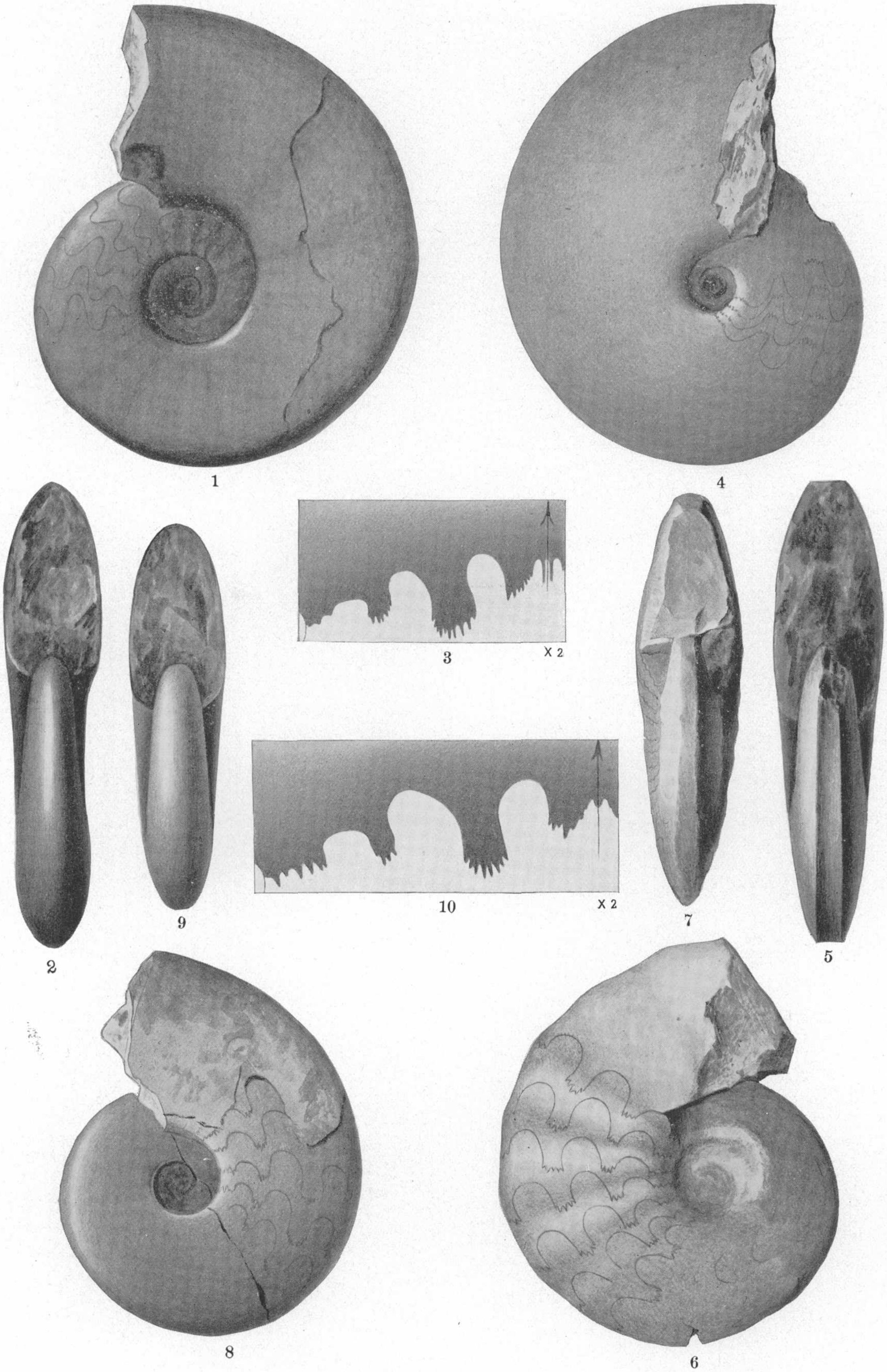


LOWER TRIASSIC AMMONOIDS

PLATE 70

FIGURES 1–3. *Flemingites russelli* Hyatt and Smith (p. 53).

1, 2. Side and front views.

3. Septum of the same specimen.

FIGURES 4–7. *Meekoceras gracilitatis* White (p. 57).

4, 5. Side and front views, showing the full length of the body chamber; diameter 77 millimeters.

6, 7. Side and front views, showing the radial folds; diameter 67 millimeters.

FIGURES 8–10. *Meekoceras (Koninckites) mushbachanum* White (p. 61).

8, 9. Side and front views (natural size).

10. Septum of the same specimen.

All specimens figured in this plate from Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho.

PLATE 71

FIGURES 1–6. *Cordillerites angulatus* Hyatt and Smith (p. 96).

1. Larval shell, showing development from *Prolecanites* to *Pronorites* stage; diameter 6.5 millimeters.
2. Septum, adolescent stage; diameter 10 millimeters.
3. Septum, adolescent stage; diameter 11 millimeters.
4. Septum; diameter 12 millimeters.
5. Septum, showing transition to *Cordillerites;* diameter 17 millimeters.
6. Adult stage, showing *Cordillerites* characters.

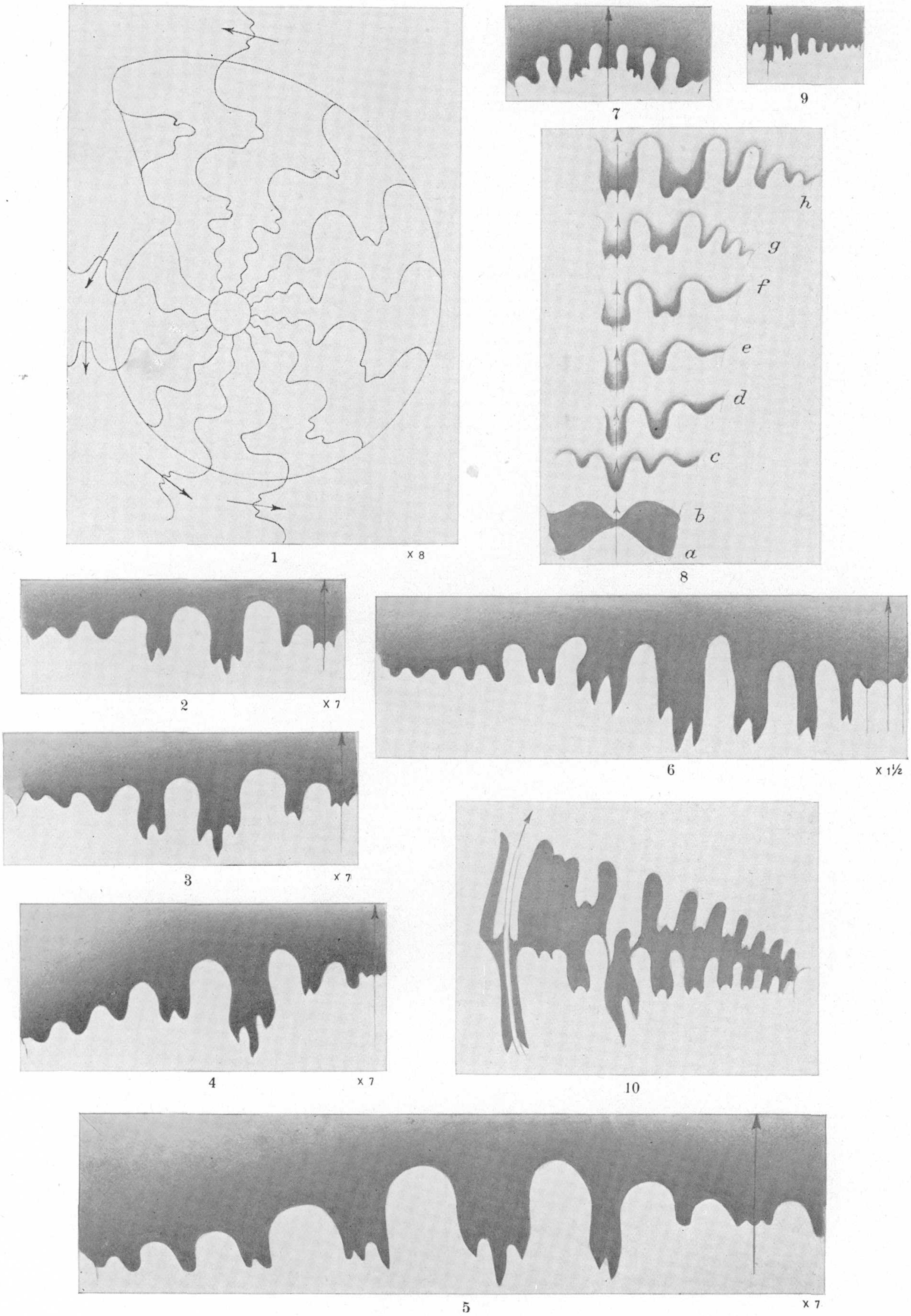
From Lower Triassic *Meekoceras* zone, Wood Canyon, 9 miles east of Soda Springs, Idaho.

FIGURE 7. *Pronorites mixolobus*, to show the tripartite first lateral lobe of *Pronorites* (p. 97). (After De Koninck, Faune du calcaire carbonifère de la Belgique, pt. 2, p. 122, fig. 1.)

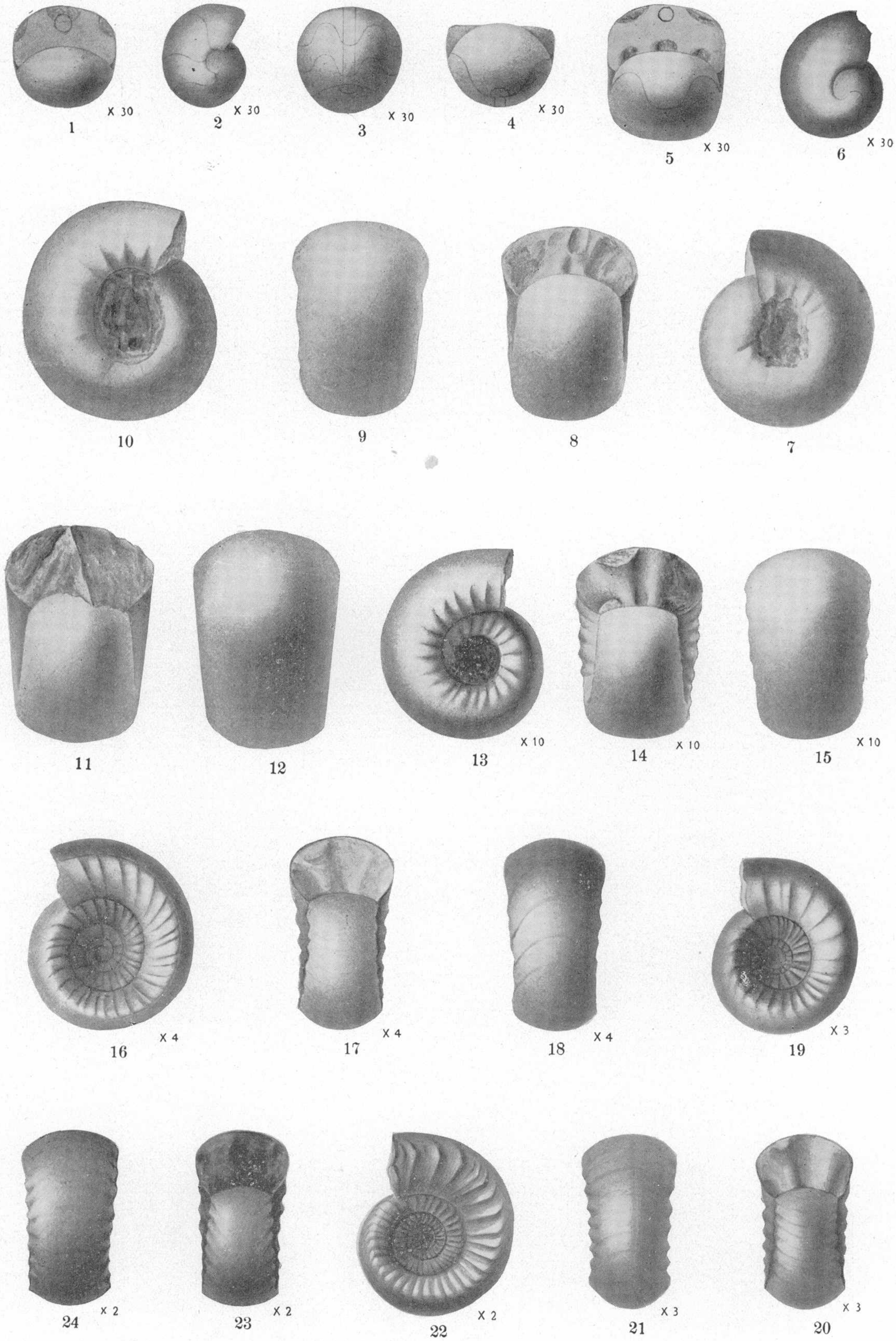
FIGURES 8a–h. *Pronorites praepermicus* Karpinsky, to show the development of the septum up to the *Pronorites* stage (p. 97). (After Karpinsky, Ueber die Ammoneen der Artinsk-Stufe, pl. 1, fig. 2, f–n.)

FIGURE 9. *Sicanites mojsvari* Gemmellaro, to show the *Sicanites* stage (p. 97). (After Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, pl. 59d, fig. 2a.)

FIGURE 10. *Propinacoceras beyrichi* Gemmellaro, to show the *Propinacoceras* stage (p. 97). (After Frech, Fritz, Lethaea geognostica, Teil 1, Das Palaeozoicum, Band 2, Lief. 3, p. 476, fig. 8.)



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 72

FIGURES 1–24. *Columbites parisianus* Hyatt and Smith (p. 107).

1–4. Protoconch and three chambers; diameter 0.50 millimeter. Figure 1 from front, 2 from right side, 3 from below, and 4 from above.

5, 6. Protoconch and two-thirds of a revolution of the larval shell; diameter 0.75 millimeter. Figure 5 from front, 6 from right side.

7–9. Left side, front, and rear views, larval stage; diameter 1.50 millimeters.

10–12. Right side, front, and rear views, larval stage; diameter 1.75 millimeters.

13–15. Right side, front, and rear views, larval stage; diameter 3 millimeters.

16–18. Right side, front, and rear views, adolescent stage; diameter 8.50 millimeters.

19–21. Left side, front, and rear views, adolescent stage; diameter 10 millimeters.

22–24. Left side, front, and rear views, adolescent stage; diameter 15 millimeters.

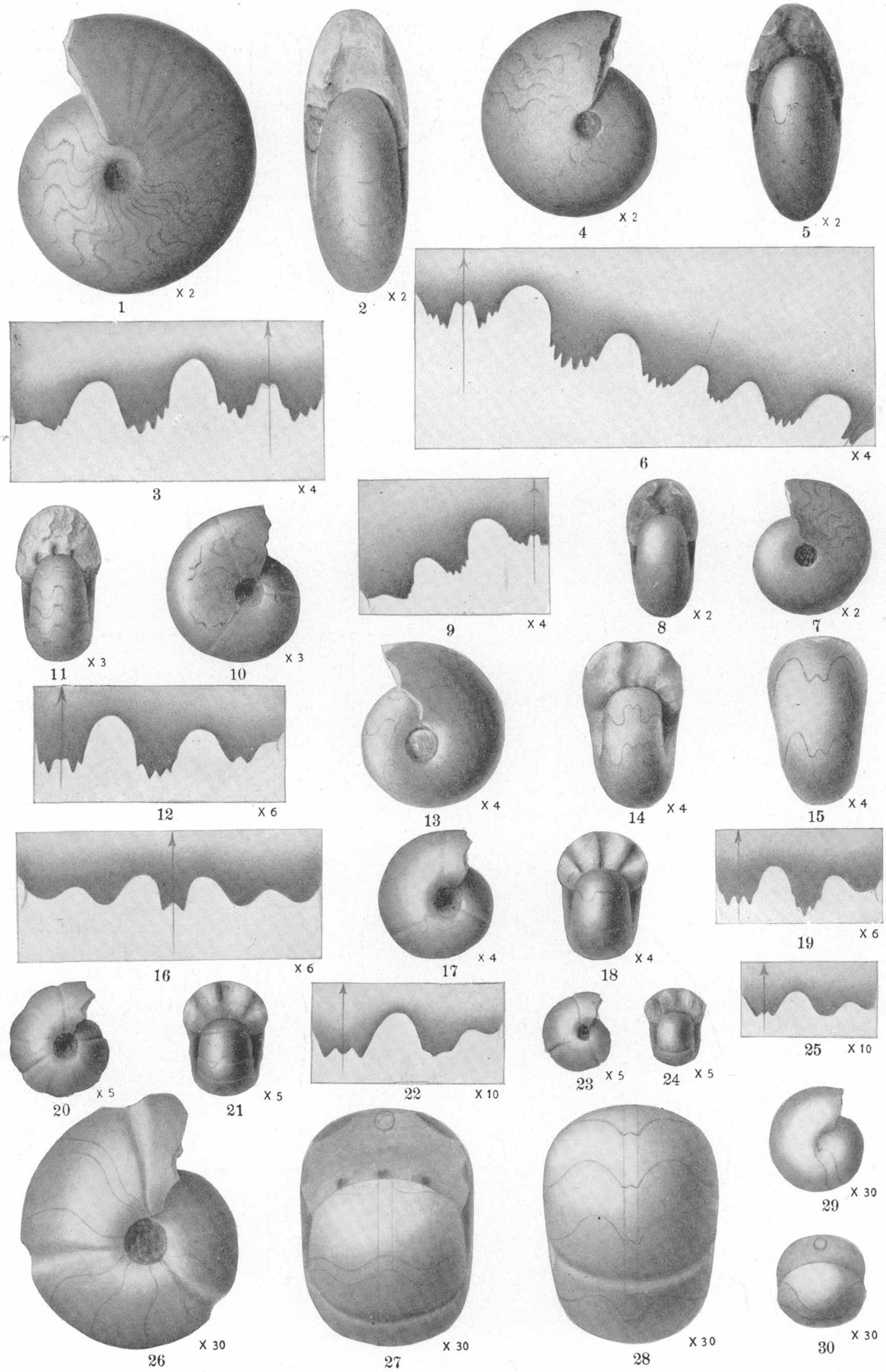
From Lower Triassic *Columbites* zone, 1 mile west of Paris, Idaho. Collection of United States Geological Survey.

PLATE 73

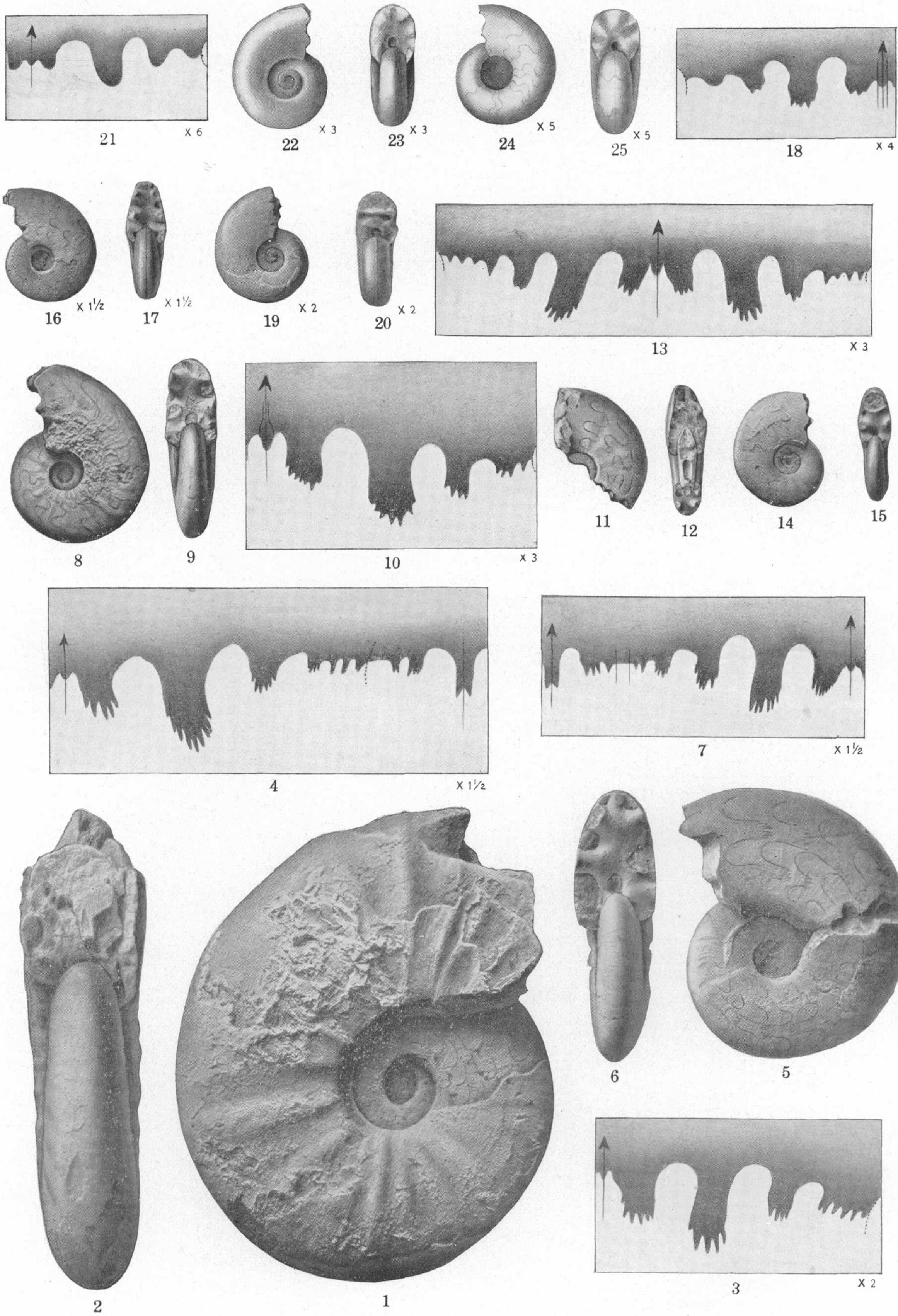
FIGURES 1–30. *Parananannites aspenensis* Hyatt and Smith (p. 98).

1, 2. Left side and front views of the type specimen.
3. Septum of the same specimen.
4, 5. Right side and front views of a smaller specimen.
6. Septum of the same specimen with the inner septum drawn from a piece broken off the coil.
7, 8. Left side and front views; diameter 12 millimeters.
9. Septum of the same specimen.
10, 11. Right side and front views; diameter 9 millimeters.
12. Septum of the same specimen.
13–15. Left side, front, and rear views, *Nannites* stage; diameter 7 millimeters.
16. Septum of the same specimen.
17, 18. Right side and front views, *Nannites* stage; diameter 5.5 millimeters.
20, 21. Right side and front views, *Nannites* stage; diameter 3.88 millimeters.
22. Septum of the same specimen.
23, 24. Right side and front views, *Pronannites* stage; diameter 2.5 millimeters.
25. Septum of the same specimen.
26, 28. Right side, front, and rear views, transition from *Parodoceras* to *Pronannites* stage; diameter 1.40 millimeters.
29, 30. Side and front views, early larval stage showing the latisellate first septum; diameter 0.54 millimeter.

From Lower Triassic *Meekoceras* zone, Wood Canyon, Aspen Ridge, 9 miles east of Soda Springs, Idaho. Collection of United States Geological Survey.



LOWER TRIASSIC AMMONOIDS



LOWER TRIASSIC AMMONOIDS

PLATE 74

FIGURES 1–25. *Meekoceras mushbachanum* White (p. 61).

1–3. Mature sculpture and septum, corresponding to *Arctoceras*.
4. Septum of another specimen.
5, 6. Adolescent stage, showing the nearly smooth compressed whorl.
7. Septum of the same specimen.
8, 9. Adolescent stage; diameter, 31 millimeters.
10. Septum of the same specimen.
11, 12. Adolescent stage; diameter, 25 millimeters.
13. Septum of the same specimen.
14, 15. Adolescent stage; diameter, 20 millimeters.
16, 17. Adolescent stage, showing the siphuncle; diameter, 14 millimeters.
18. Septum of the same specimen.
19, 20. Adolescent stage showing goniatitic septa; diameter, 10 millimeters.
21. Septum of the same specimen.
22, 23. Adolescent stage; diameter, 6.5 millimeters.
24, 25. End of larval stage; diameter, 4 millimeters.

Lower Triassic *Meekoceras* zone, southeastern Idaho, 5 miles southeast of Grays Lake. Shows the transition from *Meekoceras* to *Ceratites*.

PLATE 75

FIGURES 1–6. *Meekoceras mushbachanum* White (p. 61).

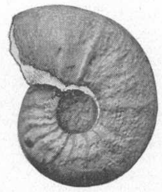
1. Specimen showing the ribs of maturity and the nearly smooth flat inner whorl.

2, 3. Adolescent inner whorl of the same specimen; diameter, 25 millimeters.

4–6. Adult stage.

Lower Triassic *Meekoceras* zone, southeastern Idaho. Collection of United States Geological Survey. Specimens shown in Figures 1–3 are from 5 miles southeast of Grays Lake. Those shown in Figures 4–6 are from 1½ miles east of Hot Springs.

1



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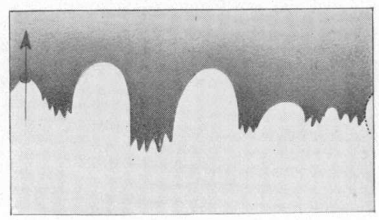

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LOWER TRIASSIC AMMONOIDS

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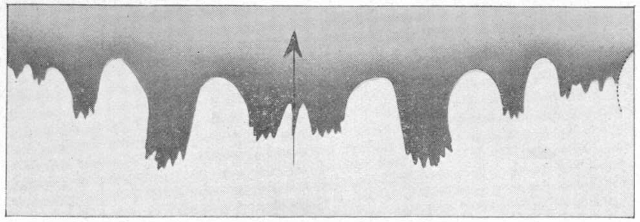

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LOWER TRIASSIC AMMONOIDS

PLATE 76

FIGURES 1–3. *Meekoceras mushbachanum* White (p. 61).

1. Adult shell, showing the rough sculpture of the mature stage and the smooth, flat, adolescent whorls.

2, 3. Adult shell, showing the sculpture and septa of maturity.

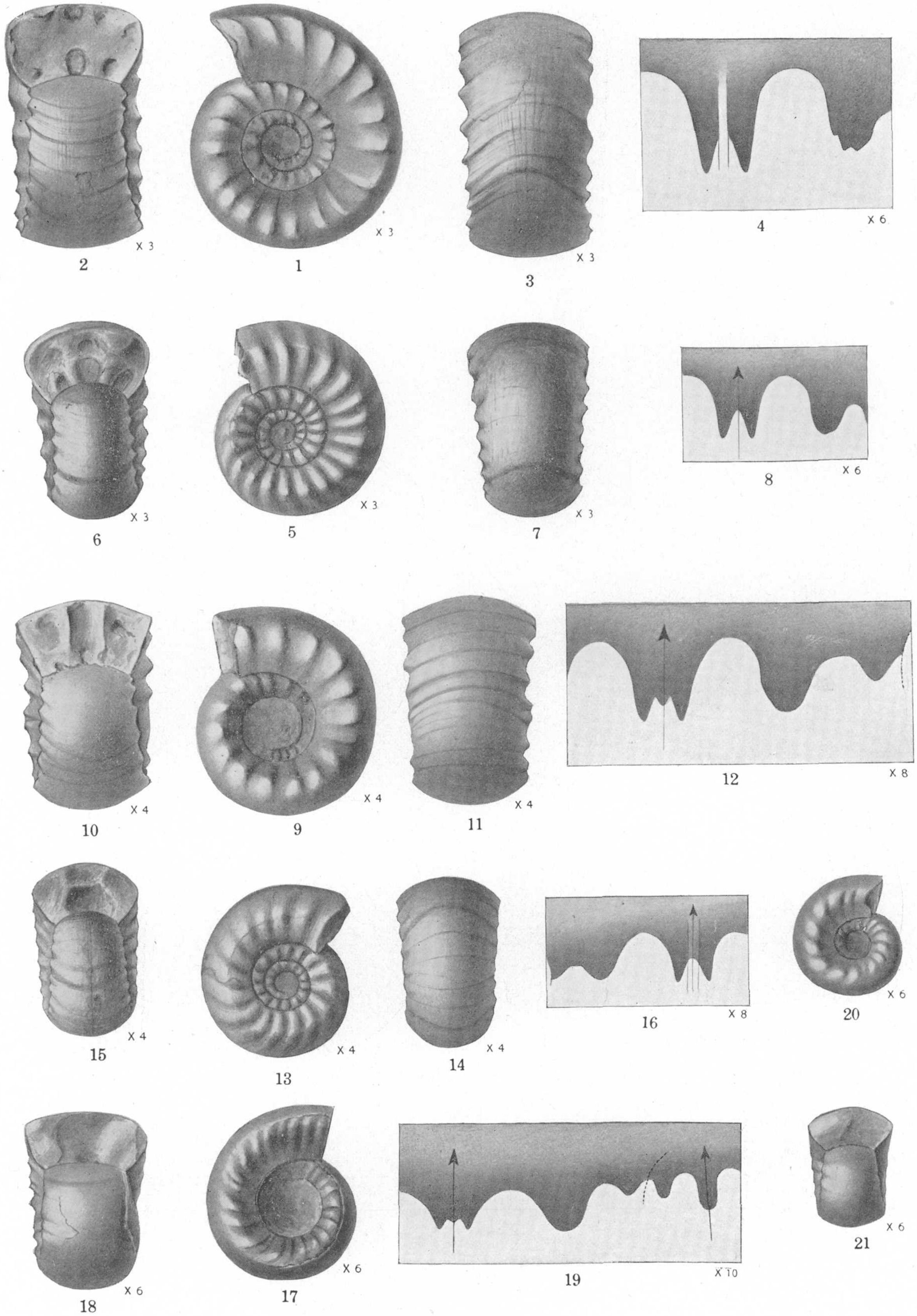
Lower Triassic *Meekoceras* zone, 5 miles southeast of Grays Lake, Idaho. Shows the transition between *Meekoceras* and *Ceratites*. Collection of United States Geological Survey.

PLATE 77

FIGURES 1–21. *Columbites spencei* Smith (p. 108).

1–3. Adolescent gastrioceran stage; diameter, 15 millimeters.
4. Septum of the same specimen.
5–7. Adolescent stage; diameter, 11 millimeters.
8. Septum of the same specimen.
9–11. Early adolescent stage; diameter, 9.5 millimeters.
12. Septum of the same specimen.
13–15. Diameter, 7.5 millimeters.
16. Septum of the same specimen.
17, 18. Diameter, 4.5 millimeters.
19. Septum of the same specimen.
20, 21. Diameter, 3 millimeters.

From the Lower Triassic *Columbites* zone in Paris Canyon, 1½ miles west of Paris, Bear Lake County, Idaho. Collection of United States Geological Survey.



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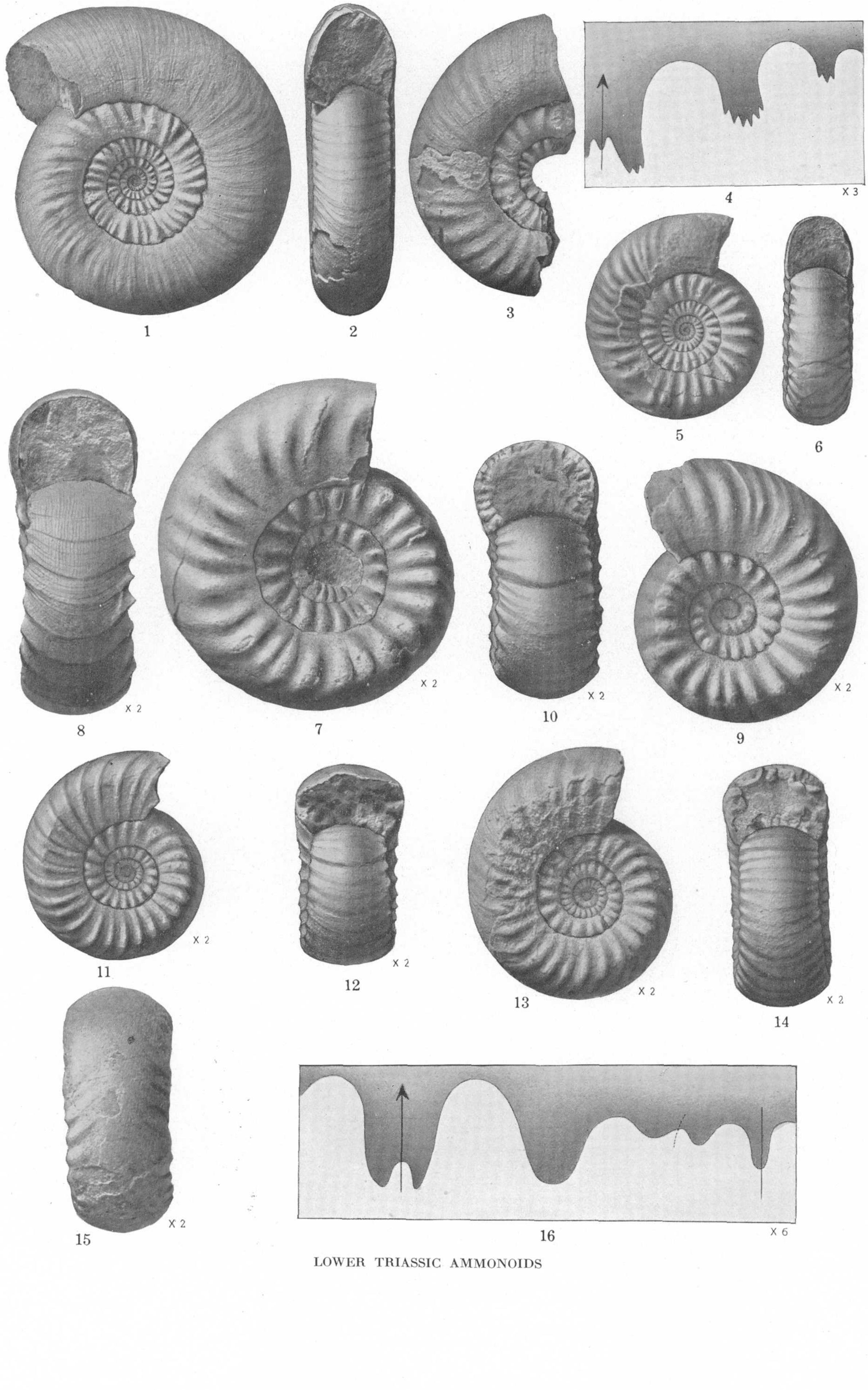


LOWER TRIASSIC AMMONOIDS

PLATE 78

FIGURES 1–16. *Columbites spencei* Smith (p. 108).

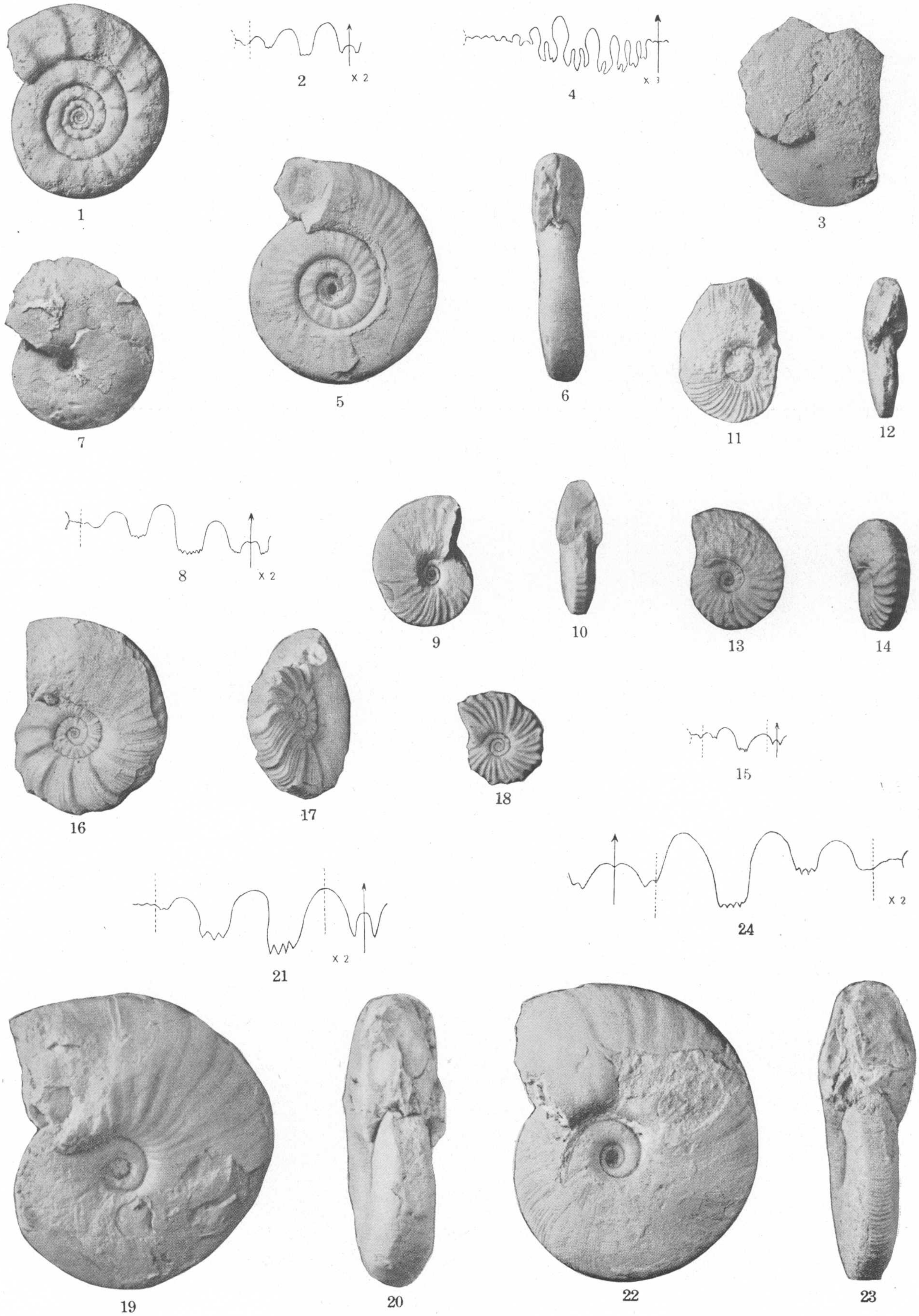
1, 2. Type specimen.
3. Fragment of an adult specimen, showing septa.
4. Septum of the same specimen.
5, 6. Late adolescent stage; diameter 40 millimeters.
6a. Septum of the same specimen.
7, 8. Adolescent stage; diameter 31 millimeters.
9, 10. Adolescent stage; diameter 25 millimeters.
11, 12. Adolescent stage, corresponding to *Gastrioceras;* diameter 20 millimeters.
13–15. Adolescent stage; diameter 23 millimeters.
16. Septum of the same specimen, drawn at diameter of 15 millimeters.

Lower Triassic *Columbites* zone, Paris Canyon, 1½ miles west of Paris, Bear Lake County, Idaho. Collection of United States Geological Survey.

PLATE 79

FIGURES 1, 2. *Xenodiscus nivalis* Diener (p. 44). (After Mathews, op. cit., pl. 1, figs. 1, 4.)
FIGURES 3, 4. *Cordillerites compressus* Mathews (p. 97). (After Mathews, op. cit., pl. 1, figs. 16, 17.)
FIGURES 5, 6. *Xenodiscus rotula* Waagen (p. 45). (After Mathews, op. cit., pl. 1, figs. 38, 40.)
FIGURES 7, 8. *Meekoceras davisi* Mathews (p. 58). (After Mathews, op. cit., pl. 1, figs. 8, 11.)
FIGURES 9, 10. *Anasibirites tenuistriatus* (Waagen) (p. 74). (After Mathews, op. cit., pl. 4, figs. 1, 2, "*Anasibirites mcclintocki.*")
FIGURES 11, 12. *Anasibirites hircinus* (Waagen) (p. 72). (After Mathews, op. cit., pl. 2, figs. 10, 11, "*Anasibirites blackwelderi.*")
FIGURES 13–15. *Anasibirites angulosus* (Waagen) (p. 70). (After Mathews, op. cit., pl. 3, figs. 28, 29, 31, "*Anasibirites pseudoibex.*")
FIGURES 16, 17. *Anasibirites kingianus* (Waagen) var. *inaequicostatus* Waagen (p. 72). (After Mathews, op. cit., pl. 3, figs. 34, 36, "*Anasibirites perrini.*")
FIGURE 18. *Anasibirites multiformis* Welter (p. 74). (After Mathews, op. cit., pl. 4, fig. 24, "*Anasibirites romeri.*")
FIGURES 19–21. *Anasibirites kingianus* (Waagen) (p. 72). (After Mathews, op. cit., pl. 4, figs. 29, 31, 32, "*Anasibirites edsoni.*")
FIGURES 22–24. *Anasibirites emmonsi* Mathews (p. 71). (After Mathews, op. cit., pl. 2, figs. 23, 25, 26, *Anasibirites emmonsi.*)

All specimens figured in this plate came from the *Anasibirites* subzone of the Fort Douglas area, Utah. The figures are copied from the paper by A. A. L. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, 1929. The originals are in The Walker Museum, University of Chicago.



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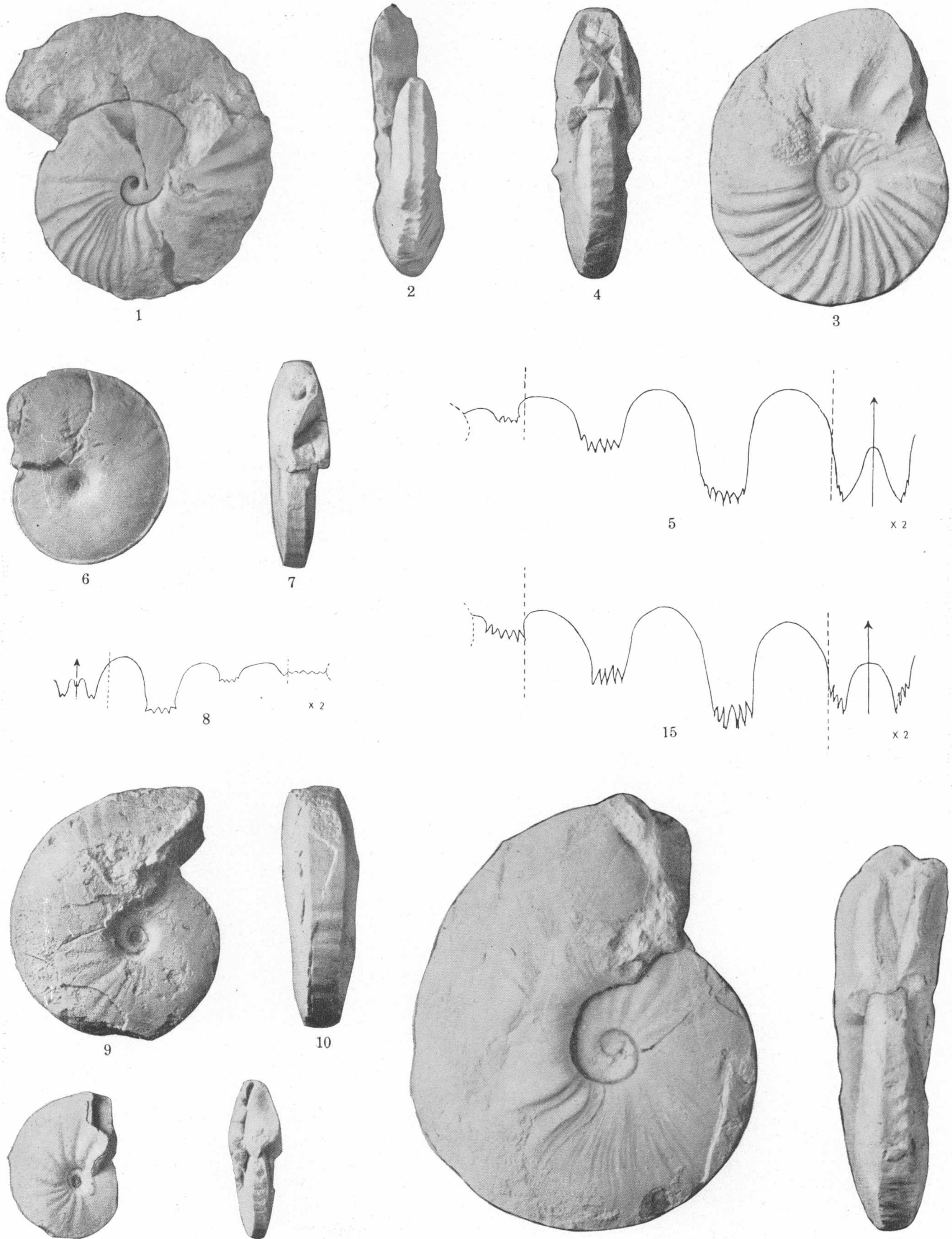

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PLATE 80

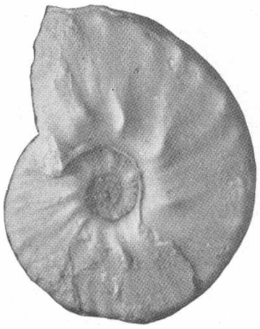
FIGURES 1, 2. *Anasibirites mojsisovicsi* Mathews (p. 73). (After Mathews, op. cit., pl. 5, figs. 2, 3.)
FIGURES 3–5. *Anasibirites bastini* Mathews (p. 70). (After Mathews, op. cit., pl. 10, figs. 7, 10, 11.)
FIGURES 6–8. *Anasibirites (Goniodiscus) typus* Waagen (p. 76). (After Mathews, op. cit., pl. 5, figs. 22, 26, 27, "*Goniodiscus americanus.*")
FIGURES 9, 10. *Anasibirites (Goniodiscus) utahensis* Mathews (p. 77). (After Mathews, op. cit., pl. 6, figs. 29, 30.)
FIGURES 11, 12. *Anasibirites (Goniodiscus) ornatus* Mathews (p. 75). (After Mathews, op. cit., pl. 6, figs. 6, 9.)
FIGURES 13–15. *Anasibirites (Goniodiscus) smithi* (Mathews) (p. 76). (After Mathews, op. cit., pl. 10, figs. 1, 3, 4, "*Gurleyites smithi.*")

All specimens figured in this plate came from the *Anasibirites* subzone of the Fort Douglas area, Utah. The figures are copied from the paper by A. A. L. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah: Walker Mus. Mem., vol. 1, No. 1, 1929. The originals are in The Walker Museum, University of Chicago.

PLATE 81

FIGURES 1, 2. *Kashmirites meeki* (Mathews) (p. 67). (After Mathews, op. cit., pl. 8, figs. 12, 14, "*Wasatchites meeki.*")
FIGURES 3–5. *Kashmirites wasatchensis* Mathews (p. 69). (After Mathews, op. cit., pl. 7, figs. 6, 7, 9, "*Kashmirites gilberti.*")
FIGURES 6–8. *Kashmirites perrini* (Mathews) (p. 67). (After Mathews, op. cit., pl. 9, figs. 1, 3, 9, "*Wasatchites perrini.*")
FIGURES 9, 10. *Kashmirites resseri* Mathews (p. 67). (After Mathews, op. cit., pl. 7, figs. 4, 5, *Kashmirites resseri.*)
FIGURES 11, 12. *Kashmirites seerleyi* (Mathews) (p. 68). (After Mathews, op. cit., pl. 8, figs. 8, 9, "*Keyserlingites seerleyi.*")

All specimens figured on this plate came from the *Anasibirites* subzone of the Fort Douglas area, Utah. The figures are copied from the paper by A. A. L. Mathews, The Lower Triassic cephalopod fauna of the Fort Douglas area Utah: Walker Mus. Mem., vol. 1, No. 1, 1929. The originals are in the Walker Museum, University of Chicago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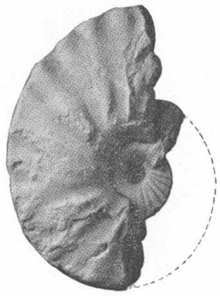
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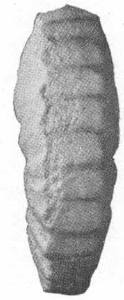
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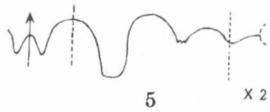

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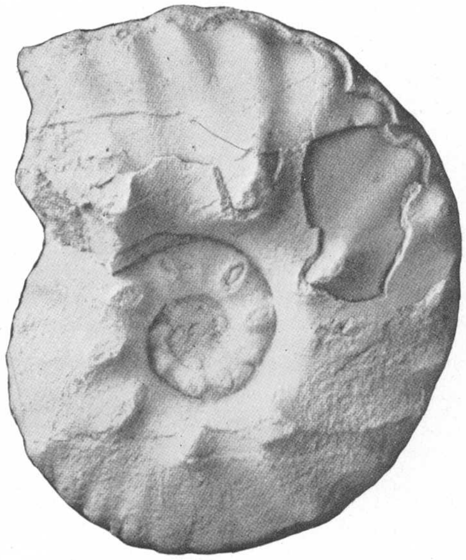
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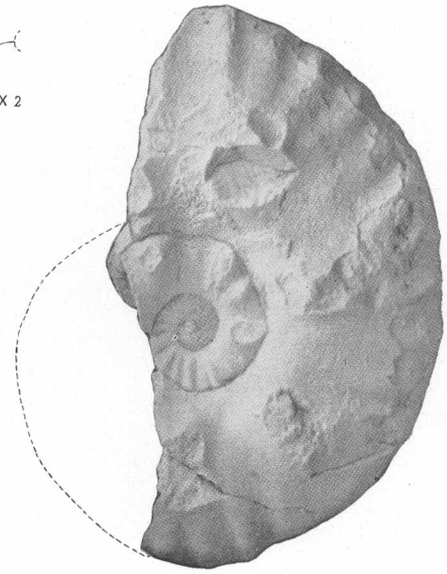
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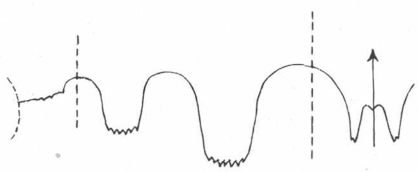
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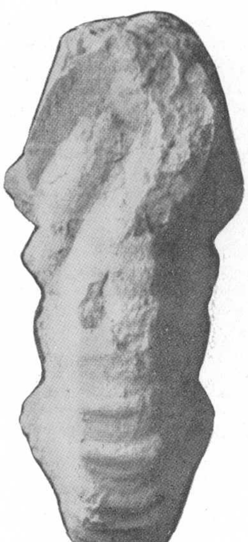
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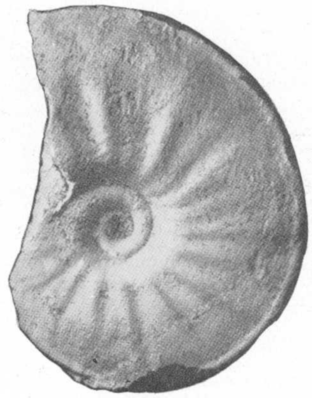
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