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CONTENTS OF VOLUME XI

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THE FAUNAS OF THE PARADOXIDES BEDS AT MANUELS, NEWFOUNDLAND

(Princeton University Contribution to the Geology of Newfoundland.— No. 7)

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A dissertation presented to the Faculty of Princeton University in candidacy for the degree of Doctor of Philosophy

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CONTENTS

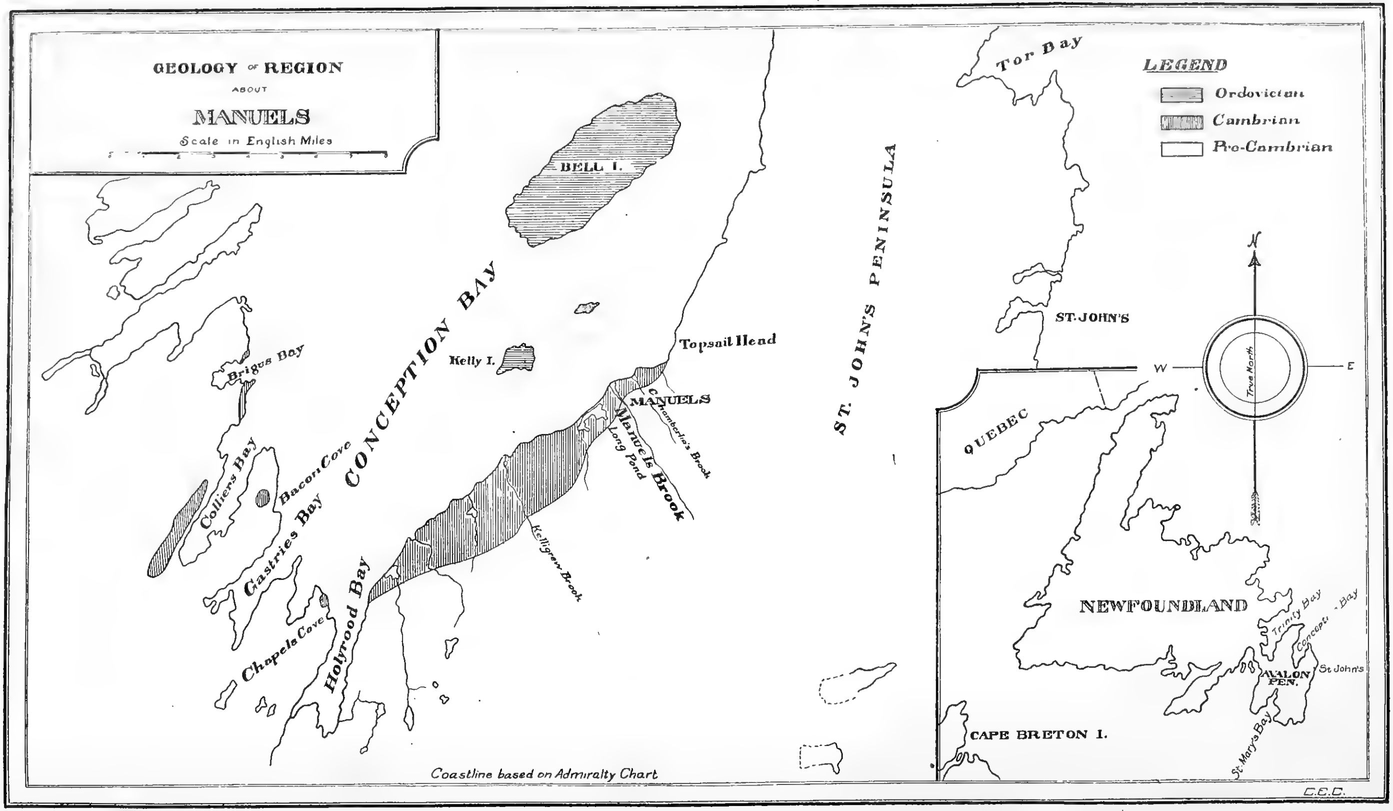


FIGURE I. Map showing the general geology about Manuels. The small inserted map shows the location of the area covered by the main map. (See pp. 19-23)

I. INTRODUCTION AND ACKNOWLEDGMENTS

The Paradoxides beds of the famous Cambrian section at Manuels, Newfoundland, whose stratigraphical and faunal succession are described in this paper, are of unusual interest because a large proportion of the many species of fossils which they contain are found also in the contemporaneous beds of northwestern Europe.

The description of the beds here presented is based on field work done at Manuels by members of four geological expeditions from Princeton University, and on laboratory studies pursued by the writer at that university and other institutions in eastern North America.

The writer makes grateful acknowledgment of the encouragement and financial support that have been extended to him in this research by the Department of Geology and the Graduate School of Princeton University, and tenders his sincere thanks to the many friends who have placed information or collections at his disposal or have assisted him in the field. He is indebted to Dr. A. O. Hayes, Professor N. C. Dale, of Hamilton College, and Professor A. F. Buddington, of Princeton, for data collected by them while members of the Princeton field parties in Newfoundland, to Professor A. H. Phillips, of Princeton, for numerous chemical analyses and mineralogical determinations, and to Dr. E. C. Cairnes, lately Fellow in Geology in the same institution, for drawing and lettering his maps. Professor Gilbert D. Harris, of Cornell University, loaned him the Hartt Collection from the Paradoxides beds of New Brunswick; Professor Percy E. Raymond, of Harvard University, and Professors Charles W. Brown and Richard M. Field, of Brown University, afforded facilities for the examination of collections in their care and loaned fossils from Newfoundland and New Brunswick and Professor Raymond conducted him to the famous Paradoxides harlani quarry at Braintree, Massachusetts, and assisted in obtaining a collection from there. Mr. James P. Howley, the late director of the Geological Survey of Newfoundland, opened the Newfoundland Survey's Cambrian collections for his examination; Professor W. A. Parks allowed him to study the Matthew Collection of New Brunswick and Newfoundland types in the Royal Ontario Museum of Palæontology; and Dr. Charles D. Walcott gave permission to examine the wonderful series of specimens from the Paradoxides beds of many countries that he has gathered together at Washington. The late Dr. G. F. Matthew and Mr. William McIntosh, of St. John, guided him to a number of the Cambrian localities in southern New Brunswick, and presented a valuable collection of fossils. Professor George H. Perkins supplied information about the Cambrian of Vermont; Mr. L. D. Burling furnished a list of the species from the Paradoxides beds of Newfoundland and eastern Canada that are represented in the collections of the Canadian Geological Survey; and Dr. Charles E. Resser, of the United States National Museum, provided much valuable information, especially about Cambrian bibliography.

Most of all, the writer desires to express his appreciation to his wife, for her constant encouragement, helpful criticism, and efficient aid in the field and laboratory; and to Professor Gilbert vanIngen, of Princeton, for the use of his large library, assistance in the preparation of the photographic illustrations, and a great deal if invaluable guidance and advice.

II. PREVIOUS WORK AND LITERATURE

J. B. Jukes, who made the earliest official geological survey of Newfoundland and was probably the first man to study and classify the rocks of the Conception Bay region, noted the presence of shales at Manuels, and referred them to the "Belle Isle" division of his "Upper Slate Formation."* (See column I of Table I, p. 12.) He found no fossils in these shales, and therefore could not determine their age. He judged from their appearance that they were very old, although he knew from their stratigraphic position that they were younger than most of the other rocks of the district. (Jukes, 1842, vol. II, pp. 245, 249, 275, 329; 1843, pp. 51, 55, 81, 135, and map.)

Alexander Murray, who was the first director of the second official Newfoundland survey, appears to have been the next geologist to work at Manuels. The first published result of his investigations was probably incorporated in Logan's "Geological Map of Canada," which appeared in 1865, and in which the beds at Manuels were mapped as belonging in the "Calciferous" division of his "Lower Silurian" "Quebec group" (Logan, 1865, p. 15, pl. 1). The next reference to the beds at that locality was in Murray's report of progress for 1866 (Murray and Howley, 1881a, p. 75) in which Murray stated that a "very good section of the more recent formation" (Jukes' "Upper Slate Formation") was exposed "on Manuels"† Brook, at Topsail Head, and at Kelly's Island." He wrote that "the obscurity or absence of organic remains" rendered it "unadvisable to express too decided an opinion" as to the age of this "forma-

* All terms and statements included in quotation marks in the present paper are quoted verbatim from other authors, and are used in the sense in which those authors used them.

† Various spellings of Manuels occur in geological literature. The spelling employed in the present paper is the one that was used by Mr. Howley on the 1907 official geological map of Newfoundland. (Howley, 1907.)

tion"; but added, in a foot-note, that a fossil, which appeared to be of earliest "Silurian" age, had been discovered in its upper beds. In his report for 1868 he presented a hypothetical section of the "Lower Silurian (Potsdam)" strata of the Conception Bay basin, showing the beds arranged in what he thought was probably nearly their true order (Murray and Howley, 1881a, pp. 156, 157, and plate facing p. 160) ; and in his report for 1870, he included a generalized composite section of all of the "Primordial Silurian" strata of southeastern Newfoundland that he and his then assistant, Mr. J. P. Howley, had discovered up to that time (Murray and Howley, 1881a, pp. 237–239). Summaries of these sections are given in columns 2 and 3 of Table I of the present paper.

Murray included the beds at Manuels in both his 1868 and his 1870 "Silurian" sections, but he had never succeeded in finding any fossils in them, and was therefore not certain that his estimate of their age was correct. In 1874 he arranged to have T. C. Weston, then collector for the Canadian Geological Survey, visit Manuels and make a thorough search for the needed paleontological evidence. Weston's search was successful. He found fossils in the Paradoxides beds in the valley of Manuels Brook, and identified the first one he discovered as a species of "Microdiscus" that was common in the Paradoxides beds of New Brunswick (Weston, 1896, p. 153). The fossils that he collected were apparently sent to Ottawa, for four years later J. F. Whiteaves, then paleontologist of the Canadian Survey, referred most of them to species that had previously been described from New Brunswick, and correlated the beds containing them with the "St. John's Group" of that province (Whiteaves, 1878).

In 1884 Dr. C. D. Walcott correlated the Paradoxides beds at Manuels with those at St. John, New Brunswick, and with "the lower part of the Menevian, or possibly with portions of the Harlech and Longmynd groups" of Great lassification Used in the Present Paper.

f most of the subdivisions, see Table III, p.)

ly Paleozoic beds that are known to occur
lliott Cove beds about Conception and Trinity
yograptus" occurs in lower beds.

rusia lenticularis and other fossils.

named beds	Agnostus pisiformis obesus, "Olenus", and other fossils.
named beds	Agnostus pisiformis.
named beds	Small fauna of unidentified forms. Possibly a "Paradoxides forchhammeri fauna".
lligrew ook forma- on. aradoxides vidis zone).	Beds 93-125 of the present paper (See pp.).
ng Pond for- tion. aradoxides icksi zone).	Beds 36-92 of the present paper. (See pp.).
hamberlin's rook forma- ion. aradoxides ennetti one).	Beds 1-35 of the present paper. (See pp.).
named ormation.	Manganiferous beds.
named beds Catadoxides zone).	Beds with Catadoxides magnificus and other fossils.
rotolenus one.	Beds with Protolenus and other fossils.
llavia one, and ssibly e-Callavia ds.	Beds with Callavia bröggeri and other fossils. Some of the beds of this division may be of pre-Callavian age; they appear to contain no trilobites, but hold a "Coleoloides".

Jukes 1842 and 1843 (Jukes, 1842; 1843)	Murray Report for 1868. (Murray and Howley, 1881a, pp. 156, 157).	Murray and Howley Report for 1870. (Murray and Howley, 1881a, p. 237)	Matthew 1886 (Matthew, 1886)	Walcott May, 1888 (Walcott, 1888a, p. 399)	Walcott October, 1888 (Walcott, 1888b)	Walcott 1889 (Walcott, 1889a, p. 383)	Marcou 1890 (Marcou, 1890, p. 226)	Walcott 1891 (Walcott, 1891a, p. 548)	Matthew 1896 (Matthew, 1896, pp. 193-194)	Matthew 1899 (Matthew, 1899a)	Walcott 1900 (Walcott, 1900a, pp. 304, 316)	vanIngen 1914 (For details, see Table III, p.)	
Upper Slate Formation. Belle Isle Shale and Gritstone.	Lower Silurian (Potsdam). Sandstones and shales of Great Bell Isle. Little Bell Isle sandstones and shales. Kelly's Island sandstones and shales.	Primordial Silurian Formation. Sandstones and shales of Bell Island. Sandstones and shales of Little Belle Island and adjacent part of Conception Bay. Kelly's Island sandstones and shales.	Fauna of the Olenus division.		Belle Isle, Upper Cambrian, (Olenus)	Belle Isle, Upper Cambrian, (Olenus)		Belle Isle, Upper Cambrian, (Olenus)		Olenian	(Belle Isle, Potsdam, Upper Cambrian) Beds above Olenus zone Olenus zone	Lower Ordovician Upper Cambrian	Wabana Series (Disconformity) Bell Island Ser. (Disconformity) Clarenville Ser. Elliott Cove Series
	Brown, black, red and green shales, containing Paradoxides bennetti in upper part.	Red, green, and black shales, and gray limestones, containing Paradoxides bennetti.	Horizon of Paradoxides Davidis. Horizon of Paradoxides Tessini. Horizon of Paradoxides spinosus (?). Horizon of the Conocoryphinee.	Newfoundland, Lower Cambrian, with Paradoxides.	Avalon, Middle Cambrian, (Paradoxides)	Avalon, Middle Cambrian, (Paradoxides)	Bohemian, or Paradoxides zone, late Middle Taconic.	Avalon, Middle Cambrian, (Paradoxides	Sub-zone of Paradoxides Davidis. Sub-zone of Paradoxides Abenacus (doubtful). Sub-zone of Paradoxides Eteminicus.	Paradoxidian	Paradoxides zone. (Avalon, Acadian, Middle Cambrian).	Middle Cambrian	Manuels Series
Variegated Slates.	Topsail limestone. Conglomerate and black and brown shales (seen at Manuels).	Topsail limestone. Red, green, and blackish shales. Conglomerate (seen at Manuels). Red and green shales and limestones.			Terra Nova, Lower Cambrian, (Olenellus)	Terra Nova, Lower Cambrian (Olenellus)	Scandinavian, or Holmia zone, early Middle Taconic. Esthonian, or Schmidtia zone, late Lower Taconic.	Placentia, Lower Cambrian, (Olenellus)		Catadoxides magnificus beds. Protolenian Etcheminian	Protolenus zone ? Olenellus zone (Placentia, Georgian, Lower Cambrian)	Lower Cambrian	(Disconformity) Hanfordian Series (Disconformity) Etcheminian Series

Classification Used in the Present Paper.
(For further details of most of the subdivisions, see Table III, p.)

Lower Ordovician (Canadian)	All the early Paleozoic beds that are known to occur above the Elliott Cove beds about Conception and Trinity Bays. "Bryograptus" occurs in lower beds.		
Possibly Ozarkian	Beds with Orusia lenticularis and other fossils.		
Cambrian in the restricted sense in which that term is used in America today	Upper Cambrian in a restricted sense	[illegible] beds	Agnostus pisiformis obesus, "Olenus", and other fossils.
		[illegible] beds	Agnostus pisiformis.
	Age unknown.	[illegible] beds	Small fauna of unidentified forms. Possibly a "Paradoxides forchhammeri fauna".
	"Newfoundland" beds of all parts of south-eastern Newfoundland. Represented about Conception Bay by the "Manuels" Paradoxides beds.	Kelligrew Brook formation. (Paradoxides davidis zone).	Beds 93-125 of the present paper (See pp.).
		Long Pond formation. (Paradoxides hicksi zone).	Beds 36-92 of the present paper (See pp.).
		Chamberlain's Brook formation. (Paradoxides bennetti zone).	Beds 1-35 of the present paper. (See pp.).
	Age unknown.	[illegible] formation.	Manganiferous beds.
	Exact age unknown.	[illegible] formation (Catadoxides zone).	Beds with Catadoxides magnificus and other fossils.
		Protolenian zone.	Beds with Protolenus and other fossils.
	Lower Cambrian in a restricted sense.	Callavia zone, and possibly pre-Callavia beds.	Beds with Callavia bröggeri and other fossils. Some of the beds of this division may be of pre-Callavian age; they appear to contain no trilobites, but hold a "Coleoloides".

Table I. Table showing the ways in which different authors have classified the early Paleozoic rocks of the Avalon Peninsula, southeastern Newfoundland.

Britain (Walcott, 1884, p. 13), and in the following year Dr. Matthew correlated them with the "Acadian" beds of St. John, New Brunswick and the Solva of Great Britain (Matthew, 1885, pp. 121 and footnote, and 122).

In 1886 Dr. G. F. Matthew tentatively divided the "Paradoxides" beds of Newfoundland into five "horizons," as follows:

5. "Horizon of Paradoxides Davidis."
4. "Horizon of Paradoxides Tessini."
3. "Horizon of Paradoxides spinosus (?)."
2. "Horizon of the Conocoryphinæ."
1. "Horizon of Agraulos strenuus."

He stated that the "Horizon of the Conocoryphinæ" occurred at Manuels, and that the others were found at other localities on the shores of Conception, Trinity, and St. Mary's Bays (see map, Fig. I). He listed the species that had been recorded from Manuels by Whiteaves in 1878, and added a number of other forms which he had found in material from the same locality that had been sent to him by Mr. Howley (Matthew, 1886b, 1887). His "Horizon of Agraulos strenuus" has since proven to be of pre-Paradoxidian age. Two years later he correlated the "Shales of Manuel R." with "Division" 1c of the "St. John Group" of Canada, the upper part of the "Upper Sparagmite formation=Etage 1b and c" of Norway, the upper part of the "Lower Paradoxides Beds" of Sweden, and doubtfully with the upper part of the "Solva group" of Great Britain (Matthew, 1888a, p. 25). At this time he considered that the "horizon of Conocoryphe at Manuel Brook" was older than the "limestone beds of Topsail and Brigus, in Conception Bay," because Murray, unable to find any fossils at Manuels, had placed the beds of that locality below the limestone of Topsail and Brigus in his stratigraphic section (Matthew, 1888d, p. 74).

In the May, 1888, issue of the American Journal of Science, Dr. Walcott applied the term "Newfoundland" to the Paradoxides beds "of the St. John's area of Newfoundland" (Walcott, 1888a, p. 399). He apparently intended his new term to apply to all the known Paradoxides beds of southeastern Newfoundland. This name appears to be the earliest one applied to these beds alone; and, if it does not prove to have been used previously in any other sense, should be used for these beds in the future.

In the summer of 1888, Dr. Walcott found an "Olenellus fauna" in beds beneath the Paradoxides beds at Manuels. He announced his discovery a few weeks later in London, at the meeting of the fourth International Geological Congress (Walcott, 1888b, 1891c). As most American geologists had believed, up until that time, that "Olenellus" belonged stratigraphically above Paradoxides, this discovery aroused a great deal of interest, and Manuels quickly became one of the famous Cambrian localities of the world. Dr. Walcott published a brief description of the section at Manuels, and gave lists of the fossils that he had found there. From the Paradoxides beds, which he divided into three zones, he recorded thirty species, some of which he recognized as forms that were characteristic of the Paradoxides beds of New Brunswick or Wales (Walcott, 1889a, pp. 378–381). He referred the beds above the "Olenellus zone" in the Manuels Brook section to a new "terrane," the "Avalon* terrane" (Walcott, 1888b; 1889a, p. 383; 1891a, p. 548; 1891b, pp. 66, 306; 1891c); but he later (Walcott, 1899, p. 219) ceased using the term "Avalon" for these rocks, and applied it to the great group of pre-Cambrian sediments that underlies the Cambrian in southeastern Newfoundland, in which sense it is now generally employed. (See Van Hise and Leith, 1909, pp. 43, 99–100, 518–529; Willis, 1912, pp. 14, 16; Buddington, 1919, p. 451.)

In 1889 Dr. Walcott (1889b, p. 445) described a tiny trilobite, which he named "Karlia minor," from the beds containing Paradoxides davidis at Manuels. He later

* Spelled "Avalan" when first used (1888); but this was probably due to a typographical error, as the name was taken from the Avalon Peninsula and was spelled "Avalon" by Dr. Walcott in all his subsequent papers.

referred this species to the genus Corynexochus (Walcott, 1916a, p. 224; 1916b, p. 319).

In 1890, Jules Marcou correlated the Paradoxides beds of Newfoundland with those of New Brunswick and with "the lower part only of the Paradoxides zone at Braintree," Massachusetts (Marcou, 1890, p. 226). In the same year, Dr. Matthew (1890, p. 137) correlated the uppermost of Dr. Walcott's three Paradoxides zones at Manuels with the Menevian of Wales, "Etage 1d" of Norway, and the "Upper Paradoxides Beds" of Sweden; and the two lower zones with the "Lower Paradoxides Beds" of Sweden, a part of the "Upper Sparagmite–Etage 1c" of Norway, and a part of the Solva of Great Britain. In 1891 he (Matthew, 1891) correlated the Newfoundland faunas with similar ones elsewhere, in the manner shown in Table II of the present paper. In the same year Dr. Walcott published the horizontal section of the beds at Manuels that is reproduced in Figure 2a of the present paper (p. 16), and gave a resume of the work that had been done up to that time on the Paradoxides beds and faunas of Newfoundland (Walcott, 1891a, pp. 528, 548, 554, 555, 565, 582, 583, and figs. 51 and 52; 1891b, pp. 50–55, 78–80, 113, 257–262, and 374; 1891d, pp. 533, 548, fig. 75, and pl. 42).

TABLE II. Dr. G. F. Matthew's 1891 correlation of the Paradoxides faunas of southeastern Newfoundland with those of other regions. Copied from Matthew (1891, p. 265)

	a	b	c	d	e	f
	P. Oelandicus	P. rugulosus	P. Tessini	P. Davidis	P. Forchhammeri	P. Lævigatus
Sardinia (Italy)	*?	*?				
Montagne Noire (France)		*				
Bohemia		*	*			
Wales	*?	*	*	*		
Sweden and Norway	*	*	*	*	*	*
Newfoundland		*	*	*		
Acadia (N. Brunswick)	*	*	*			
Massachusetts		*				

FIG. 2a. Dr. Walcott's 1891 section. Copied from Walcott (1891a, fig. 51, p. 554).

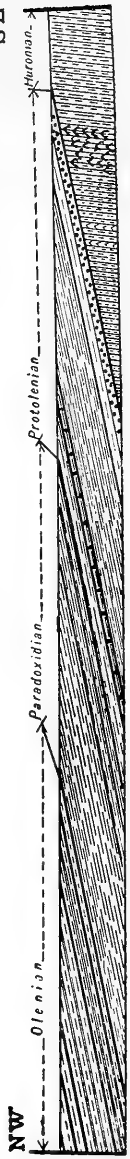


FIG. 2b. Dr. Matthew's 1899 section. Copied from Matthew (1899a, fig. 4, p. 51).

FIG. 2c. Dr. Walcott's 1900 section. Copied from Walcott (1900a, fig. 9, p. 316).

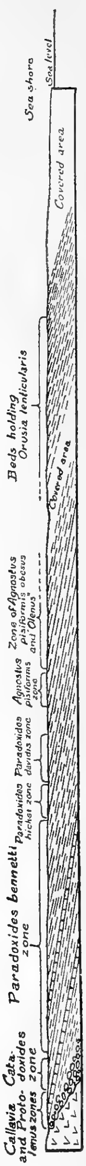


FIG. 2d. Section based upon the work of the Princeton field parties. The beds shown are those that outcrop in the valley of Manuels Brook.

FIGS. 2a-d. Sections of the Cambrian beds at Manuels, by Dr. G. F. Matthew, Dr. C. D. Walcott, and the writer, to illustrate the increases in our knowledge of the limits of the "Olenellus," "Protolenus," "Paradoxides," and "Olenus" zones at that locality. Scale of all the sections, about 1,500 feet to 1 inch

In 1896 Dr. Matthew subdivided the Paradoxides beds of Newfoundland as follows (Matthew, 1896):

3. "Sub-zone of P. Davidis."
2. "Sub-zone of P. Abenacus" (doubtfully identified in Newfoundland).
1. "Sub-zone of P. Eteminicus."

He recorded from the "sub-zone of P. Davidis" at Manuels several species not previously known from that locality, one of which he described as a new form, naming it "Plumulites manuelensis."

In 1898 Dr. Walcott described a new species of brachiopod, "Obolus (Lingulella) fragilis," from the "Middle Cambrian" shales "on Manuels Brook" (Walcott, 1898, p. 404). In the same year Dr. Matthew visited Manuels, and soon afterward published the horizontal section that is reproduced in Figure 2b of the present paper. He stated that the dividing line between the "Olenian" and "Paradoxidian" parts of his section was drawn arbitrarily (Matthew, 1899a, pp. 50–52, fig. 4). He recorded an Erinnys "from the Paradoxides Davidis sub-fauna at Manuels Brook," and "Atops trilineatus" from an unknown horizon, which he thought might be the "Davidis zone," at the same locality (Matthew, 1899c, pp. 89-95).

In 1899 Dr. Walcott visited Manuels a second time. His account of this visit, published in 1900, included a description of the beds which seemed to him to mark the lower and upper limits of the "Paradoxides zone" in the brook valley, and contained, as one of its illustrations, the horizontal section that is reproduced here as Figure 2c (Walcott, 1900a, pp. 313–317, 329–331, and figs. 9 and 10.)

In 1902 Dr. Walcott recorded a brachiopod, "Acrotreta misera Billings" from the beds of the "Paradoxides zone" at this locality (Walcott, 1902, pp. 590, 591). In 1905 he described a new species of brachiopod, "Plectorthis papias," from the same beds (Walcott, 1905, p. 268). He afterward referred the latter species to the genus Eoorthis (Walcott, 1912, p. 785).

In 1910 Professor Charles Schuchert wrote of the Paradoxides beds as follows: "In southern Newfoundland, on Manuels brook, the Acadic begins with a conglomerate having pebbles holding fossils of the Georgic strata below (Walcott, 1900, p. 315). Above this layer, which is 18 inches thick, follow argillaceous shales having a depth of 170 feet. These are succeeded by a thin limestone zone marked by the presence of Paradoxides, the latter extending 66 feet higher in a series of shales interbedded with limestone. Here occurs Paradoxides davidis and P. bennetti. Apparently a stratigraphic hiatus exists above these beds, followed by the Olenus fauna." (Schuchert, 1911, p. 522.)

In 1912 Dr. Walcott, in his monumental monograph on the Cambrian Brachiopoda, described and figured all the brachiopods known to occur in the Paradoxides beds at Manuels and listed the other fossils that he had recorded from those beds in 1889 (Walcott, 1912, pp. 140, 141, 161, 162, 170, 392, 393, 496–500, 647–649, 653, 654, 695, 785, and plates XXIII, XXIX, LXXII, XCI). In the same year Dr. B N. Peach, referring to Dr. Walcott's description of the Manuels Brook section, wrote "In Southern Newfoundland Walcott showed that the base of the Middle Cambrian division is marked in Manuel's Brook by a conglomerate containing fossils of the lower or Georgian terrane, thus indicating elevation and erosion of the Lower Cambrian rocks. Higher up the strata yielded Paradoxides davidis and P. bennetti" (Peach, 1912, p. 455).

During the summers of 1912, 1913, and 1914, Professor Gilbert vanIngen, Dr. A. O. Hayes, Dr. N. C. Dale, Dr. A. F. Buddington, and the writer studied and mapped the rocks at Manuels and collected many fossils there, including more than 3,000 from the Paradoxides beds. In 1914, Professor vanIngen (1914b) issued the "Table of the Geological Formations of the Cambrian and Ordovician Systems about Conception and Trinity Bays" that is reproduced in Table III (p. 20) of the present paper, and Dr. Dale gave a brief description of the manganiferous beds which underlie the lowest known Paradoxides beds of that region (Dale, 1914). The complete results of Dr. Dale's investigation of this "manganese zone," which were published soon afterward, included a detailed description of the "zone" at Manuels (Dale, 1915, pp. 371–409, and figs. 1–29).

In 1919 the writer examined foot by foot the Paradoxides beds in the valley of Manuels Brook, and, with Mrs. Howell's assistance, collected some 7,000 fossils from them. Summaries of two preliminary papers based largely on the work of this and the previous Princeton expeditions were published in 1920 and 1922 (Howell, 1920a; 1920b, 1922).

In 1920 Dr. Walcott recorded Protospongia fenestrata Salter from "the black shales of the Paradoxides hicksi zone" at Manuels (Walcott, 1920, pp. 305, 306).

III. GENERAL GEOLOGY OF THE REGION ABOUT MANUELS

The major features, and some of the minor details, of the geology of the Avalon Peninsula, on which Manuels is situated, have been described and mapped by Jukes (1839, pp. 1–4, 6–16, 27, 28; 1840a, pp. 104–108; 1840b, p. 1; 1842, pp. 219–226, 245, 249–254, 256–276, 321–334; 1843, pp. 25–32, 51, 55–60, 62–82, 127–140, map, and sections 1–8), Murray and Howley (1881a, pp. 138–179, 199–205, 232–249, 279–297, 478–483, 532–536; 1881b; 1918, pp. 4–32, and maps), Walcott (1889a, pp. 378–381, 388; 1891a; 1891b, pp. 50–55, 113, 257–262, 273, 360–361, 365, pl. II; 1891c; 1899, pp. 201, 218–221, 230–231; 1900a; 1900b), Chamberlin (1895), Matthew (1899a, pp. 45–52, figs. 3 and 4), van Hise and Leith (1909, pp. 43, 99, 100, 518–520), vanIngen (1914a, 1914b), Hayes (1914; 1915), Dale (1914; 1915), and Buddington (1914, 1916, 1919). Most of the information contained in this chapter has been taken from the works of these authors.

The peninsula is composed of a complex of Pre-Cambrian igneous and sedimentary rocks, with scattered remnants of a once wide-spread blanket of sediments of Cambrian, Lower Ordovican (and perhaps also Ozarkian) age clinging to it in the places where they have been protected from erosion. (See map, fig. 1, p. 8.) The Pre-Cambrian rocks include interbedded rhyolite and basalt flows, with corresponding breccias and tuffs, and volcanic dust beds, shales, sandstones, and conglomerates (the Harbour Main volcanics *; total thickness unknown); thin-bedded, greenish-gray, dense slates, feldspathic sandstones, and conglomerates (named by Dr. Walcott the Conception slates; estimated to be about 3,000 feet thick); green and reddish slates (Dr. Walcott's "Torbay slates"; estimated thickness, 3,300 feet); dark brown and blackish slates (Dr. Walcott's "Momable slates"; estimated thickness, 2,000 feet); reddish-brown and green feldspathic sandstones and conglomerates, with intercalated shale beds (the "Signal Hill sandstones" of Jukes; estimated by Dr. Buddington to reach a thickness of 10,000 feet); reddish, greenish, and white sandstones and quartzites (Dr. Walcott's "Random terrane"; supposed to be 1,000 feet thick); and intrusives of gabbro, granodiorite, granite, granophyre, quartz syenite, aplite, rhyolite porphyry, and diabase. It is probable that the Harbour Main volcanics are the oldest members of this group; and that they are succeeded in age, from oldest to youngest, by the Conception, Torbay, and Momable slates, and the Signal

* Dr. Buddington named these rocks the "Avondale volcanics" in 1916 (Buddington, 1916, map, p. 131). "Avondale" was, however, used by Frazier as a formation name in a different sense many years earlier (Frazer, 1883, p. 307). It becomes necessary, therefore, to assign a new name to the Newfoundland volcanics; and, at Dr. Buddington's suggestion, "Harbour Main" is here proposed. The rocks are well developed near Harbour Main, Conception Bay.

				Clarei	Apsey	F 3	Shales	Princetonia terranovica, nov. Parabolina harrieta, nov.	
						F 2	Brown shales	Shumardia	
			Schaghticoke		Brown Mead	F 1	Grey shales	Bryograptus	
CAMBRIAN	Upper	St. John Group	Johannian	Elliott Cove	Elliott Cove	E	Grey and black shales with cone-in-cone concretions and thin bedded sandstones	Olenus Orusia lenticularis Lingulella ferruginea	Lingula Flags
	Middle		Acadian	Manuels	Manuels	D 2	Black, brown, and olive shales, thin sandstones and kalk-ballen	Paradoxides Conocoryphe Liostracus Agnostus Microdiscus	Menevian and Solva
						D 1	Phosphorite	Lower Paradoxides	
	Lower		Hanfordian	Hanfordian	Hanford		Disconformity		Upper Comley
						C 2	Green and red shale with manganiferous limestones	Protolenus Ellipsocephalus Avalonia	
						C 1	Phosphorite	Radiolaria and sponges	
			Etcheminian	Etcheminian			Disconformity		
					Smith Point	B 3	Red limestone with red shale	Hyolithes, etc.	Lower Comley
					Brigus	B 2	Red shales with nodular lime-stone	Callavia broggeri Sternuella strenua	
					Bonavista	B 1	Red and green shales with limestone nodules	Coleoloides, etc.	Caerfai

TABLE 3. Reproduction of the Cambrian and Ordovician parts of Professor van Ingen's "Table of the Geological Formations of the Cambrian and Ordovician Systems about Conception and Trinity Bays, Newfoundland, and their Northeastern - American and Western - European Equivalents". The Pre-Cambrian part of the table has been omitted. Copied from van Ingen (1914b).

N. E. America			Series name	Formation name	Number	Kind of rock	Ore zone	Index fossils	Western Europe
LOWER ORDOVICIAN	Canadian	Bretonian; Deep Kill Bed 2	Wabana	Gravel Head	K 2	Black shale		Lingula fraseri, sp. n.	? Llandeilo
					K 1	Phosphorite		Schizocrania striata, sp. n.; Westonia, sp.	
						Disconformity			
				Upper Ore Bed	J 4	Oolitic hematite	5	Lingula lesueuri; Westonia; Schizocrania striata, sp. n.	Upper Arenig
					J 3	Sandstone and shale		Cruziana	
					J 2	Phosphorite*		Schizocrania hayesi, sp. n.; Lingula, sp.; Westonia, sp.; Synhomalonotus chambersi, sp. n.	
						Disconformity			
					J 1	Chamosite slate		Hemigyraspis cantleyi, sp. n.; Psilocephalus ?	
						? Disconformity ?			
				Scotia Ore Bed	H 4	Oolitic hematite	4	Synhomalonotus chambersi, sp. n.; Boring Algae; Cruziana similis	
					H 3	Grey shale		Didymograptus nitidus; Synhomalonotus chambersi; Orthoceras	Middle Arenig
				Pyrite Bed	H 2	Pyrite nodules in grey shale	3	Didymograptus	
					H 1	Phosphorite		Helmersenia wabana, sp. n.	
						Disconformity			
			Bell Island	Dominion Ore Bed	G 10	Oolitic hematite	2	Boring and other Algae; Lingula hawkei	Armorican
					G 9	Sandstone and shale		Lingulobolus affinis; Pizarroa terranovica	Lower Arenig
				Redmond	G 8	White sandstone			
					G 7	Grits and shales			
				Eastern Head	G 6	Ferruginous sandstone with oolitic hematite and some shales	1	Obolus burrowsi, nov.; Sphaerobolus fimbriatus, nov.; Lingula murrayi, Billings; Lingulella billingsi; Lingulella bella	
				Beach	G 5	Sandstones and shales			
				McGraw Bed	G 4	Ferruginous sandstone with oolitic hematite	O		
				Lance Cove	G 3	Sandstones and shales			
						Gap			
				Little Bell Island	G 2	Sandstones		Lingulella billingsi	
				Kelly Island	G 1	Sandstones and shales		Lingula howleyi, Matt.	
						Disconformity			
			Clarenville		F 6	Shale			Tremadoc
				Riders Brook	F 5	Grey sandy limestone		Bellerophon randomi, nov.	
				Maidment	F 4	Shales		Niobe howelli, nov.	
				Apsey	F 3	Shales		Princetonia terranovica, nov.; Parabolina harrieta, nov.	
					F 2	Brown shales		Shumardia	
		Schaghticoke		Brown Mead	F 1	Grey shales		Bryograptus	
CAMBRIAN	Upper	St. John Group; Johannian	Elliott Cove	Elliott Cove	E	Grey and black shales with cone-in-cone concretions and thin bedded sandstones		Olenus; Orusia lenticularis; Lingulella ferruginea	Lingula Flags
	Middle	Acadian	Manuels	Manuels	D 2	Black, brown, and olive shales, thin sandstones and kalkballen		Paradoxides; Conocoryphe; Liostracus; Agnostus; Microdiscus	Menevian and Solva
					D 1	Phosphorite		Lower Paradoxides	
						Disconformity			
	Lower	Hanfordian	Hanfordian	Hanford	C 2	Green and red shale with manganiferous limestones		Protolenus; Ellipsocephalus; Avalonia	Upper Comley
					C 1	Phosphorite		Radiolaria and sponges	
						Disconformity			
		Etcheminian	Etcheminian	Smith Point	B 3	Red limestone with red shale		Hyolithes, etc.	Lower Comley
				Brigus	B 2	Red shales with nodular limestone		Callavia broggeri; Sternuella strenua	
				Bonavista	B 1	Red and green shales with limestone nodules		Coleoloides, etc.	Caerfai

TABLE 3. Reproduction of the Cambrian and Ordovician parts of Professor van Ingen's "Table of the Geological Formations of the Cambrian and Ordovician Systems about Conception and Trinity Bays, Newfoundland, and their Northeastern - American and Western - European Equivalents". The Pre-Cambrian part of the table has been omitted. Copied from van Ingen (1914b).

Hill and Random sandstones; although the Conception slates may be in part contemporaneous with the Harbour Main volcanics. The Conception, Torbay, Momable, Signal Hill, and Random shales, sandstones, and conglomerates have been grouped together by Dr. Walcott in the "Avalon" series" (Walcott, 1899, pp. 218–220; 1900b). This sedimentary series has been referred by Dr. Walcott to the Algonkian, and Dr. Buddington has stated that the volcanic and intrusive igneous rocks were also possibly formed during that era.

Dr. Buddington has interpreted the beds of the Signal Hill formation as "dominantly subærial fluviatile deposits," formed "in a subarid climate"; those of the Momable as "well-decomposed marine sediments with traces of organic life"; and those of the Conception, as deposits composed of "materials derived from rocks resembling the Harbour Main volcanics, swept into the sea in a comparatively fresh, unaltered condition."

The Cambrian and overlying Ordovician (and perhaps Ozarkian) beds are shales and sandstones, with a few limestones and limy shales in the Cambrian. They probably aggregate some 10,000 feet in thickness (vanIngen, 1914a), and are not known to be divided by any angular unconformities. They are cut by dykes of basalt at some localities. The pre-Paradoxides beds of the Cambrian are conglomerates and sandstones, red and greenish shales (often with many nodules of impure limestone), and thin reddish and grayish limestones: some of them are manganiferous. They include the "Etcheminian" and "Hanfordian" * series of Professor vanIngen's 1914 table (see table III).
So far as the author is aware, these "Etcheminian" and

* The terms "Etcheminian" and "Hanfordian" were first applied to New Brunswick Cambrian rocks (Matthew, 1888b, p. 1; 1888d, p. 72; Walcott, 1891b, p. 360). The Newfoundland "Hanford formation" of the "Hanfordian series" of Professor vanIngen's 1914 table is possibly not the exact equivalent of the New Brunswick "Hanford," as that was originally described by Dr. Walcott.

"Hanfordian" sediments are the only ones of Paleozoic age that are known to have been laid down directly upon Pre-Cambrian rocks in the region about Manuels. Wherever the contacts between these Cambrian and Pre-Cambrian rocks are known, they appear to be either unconformities or disconformities The Paradoxides beds (Professor van Ingen's Manuels series) are gray, brown, and black shales, with thin beds of limestone and limy nodular shale. The beds that overlie the Paradoxides beds along the southeastern shore of Conception Bay, most or all of which belong in Profesor vanIngen's Elliott Cove series, are "grey and black shales with cone-in-cone concretions and thin-bedded sandstones" (VanIngen, 1914b). Some of these beds are of Upper Cambrian age, and some may be Ozarkian or earliest Ordovican. The three islands that lie out in the middle of Conception Bay (Bell, Little Bell, and Kellys islands) are composed of beds which have been referred to the Lower Ordovician—the Bell Island and Wabana series of Professor vanIngen's 1914 classification. They are light and dark colored shales and sandstones, with several beds of primary hematitic iron ore. Beds probably referable to Professor vanIngen's Clarenville series, which belongs stratigraphically between the Elliott Cove and Bell Island series, presumably underlie Conception Bay between the islands and the mainland. No angular unconformity is known to exist anywhere within this great stratigraphic section.

The main structural features of the Peninsula of Avalon are a series of folds and faults, whose axes lie in a general N.NE.–S.SW. direction. The Pre-Cambrian rocks were folded before the deposition of the Lower Cambrian sediments upon them. Later the Pre-Cambrian, Cambrian, and Ordovician rocks were folded, faulted, and tilted. The masses of Cambrian and Ordovician sediments that were folded or faulted by these movements into situations where they were protected from erosion are the ones that have been preserved until the present day. One of these favored masses underlies much of Conception Bay in such a way that a few small patches along the western and southern sides of the bay and a narrow strip along the eastern shore are the only parts of the mass that project above sea-level. It is in the narrow strip along the eastern shore that the exposures at Manuels are situated.

Dr. Buddington (1919, p. 454) has described the structural features of the Conception Bay basin as follows: "The core of a major anticline composed of complexly faulted and folded beds of the volcanic series, cut across at a small angle by a stock of granodiorite, is exposed at the head of Conception Bay. At Chapel Cove its eroded surface is overlain by beds constituting the south end of a northward-pitching synclinal fault block of Cambrian sediments, in which Conception Bay is excavated. We have here apparently the phenomenon of the location of a younger syncline in sediments deposited in a basin on the eroded crest of an anticline." The eastern limb of this anticline has been intruded by a batholith of granite, which forms the "backbone of the St. John's Peninsula." The block that contains the Cambrian and Ordovician rocks has been dropped a distance which Professor vanIngen has estimated at 8,000 feet along a great fault that is well exposed at Topsail Head, 3 miles northeast of Manuels (Buddington, 1916, p. 131; 1919, pp. 455, 475).

The whole surface of the Peninsula of Avalon has been deeply carved by the Pleistocene ice. Great quantities of drift are scattered over the surface of the land; and there are lakes and ponds of glacial origin everywhere. Dr. Buddington (1919, pp. 452, 453) states that the striæ on the rocks indicate that there were "local ice caps flowing into the individual bays in a direction perpendicular to the major outlines of the bays at each point," and that each of the bays "presents all the essential characteristics of a fiord." All of the large, and most of the small, bays and harbors lie with their long axes parallel to the N.NE.–S.SW. major structural axes of the region.

IV. GENERAL DESCRIPTION OF THE WHOLE CAMBRIAN SECTION AT MANUELS

The general character and distribution of the early Paleozoic beds at Manuels are indicated on the horizontal section and the outcrop map exhibited in figures 2d and 3 (p. 16). A glance at the map will show that most of of the exposures are in the valley of Manuels Brook, the outcrops of the basal conglomerate being at the falls and those of the higer beds following in succession down the stream from that point toward the shore of the bay. Scattered outcrops occur, however, outside of the brook valley, especially along the wagon roads and the railway. The strike of the beds between the bottom of the basal conglomerate and the top of the highest Paradoxides zone is about N. 82° E., true meridian, and the dip is approximately 10° to the north. These or similar figures will probably be found to apply to the rest of the beds of the section when those beds are carefully studied. No faults or thrusts of any importance have been detected anywhere in the section, but some of the shales show many slickensided surfaces, as though they had slumped toward the north by a series of small movements among themselves.

The basal beds of the Lower Cambrian, varying considerably in character (and perhaps in age) even in the small area included in the map (Fig. 3), are conglomerates in and adjacent to the brook valley, and limestones and shales at and southwest of the railway station platform. They appear to be deposits that accumulated along an uneven rocky shore. At the falls of the brook the conglomerate is 18 feet thick, and consists of well rounded boulders and pebbles, apparently derived from the adjacent Pre-Cambrian, with the interstices between them filled with sand. It is coarsest at its base, where some of its boulders are said to measure as much as 12 feet in diameter (Dale, 1915, p. 377), and grades upward through 3 feet of limy

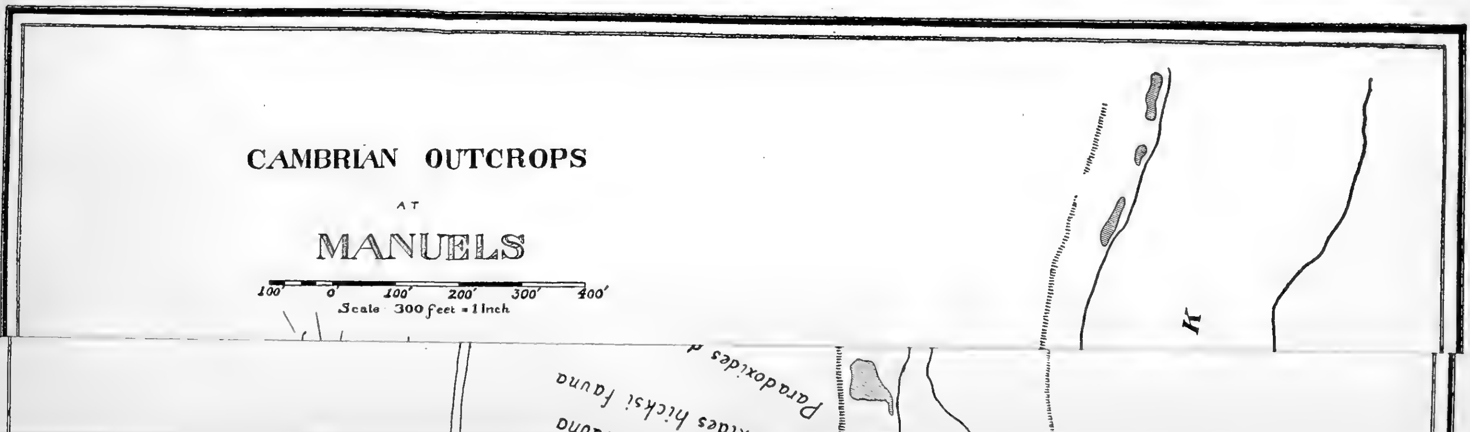
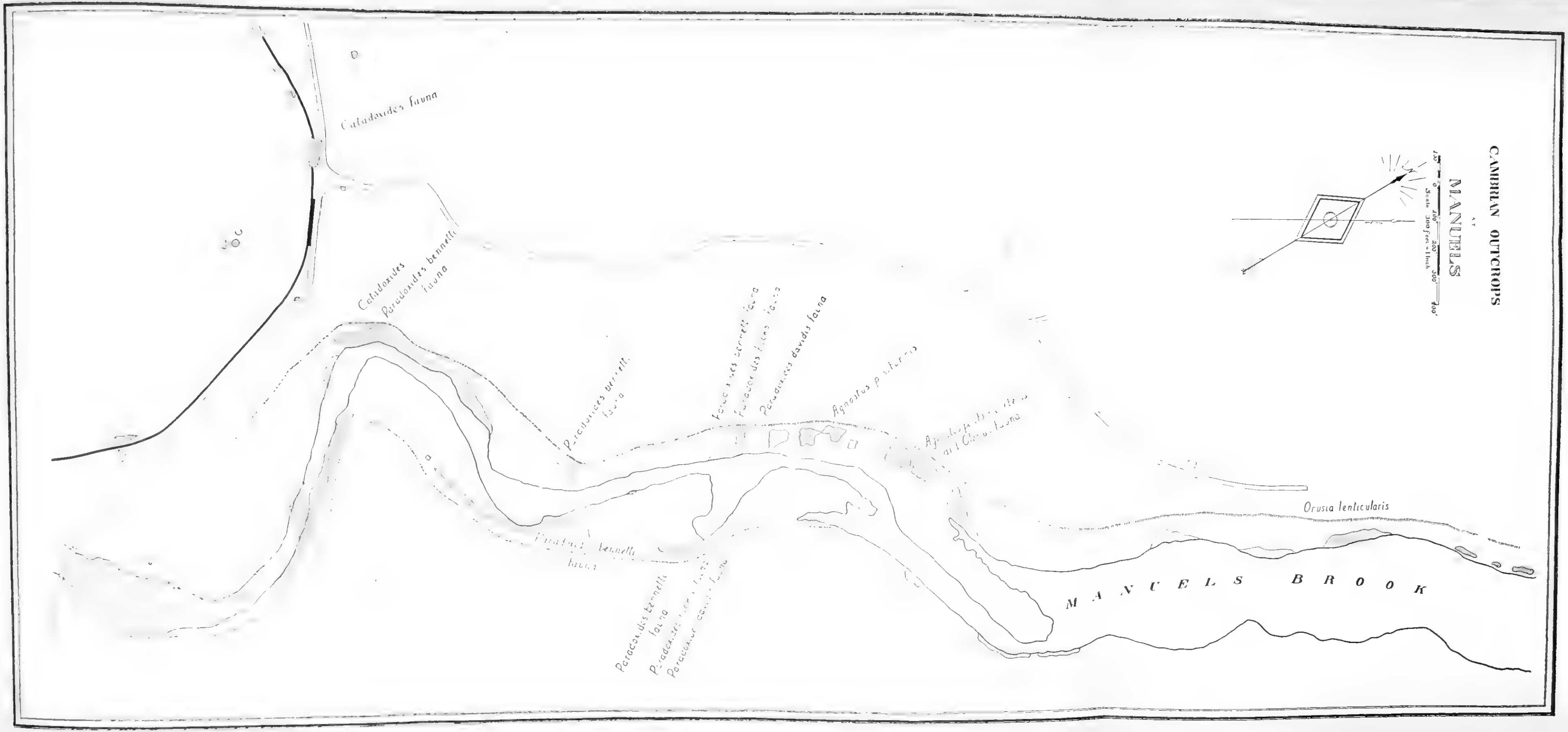


FIGURE 3. Map showing the location of Exposures of Cambrian beds at Manuels.



[illegible] Map showing the location of Exposures of Cambrian beds at Manuels.

sandstone into a shaly, pyritiferous, pink and blue limestone containing great numbers of what are probably pteropod shells.

The beds next above this limestone in the brook section are almost entirely concealed, but a single small exposure in the bed of the stream, and many loose pieces in the soil of the adjacent fields, indicate that they are probably hard olive gray shales. The next higher bed is exposed a little farther down the stream. It is a red shale, 2½ feet thick, which merges upward through some 6 inches of red and green limy shale into a bed described by Dr. Dale (1915, p. 380) as a "nodular and pebbly reddish blue limestone," which is 1½ feet thick, and contains many fragmentary fossils. Overlying this, and exposed both in the banks of the stream and along the near-by wagon roads, are about 34 feet of hard, olive gray shale, which breaks with a conchoidal fracture and contains occasional black nodules, up to 1 inch in diameter, some of which, according to Dr. Dale (1915, p. 385), "show pinkish centers of some fine-grained minerals such as rhodocrosite or manganiferous calcite." Dr. Dale has stated that the contact of this shale and the underlying limestone, as exposed in the bank of the stream, is a disconformable one. It is certainly a very uneven one; but the beds seem sometimes to grade into each other. A very careful and detailed study and comparison of this limestone and shale and the similar limestones and shales that outcrop in the vicinity of the railway will have to be made before their relative ages and the character of their contacts will be fully understood. This 34-foot thick olive-gray shale shows many small slicken-sided surfaces, and at most places yields very few fossils. In the brook exposures it has yielded nothing but some small brachiopods, and in the outcrops along the wagon roads it appears to be quite barren. In a railway cut just southwest of the railway station platform, however, beds almost certainly referable to some part of it contain a small fauna. One of the members of this fauna, a large trilobite named Catadoxides magnificus, is believed by Dr. Matthew, who discovered it, to be closely related to the Sardinian genus, Metadoxides (Matthew, 1899b; 1899c, pp. 83–87, pl. VIII).

The succeeding beds of the section are well exposed only in the valley of the brook. The first one is a peculiar, dark bluish gray shale, 4 to 5 inches thick, and full of flattened, subspherical nodules, which are 1 inch or less in diameter and are probably composed, according to Dr. Dale (1915, p. 385), of manganiferous calcite. On top of this nodular bed is a thin layer of what Dr. Dale (1915, p. 385) has described as a "Cryptozoon shale," containing "roughly concentric or zonal structures measuring 1½ inches in diameter, irregular and subspherical nodules measuring 1 inch in diameter, and intercalated lenses of maganiferous calcite." Above this "Cryptozoon" layer is a three-foot bed of hard, green shale, with manganiferous calcite nodules in its upper portion, and near its base specimens of a trilobite apparently specifically identical with Dr. Matthew's "Catadoxides magnificus."* This fossiliferous bed is followed by 10 feet and 10 inches of unfossiliferous, manganiferous, red and green shales, some of which contain small, flattened nodules. Most of these nodules are similar to those occurring in the beds below, but some of them may be phosphatic.

The next higher stratum is possibly the lowest of the Paradoxides beds in this section. It and the beds which succeed it, up to the top of the highest one known to contain

* These specimens were tentatively identified by Professor vanIngen in 1915 as "Protolenus harveyi" (Dale, 1915, p. 390), a species which Dr. Walcott had described as "Solenopleura harveyi" (Walcott, 1890, p. 45; 1891a, p. 656, pl. 97, figs. 8, 8a, not figs. 7, 7a). A recent examination of examples of Dr. Matthew' s "Catadoxides magnificus" from the type locality of that species (the railway cut just southwest of the railway station platform at Manuels) has convinced Professor vanIngen that his own specimens are more like that form than like Dr. Walcott's figure of "Solenopleura harveyi." Dr. Walcott's and Dr. Matthew's species are, however, very similar, and may be identical, their ostensible differences being perhaps due to differences in the size and preservation of the specimens on which they are based.

Paradoxides, consist of 302 feet of shales, containing occasional nodules, lenses, and thin beds of limestone. The lower 234 feet, which are grayish, heavy-bedded, hard shales, holding few fossils except in their upper 13 feet, grade gradually upward, through brown and finer-bedded shales with abundant fossils, into thin-bedded, soft, black shales, filled with trilobites. As all these beds will be discussed in detail in the next chapter, no further description of them will be given here.

The beds that overlie the uppermost known Paradoxides beds are thin-bedded, often papyraceous, dark gray and black shales, with frequent nodules of pyrite. They and their fossils have not been carefully studied. Near their base they appear to be barren. Some thirty feet up from the bottom, however, a few fossils have been found, including a brachiopod, an agnostid trilobite, and a small bivalved crustacean, which may indicate the presence of the "Paradoxides forchhammeri" and "Agnostus lævigatus" zones, the two uppermost known divisions of the Paradoxides beds, which are well developed in Scandinavia. These beds of doubtful age are succeeded by finely-bedded black shales containing a trilobite resembling Agnostus pisiformis (Linné), which are followed by similar shales holding Agnostus pisiformis obesus Belt, and other types characteristic of the "Olenus beds" of northwestern Europe. Above these "pisiformis obesus" beds are micaceous shales and sandstones showing ripple marks and other evidences of a shallow-water origin. These micaceous shallow-water beds, which include the highest beds of the brook section, seem to be barren, for the most part; but a few species, the majority of them brachiopods, have been found, one of which, Orusia lenticularis (Wahlenberg), is abundant at some horizons. No detailed measurements have been made of any of these beds above the Paradoxides zones. Their total thickness is probably some 400 or 500 feet.

V. DETAILED DESCRIPTION OF THE PARADOXIDES BEDS EXPOSED IN THE VALLEY OF MANUELS BROOK

Stratigraphical and Faunal Succession

The first published description of the Paradoxides beds at Manuels is contained in Murray's report of the progress of the Newfoundland Geological Survey for 1868, where, after describing the conglomerate which forms the bottom of the Cambrian section in the brook valley, he mentions the other beds exposed along the stream as follows: "About 400 yards below the bridge the conglomerate is overlaid conformably by a set of dark brown or blackish shales, with a very fine lamination coinciding with the bedding, which, with some hard calcareous beds interstratified, hold the banks of the brook until within a short distance of its exit into the bay." (Murray and Howley, 1881a, p. 154.)

Fossils were first discovered in the beds in (Weston, 1898, p. 153). They were collected by T. C. Weston, of the Canadian Geological Survey, and were examined by J. F. Whiteaves, paleontologist of that survey, who recognized the following eight species: "Agnostus Acadicus Hartt," "Agnostus (sp. undet.)," "Microdiscus punctatus Salter," "Microdiscus Dawsoni Hartt," "Conocephalites tener Hartt," "Conocephalites Baileyi Hartt," "Conocephalites Orestes ? Hartt," and "Paradoxides (sp. undet.)." (Whiteaves, 1878.)

In 1887 Dr. Matthew added four more species: : "Paradoxides sp.," "Agnostus gibbus (?) Linrs," "Agraulos socialis, Bill," and "Hyolithes, Sp." (Matthew, 1887, p. 149).

In 1889 Dr. Walcott published a description of the section at Manuels, a part of which is quoted herewith (Walcott, 1889a, pp. 380, 381):

6. Green argillaceous shale with thin layers of hard, dark, ferruginous sandstone, interbedded at several horizons -------- 270
Strike, N.80°E; Dip 12° N.
Fossils—Near the base the head of an Olenellus was found, also fragments of an Agraulos or Ptychoparia. At 218 feet from the base a layer of pinkish limestone contained the head of an Agraulos, like A. strenuus, and many fragments of trilobites. Fifty-two feet higher up quite an abundant fauna was found, and the following species were collected: Lingulella, sp. a, Acrothele Matthewi Hartt (sp.), Agnostus sp. a, Agnostus sp. d, Paradoxides Hicksi Salter, Conocoryphe Matthewi Hartt (sp.), Liostracus sp. a.
7. Dark argillaceous shales with thin layers of limestone and sandstone, at various horizons ---------------------------- 295
Fossils—Zone a. From 10 to 20 feet from the base the following species were collected: Lingulella sp. a, Linnarssonia misera Billings, Acrothele Matthewi Hartt (sp.), Hyolithes sp. a, Agnostus, 3 sp., a, b, c, Microdiscus punctatus Salter, Paradoxides Hicksi, Conocoryphe (C) Matthewi Hartt (sp.), Conocoryphe elegans Hartt (sp.), Agraulos socialis Billings, Liostracus tener Hartt (sp.).
Zone b. Forty-five feet higher up the fauna is much larger and includes: Linnarssonia misera Billings (sp.), Lingulella sp. a, Orthis sp. ?, Stenotheca sp. ?, Agnostus punctuosus Angelin, Agnostus 5 sp., b, e, f, g, h, Microdiscus punctatus Salter, Paradoxides Davidis Salter, Paradoxides Hicksi Salter, Paradoxides sp. ?, Anopolenus venustus Billings, Conocoryphe elegans, Ctenocephalus Matthewi Hartt (sp.), Errinnys venulosa Salter, Ptychoparia Robbi Hartt, P. variolaris Salter, Holocephalina inflata Hicks, Agraulos socialis Billings. From 235 to 250 feet from the base a belt occurs in which a small species of Aristozoa occurs in large numbers, associated with Lingulella sp. a, Agnostus sp. ? and the heads of a small Ptychoparia ?, sp. undet.

All of Dr. Walcott's division "6", except the lower part, and all of zones "a" and "b" of his division "7" are Paradoxides beds. "Ptychoparia Robbi Hartt" of zone "b" of division "7" is the only species mentioned by Dr. Walcott that the writer has not recognized as such in the material from Manuels that he has studied; it may be identical with the trilobite referred to as "Solenopleura cf. applanata (Salter)" in the faunal lists of the present chapter (see p. 37).

Dr. Walcott later described from the Paradoxides beds at this locality the brachiopod, Acrothele prima costata

(Matthew), a new brachiopod, Obolus fragilis, and a new trilobite, "Karlia" minor (which he subsequently referred to the genus Corynexochus), and a new brachiopod, "Plectorthis papias" (which he afterward placed in the genus Eoorthis). This writer has found three of these species in his Manuels collections, but has not recognized any examples of the other, the Acrothele.

In 1896 Dr. Matthew recorded from the "sub-zone of P. Davidis" at Manuels three species, "Plumulites Manuelensis, n. sp," "Agnostus Davidis, Hicks," and "Microdiscus punctatus, Salter" (Matthew, 1896, pp. 200, 225, 226, 244, 245). He was doubtful about his identification of Agnostus davidis, as it was based on a single pygidium. The writer has found no examples of davidis in the Princeton collections from Manuels. Perhaps the pygidium described by Dr. Matthew belongs to the large agnostid which is referred to in the present paper as "Agnostus lævigatus ciceroides Matthew." The writer has not yet identified any specimens of Dr. Matthew's "Plumulites Manuelensis" in his material from Manuels.

In his "Lethæa geognostica" Frech stated that "Conocephalus (Liostracus) Linnarssoni Brögg." occurred in Dr. Walcott's zone 7b at Manuels (Frech, 1897, p. 38); but this must have been a mistake on his part, for Dr. Walcott did not record it from there, and Frech gave no other authority for his record. The writer has not found the species in his collections.

In 1899 Dr. Matthew recorded "Erinnys breviceps, Ang." from beds containing the "Paradoxides Davidis subfauna" at Manuels, and "Atops trilineatus, Emmons" from "a greenish gray fine shale, similar to that which at that locality . . . holds fossils of the P. Davidis subzone of the Paradoxides Beds, where probably it belongs." Matthew, 1899c, pp. 89–95.) The writer has not found at Manuels any specimens that seem to him to be referable to Erinnys breviceps, although a form which he has identified as

Salter's "Erinnys venulosa" (called "Bailiella venulosa" in the present paper) is not uncommon in some of the beds there. It is therefore perhaps possible that Dr. Matthew's specimen is a venulosa, rather than a breviceps. No specimen of Atops trilineatus, except the one described by Dr. Matthew, has ever been recorded from Newfoundland, and, as this species has not been discovered during the careful collecting that has been done in the Paradoxides beds at Manuels, and occurs in beds supposed to be of pre-Paradoxidian age in New York, it seems probable that Dr. Matthew's Manuels example came from one of the greenish gray shales which occur beneath the lowest known Paradoxides beds, and not from the much higher horizon that Dr. Matthew supposed.

The only other species which have been recorded from the Paradoxides beds of Newfoundland that the writer has not identified at Manuels are Micromitra (Iphidella) pannula maladensis (Walcott), listed by Dr. Walcott from a "limestone near the base of the Middle Cambrian, the lowest horizon carrying Paradoxides, northwest side of Chapple Arm Harbor, about 1 mile (1.6 km.) from its head, Trinity Bay" (Walcott, 1912, p. 169), "Bathyurus gregarius, described by Billings from Trinity Bay (Billings, 1865, p. 363), "Eocystites, sp.," "Agnostus lævigatus, Dalm.," and Agnostus fissus trifissus Matthew, from the "Davidis Subzone at Chapel Arm, Trinity Bay" (Matthew, 1887, p. 150; 1896, p. 231), and "Centropleura Loveni, Ang.?," "Agnostus brevifrons, Ang.," and "Agnostus lævigatus, Dalm.," from Highland Cove in Trinity Bay (Matthew, 1887, p. 150). Billings described what he believed to be two new species of Paradoxides (P. tenellus and P. decorus)) from "Chapel Arm" in 1872 (Billings, 1874, pp. 74, 75); but an examination of specimens of trilobites in the museum at St. John's, Newfoundland, that are labeled "Paradoxides decorus" and "Paradoxides terrelus" and are supposed to be Billings' types, has convinced the writer that both these species are synonyms of Paradoxides hicksi Salter—"decorus" being based on adult specimens and "tenellus" on young ones. Professor Raymond suggested some years ago that "tenellus" might prove to be the young of "decorus" (Raymond, 1914, p. 234).

In 1900 Dr. Walcott published some notes on the Cambrian stratigraphy at Manuels, in which he described the strata which he thought marked the upper and lower limits of the "Middle Cambrian" and of the "great Paradoxides zone" there (Walcott, 1900, pp. 315–317). The stratum which he described as the bottom bed of the "Middle Cambrian" is the "nodular and pebbly reddish blue limestone" referred to on page 25 of the present paper. The stratum designated by him as the basal bed of the "great Paradoxides zone," the lowest horizon at which he found Paradoxides, is bed 19 of the present chapter (see p. 54). His description of the bed which he believed to mark the top of the "Middle Cambrian" is quoted and discussed on page 29 of this paper.

In a footnote on pages 315 and 316 of his 1900 paper Dr. Walcott stated that the "head of an Olenellus and fragments of Agraulos or Ptychoparia" that had been recorded by him in 1889 from near the base of his division '6' (see quotation on page 29 of the present paper), had probably actually come from a lower horizon, beneath the "conglomerate limestone" which underlies his division "6."

The only beds of the Manuels Brook Cambrian section that can be stated with certainty, or with any considerable degree of probability, to be of Paradoxidian age consist of 302 feet of shales and thin limestones. They are overlain by black shales that have yielded no satisfactory index fossils and whose age is therefore unknown. They are underlain by 10 feet and 10 inches of unfossiliferous manganiferous shales of undetermined age, as described on page 26. All of their 302 feet, except the lowest 3, can definitely be proved to have been formed during Paradoxian

FIG. 1. View down the gorge of Manuels Brook, showing exposures of beds of the Paradoxides bennetti zone (beds 1-20) and the underlying manganiferous beds.

FIG. 2. View of beds 1-15 and the underlying manganiferous beds, as they are exposed in the left wall of the gorge of Manuels Brook. The cliff here pictured is the one shown in the extreme lower left corner of figure 1.

FIG. 1. View down the gorge of Manuels Brook, down the stream from the part of the gorge shown in plate I, figure 1, showing exposures of beds of the Paradoxides bennetti zone, the P. hicksi zone, and the P. davidis zone, and the shales containing Agnostus pisiformis and A. pisiformis obesus and Olenus.

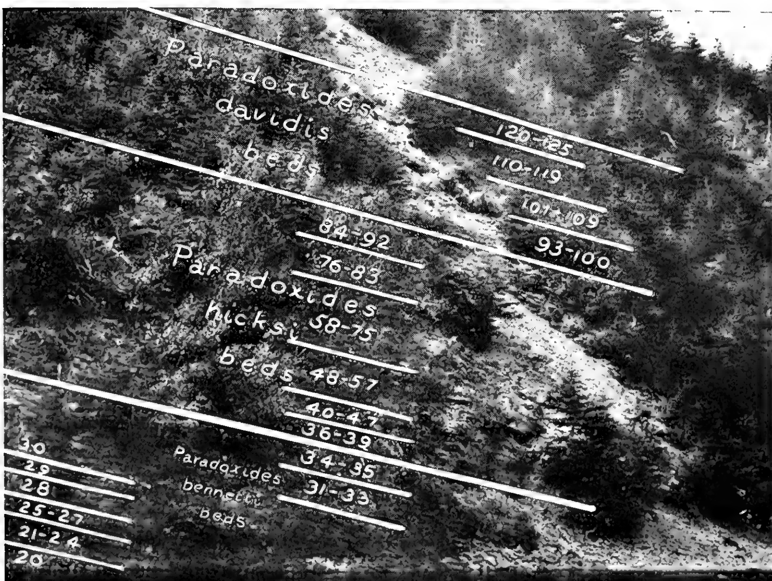


FIG. 2. View of beds of the Paradoxides bennetti zone (beds 20-35), the P. hicksi zone (beds 36-92), the P. davidis zone (beds 93-125), and some of the overlying beds of undetermined age, as they are exposed in the left wall of the gorge of Manuels Brook. The exposures here pictured are those shown at the extreme left side of figure 1.

time. The fossils that have been found in this basal 3 feet are so fragmentary that they can not be identified, but they appear to be most probably referable to a Paradoxides fauna, and a description of the beds is therefore included in the present chapter. The 10 feet of manganiferous shales beneath these beds, and the black shales overlying the highest known Paradoxides horizon, may also be of Paradoxidian age; but they appear to show no evidence of being so, and therefore will not be considered in the present chapter, where only the 299 feet that were surely, and the underlying 3 feet that were probably, formed during Paradoxidian time will be discussed. A section and table, showing the stratigraphical and faunal succession of the known Paradoxides beds that are exposed in the valley of the brook, are exhibited in figure 2d and Table IV (pp. 16 and 56), and the outcrops and exact positions of the various beds and faunal horizons are indicated in the figures on plates 1 and 2. No exposure showing a continuous section of these beds is to be found on either side of the brook valley; but a practically complete composite section can be obtained by combining the parts outcropping on the two sides. The section shown in figure 2d (p. 16) and described in the present chapter, was gotten in this way. Some mistakes may have been made in joining up the parts of this section that were exposed in unconnected outcrops, but it is believed that none of these errors can have been large or important. The lithological characters and the faunas of the individual beds are described in detail in the succeeding pages of this chapter, and are discussed on pages 57 to 72. Beds 21 to 125 are described as they occur on the western side of the brook valley. They appear to be of essentially the same character in the exposures on the eastern side.

The growth of our knowledge of the relationships existing between the Paradoxides faunas of Newfoundland and those of northwestern Europe and northeastern North America will probably necessitate the changing of a number of the specific and varietal names used in this paper, for the writer has attempted to identify his specimens from Manuels with previously described American and European species and varieties without entering into any discussion of the exact relationships or possible equivalences of those previously described forms. Detailed comparisons of the European and American forms will be included in a monograph on the Paradoxides faunas of southeastern Newfoundland, which is now in preparation. The new species and varieties mentioned in the faunal lists of the present paper are described farther on.

All the species of agnostid trilobites in these faunal lists are placed in the single "genus," Agnostus. The writer believes, with Corda (Hall and Corda, 1847), Tullberg (1880, pp. 11–15), Jækel (1909), and Raymond (1913, pp. 2 and 3), that these species should be referred to more than one genus; but, as he has been unable to assign some of them to the genera of any classification of the group that has yet been proposed, he has followed the old practice of grouping them all in "Agnostus." This procedure has at least the advantage of making the names of many of the species more intelligible to the majority of his readers than the names would have been had he referred the species to what are really their proper genera; for to the minds of most paleontologists "Agnostus" undoubtedly conveys more meaning than do "Condylopyge," "Pleuroctenium," "Lejopyge," "Peronopsis," or "Phalacroma." The best generic classification of the agnostids that has yet been proposed is that advocated by Professor Raymond (Raymond, 1913). The writer believes that, in most respects, that classification is satisfactory as far as it goes, but that it is not complete; and Dr. C. E. Resser and he are now making a detailed study of all the agnostids, in the hope of obtaining a fuller knowledge of the true lines of descent and the proper classification of that very interesting group of little trilobites.

STRATIGRAPHICAL AND FAUNAL SUCCESSION OF THE PARADOXIDES BEDS EXPOSED IN THE VALLEY OF MANUELS BROOK

The letters in parentheses indicate the relative abundance or rarity of the species, thus: r—rare, c—common, a—abundant, va—very abundant.

The ° and / mark the earliest and latest known occurrences of the species in the section, thus: °—earliest known occurrence; /—latest known occurrence.

Bed No.	Lithological Character	Thickness Feet.	Thickness Inches.
125.	Dark gray slightly micaceous, phosphatic, carbonaceous shale, containing so many small lumps of black, carbonaceous, phosphatic material that it looks almost like a conglomerate. These lumps, which appear to be either pebbles or concretions, vary from a small fraction of an inch to 3 inches in diameter, and often contain fossils. The top and bottom of the bed are uneven, but appear to show no clear evidence of the beds having been eroded after its consolidation	0	2
	Paradoxides sp. undet. (probably P. davidis Salter) (r) Hyolithid gen. and sp. undet. (possibly Hyolithes tenuistriatus Linnarsson) (r). This is the highest known Paradoxides bed in the section, the top of the "Paradoxides davidis zone" of this paper (see p. 59).		
124.	Hard greenish gray shale. The top is uneven against the uneven bottom of bed 125 and the change in lithological character between the two beds is abrupt, but there does not appear to be any clear evidence of a sedimetnary break or of the erosion of bed 124 after its consolidation	0	1
	Paradoxides sp. undet. (probably P. davidis Salter) (r).		
123.	Grayish white clay-like material, apparently resulting from the weathering of a gray shale, small pieces of which occur in the "clay"	0	1
	No fossils found.		
122.	Hard, heavy-bedded dark greenish gray and blackish shales, containing numerous black, carbonaceous, phosphatic "pebbles," 1 inch or less in diameter, similar to those in bed 125	0	5
	/Paradoxides davidis Salter (c).		
121.	Pyritiferous black shale	2	2
	Paradoxides davidis Salter (r).		

120. Pyritiferous black shale............ 1 2
Paradoxides davidis Salter (r).
/Agnostus punctuosus Angelin (r).
/Agnostus lævigatus ciceroides Matthew (r).

119. Black shale containing a few limestone nodules, some of which are a foot or more in diameter, and many small nodules of pyrite and lumps or pebbles of phosphatic material 0 8
Paradoxides davidis Salter (va).
/Corynexochus cf. minor (Walcott) (r).
Agnostus punctuosus Angelin (c).
Agnostus lævigatus ciceroides Matthew (r).
Brachiopod gen. and sp. undet. (r).

118. Soft pyritiferous bluish black shale, intermediate in character between 119 and 117............ 0 4
Paradoxides davidis Salter (r).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus ciceroides Matthew (r).

117. Soft, thin-bedded, dark gray shale containing many small concretions of pyrite............ 0 7
Paradoxides davidis Salter (a).
Centropleura sp. undet. (r).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus ciceroides Matthew (c).
/°Agnostus cf. incertus Brögger (r).

116. Pyritiferous dark gray shale............ 0 9
Paradoxides davidis Salter (a).
/Paradoxides rugulosus Corda (r).
Corynexochus cf. minor (Walcott) (r).
Conocoryphe sp. undet. (r).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus ciceroides Matthew (c).
/Agnostus cf. fallax Linnarsson (r).
/°Protospongia fenestrata Salter (r).

115. Pyritiferous dark gray shales, slightly harder and heavier-bedded than 116, containing occasional flat limestone nodules, 1 inch to 6 inches thick, some of which hold fossils. A 2-inch bed of shale, full of small phosphatic "pebbles" like those in bed 125, occurs 2 feet above the base............ 2 8
Paradoxides davidis Salter (va).
°Paradoxides rugulosus Corda (r).
/°Centropleura henrici (Salter) (r).
/°Solenopleura variolaris (Salter) (r).
/°Solenopleura communis Billings (r).
/°Holocephalina primordialis Salter (c).
/Eodiscus punctatus Salter (r).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus ciceroides Matthew (c).
/Agnostus lævigatus terranovicus Matthew (c).

/°Agnostus lævigatus mamilla Matthew (r).
Agnostus cf. fallax Linnarsson (r).
/Agnostus cf. acadicus declivis Matthew (r).
/Obolus fragilis (Walcott) (r).
/°Stenotheca cf. cornucopia Salter (r).
/°Hyolithes cf. tenuistriatus Linnarsson (r).

114. Hard, heavy-bedded, dark gray limy shale, some parts of which, more limy than the rest, are full of fragments of Paradoxides davidis — 1 0
Paradoxides davidis Salter (va).
Centropleura sp. undet. (r).
Agnostus lævigatus terranovicus Matthew (r).
Agnostus cf. fallax Linnarsson (r).

113. Hard, dark gray shale with flat nodules of limestone in its upper part — 0 6
Centropleura sp. undet. (r).
/Bailiella venulosa (Salter) (r).
/Hartshillia inflata (Hicks) (r).
Agnostus lævigatus ciceroides Matthew (c).
Agnostus cf. acadicus declivis Matthew (c).
Brachiopod gen. and sp. undet. (r).

112. Hard black and dark gray shales, some layers of which are covered with fragments of trilobites — 0 7
Centropleura sp. undet. (r).
Hartshillia inflata (Hicks) (c).
/Solenopleura cf. applanata (Salter) (c).
Eodiscus punctatus (Salter) (r).
Agnostus lævigatus terranovicus Matthew (c).
Agnostsus cf. fallax Linnarsson (r).
/Agnostus rex (Barande) (r).

Hyolithid gen. and sp. undet. (r).

111. Pyritiferous black and gray shales, not quite so hard as 112 — 0 10
Paradoxides davidis Salter (r).
Solenopleura cf. applanata (Salter) (r).
°Hartshillia inflata (Hicks) (r).
Agnostus punctuosus Angelin (va).
Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. fallax Linnarsson (c).

110. Pyritiferous black shale with occasional thin gray bands. Not quite so hard as 111 — 1 3
Paradoxides sp. undet. (r).
Solenopleura cf. applanata (Salter) (r).
Agnostus punctuosus Angelin (va).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. fallax Linnarsson (c).
/Agnostus cf. nudus (Beyrich) (r).
/Agnostus cf. granulatus (Barrande) (r).
/Agnostus sulcatus Illing (r).

/°Agnostus cf. pusillus Tullberg (r).
Hyolithid gen. and sp. undet. (r).

109. Pyritiferous brown-weathering gray and black shales, in alternating thin beds. Slightly softer than 110. Contains occasional small nodules of pyrite, and a great many fossils________________________________ 0 10

Paradoxides sp. undet. (r).
Bailiella venulosa (Salter) (r).
Solenopleura cf. applanta (Salter) (a).
°Corynexochus minor (Walcott) (r).
Eodiscuc punctatus (Salter) (va).
Agnostus granulatus (Barrande) (r).
Agnostus cf. nudus (Beyrich) (r).
Agnostus sulcatus Illing (r).
/°Agnostus longifrons parvulus n. var. (r).
/Agnostus cf. exaratus tenuis Illing (c).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. fallax Linnarsson (a).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus rex (Barrande) (r).
/Agnostus gracilis Illing (r).
/Agnostus cf. kjerulfi Brögger (r).
°Obolus fragilis (Walcott) (r).
/Acrotreta misera (Billings) (r).
Hyolithid gen. and sp. undet. (r).

108. Soft slightly pyritiferous black shale________________ 1 1

Centropleura sp. undet. (r).
Solenopleura cf. applanata (Salter) (r).
Eodiscus punctatus (Salter) (a).
Agnostus punctuosus Angelin (a).
Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. fallax Linnarsson (a).
Agnostus granulatus (Barrande) (c).
Acrotreta misera (Billings) (r).

107. Soft pyritiferous black shale__________________________ 1 0

Solenopleura cf. applanata (Salter) (r).
Eodiscus punctatus (Salter) (r).
Agnostus punctuosus Angelin (a).
Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus cf. nudus (Beyrich) (r).
Agnostus granulatus (Barrande) (c).
Agnostus cf. kjerulfi Brögger (r).
/Agnostus cf. parvifrons mammillatus Brögger (r).
/Agnostus bibullatus (Barrande) (r).
Acrotreta misera (Billings) (r).

106. Soft pyritiferous black shale__________________________ 1 10

Paradoxides sp. undet. (r).

Eodiscus punctatus (Salter) (c).
Agnostus punctuosus Angelin (c).
Agnostus lævigatus terranovicus Matthew (va).
Agnostus cf. fallax Linnarsson (c).
Agnostus granulatus (Barrande) (c).
°Agnostus bibullatus (Barrande) (r).
Acrotreta misera (Billings) (c).
Hyolithid gen. and sp. undet. (r).

105. Soft black shale with some very thin brownish layers-- 0 7
Solenopleura cf. applanata (Salter) (r).
Eodiscus punctatus (Salter) (c).
Agnostus punctuosus Angelin (r).
Agnostus lævigatus terranovicus Matthew (c).
Agnostus cf. fallax Linnarsson (c).
Agnostus granulatus (Barrande) (r).
Agnostus cf. kjerulfi Brögger (r).
°Agnostus cf. parvifrons mammillatus Brögger (r).
Acrotreta misera (Billings) (c).

104. Thin-bedded soft gray and black shales-------------- 0 8
Agnostus lævigatus terranovicus Matthew (r).
Agnostus cf. fallax Linnarsson (r).
Acrotreta misera (Billings) (r).

103. Thin-bedded pyritiferous soft black and gray shales--- 1 0
Eodiscus punctatus (Salter) (c).
Agnostus lævigatus terranovicus Matthew (c).
Agnostus sulcatus Illing (r).
Acrotreta misera (Billings) (c).

102. Thin-bedded pyritiferous soft black shale with a few thin gray and brown layers. In its upper 5 inches it is much like bed 103. Contains occasional small nodules of pyrite------------------------------ 1 4
Paradoxides sp. undet. (r).
Solenopleura cf. applanata (Salter) (r).
Eodiscus punctatus (Salter) (va).
Agnostus lævigatus ciceroides Matthew (c).
Agnostus lævigatus terranovicus Matthew (va).
Agnostus cf. fallax Linnarsson (a).
Agnostus granulatus (Barrande) (r).
Agnostus sulcatus LIlling (r).
°Agnostus cf. gracilis Illing (r).
Agnostus cf. kjerulfi Brögger (r).
/Agnostus vaningeni n. sp. (r).
Acrotreta misera (Billings) (r).

101. Thin-bedded pyritiferous soft black shale with a few thin gray layers---------------------------------- 1 6
Paradoxides sp. undet. (possibly P. davidis Salter) (r).
/Paradoxides cf. hicksi Salter (r).
Eodiscus punctatus (Salter) (a).

Agnostus cf. fallax Linnarsson (a).
Agnostus cf. nudus (Beyrich) (c).
Agnostus granulatus (Barrande) (r).
Agnostus sulcatus Illing (r).
Agnostus cf. kjerulfi Brögger (r).
/°Agnostus parvifrons punctifer n. var. (r).
Acrotreta misera (Billings) (r).
/Lingulella ferruginea Salter (r).

100. Thin-bedded pyritiferous soft black shale............ 1 6
Paradoxides sp. undet. (possibly P. davidis Salter) (r).
Agnostus lævigatus terranovicus Matthew (r).
Agnostus cf. fallax Linnarsson (c).
Agnostus cf. nudus (Beyrich) (r).
Agnostus granulatus (Barrande) (r).
Agnostus sulcatus Illing (r).
Agnostus cf. kjerulfi Brögger (r).
Agnostus vaningeni n. sp. (r).
Acrotreta misera (Billings) (r).
Stenotheca sp. undet. (r).

99. Thin-bedded pyritiferous soft black shale............ 0 8
/°Centropleura pugnax Illing (r).
Solenopleura cf. applanata (Salter) (r).
Eodiscus punctatus (Salter) (r).
Agnostus punctuosus Angelin (c).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus lævigatus terranovicus Matthew (r).
Agnostus cf. fallax Linnarsson (va).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus cf. nudus (Beyrich) (r).
Agnostus granulatus (Barrande) (r).
°Agnostus cf. kjerulfi Brögger (r).
Agnostus sulcatus Illing (c).
/Agnostus cf. parvifrons Linnarsson (r).
Agnostus cf. exaratus tenuis Illing (r).
/°Agnostus cf. fissus perrugatus Grönwall (va).
°Agnostus vaningeni n. sp. (r).
Acrotreta misera (Billings) (c).
Hyolithid gen. and sp. undet. (r).
Stenotheca sp. undet. (r).

98. Soft, but compact, black shale, in layers 1/4 to 1/3 of an inch thick.................................... 0 4
No fossils found.
The absence of fossils from this black shale is remarkable, as the very similar black shales above and below it are richly fossiliferous.

97. Soft pyritiferous black shale with occasional flat lenses of limestone. Contains several beds of white clay-like material, 1/16 of an inch thick, and has a similar bed, ½ of an inch thick, at the top................ 1 3

Agnostus punctuosus Angelin (r).
Agnostus cf. fallax Linnarsson (r).
Agnostus sulcatus Illing (r).

96. Soft pyritiferous black shale, similar to bed 95, but with Agnostus punctuosus much the most abundant member of the fauna__________ 0 8
Paradoxides davidis Salter (c).
Agnostus punctuosus Angelin (va).
Agnostus cf. fallax Linnarsson (r).
Agnostus sulcatus Illing (r).

95. Soft pyritiferous black shale__________ 1 0
Paradoxides davidis Salter (c).
°Agnostus punctuosus Angelin (c).
Agnostus cf. fallax Linnarsson (a).
Agnostus cf. nudus (Beyrich) (r).
Agnostus granulatus (Barrande) (c).
Agnostus sulcatus Illing (a).
Hyolithid gen. and sp. undet. (r).

94. Very soft pyritiferous black shale, similar to 95, but softer and less fossiliferous. Breaks into little hexagonal pieces, about ¼ of an inch in diameter, and almost as thin as paper. Pyrite nodules, ½ of an inch or less in diameter, are common__________ 1 0
°Paradoxides davidis Salter (c).
Agnostus lævigatus terranovicus Matthew (c).
Agnostus cf. fallax Linnarsson (r).
Agnostus granulatus (Barrande) (r).
Agnostus sulcatus Illing (a).
Agnostus cf. acadicus declivis Matthew (r).

93. Thin-bedded soft pyritiferous black shale__________ 1 6
Paradoxides sp. undet. (possibly P. davidis Salter) (r).
Agnostus ævigatus ciceroides Matthew (c).
°Agnostus lævigatus terranovicus Matthew (a).
Agnostus cf. fallax Linnarsson (c).
Agnostus cf. granulatus (Barrande) (r).
Agnostus cf. sulcatus Illing (a).
/Agnostus cf. umbo Matthew (r).
Stenotheca sp. undet. (c).
This is the lowest bed of the "Paradoxides davidis zone" of this paper.

92. Dark gray limestone__________ 0 4
Agnostus cf. acadicus declivis Matthew (r).
Acrotreta misera (Billings) (r).
This is the top bed of the "Paradoxides hicksi zone" of this paper.

91. Soft pyritiferous black shale with limy lenses and nodules in its upper part__________ 0 11
Solenopleura cf. applanata (Salter) (r).

/Liostracus globiceps jaculator n. var. (r).
Agnostus lævigatus ciceroides Matthew (c).
Agnostus cf. fallax Linnarsson (c).
Agnostus cf. sulcatus Illing (c).
Agnostus granulatus (Barrande) (r).
Agnostus cf. umbo Matthew (r).
/Agnostus cf. parvifrons Linnarsson (r).
/Agnostus fissus Lundgren MS (r).
Acrotreta misera (Billings) (r).
Stenotheca sp. undet. (r).

90. Soft pyritiferous black shale, slightly greenish in spots. Contains nodules of pyrite, some of which are as much as 1 inch in diameter______ 0 9
Paradoxides hicksi Salter (r).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus cf. fallax Linnarsson (c).
Agnostus cf. nudus (Beyrich) (r).
Agnostus granulatus (Barrande) (r).
°Agnostus cf. sulcatus Illing (a).
°Agnostus cf. umbo Matthew (r).
°Agnostus cf. parvifrons Linnarsson (r).
Agnostus fissus Lundgren MS (r).
/Agnostus cf. gibbus Linnarsson (r).
Acrotreta misera (Billings) (r).

89. Soft pyritiferous black shale with layers of brownish shale in its lowest inch______ 0 7
Paradoxides hicksi Salter (r).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus cf. fallax Linnarsson (va).
Agnostus fissus Lundgren MS (r).

88. Pyritiferous black shale, harder than bed 89______ 0 10
Paradoxides hicksi Salter (c).
Solenopleura cf. applanata (Salter) (r).
°Bailiella venulosa (Salter) (c).
Agnostus lævigatus ciceroides Matthew (r).
Agnostus cf. fallax Linnarsson(va).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus rex (Barrande) (r).
Agnostus granulatus (Barrande) (r).
Agnostus fissus Lundgren MS (r).
°Agnostus cf. gibbus Linnarsson (r).
Acrotreta misera (Billings) (r).

87. Soft pyritiferous black shale______ 1 5
Paradoxides hicksi Salter (c).
Centropleura sp. undet. (r).
/Conocorpyhe æqualis Linnarsson (r).
/Agraulos socialis Billings (r).
Agnostus lævigatus ciceroides Matthew (c).
Agnostus cf. fallax Linnarsson (r).
Agnostus fissus Lundgren MS (r).

86. Pyritiferous black shale, slightly brownish in some layers and greenish blue in the bottom inch	1	2
Paradoxides hicksi Salter (r).		
/°Centropleura venusta (Billings) (r).		
Solenopleura cf. applanata (Salter) (a).		
°Liostracus globiceps jaculator n. var. (r).		
Conocoryphe æqualis Linnarsson (r).		
Agraulos socialis (Billings) (r).		
Eodiscus punctatus (Salter) (c).		
Agnostus cf. fallax Linnarsson (r).		
Hyolithid gen. and sp. undet. (r).		
85. Pyritiferous black shale, harder than bed 86. Breaks with a conchoidal fracture	0	8
Paradoxides hicksi Salter (r).		
Solenopleura cf. applanata (Salter) (r).		
Agnostus fissus Lundgren MS (r).		
84. Alternating beds of dark gray limestone and thin-bedded, soft, pyritiferous gray and bluish gray shale	1	4
Paradoxides hicksi Salter (c).		
Centropleura sp. undet. (r).		
Solenopleura cf. applanata (Salter) (a).		
Conocoryphe æqualis Linnarsson (a).		
Agraulos socialis Billings (c).		
Eodiscus punctatus (Salter) (a).		
Agnostus lævigatus ciceroides Matthew (c).		
Agnostus cf. fallax Linnarsson (c).		
Agnostus cf. acadicus declivis Matthew (c).		
Agnostus fissus Lundgren MS (r).		
Hyolithid gen. and sp. undet. (r).		
83. Soft olive shale	0	3
Paadoxides hicksi Salter (c).		
Solenopleura cf. applanata (Salter) (r).		
Conocoryphe æqualis Linnarsson (c).		
Agraulos socialis Billings (c).		
Eodiscus punctatus (Salter) (c).		
82. Soft pyritiferous bluish black shale. Some of the pyrite occurs as small nodules. The fossils are poorly preserved	1	8
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (c).		
Hyolithid gen. and sp. undet. (c).		
81. Thin-bedded dark gray shale, containing a few small flat phosphatic "pebbles"	1	1
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (a).		
Eodiscus punctatus (Salter) (c).		
°Agnostus lævigatus ciceroides Matthew (r).		
Agnostus cf. fallax Linnarsson (r).		
Agnostus cf. acadicus declivis Matthew (r).		
/Agnostus barrandei Salter (r).		

Agnostus fissus Lundgren MS (c).
/Acrothele cf. matthewi (Hartt) (r).

80. Gray shale, greenish in spots. Occasional thin lenses of limestone or limy shale occur in its upper part, and 4 inches above the base there is a ½-inch bed of hard gray limestone or limy shale with uneven upper and lower surfaces 0 7

Paradoxides hicksi Salter (c).
Solenopleura cf. applanata (Salter) (r).
Agraulos socialis Billings (c).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus granulatus (Barrande) (r).
Agnostus barrandei Salter (r).
/Agnostus cf. parvifrons tessella Matthew (r).
Hyolithid gen. and sp. undet. (r).

79. Hard dark gray shale, with a 1-inch bed of dark gray limestone at the top. The bedding surfaces of the shale are rough 0 4

Conocoryphe cf. æqualis Linnarsson (r).
Agnostus rex (Barrande) (r).
Hyolithid gen. and sp. undet. (r).

78. Soft black shale, full of fragments of agnostids, most of which are too imperfect for specific identification 0 1

Paradoxides hicksi Salter (r).
Agnostus fissus Lundgren MS (c).

77. Dark gray shale, containing small concretions of pyrite and thin lenses and nodules of limestone. The shale weathers brown 0 7

Paradoxides hicksi Salter (c).
Agraulos socialis Billings (c).
Solenopleura cf. applanata (Salter) (c).
Agnostus cf. acadicus declivis Matthew (r).
Agnostus barrandei Salter (r).
Agnostus fissus Lundgren MS (r).
Hyolithid gen. and sp. undet. (r).

76. Soft dark blue shale, containing a few small black, probably phosphatic, nodules. The contained fossils are poorly preserved 0 7

Paradoxides sp. undet. (probably P. hicksi Salter (c).
Agraulos socialis Billings (r).
Agnostus cf. acadicus declivis Matthew (c).
Agnostus sp. undet. (r).

75. Hard, brown-weathering, dark gray shale, containing a few small concretions of pyrite and (in its upper half) occasional thin lenses and nodules of dark gray limestone. Some of the bedding planes have rough surfaces. The fossils are poo.ly preservd 1 4

Paradoxides hicksi Salter (r).
Agraulos socialis Billings (r).
Eodiscus punctatus (Salter) (r).

74. Thin-bedded soft black shale, containing a few small black, probably phosphatic, nodules, an inch or less in diameter	0	3
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (c).		
Agnostus cf. acadicus declivis Matthew (c).		
Agnostus granulatus (Barrande) (r).		
Agnostus fissus Lundgren MS (c).		
Lingulella ferruginea Salter (r).		
Stenotheca sp. undet. (r).		
Hyolithid gen. and sp. undet. (c).		
73. Hard pyritiferous greenish gray and brownish gray, brown-weathering, shales, alternating with black shales	0	8
Paradoxides hicksi Salter (a).		
Agraulos socialis Billings (a).		
Agnostus sp. undet. (r).		
Hyolithid gen. and sp. undet. (c).		
72. Soft dark gray, brown-weathering shale	0	2
Agraulos socialis Billings (r).		
Agnostus fissus Lundgren MS (r).		
71. Hard, tough, dark gray shale, weathering brown	0	2
Solenopleura ? sp. undet. (c).		
Agraulos socialis Billings (c).		
Agnostus cf. acadicus declivis Matthew (c).		
70. Hard dark gray shale, weathering brown	0	2
Paradoxides hicksi Salter (a).		
Agraulos socialis Billings (a).		
Solenopleura ? sp. undet. (va).		
Agnostus cf. acadicus declivis Matthew (r).		
Agnostus nudus (Beyrich) (r).		
Agnostus barrandei Salter (r).		
69. Soft dark gray shale, weathering brown	0	9
Paradoxides hicksi Salter (a).		
Solenopleura cf. applanata (Salter) (r).		
Agraulos socialis Billings (a).		
Eodiscus punctatus (Salter) (r).		
Agnostus cf. nudus (Beyrich) (r).		
Agnostus fissus Lundgren MS (c).		
Brachiopod gen. and sp. undet. (r).		
68. Dark gray limestone	0	1
No fossils found.		
67. Greenish gray shale	0	3
Paradoxides hicksi Salter (a).		
Solenopleura cf. applanata (Salter) (r).		
Agraulos socialis Billings (a).		
°Conocoryphe cf. æqualis Linnarsson (r).		
Eodiscus punctatus (Salter) (va).		
66. Dark bluish gray shale with a 1-inch limestone bed an inch below the top. The shale contains small black, probably phosphatic, nodules, an inch or less in		

diameter	0	5
Paradoxides hicksi Salter (a).		
Agraulos socialis Billings (c).		
Agnostus sp. undet. (r).		
65. Soft blue, brown-weathering shale with a 1-inch bed of limestone 2 inches above the base	0	6
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (c).		
Agnostus cf. fallax Linnarsson (r).		
Agnostus rex (Barrande) (r).		
Agnostus barrandei Salter (r).		
64. Soft, slightly pyritiferous, bluish gray shale, weathering brown	0	4
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (c).		
Agnostus barrandei Salter (r).		
Agnostus cf. fallax Linnarsson (r).		
Agnostus fissus Lundgren MS (c).		
63. Dark gray limestone	0	3
No fossils found.		
62. Heavy-bedded, brown-weathering blue shale, becoming a limestone in its lower inch at some places along it outcrop	0	6
Paradoxides hicksi Salter (c).		
Agraulos socialis Billings (c).		
61. Soft, thin-bedded, dark blue shale, weathering brown	0	2
Paradoxides hicksi Salter (r).		
Agraulos socialis Billings (r).		
60. White clay, containing small pieces of soft dark blue shale	0	2½
No fossils found.		
59. Soft, thin-bedded, dark blue shale, similar to the shale in bed 60	0	1½
No fossils found.		
58. Heavy-bedded, hard, tough, brownish gray shales, alternating with thinner-bedded black shales. Some of the bedding surfaces are smooth and some are rough. Occasional thin nodules of dark gray limestone, up to 1 foot or more in diameter, occur in the shale	0	8
Paradoxides hicksi Salter (a).		
Agraulos socialis Billings (a).		
Agnostus fissus Lundgren MS (c).		
Agnostus barrandei Salter (r).		
57. Soft pyritiferous black shale, the upper 6 inches softer and more fossiliferous than the lower 5	0	11
Paradoxides hicksi Salter (c).		
Centropleura ? sp. undet. (r).		
Solenopleura cf. applanata (Salter) (r).		
Agraulos socialis Billings (c).		
Agnostus cf. acadicus declivis Matthew (r).		

Agnostus rex (Barrande) (r).
Agnostus fissus Lundgren MS (a).
Agnostus barrandei Salter (r).
Brachiopod gen. and sp. undet. (r).
Hyolithid gen. and sp. undet. (r).

56. Thin-bedded, hard, brown-weathering dark gray shale, with a ½-inch bed of dark gray limestone at the top 1 0
Paradoxides hicksi Salter (c).
Agraulos socialis Billings (c).
Agnostus cf. acadicus declivis Matthew (r).

55. Dark gray shale, weathering brown 0 10
Paradoxides hicksi Salter (c).
Solenopleura cf. applanata (Salter) (r).
Agraulos socialis Billings (a).
Agnostus cf. acadicus declivis Matthew (c).
Agnostus barrandei Salter (r).
/Alga ? (a).

54. Soft black shale. Not as soft as the soft black shales of the lower part of the Paradoxides davidis zone 0 11
Paradoxides hicksi Salter (r).
Agraulos socialis Billings (c).
Eodiscus punctatus (Salter) (r).
Agnostus cf. acadicus declivis Matthew (a).

53. Dark gray shale, with a few thin black shales in the upper part 0 4
Paradoxides hicksi Salter (a).
Agraulos socialis Billings (va).
Agnostus cf. acadicus declivis Matthew (c).
Alga ? (a).

52. Dark gray shale, weathering brown. Contains a few thin nodules of gray limestone near its base, and a very few small, yellow-weathering, pyritiferous masses, like those shown in beds 50 and 51 0 11
Paradoxides hicksi Salter (a).
/Paradoxides cf. abenacus Matthew (r).
Agraulos socialis Billings (va).
Eodiscus punctatus (Salter) (r).
Agnostus cf. fallax Linnarsson (r).
Agnostus cf. acadicus declivis Matthew (c).
Agnostus rex (Barrande) (r).
Alga ? (r).

51. Dark gray, brown-weathering, shales, greenish in places, with a ¼-inch bed of dark gray limestone 2 inches above the base. Contains a very few yellow-weathering pyritiferous masses, like those in beds 50 and 52 1 5
Paradoxides sp. undet. (r).
Paradoxides hicksi Salter (r).
°Paradoxides cf. abenacus Matthew (r).
Agraulos socialis Billings (va).
Eodiscus punctatus (Salter) (r).

Agnostus cf. acadicus declivis Matthew (c).
Agnostus granulatus (Barrande) (r).
Agnostus fissus Lundgren MS (r).
Agnostus barrandei Salter (r).
Hyolithid gen. and sp. undet. (r).
Alga ? (r).

50. Dark gray shale, containing a very few of the small, yellow-weathering, pyritiferous masses that occur commonly in the beds below. In beds 50 to 52 these masses are smaller than in some of the lower beds, being only an inch or less in diameter. This bed is slightly harder than bed 51______________________ 1 0
Paradoxides sp. undet. (r).
Agraulos socialis Billings(va).
Agnostus cf. parvifrons tessella Matthew (c).

49. Thinly and evenly bedded black shale________________ 0 4
Paradoxides cf. eteminicus Matthew (r).
Paradoxides hicksi Salter (c).
Agraulos socialis Billings(va).
Agnostus sp. undet. (r).

48. Soft black shale, full of agnostids__________________ 0 1
°Solenopleura cf. applanata (Salter) (r).
Agnostus cf. acadicus declivis Matthew (c).
Agnostus barrandei Salter (r).
°Agnostus cf. parvifrons tessella Matthew (a).
/°Agnostus cf. gibbus hybrida Brögger (va).
°Acrotreta misera(Billings) (a).
Hyolithid gen. and sp. undet. (a).

The presence of this soft black shale, full of agnostids—especially Agnostus cf. gibbus hybrida, which is not known to occur elsewhere in the section—among heavier gray shales with comparatively few agnostids, is noteworthy.

47. Thin-bedded gray and olive gray shales______________ 0 1
Paradoxides sp. undet. (c).
Agnostus barrandei Salter (r).
Alga ? (c).

46. Hard gray shale__________________________________ 0 1
Paradoxides hicksi Salter (a).
Agraulos socialis Billings (a).
Agnostus rex (Barande) (r).
Agnostus granulatus (Barrande) (r).

45. Heavy-bedded, hard, grayish black shale, containing a few small lens-shaped, yellow-weathering, pyritiferous masses, like those in beds 50 to 52_____________ 0 7
Paradoxides sp. undet. (r).
Paradoxides hicksi Salter (c).
Agraulos socialis Billings (va).
Agnostus cf. fallax Linnarsson (r).
Agnostus cf. nudus (Beyrich) (r).

°Alga ? (c).

44. Thin-bedded blackish gray and brownish gray shale, blacker and heavier-bedded below than above, and containing a few small lens-shaped, yellow-weathering, pyritiferous masses — 0 8
Paradoxides hicksi Salter (c).
Agraulos socialis Billings (va).
Eodiscus punctatus (Salter) (r).
Agnostus acadicus declivis Matthew (r).
°Agnostus cf. nudus (Beyrich) (r).
Agnostus rex (Barrande) (r).
Stenotheca sp. undet. (r).

43. Hard, brown-weathering gray shale, heavy-bedded in its lower half, but somewhat thinner-bedded above — 0 11
Paradoxides hicksi Salter (c).
Agraulos socialis Billings (va).
°Agnostus cf. fallax Linnarsson (r).
Agnostus acadicus declivis Matthew (r).
Agnostus rex (Barrande) (r).
Agnostus granulatus (Barrande) (r).
Agnostus barrandei Salter (c).
Hyolithid gen. and sp. undet. (r).

42. White clay, underlain by ½ inch of gray shale, having an uneven upper surface — 0 1
No fossils found.

41. Thin-bedded, brown weathering, gray shale, containing occasional thin lenses of dark gray limestone, and numerous thin sheets of yellow-weathering, probably pyritiferous, material, some of which are a foot or more across. The bottom ½ inch of the bed is hard gray shale. The fossils are well preserved — 0 6
Paradoxides sp. undet. (possibly P. bennetti Salter) (r).
Paradoxides hicksi Salter (c).
/Conocoryphe elegans (Hartt) (r).
Agraulos socialis Billings (c).
Agnostus cf. acadicus declivis Matthew (r).
°Agnostus fissus Lundgren MS (c).
°Agnostus barrandei Salter (c).
Lingulella ferruginea Salter (r).
Hyolithid gen. and sp. undet. (r).

The faunas of this bed and of beds 37 to 40 are somewhat transitional between the typical bennetti and hicksi faunas.

40. Dark gray, brown-weathering shale, softer than the beds just below, and having uneven bedding planes, especially in its lower half. Contains a few thin limy lenses, and many scattered crystals of barite, about ¼ of an inch long — 2 3
Paradoxides hicksi Salter (r).
/Liostracus tener (Hartt) (va).

Conocoryphe elegans (Hartt) (c).
Agraulos socialis Billings (r).
°Eodiscus punctatus (Salter) (r).
°Agnostus cf. acadicus declivis Matthew (r).
Lingulella ferruginea Salter (c).

39. Hard, heavy-bedded, very dark gray shale, weathering black ---- 1 6
Paradoxides sp. undet. (r).
Liostracus tener (Hartt) (r).
Lingulella ferruginea Salter (c).

38. Hard, heavy-bedded, very dark gray shale, weathering black. Contains many small crystals of barite and numerous small black concretions of undetermined chemical composition ---- 1 6
Liostracus tener (Hartt) (c).
Lingulella ferruginea Salter (c).

37. Hard, tough, heavy-bedded, dark gray shale, containing thin lenses and beds of dark gray limestone. Has a 1-inch bed of nodular shale at the base. Beneath one of the limestone beds, 5 inches above the base are 2 or 3 inches of bluish shale with an uneven upper surface, but no evidence of ripple marks or erosion ---- 0 9
°Paradoxides hicksi Salter (r).
°Agraulos socialis Billings (c).
Lingulella ferruginea Salter (a).

36. One-half inch of soft blue shale, underlain by 1½ inches of unctuous white clay. The clay, like the similar, but thinner ones, in the beds above, is probably the result of the weathering of a shale bed ---- 0 2
No fossils found.
This is the lowest bed of the "Paradoxides hicksi zone of this paper.

35. Shaly, nodular, dark gray limestone ---- 1 0
Paradoxides sp. undet. (probably P. bennetti Salter) (r).
/Paradoxides eteminicus Matthew (c).
Liostracus tener (Hartt) (c).
/Bailiella cf. baileyi (Hartt) (r).
/Harttella matthewi (Hartt) (r).
Linguella ferruginea Salter (a).
Acrothele matthewi (Hartt) (c).
This is the top bed of the "Paradoxides bennetti zone" of this paper.

34. Hard, well-bedded, brown-weathering, black shale, containing many small crystals of barite ---- 1 1
Paradoxides sp. undet. (probably P. bennetti Salter) (r).
Paradoxides eteminicus Matthew (a).
Liostracus tener (Hartt) (r).
Conocoryphe elegans (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).

Harttella matthewi (Hartt) (r).
Lingulella ferruginea Salter (va).
Acrothele matthewi (Hartt) (c).
Brachiopod gen. and sp. undet. (r).
This bed is remarkable for an abundance of brachiopods and a comparative scarcity of trilobites.

33. Olive shale, breaking with a conchoidal fracture and full of small nodules of gray limestone	0	5

Paradoxides sp. undet. (probably P. bennetti Salter) (r).
Paradoxides eteminicus Matthew (a).
Liostracus tener (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).

32. Olive shale, breaking with a conchoidal fracture and containing at some horizons many small limy nodules, which vary from 2 to 6 or more inches in diameter	1	1

/Paradoxides bennetti Salter (r).
Paradoxides eteminicus Matthew (a).
Liostracus tener (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).
Harttella matthewi (Hartt) (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).

31. Olive shale, breaking with a conchoidal fracture and containing many small limy nodules in some of its layers	2	9

Paradoxides bennetti Salter (c).
Paradoxides eteminicus Matthew (va).
Liostracus tener (Hartt) (r).
/Liostracus ouangondianus (Hartt) (r).
Conocoryphe elegans (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).
Harttella matthewi (Hartt) (r).
/Agnostus cf. fallax trilobatus Matthew (r).
Agnostus cf. rex (Barrande) (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).
Brachiopod gen. and sp. undet. (r).

30. Hard dark gray and olive gray shales, breaking with a conchoidal fracture	1	10

Paradoxides bennetti Salter (r).
Paradoxides eteminicus Matthew (r).
Liostracus tener (Hartt) (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).
Brachiopod gen. and sp. undet. (r).

29. Hard, heavy-bedded, olive shale, with some of its layers full of limestone nodules	1	0

Paradoxides bennetti Salter (c).

Paradoxides eteminicus Matthew (a).
Liostracus tener (Hartt) (a).
Liostracus ouangondianus (Hartt) (a).
Conocoryphe elegans (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).
Harttella matthewi (Hartt) (c).
Agnostus cf. fallax trilobatus Matthew (r).
Agnostus cf. rex (Barrande) (c).
Agnostus granulatus (Barrande) (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (a).
/Acrotreta gemmula Matthew (r).

28. Dark gray shale -- 1 7
Paradoxides bennetti Salter (c).
Paradoxides eteminicus Matthew (a).
Liostracus tener (Hartt) (a).
Liostracus ouangondianus (Hartt) (c).
Conocoryphe elegans (Hartt) (c).
Harttella matthewi (Hartt) (r).
Agnostus granulatus (Barrande) (r).
Agnostus cf. rex (Barrande) (r).
/Agnostus barlowi definitus n. var. (r).
Lingulella ferruginea Salter (r).
Acrothele matthewi (Hartt) (c).
Acrotreta cf. gemmula Matthew (r).

27. Olive shale full of limestone nodules ------------------ 0 3
Paradoxides bennetti Salter (r).
Paradoxides eteminicus Matthew (c).
Liostracus tener (Hartt) (c).
Conocoryphe elegans (Hartt) (r).
Harttella matthewi (Hartt) (c).
Eoorthis sp. undet. (r).

26. Hard olive shale, breaking with a conchoidal fracture -- 0 10
Paradoxides bennetti Salter (c).
Paradoxides eteminicus Matthew (a).
/Paradoxides parvoculus n. sp. (r).
Liostracus tener (Hartt) (c).
Liostracus ouangondianus (Hartt) (a).
Conocoryphe elegans (Hartt) (r).
Harttella matthewi (Hartt) (a).
Agnostus cf. fallax trilobatus Matthew (c).
°Agnostus cf. exaratus tenuis Illing (r).
Agnostus cf. rex (Barrande) (a).
Agnostus barlowi definitus n. var. (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).

25. Olive shale, full of nodules of tough gray limestone ---- 0 4
Paradoxides eteminicus Matthew (c).
°Liostracus tener (Hartt) (r).
Conocoryphe elegans (Hartt) (r).
Bailiella cf. baileyi (Hartt) (r).

Harttella matthewi (Hartt) (c).
Agnostus cf. rex (Barrande) (r).
Eoorthis sp. undet. (r).
Linguiella ferruginea Salter (r).

24. Tough, nodular gray limestone, with uneven upper and lower surfaces that are probably due to the nodular character of the bed and not to erosion ---- 0 6
Paradoxides bennetti Salter (c).
Paradoxides eteminicus Matthew (c).

23. Hard, well-bedded, olive and bluish gray shale, breaking with a conchoidal fracture and containing occasional aggregations of tiny black, probably phosphatic, nodules and a few small concretions of pyrite. Holds many well preserved fossils, including some whole trilobites ---------------------------------- 0 8
Paradoxides bennetti Salter (a).
Paradoxides eteminicus Matthew (a).
°Paradoxides parvoculus n. sp. (r).
Liostracus ouangondianus (Hartt) (a).
°Conocoryphe elegans (Hartt) (r).
°Bailiella cf. baileyi (Hartt) (r).
Harttella matthewi (Hartt) (a).
Agnostus cf. fallax trilobatus Matthew (c).
Agnostus cf. rex (Barrande) (a).
°Agnostus granulatus (Barrande) (a).
/°Agnostus claræ n. sp. (r).
°Agnostus barlowi definitus n. var. (r).
Lingulella ferruginea Salter (c).
Acrothele matthewi (Hartt) (c).
Almost entire specimens of Paradoxides bennetti, Liostracus ounangondianus, Conocoryphe elegans, and Harttella matthewi were collected from this bed.

22 Olive shale, much slickensided against the nodular upper surface of bed 21-------------------------- 0 1
Paradoxides bennetti Salter (c).
Paradoxides eteminicus Matthew (c).
Harttella matthewi (Hartt) (a).
/°Eoorthis cf. papias (Walcott) (r).

21. Hard, tough, nodular gray limestone, with uneven upper and lower surfaces, which are probably due to the nodular character of the bed and not to erosion. Contains scattered crystals of pyrite--------------- 0 7
Paradoxides bennetti Salter (r).
Paradoxides eteminicus Matthew (c).
/°Paradoxides lamellatus Hartt (r).
Liostracus cf. ouangondianus (Hartt) (r).
°Harttella matthewi (Hartt) (c).
Linguella ferruginæ Salter (r).
Acrothele sp. undet. (r).
°Acrotreta cf. gemmula Matthew (r).

/°Micromitra (Iphidella) cf. ornatella (Linnarsson) (r).
Stenotheca sp. undet. (r).

20. Alternating beds of greenish gray and bluish gray shales, which break with a conchoidal fracture and weather olive brown. They vary in hardness, but none of them are soft---------- 82 0
No fossils found.
These unfossiliferous shales and the similar shales of beds 6 to 18, below, are in marked contrast with the generally richly fossiliferous shales of the rest of the section.

19. Two beds of tough, nodular, shaly gray limestone, 16 and 18 inches thick, with 6-inch beds of bluish gray shale between, above, and below them---------- 4 5
Paradoxides bennetti Salter (c).
°Paradoxides cf. eteminicus Matthew (c).
Liostracus cf. ouangondianus (Hartt) (c).
/°Conocoryphe bullata n. sp. (r).
/°Goniodiscus dawsoni (Hartt) (r).
Agnostus cf. rex (Barrande) (r).
Lingulella ferruginea Salter (r).
Eoorthis sp. undet. (r).
Brachiopod gen. and sp. undet. (r).

18. Alternating beds of bluish gray and olive gray shales. The beds are usually several feet in thickness, and grade very gradually into each other---------- 40 0
No fossils found.

17. Bluish gray shales. Fossils very rare---------- 15 0
Liostracus cf. ouangondianus (Hartt) (r).

16. Alternating beds of light bluish gray and olive gray shales, grading very gradually into each other. The beds vary from a few inches to several feet in thickness, and sometimes change from the one color to the other along the strike---------- 11 0
No fossils found.

15. Olive gray shale, harder and heavier-bedded than 16, 17, and 18. A few of the beds contain numbers of lens-shaped cavities, 6 inches to 3 feet in diameter, which have probably been formed by the weathering of pyrite nodules. Fossils very rare---------- 40 0
Paradoxides sp. undet. (r).
°Liostracus cf. ouangondianus (Hartt) (r).
Hyolithid gen. and sp. undet. (r).

14. Dark bluish gray shale, weathering brown. More finely bedded than the shales of 13 and 15---------- 2 0
No fossils found.

13. Hard, heavy-bedded, olive shale, containing many black, probably phosphatic, nodules in some of its beds. Lenses of dark gray limestone, with uneven upper and lower surfaces, occur in the shales. These

lenses vary from a few inches to a foot or more in thickness, and are usually from one to four or more feet broad 6 0

Paradoxides bennetti Salter (r).

12. Dark olive gray shale, not so hard as the shales of 11 and 13 .... 3 6

No fossils found.

11. Hard, heavy-bedded, dark gray shale 4 6

No fossils found.

10. Dark gray shale, not so hard as the shales of 8 and 11 .... 2 5

Paradoxides sp. undet. (probably P. bennetti Salter) (r).
Lingulella ferruginea Salter (r).
Acrothele cf. matthewi (Hartt) (r).
Hyolithid gen. and sp. undet. (r).

9. Dark olive gray shale, not so hard as the shales of 8 and 11 .... 1 0

No fossils found.

8. Hard, heavy-bedded, bluish gray shale, weathering reddish brown on joint and bedding planes, and breaking with a conchoidal fracture. Contains a little manganese 2 2

Paradoxides bennetti Salter (r).
/°Ptychoparia rogersi Walcott (r).
/°Agraulos cf. affinis Billings (r).
°Agnostus cf. fallax trilobatus Matthew (r).
°Agnostus cf. rex (Barrande) (r).

7. Hard, heavy-bedded, olive shale, breaking with a conchoidal fracture. Contains manganese and weathers black 1 6

Paradoxides bennetti Salter (r).

6. Olive shale, softer than 4 and 7, and containing many small black, probably phosphatic, nodules. Contains some manganese and weathers black 1 6

°Paradoxides bennetti Salter (c).

5. Olive shale, softer than 4 and 7, and full of fragments of a large trilobite. The shale contains some manganese and weathers black 0 1

Paradoxides ? sp. undet. (probably Paradoxides bennetti Salter) (va).

4. Hard, tough, nodular manganiferous, calcareous, shale, with uneven upper and lower surfaces, which are apparently due to the nodular character of the bed and not to erosion. Contains many small black phosphatic nodules 0 5

Hyolithid gen. and sp. undet. (a).

3. Hard, greenish gray shale, containing in some of its layers many small black phosphatic nodules, which are white when weathered 0 9

Paradoxides ? sp. undet. (probably Paradoxides bennetti Salter) (r).

°Lingulella cf. ferruginea Salter (r).
°Acrothele cf. matthewi (Hartt) (r).

The small black nodules are not evenly distributed through the bed, but are usually arranged in bands or bunches. The fossils are found in the beds that hold the fewest nodules.

2. Hard dark blue shale, containing many small black phosphatic nodules, which are more abundant in some layers than in others 1 3

Paradoxides ? sp. undet. (probably Paradoxides bennetti Salter) (r).

The fosils, which are rare and fragmentary, are found only in the layers in which the nodules are least abundant.

1. Hard, tough, nodular, manganiferous, argillaceous, dolomite. Has uneven upper and lower surfaces. which are probably due to the nodular character of the bed and not to erosion. Contains much phosphatic material, barite, and hematite. Fossils fragmentary 0 6

Brachiopod gen. and sp. undet. (r).
Hyolithid gen. and sp. undet. (r).
Sponge gen. and sp. undet. (r).

This is the bottom bed of the "Paradoxides bennetti zone," and therefore the lowest of the "Paradoxides beds" of this paper. It has been described in detail by Dr. Dale, as bed "219A11" (Dale, 1915, pp. 405-407).

Total thickness 302 0

Further work will probably extend the vertical ranges of most of the species included in these faunal lists and will surely add many new names. There are at the present time in the Princeton collections from the davidis zone at Manuels the following six forms, which are not mentioned in these lists because the exact stratigraphical horizons from which they came are unknown: Ctenocephalus coronatus (Barrande), Agnostus cf. planicauda Angelin, Agnostus bifurcatus Illing, Agnostus barlowi Belt, Agnostus rectangularis n. sp., and Acrotreta sagittalis (Salter). Future studies will probably show in which beds these forms occur.

Of the 25 genera included in the above lists, 1 (Protospongia) is a sponge, 1 (Hyolithes) is a pteropod, 1 (Stenotheca) is a gasteropod, 6 (Acrothele, Acrotreta, Eoorthis,

109	110	111	112	113	114	115
		r			va	va
						r
						r
a	r	r	c			
						r
						r
r						
r				r		
		r	c	r		
						c
va			r			r
r			r			
r	r					
c						
a	c	c	r		r	r
r	r					
r				c		r
a	a	a	c		r	c
						r
r	r			c		c
r						
r	va	va				r
r	r					
r						
	r					
r						
r						r
r						
						r
						r

Poland.

	Name	Paradoxides bennetti zone (Chamberlain's Brook formation) — columns 1–36; Paradoxides hicksi zone (Long Pond formation) — columns 37–60; Paradoxides davidis zone (Manuels Brook formation) — columns 61–125	Found also in the Paradoxides beds of
1	Paradoxides bennetti Salter	[illegible]	
2	P. eteminicus Matthew	[illegible]	New Brunswick
3	P. lamellatus Hartt	[illegible]	New Brunswick
4	P. parvoculus, n. sp.	[illegible]	
5	P. hicksi Salter	[illegible]	Great Britain and Scandinavia
6	P. cf. abenacus Matthew	[illegible]	New Brunswick
7	P. davidis Salter	[illegible]	Great Britain and Scandinavia
8	P. rugulosus Corda	[illegible]	Great Britain, Scandinavia, and Bohemia
9	Centropleura pugnax Illing	[illegible]	Great Britain
10	C. henrici (Salter)	[illegible]	Great Britain
11	C. venusta (Billings)	[illegible]	
12	Ptychoparia cf. rogersi (Walcott)	[illegible]	Massachusetts (P. rogersi).
13	Solenopleura cf. applanata (Salter)	[illegible]	Great Britain (S. applanata).
14	S. variolaris (Salter)	[illegible]	Great Britain
15	S. communis Billings	[illegible]	
16	Liostracus ouangondianus (Hartt)	[illegible]	New Brunswick
17	L. cf. ouangondianus (Hartt)	[illegible]	N.B. ("L. ouangondianus plana" Matthew)
18	L. tener (Hartt)	[illegible]	New Brunswick
19	L. globiceps jaculator, n. var.	[illegible]	
20	Agraulos cf. affinis Billings	[illegible]	
21	A. socialis Billings	[illegible]	New Brunswick
22	Corynexochus minor (Walcott)	[illegible]	
23	Bailiella cf. baileyi (Hartt)	[illegible]	New Brunswick (B. baileyi).
24	B. venulosa (Salter)	[illegible]	Great Britain and Scandinavia
25	Conocoryphe bullata, n. sp.	[illegible]	
26	C. elegans (Hartt)	[illegible]	New Brunswick
27	C. aequalis Linnarsson	[illegible]	Great Britain and Scandinavia
28	Hartella matthewi (Hartt)	[illegible]	New Brunswick
29	Hartshillia inflata (Hicks)	[illegible]	Great Britain
30	Holocephalina primordialis Salter	[illegible]	Great Britain and Scandinavia
31	Goniodiscus dawsoni (Hartt)	[illegible]	New Brunswick
32	Eodiscus punctatus (Salter)	[illegible]	G.B. and S. (A. incertus Linnarsson)
33	Agnostus rex (Barrande)	[illegible]	Great Britain, Scandinavia, and Bohemia.
34	A. cf. rex (Barrande)	[illegible]	M. and N.B. (A. regulus Matthew)
35	A. granulatus (Barrande)	[illegible]	Great Britain and Bohemia
36	A. clarae, n. sp.	[illegible]	
37	A. barlowi definitus, n. var.	[illegible]	
38	A. cf. aratus tenuis Illing	[illegible]	Great Britain
39	A. cf. fallax Linnarsson	[illegible]	N.B., G.B., S., and P. (A. fallax)
40	A. cf. " trilobatus Matthew	[illegible]	N.B. (A. fallax trilobatus), G.B. ("A. lobatus")
41	A. cf. umbo Matthew	[illegible]	New Brunswick (A. umbo)
42	A. sulcatus Illing	[illegible]	Great Britain
43	A. cf. gibbus Linnarsson	[illegible]	Scandinavia (A. gibbus) and Poland (A. gibbus)
44	A. cf. " hybrida Brögger	[illegible]	Scandinavia (A. gibbus hybrida)
45	A. fissus Lundgren MS.	[illegible]	New Brunswick, Great Britain, and Scandinavia
46	A. cf. fissus perrugatus Grönwall	[illegible]	G.B. and S. (A. fissus perrugatus)
47	A. barrandei Salter	[illegible]	Great Britain
48	A. cf. acadicus declivis Matthew	[illegible]	New Brunswick (A. acadicus declivis)
49	A. cf. parvifrons Linnarsson	[illegible]	N.B., G.B., and S. (A. parvifrons)
50	A. cf. " tessella Matthew	[illegible]	New Brunswick (A. parvifrons tessella).
51	A. " mammillatus Brögger	[illegible]	Scandinavia (A. parvifrons mammillatus)
52	A. " punctifer, n. var.	[illegible]	
53	A. laevigatus terranovicus Matthew	[illegible]	Scandinavia ("A. lens" of Grönwall)
54	A. " manilla Matthew	[illegible]	Scandinavia ("A. rotundus" of Grönwall)
55	A. " ciceroides Matthew	[illegible]	Scandinavia ("A. altus" of Grönwall)
56	A. cf. kjerulfi Brögger	[illegible]	G.B. (A. kjerulfi) and S. (A. kjerulfi)
57	A. cf. incertus Brögger	[illegible]	G.B. (A. incertus) and S. (A. incertus)
58	A. bibullatus (Barrande)	[illegible]	Great Britain and Bohemia
59	A. punctuosus Angelin	[illegible]	Great Britain and Scandinavia
60	A. cf. nudus (Beyrich)	[illegible]	G.B. (A. nudus) and B. (A. nudus)
61	A. vanizeni, n. sp.	[illegible]	
62	A. longifrons parvulus, n. var.	[illegible]	
63	A. cf. pusillus Tullberg	[illegible]	Scandinavia (A. pusillus)
64	A. gracilis Illing	[illegible]	Great Britain
65	Lingulella ferruginea Salter	[illegible]	New Brunswick, Great Britain and Scandinavia
66	Obolus fragilis (Walcott)	[illegible]	
67	Acrothele matthewi (Hartt)	[illegible]	New Brunswick
68	Acrotreta gemmula Matthew	[illegible]	
69	A. micmac (Billings)	[illegible]	New Brunswick
70	Eoorthis papias (Walcott)	[illegible]	
71	Micromitra (Iphidella) cf. ornatella (Linnarsson)	[illegible]	
72	Stenotheca cf. cornucopia Salter	[illegible]	Great Britain (S. cornucopia)
73	Hyolithes cf. tenuistriatus Linnarsson	[illegible]	Scandinavia
74	Hyolithid gen. and sp. undet.	[illegible]	
75	Protospongia fenestrata Salter	[illegible]	Great Britain and perhaps Scandinavia
76	Sponge gen. and sp. undet.	[illegible]	

Table IV. Table showing vertical distribution of species in the Paradoxides beds at Manuels (r = rare, c = common, a = abundant, va = very abundant). A few species which have been found at Manuels, but whose ranges are unknown, are not included. In the column at the right, M. = Massachusetts, N.B. = New Brunswick, G.B. = Great Britain, S. = Scandinavia, B. = Bohemia, and P. = Poland.

Lingulella, Micromitra (Iphidella), and Obolus) are brachipods, and the remaining 16 (Agnostus, Agraulos, Bailiella, Centropleura, Conocoryphe, Corynexochus, Ctenocephalus, Eodiscus, Goniodiscus, Hartshillia, Harttella, Holocephalina, Liostracus, Paradoxides, Ptychoparia, and Solenopleura) are trilobites. Algæ are also probably represented.

DISCUSSION OF THE STRATIGRAPHY

The classification of the subdivisions of the Paradoxides beds at Manuels that is used in this paper is shown in Table I, p. 12. The beds are there referred to the Acadian epoch of the Cambrian period. In 1874 Murray wrote of the shales exposed in the gorge of Manuels Brook as "my Manuel's River rocks" (Weston, 1898, p. 153), and in 1889 Mr. Howley mentioned "the Manual Creek shales just above the Topsail Head limestone" (Howley, 1889, p. 123) ; but it is doubtful whether either of these authors intended to use their terms strictly in the sense of formation names; at any rate, they did not define them as such. In 1888 Dr. Walcott spoke of the Paradoxides beds of southeastern Newfoundland as the "Newfoundland" beds (Walcott, 1888a, p. 399). In 1914 Professor vanIngen (1914b) described the Paradoxides beds about Conception and Trinity Bays as the "Manuels series," composed of a single formation, which he called the "Manuels formation" (see Table III, p. 20). The known Paradoxides beds at Manuels and elsewhere in southeastern Newfoundland appear, however, to be divisible into at least three distinct formational units, and the writer therefore suggests, with Professor vanIngen's approval, that the term "Manuels" be abandoned as a formation name and retained in its larger sense alone. In the present paper Dr. Walcott's term "Newfoundland" is used as a general series name for all the Paradoxides beds of southeastern Newfoundland (some of which differ lithologically from the Paradoxides beds at Manuels), and Professor vanIngen's series name "Manuels" is restricted to the Paradoxides beds of the Conception Bay region, where the lithological character of the beds appears to be everyhere approximately the same as it is at the type locality, Manuels. It is possible that the Paradoxides beds of Newfoundland do not represent a whole "series," in the sense in which that term was defined by the International Geological Congress of 1900; but the course suggested above would seem to be the best one to pursue at the present time. (This question is discussed further in Chapter VII.

The three major units into which the beds known to contain Paradoxides at Manuels seem to be most naturally divisible, both lithologically and faunally, are here named the Chamberlin's Brook formation, the Long Pond formation, and the Kelligrew Brook formation. The Chamberlin's Brook formation, which is the oldest of the three, outcrops in the banks of Chamberlin's Brook, a mile or two northeast of Manuels. It contains a fauna whose most characteristic species is the big trilobite, Paradoxides bennetti. (This species is perhaps identical with the earlier described one, Paradoxides harlani Green, of Massachusetts, and it is possible that the zone ought to be called the 'harlani zone'; but until the Newfoundland and Massachusetts fossils can be proved to be referable to a single species, it seems best to continue to use the name bennetti. See pages 60, 61). The Long Pond formation, whose type locality is on the shores of Long Pond, a couple of miles southwest of Manuels, is characterized by a smaller Paradoxides, P. hicksi. The Kelligrew Brook formation is exposed on the northeast side of the valley of Kelligrew Brook, about five miles southwest of Manuels. It is distinguished by the presence of another large trilobite, Paradoxides davidis.

It is not known whether these divisions should be considered as "stages" or as "zones" when measured by the stratigraphic units of the International Geological Congress. In the present paper they will be spoken of as "formations" or "zones." They are probably recognizable as lithologic units (formations) throughout the Conception

Bay region, and as faunal units (zones) throughout southeastern Newfoundland. As no subdivisions of Acadian time that are applicable to the whole world have yet been defined by students of Cambrian history, it is not possible to refer these zones to any smaller universal time units.

The Chamberlin's Brook, Long Pond, and Kelligrew Brook formations grade gradually into each other. The same is true of the bennetti, hicksi, and davidis faunas. It has therefore been found necessary to draw the exact vertical boundaries between the zones more or less arbitrarily. The zones may be characterized briefly as follows, beginning with the highest:

III. Paradoxides davidis zone (Kelligrew Brook formation). Beds 93 to 125; 31 feet thick.

Soft black and gray shales, the latter often containing flat nodules and lenses of dark gray limestone, which are sometimes as much as 6 feet in diameter and 1 foot in thickness. Small nodules of pyrite are common in the upper 4½ feet. A bed, 1 to 2 inches thick and full of small black phosphatic nodules, occurs 24 feet above the base, and there is a similar, but slightly thicker, bed at the summit. Fossils are common in almost all of the beds and are very abundant in many of them, especially in the softer shales, which are often full of agnostids and other trilobites.

II. Paradoxides hicksi zone (Long Pond formation). Beds 36 to 92; 37 feet thick.

The lower 25 feet are composed of heavy-bedded, brown-weathering and black-weathering, dark gray shales (with a few thin beds of soft black shale and some thin limy layers and lenses in their lower part) which grade upward into 10 feet of softer gray and black shales containing small lenses and nodules of limestone. Small concretions of pyrite occur at various horizons. The top is a 4-inch bed of dark gray limestone; the bottom is a 1½-inch layer of unctuous white clay. Fossils are common in most of the beds, and agnostids are very abundant in many of the soft black shales.

I. Paradoxides bennetti zone (Chamberlin's Brook formation). Beds 1 to 35; 234 feet thick.

Hard olive gray, and somewhat softer bluish gray, shales, with several beds of impure nodular limestone. Two of the limestone beds are at the base, about two feet apart, a third is 134 feet above the base, and the others are scattered through the upper 13½ feet. A few of the shale beds in the upper 13½ feet are full of small limestone nodules. Small black phosphatic nodules, usually an inch or less in diameter, occur commonly in the lower 2 feet and 11 inches, and bodies of similar size and appearance, some or all of which are probably phosphatic, are found occasionally in the shales of the rest of the zone. Lens-shaped cavities, varying from a fraction of an inch to 6 inches or more in diameter and wholly or partly filled with a yellow earthy material that appears to have resulted from the weathering of pyrite concretions, occur at several horizons, especially in the 40 feet of olive gray shale that overlie the lower 28 feet. The shales break with a conchoidal fracture. The two lowest limestone beds (beds 1 and 4) are manganiferous. The shales are mostly barren except in the upper 13½ feet, where they contain many fossils and appear to be limier than below. The limestones are fossiliferous.

The beds of these three divisions appear to occur in an unbroken stratigraphic succession from the heavy-bedded, hard, olive gray and bluish gray shales of the bennetti zone, through the somewhat thinner-bedded, softer and darker shales of the hicksi zone, up to the predominately thin-bedded soft black shales of the davidis zone. The shales of the bennetti zone usually weather to a very dark olive brown color, those of the hicksi zone to brown or brownish black, and those of the davidis zone to black (except where stained brown by the weathering of pyrite). The limestones of the bennetti zone are generally light gray or pinkish in color, and occur in thin beds or in roughly oval or spheroidal nodules that appear to be of the same general type as the limestone nodules commonly found in the pre-Paradoxides beds of the Conception Bay region. The limestones of the hicksi zone are generally thinner than those of the bennetti zone, have smoother bedding planes, and occur usually as discontinuous sheets or thin lenses, rather than as continuous beds, and are dark gray, instead of light gray or pink, in color. In many ways they resemble the limestones of the overlying davidis zone, in which zone the limestones are not found as continuous beds, but as lenses and nodules, some of which are as much as a foot in thickness and six feet in diameter. Two beds filled with small masses of phosphatic material are present in the davidis zone—one at the top of the zone and the other 7 feet below it—and phosphatic bodies occur more or less abundantly in many of the shales of each of the three zones and in the two lowest limestones (beds 1 and 4) of the bennetti zone. The phosphatic bodies in the bed at the top of the davidis zone, and in the similar bed 7 feet below, sometimes contain fossils. Pyrite is common in all the zones, but is most abundant in the upper two. It usually occurs in small concretions and lenses, up to an inch or more in diameter, or in thin sheets, a small fraction of an inch thick. Some of the pyrite is associated with fossils. In a few instances hyolithid shells seem to have been filled with it. Barite is present in the dolomitic limestone (bed 1), at the bottom of the bennitti zone, and in the hard black shlaes of beds 38 and 40, near the base of the hicksi zone. In the latter two beds it occurs as little crystals, about ¼ of an inch long, scattered irregularly through the black shales. Thin beds of unctuous white clay, apparently derived from the decomposition of some sort of a shale, occur at several horizons in the hicksi and davidis zones.

The writer has discerned no good evidence of sub-ærial erosion in any part of the Paradoxides section at Manuels. The varied character of the sediments involved proves that the conditions of deposition changed from time to time. Some of the beds, such as the phosphatic ones at the base and summit, may possibly indicate some sort of stratigraphical break, for some or all of their phosphatic bodies may really be pebbles that have been rolled into place; but no good evidence of the erosion of any bed after its consolidation has been found, nor have any sun cracks or indubitable ripple marks been discovered. More field work will probably have to be done before these questions can be finally answered. The upper and lower surfaces of bed 1 are uneven. Dr. Dale (1915, p. 406) has stated that the upper surface is ripple marked, and when looked at in cross section, it does appear to be so; but in the late summer, when there is comparatively little water in the brook, several square yards of it are exposed, presenting evidence that the uneveness should probably be interpreted in a different way. The bed is divided by joint planes into roughly rectangular pieces with approximately square upper faces, so that, when viewed from above, it looks like a pavement of blocks. The upper face of each block has an area of about one square foot, and is slightly higher in the center than around the edges. Blocks whose upper portions have been removed by erosion show a black central core, which shows evidence of being more resistant than the rest of the mass, and seems to indicate that each block is essentially a nodule and that the unevenness of the upper and lower surfaces of the bed is due to these nodules rather than to ripple marking or erosion. Bed 4 shows the same features, although in a less pronounced degree, and beds 21 and 24 have similar, but less regular, nodular structures and uneven upper and lower surfaces. Bed 27 seems to be much like bed 24, except that its individual nodules have not originated near enough to each other, or have not grown large enough, to form a continuous bed of limestone, so that a shale full of limestone nodules has resulted instead.

Bed 125 seems to have been interpreted by Dr. Walcott as a true basal conglomerate, for in notes on the Manuels Brook Cambrian section, published in 1900 (Walcott, 1900, p. 317), he says: "Six feet above the thickest band of limestone, in which Paradoxides davidis occurs, there is a thin layer of calcareous conglomerate, varying from 2 to 6 inches in thickness. It contains many dark argillaceous concretions, also pebbles of a reddish siliceous rock. This narrow band of conglomerate is found on both sides of the ri and is taken as the base of the Upper Cambrian. Of the fauna occurring below it one species of Agnostus and one brachiopod, Obolus (Lingulella) ferruginea, pass up into the Olenus fauna." The "thickest bed of limestone" mentioned in the first sentence of this quotation is probably a shale bed containing one or more of the large limestone lenses characteristic of the upper 7 feet of the davidis zone. A number of these lenses, lying end to end, might easily be mistaken for a part of a continuous stratum. The writer has not seen in bed 125 any of the "pebbles of a reddish siliceous rock" mentioned by Dr. Walcott. This bed should probably not be considered to be a conglomerate, in the usual sense of that term, because many of the pebbles, concretions, or whatever they may be, that occur in it appear to show by their shapes and positions that they could not have been rolled into place. It is true that the bed marks the line between the fossiliferous shales of the Paradoxides davidis zone and the superjacent barren measures of unknown age; but, that a deposit of this peculiar character does not necessarily prove the presence of an important sedimentary break, is suggested by the fact that the faunas of the shales that overlie and underlie the similar phosphatic "pebble" layer in bed 115 appear not to differ from each other in any appreciable way. However, as the only fossils that have been discovered in bed 125 occur in the masses of phosphatic material (none having been found in the surrounding matrix), it is possible that the phosphatic masses of this bed are really fragments of older deposits. It seems more probable, however, that they are either concretions formed in the bed in which they now occur, or that they are pieces of unconsolidated contemporary or slightly older sediments that were being broken up at the time when bed 125 was being formed.

It is true that the Agnostus pisiformis and Agnostus pisiformis obesus ("Olenus") faunas, which occur not far above the Paradoxides beds in the brook section (see p. 27), appear to be fundamentally different from the davidis fauna, and that there is, therefore, probably a stratigraphic break somewhere in the 30 or more feet of shales that lie between the highest beds known to contain Paradoxides and the lowest beds in which Agnostus pisiformis has been found; but this break may well occur somewhere above bed 125.

At the base of the Paradoxides section, the fossils of the bennetti zone seem to differ considerably from those of the underlying "Catadoxides magnificus" beds (see pp. 16 and 26), and some sort of a sedimentary break may very possibly exist in the 10 feet and 10 inches of unfossiliferous manganiferous shales that intervene between the lowest known Paradoxides bed and the highest known Catadoxides horizon.

These question will be taken up again in a future paper, in which the microscopical character, chemical composition, and mode of deposition of the Paradoxides beds of the Conception Bay region will be discussed in detail.

DISCUSSION OF THE CHARACTER AND OCCURRENCE OF THE FAUNAS

The general composition of the Paradoxides faunas at Manuels is shown in the faunal lists on pages 35 to 56 and in Table IV and the Manuels lists of Chapter VII. An examination of these lists and table will show that in each of the three zones the trilobites far exceed in both numbers and variety all the other types of life. The number of individuals of each group (trilobites, brachiopods, etc.) in each zone is probably roughly proportional to the number of species present. It will be noted that almost all of the Newfoundland species are represented by identical or nearly identical forms in New Brunswick, Massachusetts, or Europe. The European and continental American types that have been recognized at Manuels are indicated in Table IV and discussed on pages 100-132.

Wherever Paradoxides faunas have been carefully studied, they appear to be roughly assignable to one or more of four large groups. Three of these four groups correspond to the Paradoxides bennetti, Paradoxides hicksi, and Paradoxides davidis faunas of Newfoundland; the fourth group, which is the youngest, is characterized by the presence of Paradoxides forchhammeri, and is known to be well developed only in Scandinavia. Possibly future work will demonstrate that this classification is not the most natural one, but it is a convenient one to use when discussing the faunas of southeastern Newfoundland and correlating them with their contemporaries in northwestern Europe and continental North America. At Manuels the bennetti, hicksi, and davidis faunas can each be divided into subfaunas; but, as the composition of some of these subfaunas may be due to very local facial conditions, it seems best to defer a discussion of them until more is known about the Paradoxides faunas of other Newfoundland localities.

The bennetti, hicksi, and davidis faunas are not sharply separated from each other in the Manuels Brook section, for their species frequently range from one fauna into the next. There seems to be no evidence of the sudden disappearance of a fauna except at the top of the davidis zone. There is good evidence of the more or less sudden arrival of new groups of species, such as the group characterized by Paradoxides davidis and Agnostus punctuosus, which appears abruptly in the bottom of the davidis zone; but, in all known instances, a number of the species previously established in the region continued to exist there for some time after the arrival of the new forms. As a result of these conditions no bedding planes forming natural frontiers between the different zones have been discovered, and the stratigraphical limits here set to the zones are therefore of necessity chosen more or less arbitrarily, and may prove on further investigation not to be the best ones.

Of the 25 genera and 79 species and varieties identified by the writer in the Paradoxides beds at Manuels, 13 genera and 54 species and varieties have been found in one zone only, 9 genera and 8 species and varieties have been found in both the bennetti and hicksi zones, 8 genera and 16 species and varieties have been found in both the hicksi and davidis zones, and 6 genera and 4 species have been found in all three zones.

No member of any of the Paradoxides faunas has been recognized in beds below the bennetti zone at Manuels; but in the upper part of that zone there has been found a tiny brachiopod which appears to be referable to Acrotreta gemmula Matthew, a species occurring in the pre-Paradoxides beds of New Brunswick and Cape Breton (Walcott, 1912, p. 686). Dr. Walcott (1900, p. 317) has stated that two species (Lingulella ferruginea and an Agnostus) range up from the Paradoxides beds into the Olenus beds at Manuels (see p. 63).

No comprehensive discussion of the probable habitats and facial pecularities of the Paradoxides faunas at Manuels will be attempted in the present paper, as it is believed that a full consideration of these subjects should be deferred until after further examinations have been made of the other exposures of Paradoxides beds in the Conception Bay region. A few observation on the distribution of the fossils in the different kinds of beds represented in the section can, however, properly be recorded at this time, and are therefore presented below.

Distbibution of Fossils According to Lithological Character of Beds

Fossils are rare in the hard olive gray and bluish gray shales of the lower 220 feet of the bennetti zone, are common in the nodular limestones and the upper 14 feet of gray shales of that zone, and are usually common, and often abundant, in the gray shales of the hicksi and davidis zones. It is in the thin-bedded soft black and gray shales of the hicksi and davidis zones, however, that they occur in the greatest profusion, some of these beds being literally full of agnostids and other trilobites. They are rare in the upper 5 feet of heavy-bedded black and dark gray shales of the davidis zone and in the thin phosphatic bed (bed 125) at the top of that zone. Trilobites are the most abundant types in most of the beds, but they are outnumbered by the brachiopod, Lingulella ferruginea, at a few horizons in the heavy-bedded dark gray shales of the upper part of the bennetti, and the lower part of the hicksi, zones (beds 35, 37, 38, and 39). The limestone nodules and beds appear to hold the same species as do the shale beds in, or between which, they lie. It is probable that the limestone nodules were formed in the muds after the muds had been laid down and before they had become consolidated into shales; for the fossils in the limestones retain their convexity, where those in the surrounding shales are flattened, and the shales are often slickensided where they have settled down around the resistant nodules. The two limestones of bed 19 were perhaps deposited originally as impure lime muds. They contain many fossils, whereas the shales which precede and succeed them are almost entirely barren. The fauna which they contain is, however, not greatly different in its general composition from the one which occurs in the shale beds, 23 and 26, higher up in the bennetti zone.

The general rarity of fossils and the scarcity of limestones in most of the gray shales of the lower 220 feet of the bennetti zone may both be due partly to the same cause, whatever that cause may be. The smaller fossils that are preserved in these shales frequently retain some or all of their convexity, but the larger ones, such as Paradoxides bennetti, are usually flattened and crumpled, as though the limy material that must have been originally present in their shells had been removed before the consolidation of the surrounding sediments. The question of chemical composition and method of preservation of the tests and shells of Cambrian organisms has been discussed in an interesting paper by Hicks (Hicks, 1875).

Considering the different types of fossils separately, we find that the larger trilobites, such as Paradoxides, Conocoryphe, Bailiella, Harttella, and Centropleura, are mainly confined to the harder, heavier-bedded, shales and the limestone beds and nodules. The trilobites of medium size, such as Solenopleura, Liostracus, Agraulos, and Holocephalina, are likewise found in the harder and heavier beds, but also occur commonly in the soft, thinly-bedded shales. The agnostids are most abundant in the soft black shales, from which most other trilobites are usually absent; but they are sometimes present in large numbers in the soft gray shales and the limestone nodules of the davidis zone. They are rare in the bennetti zone, where only 6 different forms have been discovered; they are common in the hicksi zone, 14 kinds having been found there, some of them in considerable numbers; and they are the most abundant and characteristic fossils of the davidis zone, which contains countless thousands of individuals, belonging to no less than 26 species and varieties.

The diversity of species of agnostids in the davidis zone may be more or less independent of the lithological character of the containing rocks, but the great abundance of individuals in some of the beds of that division, particularly in some of the black shales, surely must have some facial significance. Bed 48 and its fauna are especially interesting in this connection. This bed, which occurs below the middle of the hicksi zone, is a soft black shale of the sort commonly found filled with agnostids in the lower part of the davidis zone, but very rare in the lower half of the hicksi zone, where most of the beds are somewhat heavily bedded gray shales containing relatively few of these little trilobites. Bed 48 is, however, as full of agnostids as a typical davidis zone black shale. Most of the agnostids present in the bed are found at other horizons in the hicksi zone, but the most abundant form, Agnostus cf. gibbus hybrida Brögger, has not been found at any other horizon at Manuels, and its presence in bed 48 is probably directly due to the black mud facial conditions obtaining at the time that that bed was deposited.

Agnostids are conspicuously absent from the olive and dark gray shales and the nodular limestones of the uppermost part of the bennetti zone (beds 32 to 35), and the hard, heavy-bedded, dark gray shales of the lower part of the hicksi zone (beds 36 to 39). Trilobites are comparatively rare in beds 36 to 39, and the absence of agnostids from those horizons is therefore not surprising. It is more difficult to imagine why they should be absent from beds 32 to 35, which contain many other trilobites.

The relative abundance of agnostids in the soft black and gray shales does not appear to be due to a better preservation of their tests in those kinds of deposits, for the individual specimens are no more perfect than the ones that are enclosed in the harder, heavier-bedded, gray shales. There does seem, however, to be a greater proportion of complete individuals in the softer shales, particularly in the black shales. This may indicate that the softer shales were deposited in quieter waters than the harder ones, although the harder, heavier-bedded, shales usually appear to be just as fine-grained as the softer ones. Remains of the larger trilobites, such as Paradoxides and Centropleura, are comparatively rare in the softer, thinner-bedded, shales, but when they do occur they are usually fairly well preserved, so that their comparative scarcity in such beds would seem to be due, in some instances at least, to other causes than lack of conditions favorable to good preservation. For example, although specimens of Paradoxides are common in the soft black agnostid shales of beds 94, 95, and 96, they are usually absent from the soft black and gray shales of the lower part of the davidis zone, and have not been found at all in the black shale, bed 48, although occurring in large numbers in most of the other beds of that part of the section.

Of the brachiopods, Lingulella ferruginea and Acrothele matthewi are found most frequently in the hard, heavy-bedded, greenish gray shales of the bennetti zone and the equally hard and heavily bedded dark gray shales of the lower part of the hicksi zone, and Acrotreta misera is commonest in the soft black agnostid shales of the lower half of the davidis zone and in the similar shale of bed 48 of the hicksi zone.

Although there is this general relation between certain types of fossils and particular kinds of beds, yet beds of the same lithological character that are separated from each other by a bed, or beds, of a different sort seldom contain exactly the same faunas. For instance, three soft black shales in the lower half of the davidis zone may be, to all appearances, identical in lithological character, and may contain typical agnostid faunas, but each of the three faunas will differ slightly from the other two, and, when any species occurs in two of the beds, it is likely to be rare in one and abundant in the other.

Many species seem to have lived at Manuels only intermittently, for they appear in, and disappear from, the faunas there a number of times. In some cases the presence or absence of these forms seems to be due to the presence or absence of a particular type of sediment, but in other cases no such cause is apparent. For example, Corynexochus minor is found in beds 109 (a soft gray shale), 116 (a hard gray shale), and 119 (a black shale of medium hardness), but has not been discovered in any of the intervening gray and black shales. The individuals occurring in beds 116 and 119 may possibly differ slightly from those in bed 109 and may perhaps belong to a variety of the species, but, if any differences exist, they must be small. Similarly, Agnostus punctuosus appears to be absent from beds 100 to 105, although it occurs (often in great abundance) in the overlying and underlying strata. Agnostus granulatus, with a much longer time range, is even more irregular in its occurrence. It has been recognized only in beds 23, 28, 29, 43, 46, 51, 74, 80, 88, 90, 91, 93, 94, 95, 99, 100, 101, 102, 105, 106, 107, 108, 109, and 110, but these beds include examples of the hard olive shales of the bennetti zone, the hard gray and the soft gray and black shales of the hicksi zone, and the soft black and gray shales of the davidis zone. The species was a long-lived one, with a wide geographical range (it has been reported from Bohemia, England, and Newfoundland), yet it seldom occurs in large numbers in any one of the beds of the Manuels Brook section. Eodiscus punctatus also has a remarkable vertical distribution, being present in beds 40, 44, 51, 52, 54, 67, 69, 75, 81, 83, 84, 86, 99, 101, 102, 103, 105, 106, 107, 108, 109, 112, and 115, but seemingly absent from the intervening beds. It shows a preference for gray, rather than black, shales, but sometimes occurs in the latter, and is frequently absent from the former. It is probable, however, that future work will disclose the presence of these four species, as well as many others, in beds which have so far yielded no traces of them.

In contrast to these species of intermittent range are others which seem to have lived continuously at Manuels, and to have been much less susceptible to the effects of changing environments. Such species sometimes range through a succession of beds of different lithological character. Agraulos socialis, one of the most characteristic members of the hicksi fauna, is one of these persistent types; Paradoxides hicksi is another.

On the whole, it seems likely that, although certain of the members of the Paradoxides faunas were largely influenced by the changes that took place in the local environmental conditions at Manuels, others were very little affected by them; and the invasion of the district by new forms from some unknown outside region was probably the most important factor in bringing about the faunal changes that took place from time to time. Only a few of the species and varieties present in the hicksi and davidis faunas seem to have evolved from forms previously existing in the district; the majority appear to have been invaders from without. This matter is discussed further on pages 101-3.

IMPORTANCE OF AGNOSTIDS IN THE PARADOXIDES FAUNAS

Although the various species of Paradoxides are the most characteristic members of the Paradoxides faunas of the world, they are far surpassed in numbers and variety by the agnostids. Paradoxides supplies the best index fossils for the Paradoxides beds in general, and for the main faunal subdivisions in particular, because it is found all through the Paradoxides beds, is confined entirely to them, and is represented by different and widespread forms at different horizons. The agnostids are, however, usually the most useful group for distinguishing and identifying the smaller faunal divisions because of their great number and variety, their apparent ability to spread rapidly over large areas, and the ease with which their small shields are preserved entire, so that they can be specifically identified. Moreover, although they are most abundant in the Paradoxides beds (particularly in the hicksi, davidis, and forchhammeri zones), they are also found commonly in other Cambrian strata; and will probably prove ultimately to be one of the greatest aids in correlating not only the Paradoxides faunas, but also some of the later faunas of different parts of the world.

One of the most striking differences between the Paradoxides faunas and those which underlie them is that, while the Paradoxides faunas contain agnostids, the others do not. Obviously the ancestors of the Paradoxidian agnostids must have lived in pre-Paradoxidian times, and their absence from the known pre-Paradoxides beds in all the regions where Paradoxides is known to occur indicates that the waters in which those older beds were deposited were either cut off by some barrier from the seas which contained agnostids at those times, or (what is less likely—for the later pre-Paradoxides beds, at least) that agnostids had not yet been evolved when those beds were laid down. Agnostids occur in Siberia, however, in faunas which may be of Catadoxidian (pre-Paradoxidian) age. (See vonToll, 1899.)

Agnostids occur in the beds which overlie the Paradoxides beds, but most of them are very different from those in the Paradoxides beds, and there are not nearly so many different species as there are in the Paradoxides faunas.

VI. DESCRIPTION OF NEW SPECIES FROM THE PARADOXIDES BEDS AT MANUELS

The following nine forms, believed to be new, have been discovered in the Paradoxides beds at Manuels in the course of the present investigation:

Agnostus claræ.
Agnostus barlowi definitus.
Agnostus parvifrons punctifer.
Agnostus vaningeni.
Agnostus longifrons parvulus.
Agnostus rectangularis.
Conocoryphe bullata.
Paradoxides parvoculus.
Liostracus globiceps jaculator.

These forms are described below and figured on Plate 3.

In describing the agnostids the writer employs the terminology of parts that has been in common use since Barrande's day. Professor Raymond has called attention to the fact that paleontologists have perhaps been confusing the pygidia and cranidia of the agnostids, calling the pygidium the cranidium and vice versa (Raymond, 1917; 1920). The writer believes that this is possibly true, and that the question of which end of an Agnostus is which is still an open one. He feels, however, that such evidence as we have at present is more in favor of the long-accepted view than of Professor Raymond's newly-suggested one.

Agnostus claræ, new species Pl. 3, Fig. 1

Only the pygidium is known.

Pygidium, subquadrate, with a thin, tapering, sharply pointed, cusp or spine at each of the two posterior angles. Lateral lobes, wide, tapering and depressed behind the axis, but confluent, separating the rear end of the axis from the marginal furrow. Axis cylindrical, 7/10 as long and 1/3 as wide as the whole pygidium, nearly parallel-sided, but with a very slight constriction and faint indications of a transverse furrow at a point about 1/3 of the way back from its forward end, evenly rounded posteriorly. Margin of moderate width all around. The marginal furrow and the furrow surrounding the axis are of moderate width and depth. In the single specimen known, which is slightly flattened, the axis is very convex, with some indications of a tubercle or keel on the anterior half. The side lobes are only slightly convex. The pygidium, as a whole, seems to have been a little higher at the front than at the rear. The ends of the spines at the posterior angles are broken off, but there is no evidence to indicate that they were unusually long. The surface of the test is smooth.

Length, 5mm. Breadth, 5 mm. at the rear, 6 mm. at the front. The greater breadth in front may be due to expansion on flattening, if the front was more convex than the rear.

Horizon, bed 23, in the upper part of the Paradoxides bennetti zone. Very rare.

The specific name is given in honor of Mrs. Howell.

This species is based on a single pygidium, which is specimen 8000 in the paleontological collection of Princeton University. The most striking features of this pygidium are its quadrate form and its short, blunt, very convex axis. Of the agnostids that have been described from the Paradoxides beds of Europe and North America, Agnostus fallax vir Matthew (1886, p. 69; 1896, p. 215), of New Brunswick, and A. fallax ferox Tullberg (1880, p. 32), of Scandinavia, appear to approach it more closely. The tails of vir and ferox differ from that of claræ in having more tapering and slightly longer axes, and in being less quadrate in shape. The cranidium of claræ is unknown, but will probably prove to be more or less like that of fallax vir. Cranidia of that general type have been found in bed 23, but some or all of them probably belong to a form like Agnostus fallax trilobatus Matthew (1886, p. 68), pygidia of which occur commonly in that bed. Two cranidia (Nos. 8003 and 8025) of a similar form, but with the glabella only very faintly defined, also found in bed 23, may belong to claræ. It seems more probable, however, that they belong to another form, Agnostus barlowi definitus, and they are therefore described and discussed in the account of that species, which follows the present description. Until the cranidium of claræ is discovered, it will be impossible to assign the species definitely to any one of the numerous subdivisions into which different authors have proposed to split up the old genus, Agnostus. If it proves to have a fallax-like head, it will belong to Tullberg's subdivision, "Fallaces," of his group, "Limbati" (Tullberg, 1880, p. 11), and to Corda's genus, Peronopsis (Hawle and Corda, 1847, p. 115; Raymond, 1913, p. 2; Zittel-Eastman, 1913, p. 710).

Agnostus barlowi definitus, new variety Pl. 3, Figs. 2, 3

Only the pygidium is definitely known.

Pygidium semi-elliptical, about 1/8 longer than wide, with a broad, shallow, mariginal furrow and a somewhat convex margin. The margin is of medium width in front, but becomes very wide behind, where it bears two short, broad, sharply pointed cusps or spines. Lateral lobes of medium width, confluent behind the axis, where they are almost as broad as at the sides. Axis broad and very bluntly pointed; slightly constricted in its forward third, where it bears an elongated tubercle; widening rapidly toward the front where it reaches its greatest breadth. It is about 3/7 as wide and 5/7 as long as the whole pygidium, and is completely surrounded by a narrow, shallow furrow, which is often very weakly impressed around the rear half of the axis. The whole pygidium is of medium convexity, highest in the front half and sloping gradually toward the sides and rear.

Length, 3½ to 4½ mm. Breadth, 3¼ to 4¼ mm.

Horizons, beds 23, 26 and 28, in the upper part of the Paradoxides bennetti zone. Rare.

The holotype is specimen No. 8001 in the paleontological collections of Princeton University. It is from bed 23.

The varietal name refers to the fact that the axis is completely defined by a furrow.

This pygidium is very similar to that of Agnostus barlowi spinatus Illing (1916, p. 413). It differs from that form in having the axis completely defined by a furrow, instead of merely indicated by two short grooves near the front of the pygidium, in having the marginal border broader at the rear; and in having the cusps or spines farther back. Barlowi spinatus has been found only in the hicksi zone of England, while barlowi definitus is known to occur only in the upper part of the bennetti zone of Newfoundland. Only a few specimens of either form have been discovered, and it is possible that a large series of specimens from either England or Newfoundland would show that the two varieties are one. However, as they occur at different horizons so that their varietal pecularities may have some phylogenetic significance, it has seemed best to describe the Newfoundland form under a separate name.

The author has followed Illing's example in calling definitus a variety of barlowi. Whether spinatus and definitus are really varieties of Agnostus barlowi Belt (1868, p. 11) must remain an open question until the crinidium of either spinatus or definitus is discovered. There are two cranidia from bed 23 in the Princeton collections which may possibly belong to definitus (Nos. 8003 and 8025 in the paleontological collections of Princeton University; see plate 3, figure 3). They agree with Lake's (1906, p. 17) description of the head of barlowi except that they have a marginal fold of medium width, instead of the very narrow one of that form, and that a two-lobed glabella is faintly outlined, instead of having only the rear end of it suggested by short furrows, as in Belt's species. Lake's figure of barlowi seems to show a faintly outlined glabella, with no sign of a cross-furrow separating it into two lobes. It is barely possible that these two Newfoundland heads belong to Agnostus claræ (see description above), the head of which is unknown and may very well be of this type. They are referred to barlowi definitus mainly because definitus seems, from the number of pygidia found, to have been more common than claræ in the beds in which the heads were found. If the heads do belong to barlowi definitus, we would appear to have in the phylogeny of the barlowi line a progressive loss of furrows from both cranidium and pygidium, as well as a loss of spines from the pygidium—indicating, perhaps, a progressive loss of vitality in the race, resulting ultimately in extinction. Belt stated that the type specimens of barlowi came from the Tremadoc. Lake supposed that since Agnostus cicer Tullberg (1880, p. 26), which appears to be identical with barlowi, was recorded by Tullberg from the

Conocoryphe æqualis zone and Agnostus intermedius zone (both of which zones are well up in the hicksi zone), Belt must have been mistaken when he recorded barlowi from the Tremadoc. The finding of "cicer" in the Paradoxides davidis beds by Grönwall (1902, p. 167), of spinatus in the lower hicksi beds by Illing, and of definitus in the upper bennetti beds, as here recorded, indicates that the race may have ben a long-lived one and may really have ranged up into the Tremadoc, after all.

Grönwall (1902, pp. 59, 60, 210) has described a variety of barlowi from the davidis zone of Bornholm Island, Denmark, which he has named "cicer forfex," the tail of which differs from cicer, as that of a definitus differs from that of a spinatus, in having the axes completely outlined. Forfex's tail differs from that of definitus in having a more bluntly pointed axis, no spines, and a narrower marginal fold. Barlowi, barlowi spinatus, and barlowi definitus have unusually wide marginal folds, however. Belt notes how the wide fold of barlowi makes the species resemble Agnostus nudus (Beyrich), (Beyrich, 1845, p. 46; Barrande, 1852, p. 903), and this resemblance is even more striking in definitus, with its still wider border, widest at the rear.

Agnostus parvifrons punctifer, new variety Pl. 3, Figs. 4, 5

Only the pygidium is definitely known.

Pygidium semi-elliptical, about as wide as long, with a slightly convex margin, which is of medium width in front but becomes very broad at the rear, reaching its greatest breadth back of the rear end of the axis. Lateral lobes of medium width, tapering at the rear, not confluent. Axis of medium width, very slightly constricted near its anterior end, tapering backward to a fine point which separates the lateral lobes from each other and reaches the marginal furrow; very convex, reaching its greatest height in the middle, where it is prolonged upward and backward into a sharp-pointed, somewhat elongated, peak or super-tubercle, which slopes toward the front of the pygidium at an angle of about 45°, slopes somewhat more steeply toward the sides, and has a very steep, concave slope toward the rear, the concavity being due to the fact that the peak bends backward so that it slightly overhangs the posterior slope. The lateral lobes and marginal fold are only very slightly convex, and the axis rises very prominently above them. The lateral lobes are separated from the axis and the marginal fold by furrows which are very wide and fairly deep in the type specimen, which is exfoliated, but which are probably very much less prominent—perhaps even indistinct—in unexfoliated specimens.

Length, 3 mm. Width, 3 mm. Height of the peak of the axis above the lateral lobes, 1 mm.

Horizon, bed 101, in the lower part of the davidis zone. Rare.

The holotype is specimen 8004 in the paleontological collections of Princeton University. The natural mold is specimen 8005.

The varietal name refers to the elongated tubercle borne on the axis.

The pygidium of this remarkable little agnostid is very similar to that of "Agnostus parvifrons mammillata" Brögger (1878, p. 56), appearing to differ from that form only in having the peculiar elevation of the middle of the axis more pronounced and slightly bent backward instead of being symmetrical. An immature pygidium 1½ x 1½ mm. in size (specimen 8006 in the paleontological collections of Princeton University) found in the same bed as the type of parvifrons punctifer and probably belonging to that form, appears to differ in no essential respect from immature pygidia of "parvifrons mammillata" from Scandinavia contained in the Princeton collections (specimens 8009 and 8010).

The thorax and cranidium of parvifrons punctifer are not definitely known. The cranidium is probably like that of "parvifrons mammillata." An immature cranidium about

$1\frac{1}{4} \times 1\frac{1}{4}$ mm. in size (8008 in the Princeton collections), from the same bed as the holotype pygidium of punctifer, appears to differ in no way from an immature cranidium of "mammillata" on specimen 8010. It is similar to the adult head of "mammillata" figured by Brögger (1878, pl. V, fig. 3a), being semi-elliptical, rather convex, and surrounded by a margin of medium width, which is separated from the rest of the cranidium by a furrow that is of medium width and depth in this particular specimen, which is exfoliated, but would probably be much less distinct on an unexfoliated specimen. The glabella is very convex, slightly longer than wide, and is surrounded by a furrow of medium depth and width, which would probably be shallower on an unexfoliated specimen. The basal lobes are of medium size, and are confluent behind the glabella.

It is possible that the single pygidium upon which this new variety is based is a deformed or aberrant example of "parvifrons mammillata," as pygidia nearer to the normal "mammillata" type occur only a few feet higher in the section (in bed 74).

Agnostus parvifrons and its varieties appear to have been an extremely variable group, however, and it is quite possible that punctifer is a valid variety. Whether punctifer and mammillata should really be classed as varieties of Agnostus parvifrons Linnarsson (1869, p. 82) is perhaps an open question. It seems best to follow Brögger for the present, however, and consider them as such. If future research proves that the two are not varieties of parvifrons, then punctifer will become a variety of mammillata. Jækel (1909) has proposed the genus, Hypagnostus, for Agnostus parvifrons and its allies; and if that genus is accepted as defined by Jækel, punctifer will belong to it.

Agnostus vaningeni, new species Pl. 3, Fig. 6

Pygidium semi-elliptical, moderately and fairly evenly convex, surrounded by a margin of medium width and convexity, which is separated from the rest of the tail by a shallow furrow of medium width. Axis large, 1½ times as wide as the lateral lobes; long; evenly tapering, except at a point just back of the front end, where it is very slightly constricted; ending in a blunt point a short distance in front of the marginal furrow; separated from the lateral lobes by a narrow, shallow furrow; bearing a somewhat elongated tubercle about one-third of the way back from its forward end. Lateral lobes of medium width in front, tapering regularly to rather blunt points at the rear, where they are separated by a narrow, shallow furrow, which connects the furrow surrounding the axis with the marginal furrow. The whole pygidium is evenly and very moderately convex.

Length of the holotype pygidium, 3½ mm.; breadth, 3½ mm. Other specimens identified as belonging to this species (specimens 8013 and 8030) are 1 mm. or more larger. The axis of the holotype is 3 mm. long, and 1¾ mm. wide.

Horizon of the holotype, bed 99. Other specimens possibly belonging to this species(specimens 8031 and 8032) were found in beds 100 and 102. All of these beds are in the lower part of the davidis zone. Rare.

The holotype is specimen 8011 in the paleontological collections of Princeton University. The natural mold of the holotype is specimen 8012.

The specific name is given in honor of Professor Gilbert vanIngen.

The pygidium of this species resembles those of Agnostus lævigatus terranovicus Matthew (1896, p. 233), Agnostus parvifrons tessella Matthew (1886a, p. 71), and Agnostus rotundus Grönwall (1902, p. 78). From lævigatus terranovicus it is distinguished by its longer axis and the separation of its lateral lobes at the rear. It differs from rotundus in having a longer and wider axis, and tapering side lobes, completely separated at the rear. It is not greatly different from parvifrons tessella in general shape, but has a slightly wider and longer axis, the marginal furrow and the furrow surrounding the axis are less distinct, and there are no distinct furrows crossing the axis, such as there are in that form.

Although the crandium of Agnostus vaningeni is unknown, it is probably more similar to that of lævigatus terranovicus and rotundus than to that of parvifrons tessella, as certain cranidia of the terranovicus-rotundus type occur in association with the vaningeni pygidia. Possibly vaningeni represents an intermediate stage of evolution between parvifrons tessella and lævigatus terranovicus. It is interesting to note, in this connection, that the unexfoliated pygidia of vaningeni look very much like those of lævigatus terranovicus, while exfoliated tails much resemble those of parvifrons tessella. Vaningeni is probably nearest to terranovicus, as its crandium is almost certainly of the terranovicus type. It may prove, however, to be even nearer to the British form which Lake (1906, p. 14) has referred to rotundus, but which, to judge from his figures and description, is perhaps nearer to lævigatus terranovicus than to rotundus. Perhaps parvifrons tessella, vaningeni, lævigatus terranovicus, and lævigatus Dalman (1828, p. 136) represent a single line of development, to a branch of which rotundus and the closely related Newfoundland form, lævigatus mamilla Matthew (Matthew, 1896, p. 234) may belong. Agnostus lens Grönwall (1902, p. 65) appears also to be very similar to lævigatus terranovicus, and, as lens is found at a horizon in Scandinavia that appears to be lower than the one at which vaningeni occurs in Newfoundland, it is possible that terranovicus is descended from lens, and not from vaningeni. Vaningeni, like lævigatus terranovicus, lævigatus mamilla, lens, rotundus, and the somewhat similar Paradoxidian form, Agnostus lævigatus ciceroides Matthew (1896, p. 234), and the very similar or identical form, Agnostus altus Grönwall (1902, p. 58), together with Agnostus lævigatus forfex Brögger (1878, p. 58), Agnostus barrandei Salter (Hicks, 1872, p. 176), Agnostus lens frontosa Grönwall (1902, p. 66), Agnostus barlowi Belt (1868,

p. 11), Agnostus barlowi forfex Grönwall (1902, p. 59), Agnostus barlowi spinatus Illing (1916, p. 413), and Ag.barlowi definitus (described above, see p. 76), does not appear to fit into any of the genera of Jækel's or Professor Raymond's classifications. Some of them, such as lævigatus terranovicus and lævigatus forfex, are probably so closely allied to lævigatus, the type of Corda's genus, Lejopyge (Hawle and Corda, 1847, p. 51), that they should be classed in that genus, but the others should probably be assigned to one or more new genera. If vaningeni is really derived from parvifrons tessella, it is probable that teseslla belongs to a different group from parvifrons Linnarsson (1869, p. 82), and should not be called a variety of that species.

Agnostus longifrons parvulus, new species Pl. 3, Figs. 7, 8

Only the cranidium is definitely known.

Cranidium small, semi-elliptical, evenly and moderately convex, surrounded by a narrow, convex margin, which is separated from the rest of the cranidium by a narrow marginal furrow of medium depth. Glabella bilobed, parallel-sided, the front lobes separated by a straight furrow of medium width and depth. The glabella is surrounded by a deep, narrow furrow, which is continued forward in front of the front lobe, so that it joins with the marginal furrow and separates the two cheeks. The front lobe of the glabella is roughly triangular in shape, the two sides of the triangle being convex and the apex an obtuse angle. It is of moderate convexity, approximately the same as the cheeks. The rear lobe is about twice as long as wide; the front third is moderately convex, like the front lobe, but the posterior two-thirds is evenly and highly convex, and is crowned with a tubercle. The basal lobes are small and triangular. The cheeks are somewhat wider than the glabella, are moderately convex, of approximately equal width throughout, and are separated by a furrow in front of the glabella.

Length of the holotype cranidium, 2 mm.; breadth, 1¾ mm. This is an average sized adult cranidium.

Horizon, bed 109, the middle part of the davidis zone. Rare.

The holotype is specimen 8014 in the paleontological collections of Princeton University.

The varietal name refers to the small size of the variety.

The holotype of this variety is a cranidium. No well preserved and certainly identifiable complete individual has been discovered to prove beyond question just what the pygidium is like; but a poorly preserved specimen showing both cranidium and pygidium (specimen 8015 in the Princeton collections), which is almost certainly of this variety, and numerous little pygidia found associated with longifrons parvulus cranidia, enable us to be reasonably certain about the matter. The description of the pygidium given below is based upon an impression on a piece of shale (Princeton specimen 8016) broken from the piece holding the holotype cranidium, and upon pygidia found on Princeton specimens 8017, 8018, 8033, and 8037. Specimen 8033 and its counterpart 8037 hold a cranidium that is believed to belong to this species.

Pygidium small, semi-elliptical, surrounded by a margin of medium convexity and width, and by a shallow, narrow, marginal furrow. Axis convex, narrow, slightly constricted in its anterior third, tapering to a rounded point at the rear. It is divided into three segments. The anterior lobe is short. The middle segment is about the same length as the anterior one, but is expanded in the middle so that it juts forward and backward until it is nearly twice as long there as it is at the sides. It bears a prominent median tubercle or keel. The posterior segment is about twice as long as the two anterior segments combined, but does not reach the marginal furrow behind. The lateral lobes are convex, but not so much so as the axis; they are wider than the axis, and are somewhat narrowed behind, where they are separated by a narrow, shallow, furrow, which joins the marginal furrow to the narrow, but rather deep, furrow that surrounds the axis. The pygidia have about the same general dimensions as the cranidia.

This form is very closely related to Agnostus longifrons Nicholas (1916, p. 453). It differs from longifrons in being smaller, in having the anterior lobe of the glabella shorter, and in having the posterior lobe of the glabella longer, with the greatest convexity 1/3 of the length of the lobe forward from the posterior margin, instead of just in front of it. The pygidia of the two forms appear to be identical, except for size, and the thorax of longifrons parvulus will probably prove, when it is discovered, to be like that of longifrons.

Agnostus longifrons, which is a Welsh species, apparently occurs in the hicksi zone, while longifrons parvulus is found well up in the davidis zone. Mr. Nicholas has pointed out, in his description of longifrons (1916, p. 454), how this type of agnostid resembles Agnostus gibbus Linnarsson (1869, p. 81).

Agnostus longifrons parvulus is one of the smallest of all known agnostids, and therefore one of the smallest of known trilobites. It is perhaps the smallest trilobite yet discovered. It is almost surely descended from the Agnostus longifrons line. It belongs in the genus Agnostus, sens. strict., of Jækel's and Raymond's classifications.

Agnostus rectangularis, new species Pl. 3, Fig. 9

Only the cranidium is known.

Cranidium roughly rectangular, slightly longer than broad, with rounded corners. Margin broad and nearly flat. Marginal furrow broad and shallow. Cheeks of medium width, approximately equal in width throughout, confluent in front of the glabella. Glabella of medium length and width, about as wide as the cheeks, and two-thirds as long as the cranidium, not bilobed. It narrows slightly toward the front, where it is evenly rounded, and it is separated from the cheeks by a shallow furow. The basal lobes are large, triangular in shape, and rather indistinctly marked off from the rest of the glabella. There is a very indistinct tubercle on the glabella about 1/3 of the way forward from the rear margin. The whole cranidium is rather flat. It is highest at the rear.

Length of the holotype, $3\frac{1}{2}$ mm., breadth, $3\frac{1}{4}$ mm. The only other specimen known is 4 mm. long and $3\frac{1}{2}$ mm. broad.

Horizon, somewhere in the upper half of the davidis zone. Exact horizon unknown, but probably bed 115 or a nearby bed.

The holotype is specimen 8019 in the paleontological collections of Princeton University. The natural mould of the holotype is specimen 8039. The other specimen is numbered 8020.

The specific name refers to the rectangular appearance of the cranidium.

At first glance, the cranidium of this species reminds one of that of Agnostus fallax Linnarsson (1869, p. 81), because of its quadrate form and wide margin. Fallax, however, has a bilobed glabella. The cranidium of Agnostus obtusus Belt (Belt, 1868, p. 10; Lake, 1906. p. 28) is similar to that of rectangularis in general shape, but it has, like fallax, a bilobed glabella. Agnostus tardus Barrande (1852, p. 913), and the closely related forms, A. glabratus Angelin (1878, p. 6) and A. lentiformis Angelin (1878, p. 7), have cranidia somewhat similar to that of rectangularis, as do A. sidenbladhi Linnarsson (1869, p. 82), A. callavei Raw MS., (Lake, 1906, p. 25), and A. sallesi Munier-Chalmas and Bergeron (Bergeron, 1889, p. 337). Tardus, glabratus, lentiformis, sidenbladhi and callavei are of much younger age than rectangularis, but sallesi is from the Paradoxides beds of southern France. The figure and description of sallesi given by Munier-Chalmas and Bergeron are not clear and detailed enough to show just how similar their species is to rectangularis, but they are sufficient to suggest that it is very close, so that the Newfoundland form may yet prove to be a variety of the French one, or even identical with it. Rectangularis is probably referable to the genus Arthrorachis Corda of Raymond's classification.

The cranidium of rectangularis exhibited on specimen 8020 shows faint traces of two peculiar diagonal furrows on the front of the glabella in just the same position as those described and figured by Raw and Lake on the glabella of callavei (Lake, 1906, p. 26, pl. II, fig. 20). Lake states that these furrows may be adventitious cracks in callavei, and the same may be the case with the one cranidium of rectangularis. The holotype cranidium of rectangularis does not show any clear evidence of such furrows, although there appear to be slight indentations present, which may be traces of similar grooves. These furrows, if they really are such, the general character of the cranidium, and the presence in beds of the same, or nearly the same, horizon of pygidia somewhat resembling the pygidium of Agnostus quadratus Tullberg (1880, p. 34), suggest the possibility that rectangularis may prove to be related to quadratus, rather than to the other species mentioned above. To judge from Tullberg's figure, quadratus has a more pointed glabella than rectangularis, and shows more definite indications of furrows. The quadratus-like pygidia from Manuels also differ from the pygidium of quadratus in having much shorter axes. Quadratus occurs in the Paradoxides forchhammeri beds of Sweden, above the Paradoxides davidis beds, and perhaps rectangularis is an ancestor of quadratus.

The exact horizon of the quadratus-like pygidia found in loose limestone nodules at Manuels is not known, but it is somewhere in the davidis zone, and, to judge from the fossil evidence, from the same, or about the same, horizon as the rectangularis cranidia. A typical example of this sort of pygidium is shown on Princeton specimen 8038.

Conocoryphe bullata, new species — Pl. 3, Figs. 10, 11

Only the cranidium is known.

Cranidium roughly semicircular, twice as wide as long, with broad, upturned anterior and posterior margins and broad deep anterior and posterior marginal folds, and a nearly straight facial suture. Glabella conical; about 3/5 as long as the whole cephalon, with probably three furrows (the only known specimens are imperfect and show only the forward part of the glabella). The glabella is surrounded by a furrow of medium depth and width. The cheeks are confluent in front of the glabella, where they are slightly convex. The main part of each fixed cheek is remarkably convex, reaching its greatest height opposite the middle of the glabella. The whole surface of the cephalon is covered with small tubercles, about 4 in each square millimeter. A small keel-shaped prominence on the outer front edge of the swollen portion of the cheek may be the rudiment of an ocular ridge.

Length of the holotype cranidium 1 cm., breadth, 2 cm. Height of elevated portion of fixed cheek above bottom of posterior marginal furrow just back of highest part of the fixed cheek, about 5 mm.

Horizon, bed 19, in the middle of the Paradoxides bennetti zone. Rare.

The holotype is specimen 8021 in the paleontological collections of Princeton University. The natural mould of the holotype is specimen 8040. A smaller head, believed to be referrable to this species (fig. 11), is numbered 8026.

The specific name refers to the bubble-like elevation of the fixed cheeks.

This Conocoryphe resembles Conocoryphe dalmani Angelin (1878, p. 63) in its general shape, but differs markedly from that species in its greatly elevated fixed cheek. This elevation of the fixed cheek is characteristic of Ctenocephalus, rather than Conocoryphe, as exemplified in Ctenocephalus tumida Grönwall (1902, p. 99), and its presence in this very early Conocoryphe may perhaps indicate a convergence of the Conocoryphe and Ctenocephalus stems.

Paradoxides parvoculus, new species Pl. 3, Figs. 12, 13

Only the cranidium is known.

Cranidium of the ordinary Paradoxidian form. Glabella large, evenly rounded in front, and narrowed at the rear so that it is only ¾ as wide at the neck ring as it is at the widest part in front. The widest part of the glabella is 1/3 of the way back from the front. At this widest point the glabella is a little more than half as wide as the cephalon is long. There are four glabellar furrows in addition to the neck furow. The neck furrow is transverse and rather lightly impressed across the axis of the glabella, but is curved forward at an angle of 45 degrees and is deeply impressed at the sides. The second glabellar furrow is nearly transverse at the sides, but curves backward to form a shallow, backward-pointing arc over the axis. The third furrow is not continuous across the glabella, but is represented by two short furrows, extending in from each side about half the way to the median axis of the glabella, and about at right angles to that axis. The anterior, or fourth pair of glabellar furrows, which are situated opposite the anterior ends of the palpebral lobes and at the widest part of the glabella, are slightly shorter than the third pair and are deflected slightly forward from the outside toward the inside of the glabella. The neck ring of medium width, with a small tubercle. Fixed cheeks subtriangular, about 1/6 longer than wide. Brim flat or perhaps with a slightly elevated rim on its front edge. The brim is narrow in front of the glabella, but widens toward each side. In the holotype, which is 22 mm. long, the brim is 1 mm. wide in front of the median axis of the glabella, and 4 mm. wide at the sides. The glabella is separated from the brim and from the fixed cheeks by a continuous furrow of medium width and depth. The posterior marginal furrow, running transversely across the rear ends of the fixed cheeks, is also of medium width and depth. The eyes are very short and narrow. They are curved, and extend obliquely backward from a point close to the glabella at the glabella's widest part. They are only about half as long as the free cheeks, reaching back only to a point opposite the middle of the second glabellar furrow. They are very narrow, being slightly less than 1 mm. wide on the holotype cranidium, which is 22 mm. long. The anterior branch of the facial suture is at an angle of about 45° with the median axis of the cranidium; the posterior branch is straight, and is directed at an angle of about 25° from the median axis of the cephalon. The surface of the fixed cheeks is covered with many anastomosing raised lines, which form a fine and somewhat irregular wrinkled network. The rest of the cranidium appears to be smooth or ornamented only with very fine concentric or parallel lines, and perhaps very fine tubercles.

Length of the holotype head, 22 mm.; width at rear, 16 mm.; length of eye lobe, 5 mm.; width of eye lobe, 1½ mm.; length of posterior branch of facial suture (behind the palpebral lobe), 6 mm.

Horizon, beds 23 and 26, in the upper part of the bennetti zone. Rare.

The holotype is specimen 8027 in the paleontological collections of Princeton University. It is from bed 23 A smaller head, whose exact horizon is unknown but which was found either in bed 23 or an adjacent bed, is number 8022. Both it and the holotype are figured. Another small head from bed 23, which seems to be referrable to this species, is numbered 8028 (natural mould, 8041).

The specific name refers to the size of the eye lobes, which are unusually small for a Paradoxides.

Parvoculus has perhaps the smallest eye lobe of any known species of Paradoxides. It appears to be most closely related to Paradoxides hicksi, and may prove to be an ancestral variety of that species; but it seems best not to call it such until more is known of the ontogeny and phylogeny of hicksi. Hicksi appears to be a variable species, but some of the British forms assigned to it should perhaps be considered as varieties of the typical form. Parvoculus differs from hicksi as described by Salter (1869, p. 55) in having narrower eye lobes, a shorter glabella that is more evenly rounded at the front, with the two rear glabella furrows extending all the way across the glabella in adult species, and a flat or nearly flat brim. It closely resembles one of the heads figured by Illing (1916, pl. XXXVI, fig. 3) as P. hicksi, differing only in the fact that, while the second glabellar furrow of Illing's specimen arches forward, that of parvoculus bends backward. Illing's specimen came from a much higher horizon than parvoculus, however (the upper part of the hicksi zone). In the general shape of the glabella and the thinness of the eye lobe, parvoculus resembles young specimens of hicksi occurring in the hicksi zone at Manuels, and it seems probable, therefore, that it is the ancestor of hicksi, and that hicksi may have evolved in America. The flat or nearly flat brim of parvoculus is also characteristic of early types of Paradoxides, as pointed out by Professor Raymond (1914, p. 235).

Liostracus globiceps jaculator, new variety Pl. 3, Fig. 14

Only the cranidium is known.

Cranidium moderately convex (in specimens preserved in shale), the glabella only a little more convex than the rest of the cephalon. The front of the cephalon is an arc of very slight curvature, and the facial suture runs so nearly straight back from this front edge to the palpebral lobe that the front half of the cranidium has a rectangular appearance. Back of the palpebral lobe the facial suture runs diagonally backward and meets the posterior marginal furrow at an angle of about 45°. The brim is flat and broad, and is separated from the rest of the cephalon by a broad, shallow furrow. The fixed cheeks, which are moderately convex, join broadly in front of the glabella, the distance between the front of the glabella and the anterior marginal furrow being slightly more than half the distance between the side of the glabella and the palpebral lobe. The fixed cheek is almost twice as wide at its posterior end as it is opposite the palpebral lobe, so that the cephalon is only 2/3 as wide at the front as it is at the rear. The posterior marginal furrows are wide and shallow, as is the furrow that separates the glabella from the fixed cheeks. A facial ridge runs from near the front of the glabella outward and slightly backward, in a gentle curve, to the anterior end of the palpebral lobe The neck ring is of medium size, and is prolonged backward into a spine, which is so long that the spine and neck ring combined are almost as long as the glabella. The glabella tapers slightly toward the front, where it is evenly rounded. It has four pairs of short, shallow, indistinct furrows which run obliquely backward at an angle of about 20°, from the outer edge of the glabella ½ to 2/3 of the distance toward the middle line of the glabella. The anterior pair of furrows are the shortest, the posterior the longest, the other two being intermediate in length. The anterior furrow starts from a point opposite the inner end of the facial ridge. The surface of the cranidium is covered with closely set tiny pits, not visible to the naked eye, and there are faint indications of parallel lines running across the part of the free cheeks in front of the facial ridge in a direction perpendicular to the facial ridge, such as are frequently found in other species of Liostracus and allied genera.

Length of largest cranidium referred to this form, 10 mm.; width at front of cephalon, 10 mm.; width at rear of cranidium, 15 mm.; length of glabella, 6 mm.; width of glabella at rear, 6 mm.

Horizon, beds 86 and 91, in the upper part of the hicksi zone. Rare.

The holotype is specimen 8023 in the paleontological collections of Princeton University. It is a small cranidium, being only 7 mm. in length, including the spine. It is chosen as the holotype because it is the only specimen now in hand in which the spine is well shown. It is from bed 86. Other specimens referred to this form are numbered 8034, 8035, and 8036. The measurements given above for the "largest cranidium" were taken from specimen 8035.

The specific name refers to the spine, which distinguishes the variety from Liostracus globiceps.

This form appears to be certainly a variety of Liostracus globiceps Grönwall (1902, pp. 145, 146, 218, pl. IV, figs. 12a, 12b). It seems to differ from that form only in the possession of a large neck spine. Grönwall describes and figures only a little spine on the neck ring of globiceps. Grönwall's cephala seem to have been more convex than the specimens from Manuels, but, as the Manuels specimens are in shale, and probably somewhat flattened, it is not likely that the two forms differed in convexity in life. Grönwall records globiceps from Bornholm Island, Denmark, probably from the davidis zone.

EXPLANATION OF PLATE 3

NEW TRILOBITES FROM THE CAMBRIAN PARADOXIDES BEDS AT MANUELS, NEWFOUNDLAND

PAGE

FIG. 1. *Agnostus claræ,* n. sp. Holotype pygidium. 4/1. Bed 23, in the upper part of the Paradoxides bennetti zone. Princeton catalog number 8000 74

FIG. 2. *Agnostus barlowi* Belt, var. *definitus,* n. var. Holotype pygidium. 4/1. Bed 23, in the upper part of the Paradoxides bennetti zone. Princeton catalog number 8001 76

FIG. 3. *Agnostus barlowi* Belt, var. *definitus,* n. var. Cranidium referred to this form. 4/1. Bed 23, in the upper part of the Paradoxides bennetti zone. Princeton catalog number 8003 76

FIG. 4. *Agnostus parvifrons* Linnarsson, var. *punctifer,* n. var. Holotype pygidium, top view. 4/1. Bed 101, in the lower part of the Paradoxides davidis zone. Princeton catalog number 8004 78

FIG. 5. *Agnostus parvifrons* Linnarsson, var. *punctifer,* n. var. Side view of the pygidium whose top view is shown in Fig. 4. 4/1 78

FIG. 6. *Agnostus vaningeni,* n. sp. Holotype pygidium. 4/1. Bed 99, in the lower part of the Paradoxides davidis zone. Princeton catalog number 8011 80

FIG. 7. *Agnostus longifrons* Nicholas, var. *parvulus,* n. var. Holotype cranidium. 4/1. Bed 109, in the middle part of the Paradoxides davidis zone. Princeton catalog number 8014 83

FIG. 8. *Agnostus longifrons* Nicholas, var. *parvulus,* n. var. Pygidium referred to this form. 4/1. Middle part of the Paradoxides davidis zone. Princeton catalog number 8017 83

FIG. 9. *Agnostus rectangularis,* n. sp. Holotype cranidium. 4/1. Upper part of the Paradoxides davidis zone. Princeton catalog number 8019 85

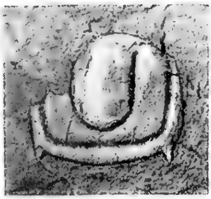
FIG. 10. *Conocoryphe bullata,* n. sp. Holotype cranidium. 3/2. Bed 19, in the middle part of the Paradoxides bennetti zone. Princeton catalog number 8021 87

FIG. 11. *Conocoryphe bullata,* n. sp. Cranidium referred to this species. 2/1. Bed 19, in the middle part of the Paradoxides bennetti zone. Princeton catalog number 8026 87

FIG. 12. *Paradoxides parvoculus,* n. sp. Holotype cranidium. 1/1. Bed 23, in the upper part of the Paradoxides bennetti zone. Princeton catalog number 8027 89

FIG. 13. *Paradoxides parvoculus,* n. sp. Cranidium. 1/1. Upper part of the Paradoxides bennetti zone. Princeton catalog number 8041 89

FIG. 14. *Liostracus globiceps* Grönwall, var. *jaculator,* n. var. Holotype cranidium. 2/1. Bed 86, in the upper part of the Paradoxides hicksi zone. Princeton catalog number 8023 91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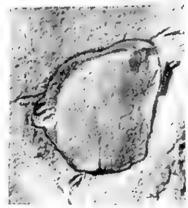
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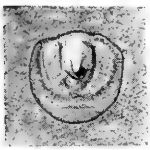
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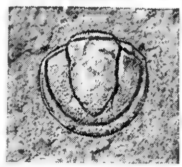
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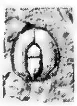
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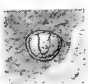
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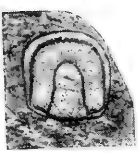
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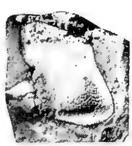
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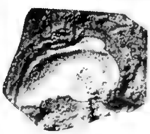
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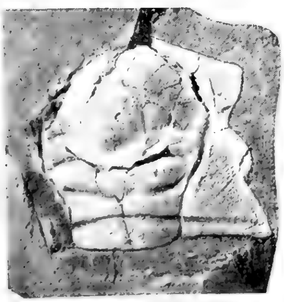
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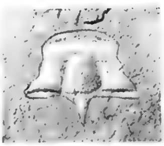
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VII. CORRELATION

Very few of the species of the Paradoxides faunas occur in any of the other known Cambrian faunas of the world; and none of those species are sufficiently diagnostic to enable us to use them with any confidence in close correlation. Therefore, although the Paradoxides beds and their fossils have been long known and much studied by geologists and paleontologists, and have proved so easy to correlate among themselves that it has been possible to make close comparisons of beds on opposite sides of the Atlantic, yet their exact age relationships with the other known faunas that are supposed to have existed in the world at about the same time are not well understood.

For many years after their discovery the Paradoxides faunas were considered to be the oldest well developed faunas known. They were spoken of as the "first fauna" or "primordial fauna." (Barrande, 1852; Murchison, 1872; Logan, 1866, in Murray and Howley, 1881, p. 49; Dawson, 1868, p. 638; etc.). Later when the term "Cambrian" came into general use, they were referred to as "Lower Cambrian" (Walcott, 1884). Finally, when in 1888, it was discovered that the "Olenellus" faunas really belonged below and not above them, the Paradoxides faunas were assigned to their present position in the Middle Cambrian (Walcott, 1888b).

In 1914 Professor vanIngen correlated the Paradoxides beds of Conception and Trinity bays, Newfoundland, including those at Manuels, with the "Acadian" division of the "St. John Group" of New Brunswick and the "Menevian and Solva" of Great Britain (vanIngen, 1914b). In the present unsettled condition of Cambrian nomenclature it seems wisest to refer to the beds of the Manuels series merely as "Cambrian Paradoxides beds," without using the qualifying "Middle." That the Paradoxides beds belong roughly in the middle, or what is now generally called the "Acadian," portion of what we now know as the Cambrian is possible, but they cannot be correlated definitely with any part of the Cambrian of the southern, central, or western parts of North America, or of Asia or Australia, and the base and, more especially, the summit of the Cambrian system are at present so undefined, and may yet be so shifted, that it seems quite possible that the Paradoxides beds may at some time in the future be called something quite different from "Middle Cambrian." Indeed, Professor Charles Schuchert has proposed raising the "Middle Cambrian, Acadian, or Paradoxides epoch" to the rank of a period, the "Acadic Period" (Schuchert, 1910, pp. 520–522).

In his great work, "Revision of the Paleozoic Systems," Dr. E. O. Ulrich accepts the Middle Cambrian age of the Paradoxides beds, but objects to the assignment of the overlying "Olenus" beds to the Upper Cambrian, stating reasons for his belief that they were formed much later, probably in "Canadian" time (Ulrich, 1911, pp. 621, 678–680).

Whether the Paradoxides beds should be considered to include all of the Middle Cambrian of the Manuels Brook section is another question. The lowest of the overlying Agnostus pisiformis beds are certainly not Middle Cambrian in the sense in which that term is usually used today, and the same can be said of the underlying beds containing Callavia broggeri. The age of the black shales which intervene between the highest known Paradoxides beds and the lowest known Agnostus pisiformis horizon must remain in doubt until more is known about their fossils. The same is true of the beds lying between the lowest known Paradoxides beds and the highest beds in which Catadoxides magnificus has been found (see discussion of this question in Chapter IV, pp. 26, 27). The beds between the highest known Callavia horizon and the uppermost stratum in which Catadoxides magnificus is known to occur have been assigned to the Middle Cambrian by Dr. Walcott (1900a, pp. 315, 316; 1912, p. 140), and to the Lower Cambrian by Professor vanIngen (1914b).

The Paradoxides faunas are so distinctive and char-

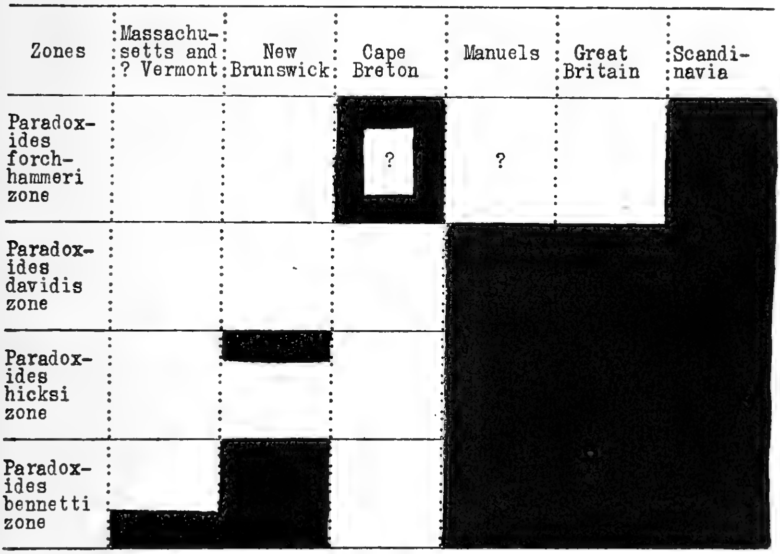

TABLE V. Correlation of the Paradoxides faunas found at Manuels with those found in northwestern Europe and northeastern North America

acteristic that they are generally easy to recognize and correlate with each other. Salter (1859) and Jackson (1859a) compared the first specimens of Paradoxides discovered in Newfoundland (examples of Paradoxides bennetti) with Paradoxides spinosus of Bohemia and Paradoxides harlani of Massachusetts. Billings, who studied the collections made by the Geological Survey of Newfoundland, correlated the beds containing Paradoxides faunas there with "the Lower Lingula flags of Great Britain, or the Menevian Group of Salter and Hicks" (Billings, 1872, p. 470; 1874, p. 69); and Dawson (1873, p. 5) correlated them with the "Acadian Group" of New Brunswick, "the gold-bearing rocks of Nova Scotia," "the slates of Braintree in Massachusetts," and the "Menevian of Salter, Etage D of Barrande." In his report of the progress of the Newfoundland Survey for 1868, Murray referred the Paradoxides beds at Manuels to the "Lower Silurian," although he had found no fossils in them. Weston, who in 1874 made the first discovery of fossils at Manuels, correlated the beds containing them with the Paradoxides beds of New Brunswick on the evidence of the first specimen he found (Weston, 1898, p. 153). The New Brunswick beds had been correlated in 1865 by C. F. Hartt and Dr. G. F. Matthew with the Paradoxides beds of Massachusetts, the Paradoxides bennetti beds of St. Mary's Bay, Newfoundland, the Lingula flags of Great Britain, the "alum-schists" of Scandinavia, and "Etage C of Barrande in Bohemia" (Matt., 1865, p. 427). In 1878 Whiteaves also correlated the Manuels Paradoxides beds with the "St. John's group" of New Brunswick (Whiteaves, 1878). In 1881 Etheridge correlated the Menevian of Wales with "the St. John's group in Newfoundland" (Etheridge, 1881, p. 68). In 1884 Dr. C. D. Walcott (1884, p. 13) correlated these beds with the New Brunswick beds and with "the lower part of the Menevian, or possibly with portions of the Harlech and Longmynd group" of Great Britain. He pointed out the fact that the species then known to occur in the Paradoxides harlani beds of Braintree, Massachusetts, all appeared to be represented by very similar forms in Newfoundland (1884, p. 44). None of the Newfoundland species that he mentioned as comparable with the Braintree forms were then known to occur at Manuels, but most, or all, of them have since been found there.

In 1885 Dr. Matthew stated that the fossils then known from the Paradoxides beds of Manuels Brook appeared to be of early Paradoxidian age, like those of the "Acadian" of St. John, New Brunswick, and the Solva of Great Britain (Matthew, 1885, pp. 121 and footnote, and 122). In the following year he referred the Manuels fossils to the "Horizon of the Conocoryphinæ," the lowest Paradoxides horizon then known in Newfoundland (Matthew, 1886, p. 149); and two years later he correlated the "Shales of Manuel R." with "Division" 1c of the "St. John Group" of Canada, the upper part of the "Upper Sparagmite formation=Etage 1b and c" of Norway, the upper part of the "Lower Paradoxides Beds" of Sweden, and doubtfully with the upper part of the "Solva group" of Great Britain (Matthew, 1888a, p. 25).

In 1888 and 1891 Dr. Walcott (1888b, p. 551; 1889a, pp. 383, 386; 1891a, pp. 582, 583; 1891b, pp. 66, 360; 1891c) correlated the Paradoxides beds at Manuels with those of New Brunswick, Massachusetts, and Great Britain.

In 1890 Dr. Matthew (1890, p. 137) correlated the upper Paradoxides beds at Manuels with the Menevian of Wales, "Etage 1d" of Norway, and the "Upper Paradoxides Beds" of Sweden; and the two lower "zones" of the Paradoxides beds at Manuels with the "Lower Paradoxides Beds" of Sweden, a part of the "Upper Sparagmite–Etage 1c" of Norway, and a part of the Solva of Great Britain. In the following year he correlated the Newfoundland faunas with those in other parts of the world, as shown in table II (page 15 of the present paper). In 1896 he divided them into the following subzones:

3. "Subzone of P. davidis."
2. "Subzone of P. abenacus" (doubtfully identified in Newfoundland).
1. "Subzone of P. eteminicus."

and correlated these subzones with what he considered to be their equivalents in Massachusetts, New Brunswick, France, Spain, Bohemia, Sweden, Norway, and Wales (Matthew, 1896, pp. 193, 194).

In 1897 Frech correlated the "Zone mit P. Davidis und Ptych. Linnarsoni Brögg." at Manuels with the "Middle Menevian mit Par. davidis" of Wales, the zone of "Par. Davidis (Microdiscus u. Par. Tessini)" of Sweden, and the "Schiefer m. Par. rugulosus, Con. Sulzeri, Agnostus nudus" of Norway; and correlated the "Schichten mit Paradoxides Hicksi" at Manuels with the "Lower Menevian mit Par. Hicksi und aurora" of Wales, the zone of "Par. Tessini (u. Par. Hicksi, Ellips. granulatus, Conoc. exsulans, Ptych. Linnarssoni, Agnostus rex)" of Sweden, the "Schiefer mit Par. Tessini" of Norway, and the "Sandstein mit Par. Tessini" of Sandomir, Poland (Frech, 1897, pp. 34-38).

In 1899 Dr. Matthew (1899c, p. 67) subdivided the Paradoxides beds of Newfoundland and correlated them with beds in New Brunswick, as shown below (the notes in parenthesis refer to New Brunswick):

Horizon of Paradoxides davidis (unknown in New Brunswick).
Horizon of Paradoxides tessini (=subzone of Paradoxides abenacus).
Horizon of Paradoxides spinosus (=subzone of Paradoxides eteminicus).
Horizon of the Conocoryphinæ (=subzone of Paradoxides eteminicus).

In 1914 Professor vanIngen correlated the Manuels series with the "Acadian" of "N. E. America" and the Menevian and Solva of "Western Europe," as mentioned above (vanIngen, 1914). A more detailed correlation table, drawn up by the writer, is shown in table V .

As far as can be told at the present time, the Paradoxides faunas of southeastern Newfoundland are more nearly related to those of New Brunswick, Massachusetts, Great Britain and Scandinavia, than to those of France, Bohemia, Poland and southern Europe. The fossils of the Paradoxides beds of Vermont will probably also prove to be closely related to those of Newfoundland, but they are at present too little known to make a satisfactory comparison possible (see page 106).

The succession of early Paleozoic faunas in southeastern Newfoundland, from the Lower Cambrian to the Lower Ordovician, appears to have been very much the same as it was in Massachusetts, New Brunswick, Great Britain, and Scandinavia, as is shown in table VII (p. 101). Recent discoveries in Shropshire and Warwickshire, England, also indicate the presence there of "Callavia" and "Protolenus" faunas very similar to those of southeastern Newfoundland (Cobbold, 1910; 1919; 1921; Illing, 1913; 1914a, 1916).

One of the most interesting things about the Paradoxides fossils at Manuels is their very close resemblance to the contemporary fossils of Europe, in general, and of Great Britain, in particular. The number of identical or nearly identical species found at Manuels and in Europe, and the similarity of their ranges on the two sides of the Atlantic, are illustrated in table VI and on pages 117-132. What we know of the species occurring above and below the Paradoxides beds at Manuels, including those found in the beds of Kelly's, Little Bell, and Great Bell Islands, in Conception Bay, indicates that they, too, are closely related to forms of the same age in Europe. Altogether, they and the fossils of the Paradoxides beds exhibit one of the most interesting examples known of a succession of very similar faunas on opposite sides of the Atlantic Ocean.

The Paradoxides faunas of Scandinavia seem also to be very similar to those of Manuels, but they do not seem to show quite so close a resemblance as do those of Great Britain. They are compared on pages 125 - 132 . Interesting n e   a t   N

	112	113	114	11
		1		
		2	x	
		3		
		4		
		5		
		6		
	x	7		
		8		
		9x		
	x	10x		
		1		
	x	2		
		3		
	x	4		
		5		
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		5		
		6		
		7x		
–	–	8		
		9		
x	x	30	x	
		1		
		2x		
		3		
		4		
		5		
		6		
x		7		
		8		
		9		
		40		

and beds may be n

Paradoxides sjogreni beds at Hartshill Hayes — Paradoxides aurora zone at Hartshill Hayes — Paradoxides [illegible] zone at Hartshill Hayes — Hartshillia zone [illegible]

Paradoxides bennetti zone at Manuels — Paradoxides hicksi zone [illegible]

	NAME
1	Paradoxides hicksi Salter
2	P. davidis Salter
3	P. rugulosus Corda
4	Centropleura pugnax Illing
5	C. [illegible] (Salter)
6	Solenopleura applanata (Salter)
7	S. cf. applanata (Salter)
8	S. variolaris (Salter)
9	Bailiella venulosa (Salter)
10	Hartshillia inflata (Hicks)
11	Holocephalina primordialis Salter
12	Eodiscus punctatum (Salter)
13	E. punctatum scanicus Linnarsson
14	Agnostus rex (Barrande)
15	A. cf. rex (Barrande)
16	A. granulatus (Barrande)
17	A. exaratus tenuis Illing
18	A. fallax Linnarsson
19	A. cf. fallax Linnarsson
20	A. cf. fallax trilobatus Matthew ("A. lobatus" of Illing)
21	A. solutus Illing
22	A. fissus Lundgren MS
23	A. fissus perrugatus Grönwall
24	A. cf. fissus perrugatus Grönwall
25	A. [illegible] Salter
26	A. exaratus Grönwall
27	A. acadicus declivis Matthew
28	A. parvifrons Linnarsson
29	A. cf. parvifrons Linnarsson
30	A. laevigatus terranovicus Matthew ("A. lens" of Grönwall)
31	A. laevigatus [illegible] Matthew ("A. rotundus" of Grönwall)
32	A. laevigatus ciceroides Matthew ("A. altus" of Grönwall)
33	A. kjerulfi Brögger
34	A. cf. kjerulfi Brögger
35	A. cf. incertus Brögger
36	A. bibullatus (Barrande)
37	A. punctuosus Angelin
38	A. nudus (Beyrich)
39	A. cf. nudus (Beyrich)
40	A. gracilis Illing

Table 91. Table to show the similarity of the ranges of the species of trilobites common to the Paradoxides beds of Manuels and Hartshill Hayes, Warwickshire. The x's mark the ranges of the species at Manuels, the lines, their ranges [illegible]

EAT BRITAIN	SCANDINAVIA
aunas, with Didy- s,Tetragraptus,etc.	"Arenig" faunas, with Didy- mograptus,Tetragraptus,etc.
and Upper Lingula as, with Niobe, ,Bryograptus,Parab- d Orusia lenticular-	"Tremadoc" faunas, with Ceratopyge,Shumardia,Parabolina, and "Dictyograptus" (Dictyonema).
racterized by Ag- siformis obesus es of Olenus.	Fauna characterized by Agnos- tus pisiformis obesus and species of Olenus.
be lacking in the in some districts Britain, but part larly some of the des forchhammeri ay prove to be in other districts.	Agnostus pisiformis. Agnostus laevigatus. Paradoxides forchhammeri fauna.
des davidis fauna.	Paradoxides davidis fauna.
des hicksi fauna.	Paradoxides hicksi fauna.
des groomi fauna.	Paradoxides ölandicus fauna.
to be present. Pos- resented in the mostone" of Comley ropshire.	Not known to be present.
s fauna.	Not known to be present
fauna.	Fauna or faunas characterized by Holmia and Mesonacis.

ower Ordovician faunas
and Scandinavia.

SOUTHEASTERN NEWFOUNDLAND	MASSACHUSETTS	NEW BRUNSWICK	GREAT BRITAIN	SCANDINAVIA
"Arenig" faunas, with Didymograptus, etc.		Fauna or faunas characterized by Didymograptus and Tetragraptus (C 3 d).	Arenig faunas, with Didymograptus, Tetragraptus, etc.	"Arenig" faunas, with Didymograptus, Tetragraptus, etc.
"Tremadoc" faunas, with Niobe, Parabolina, Shumardia, Bryograptus, and Orusia lenticularis.	Not known to be present	Faunas characterized by Ctenopyge, Parabolina, Bryograptus, and Dictyonema (C 3a-c).	Tremadoc and Upper Lingula Flag faunas, with Niobe, Shumardia, Bryograptus, Parabolina, and Orusia lenticularis.	"Tremadoc" faunas, with Ceratopyge, Shumardia, Parabolina, and "Dictyograptus" (Dictyonema).
Fauna characterized by Agnostus pisiformis obesus and species of Olenus.		Probably represented in part, at least, by the fauna or faunas characterized by Acantholenus and varieties of Agnostus pisiformis (C2).	Fauna characterized by Agnostus pisiformis obesus and species of Olenus.	Fauna characterized by Agnostus pisiformis obesus and species of Olenus.
Agnostus pisiformis.			Known to be lacking in the sections in some districts in Great Britain, but part (particularly some of the Paradoxides forchhammeri fauna) may prove to be present in other districts.	Agnostus pisiformis.
Agnostus laevigatus ?		Not known to be present.		Agnostus laevigatus.
Paradoxides forchhammeri fauna?		Not certainly known to be present. Possibly represented in Cape Breton.		Paradoxides forchhammeri fauna.
Paradoxides davidis fauna.		Not certainly known to be present.	Paradoxides davidis fauna.	Paradoxides davidis fauna.
Paradoxides hicksi fauna.		Paradoxides abenacus fauna (C1d).	Paradoxides hicksi fauna.	Paradoxides hicksi fauna.
Paradoxides bonnetti fauna.	Paradoxides harlani fauna.	Paradoxides regina fauna, with P. lamellatus and P. eteminicus (C1c1,2).	Paradoxides groomi fauna.	Paradoxides ölandicus fauna.
Catadoxides fauna.	Not known to be present	Not known to be present.	Not known to be present. Possibly represented in the "black limestone" of Comley Quarry, Shropshire.	Not known to be present.
Protolenus fauna.		Protolenus fauna.	Protolenus fauna.	Not known to be present
Callavia fauna.	Callavia fauna.	Callavia fauna.	Callavia fauna.	Fauna or faunas characterized by Holmia and Mesonacis.

Table VII. Table to show the similarity in the succession of Cambrian, Ozarkian, and Lower Ordovician faunas in southeastern Newfoundland, Massachusetts, New Brunswick Great Britain, and Scandinavia.

correlations might also be made between the Manuels faunas and those of Bohemia, Poland, France, and the Iberian Peninsula; but, as they can be made with much greater accuracy after the Paradoxides faunas of all of southeastern Newfoundland have been more thoroughly studied, they are not attempted in this paper.

The great similarity between the Paradoxides faunas of North America and Europe naturally raises the question of migration between the two regions. Did any or all of the faunas originate in one of these regions and migrate to the other; or did they come in from some outside source? If they came from outside, did they occupy one of the two regions for any appreciable period before advancing to the other; or did they invade both regions quite, or nearly quite, simultaneously? These are difficult questions, most of which probably cannot be satisfactorily answered with the information now at hand. In the regions where the Paradoxides faunas and those which preceded them have been most carefully and thoroughly studied, none has been found which can be said to have been the immediate ancestor of the earliest known Paradoxides assemblage. This indicates either that the first known Paradoxides faunas entered those regions from outside, or that, if they evolved in those regions, conditions at the time of their evolution and since have destroyed all records of their earlier stages. There are unconformities between the Paradoxides beds and the beds underlying them in some regions, but there is certainly no angular unconformity at the bottom of the Paradoxides beds at Manuels, and, as has been stated before, it is doubtful whether there is any well marked disconformity present.

The first Paradoxides faunas seem to have come in with an advancing sea in most of the regions in which they have been found, and appear to have been followed by successive invasions of later and slightly different forms; for while the changes from one fauna to the next succeeding one are usually gradual, in the sense that old species slowly drop out as new ones come in and that some stems gradually change in character, nevertheless, many entirely new types enter which could have had no antecedents in this region; so that there must certainly have been open an outside source of new life during most of known Paradoxidian time.

In almost every section where any two of the three sets of faunas, the "Olenellus," "Paradoxides," and "Olenus," have been reported in the regions where Paradoxides is known to occur (Europe and northeastern North America) there are present either the "Olenellus" and "Paradoxides," "Olenellus," "Paradoxides" and "Olenus," or "Paradoxides" and "Olenus" faunas—very seldom the "Olenellus" and "Olenus" faunas together without the "Paradoxides."

Probably the following tenative deductions are the ones which can most logically be drawn from the facts now at hand:

1. No fauna immediately ancestral to the earliest known Paradoxides faunas has been found. The nearest ancestral faunas now known are probably those characterized by Catadoxides in southeastern Newfoundland and by Metadoxides in Sardinia.
2. The earliest known Paradoxides faunas probably invaded the regions where their remains are now found from some outside area, and the new types which distinguish the succeeding faunas also came in from the same or some other outside place or places, those after the earliest one being composed of a combination of these new types and survivals and derivatives of the fauna or faunas which preceded them. Some or all of the ancestors of the Paradoxides faunas may have developed in the regions where Paradoxides is now found, but, if they did, no record of their presence there has been discovered.
3. The migrations of the Paradoxides faunas over the European and northeastern North American

regions appear to have been mainly in the nature of direct invasions from some outside region.

4. There is a great faunal break between the latest Paradoxides fauna and the next succeeding well-developed one at every known place where they occur.

The similarities and differences betwen the Paradoxides faunas found at Manuels and other regions are roughly indicated in tables IV and V, and are briefly described under separate headings in the remaining part of this chapter.

COMPARISON OF THE PARADOXIDES FAUNAS OF MANUELS WITH THOSE OF BRAINTREE, MASS.

The Braintree fauna and the fauna of the lower 21 feet and 7 inches (beds 1–13) of the bennetti zone at Manuels, so far as they are known at the present time, are essentially alike. The two faunas are listed below, species which are known to be identical or very similar being placed opposite each other. The Braintree list is taken partly from Walcott (1884) and Grabau (1900). The Manuels list, like all the other lists of fossils from Manuels in this chapter, includes only species which the author has found at that locality. The numbers in parenthesis following the names of the species in the Manuels list indicate the particular beds of the lower 21 feet and 7 inches of the bennetti zone in which each species has been found.

Lower Paradoxides bennetti Fauna at Manuels	Paradoxides harlani Fauna at Braintree
Paradoxides bennetti Salter (2?, 3?, 5?, 6-8, 10?, 13)	Paradoxides harlani Green
	Paradoxides haywardi Raymond
Ptychoparia rogersi (Walcott) (8)	Ptychoparia rogersi (Walcott)
Agraulos cf. affinis Billings (8)	Agraulos quadrangularis (Whitfield)
Agnostus cf. rex (Barrande) (8)	Agnostus cf. rex (Barrande)
Acrothele cf. matthewi (Hartt) (3, 16)	Acrothele gamagei (Hobbs)
Lingulella ferruginea Salter (3, 10)	
Hyolithid gen. & spec. undet. (1, 4?)	
Hyolithid gen. and spec. undet., different from the one found in bed 1? (10)	
	Hyolithes shaleri Walcott
	Hyolithes (?) haywardensis Grabau
Sponge gen. and sp. undet. (1)	

It would seem that faunas so nearly the same as these two must certainly be of almost or exactly the same age.

It appears to be quite within the realms of possibility that true Paradoxides harlani occurs in the bennetti beds of Newfoundland, and that some or all of the known specimens of bennetti are to be referred to harlani, or that bennetti is to be considered a variety of harlani. These possibilities have been considered by Jackson (1859a, 1859b), Rogers (1859), and Dr. Walcott (1884, p. 44). The question cannot be answered properly until an examination has been made of the type specimen or specimens of bennetti, which are in England. It will be dealt with further in a future paper, in which the bennetti and harlani faunas will be compared in detail. Paradoxides regina Matthew, of New Brunswick, is also closely related to harlani and bennetti, as pointed out by Matthew (1888c, pp. 122, 123) and Grabau (1900, pp. 687–689). Paradoxides groomi Lapworth (1891, p. 532, footnote) appears to be another very similar form.

Whatever may be the relations of bennetti to harlani, the recognition of a bennetti fauna in the lower part of the Manuels Brook Paradoxides section and the close resemblance of the lower "bennetti" sub-fauna to the harlani fauna make it possible for us to place the two definitely in their proper part of the North American Paradoxides section. If the "bennetti" of this lower sub-fauna proves to be a distinct form, we shall be able to separate the lower sub-fauna as the "harlani" sub-fauna or fauna.

Dr. Matthew (1887, p. 149) placed his "Horizon of P. spinosus" (the lower bennetti zone of the present paper) above the "Horizon of the Conocoryphinæ" (the upper bennetti zone of this paper) in his classification of the Paradoxides beds of Newfoundland; and Jules Marcou (1889, pp. 122, 123; 1890a, pp. 357, 368, 369; 1890b, pp. 83, 84), apparently on the strength of unpublished information furnished to him by Mr. Howley, stated that the Paradoxides bennetti beds were probably the oldest Paradoxides beds known in Newfoundland; but he was not certain about the matter, and presented no satisfactory evidence in support of his views; and it was not until the bennetti fauna was recognized in the Manuels section that its exact stratigraphic position became known.

The presence at Braintree of an agnostid resembling Agnostus rex has not been previously recorded. A head of the rex type was found in Hayward's quarry in that town by Professor P. E. Raymond and the writer in 1918. It is specimen 8042 in the paleontological collections of Princeton University. The counterpart of the head is in the Museum of Comparative Zoology at Cambridge.

The species Parmophorella acadia (Hartt), which was recorded from Braintree by Grabau (1900, pp. 625, 626), has not been included in the list of species found in the Paradoxides beds of Massachusetts because, after a comparison of the very fragmentary specimen on which Dr. Grabau's identification was based with examples of Acrothele gamagei and with the type specimen of Parmophorella acadia, the writer belives that Dr. Grabau's fossil is a valve of Acrothele gamagei, and almost certainly not a Parmophorella.

It is an interesting fact that the shale holding the Paradoxides harlani fauna at Braintree is a hard, heavy-bedded, brown-weathering, gray rock, which seems to be very similar to the gray shales of the lower part of the bennetti zone at Manuels, except that it is harder and more heavily bedded.

COMPARISON OF THE PARADOXIDES FAUNAS OF MANUELS WITH THE PARADOXIDES FAUNA OF VERMONT

Very little has been published about the Paradoxides fauna of Vermont. Between 1886 and 1905 Dr. Walcott recorded the finding of a few fossils which may prove to belong to this fauna (Walcott, 1887, p. 17; 1891b, p. 310; 1898, pp. 404, 405; 1905, pp. 291, 292). In 1908 Dr. G. H. Perkins reported that some fossils collected by Mr. G. E. Edson of St. Albans had been referred by Dr. Walcott to the genera "Obolus, Lingulella, Hyolithes, Leperditia, Agnostus (two species), Agraulos, Menocephalus, Ptychoparia (three species), Anomocare, Paradoxides" (Perkins, 1908, pp. 208, 209). In 1910 Dr. Walcott identified the Paradoxides as Paradoxides harlani Green (Walcott, 1910, p. 254); and in 1912 he recorded two species of brachiopods, "Obolus matinalis?" and "Huenella vermontana," from the beds holding this Paradoxides, and described and figured two species of brachiopods (Lingulella franklinensis and Huenella billingsi) and recorded one species of trilobite (Ptychoparia adamsi) from beds in the same general region which he thought might be of "Middle Cambrian" age (Walcott, 1912).

In the summer of 1922 the writer examined the beds in which Mr. Edson had found his fossils and other similar beds in northwestern Vermont which appeared to be of the same age, and collected several hundred fossils from them. The beds consist of dark shales and peculiar conglomerates whose "pebbles," which are frequently sharply angular, are of all sizes from blocks many tons in weight to pieces no larger than a pea, and whose martrix is sometimes sand, sometimes shale, sometimes limestone, and sometimes a mixture of two or all of those materials. Fossils were found only in the dark shales and the "pebbles" of the conglomerate. Most of them are trilobites, but there are also a few brachiopods. They are evidently Cambrian, but whether they are all of Paradoxidian age has not yet been determined. One fragmentary trilobite cranidium was found that may be referable to Paradoxides harlani (specimen 8043 in the Princeton paleontological collections), and several other fragments that are probably Paradoxides were collected. Some of the other specimens collected may also prove to be referable to species that are associated with

Paradoxides elsewhere than in Vermont. But the assemblage, as a whole, is not like any of the Paradoxides faunas that have been described from any other region. The writer plans to make a more detailed study of these beds in the summer of 1925, in the hope of being able to learn more about their fossils.

COMPARISON OF THE PARADOXIDES FAUNAS OF THE MANUELS BROOK SECTION WITH THOSE OF NEW BRUNSWICK AND CAPE BRETON

Dr. Matthew has divided the Paradoxides beds of New Brunswick and Cape Breton into five zones, which he has designated as follows, from the highest downward (189˘, p. 259):

C2 —Gray quartzites, flags and slates (Upper Paradoxides fauna).
C1d2—Dark gray shales and limestone lentils (Dorypyge sub-fauna).
C1d1—Dark gray shales (Paradoxides abenacus sub-fauna).
C1c2—Gray shales (Paradoxides eteminicus sub-fauna).
C1c1—Gray shales (Paradoxides lamellatus sub-fauna).

The highest of these zones has been recognized only in Cape Breton. It appears to be correlatable with the "Paradoxides forchhammeri" zone of Scandinavia, which is not known to be represented in Newfoundland. The other four zones are probably included, in whole or in part, in the bennetti, hicksi, and possibly the lowest part of the davidis, zones of the Manuels Brook section. The "lamellatus" and "eteminicus" zones are well developed only in New Brunswick. They appear to be correlatable with the bennetti beds at Manuels, but their fossils do not seem to be clearly distinguishable as two separate faunas there.

The trilobites and brachiopods of the faunas recorded by Dr. Matthew and by Dr. Walcott from the "lamellatus" and "eteminicus" zones are compared below with the trilobites and brachiopods of the bennetti fauna of the Manuels Brook section, so far as that fauna is now known. Identical and similar species are placed opposite each other in the two lists. The horizon of each species in New Brunswick is indicated as it is recorded by Dr. Matthew (1893, pp. 113–119; 1904) "C1c1" indicating the "lamellatus" zone, "C1c2" the "eteminicus" zone, and "C1c" either one or both of the two. The numbers following the names of the Newfoundland species refer to the beds of the Manuels Brook section, as they are numbered in the present paper (pp. 43–93). This and the other New Brunswick lists of the present chapter are made up from information contained in Dr. Matthew's papers and Dr. Walcott's monograph, "Cambrian Brachiopoda" (Walcott, 1912).

Species Found in the Bennetti Zone at Manuels		Species Found in the Lamellatus and Eteminicus Subzones of New Brunswick
(The numbers in parentheses indicate the beds in which each species has been found.)		
Trilobites		*Trilobites*
Paradoxides bennetti Salter (2?, 3?, 5?, 6-8, 10?, 13, 19, 22-24, 26-32, 33?, 34?, 35?)	C1c2	Paradoxides regina Matthew
Paradoxides lamellatus Hartt (21)	C1c1	Paradoxides lamellatus Hartt
	C1c2	Paradoxides lamellatus loricatus Matthew
Paradoxides eteminicus Matthew (19, 21-35)	C1c2	Paradoxides eteminicus Matthew
	C1c2	Paradoxides eteminicus breviatus Matthew
	C1c2	Paradoxides eteminicus malicitus Matthew
	C1c2	Paradoxides eteminicus quacœnsis Matthew
	C1c2	Paradoxides eteminicus suricoides Matthew
	C1c2	Paradoxides acadicus Matthew
	C1c2	Paradoxides acadicus suricus Matthew
	C1c2	Paradoxides micmac Hartt
	C1c1	Paradoxides micmac pontificalis Matthew
Paradoxides parvoculus, n. sp. (23, 26)		
	C1c1	Bailiella walcotti (Matthew)
Bailiella baileyi (Hartt) (23, 25, 29, 31-35)	C1c2	Bailiella baileyi (Hartt)
	C1c2	Bailiella baileyi arcuata Matthew
Conocoryphe elegans (Hartt) (23, 25-29, 31, 34)	C1c2	Conocoryphe elegans (Hartt)
	C1c2	Conocoryphe elegans granulata Matthew
Conocoryphe bullata, n. sp. (19)		
Harttella matthewi (Hartt) (21-23, 25-29, 32, 34, 35)	C1c2	Harttella matthewi (Hartt)
	C1c2	Harttella matthewi hispidus Matthew
	C1c2	Hartella matthewi geminispinosus Matthew
	C1c1	Harttella matthewi perhispidus Matthew
Liostracus ouangondianus (Hartt) (23, 26, 28, 29, 31)	C1c1	Liostracus ouangondianus (Hartt)

	C1c1	Liostracus ouangondianus gibba Matthew
Liostracus cf. ouangondianus (Hartt) (15, 17, 19, 21)	C1c1	Liostracus ouangondianus plana Matthew
	C1c2	Liostracus ouangondianus aurora Matthew
	C1c2	Liostracus ouangondianus emarginata Matthew
Liostracus tener (Hartt) (25-35)	C1c1	Liostracus tener (Hartt)
	C1c2	Liostracus tener acuminata Matthew
Agraulos cf. affinis Billings (8)		
	C1c1	Agraulos (?) whitfieldianus Matthew
	C1c1	Agraulos whitfieldianus compressa Matthew
	C1c2	Agraulos halliana Matthew
	C1c2	Agraulos (?) holeocephalus Matthew
	C1c2	Agraulos (?) nannus Matthew
	C1c2	Agraulos (?) pusillus Matthew
	C1c2	Agraulos roberti Matthew
Ptychoparia cf. rogersi (Walcott) (8)		
	C1c2	Solenopleura robbi (Hartt)
	C1c2	Solenopleura robbi orestes (Hartt)
	C1c2	Eodiscus precursor (Matthew)
Goniodiscus dawsoni (Hartt) (19)	C1c1	Goniodiscus dawsoni (Hartt)
Agnostus cf. fallax trilobatus Matthew (8, 23, 26, 29, 31)	C1c1	Agnostus fallax trilobatus Matthew
	C1c1	Agnostus fallax vir Matthew
	C1c1	Agnostus gibbus Linnarsson
Agnostus granulatus (Barrande) (23, 28, 29)		
Agnostus cf. rex (Barrande) (8, 19, 23, 25, 26, 28, 29, 31)	C1c1	Agnostus regulus Matthew
Agnostus cf. exaratus tenuis Illing (26)	C1c2	Agnostus acadicus Hartt
Agnostus barlowi definitus, n. var. (23, 26, 28)		
Agnostus claræ, n. sp. (23)		

Brachiopods		*Brachiopods*
Lingulella ferruginea Salter (3, 10, 19, 21, 23, 26, 28-35)	C1c1 & 2	Lingulella ferruginea Salter
Acrothele matthewi (Hartt) (3?, 10?, 23, 26, 28-35)	C1c	Acrothele matthewi (Hartt)
	C1c	Acrothele matthewi lata Matthew
	C1c	Acrothele matthewi multicostata Matthew
Acrotreta gemmula Matthew (29)		
Acrotreta cf. gemmula Matthew (21, 28)		
	C1c	Acrotreta sagittalis magna (Matthew)
	C1c	Acrotreta sagittalis transversa (Hartt)
	C1c1	Discinopsis gulielmi (Matthew)
Micromitra (Iphidella) cf. ornatella Linnarsson (21)		
	C1c1 & 2	Protorthis billingsi (Hartt)
	C1c2	Prothorthis latourensis (Matthew)
	C1c2	Protorthis quacœnsis (Matthew)
	C1c	Eorthis hastingsensis (Walcott)
Eorthis cf. papias (Walcott) (22)		

The trilobites and brachiopods of the faunas recorded by Dr. Matthew and Dr. Walcott from the "Paradoxides abenacus" and "Dorypyge" zones of New Brunswick are compared below with the known trilobites and brachiopods of the faunas of the hicksi zone of the Manuels Brook section. The presence in the "Dorypyge" zone of "Agnostus punctuosus var." may indicate that some of that zone may lap over from hicksi into davidis time, as punctuosus is not known below the davidis zone at Manuels. The apparent absence of Paradoxides hicksi from New Brunswick is very remarkable, and appears to indicate that a part of the hicksi zone is lacking there. The horizons are indicated as in the former list. "C1d1" is the "Paradoxides abenacus" zone; "C1d2," the "Dorypyge" zone. Where "C1d" is used it indicates that Dr. Matthew has not stated in which of the two zones the species occurs.

Species That Have Been Recognized in the Hicksi Zone at Manuels		Species Found in the Paradoxides Abenacus and Dorypyge Sub-zones of New Brunswick
Trilobites		*Trilobites*
Paradoxides bennetti Salter ? (41)		
Paradoxides cf. abenacus Matthew (51, 52)	C1d	Paradoxides abenacus Matthew
Paradoxides cf. eteminicus Matthew (49)		
Paradoxides hicksi Salter (37, 40, 41, 43-46, 49, 51-58, 61, 62, 64-67, 70, 73-75, 77, 78, 80-90)		
Centropleura venusta Billings (86)		
Bailiella venulosa (Salter) (88)		
Conocoryphe elegans (Hartt) (40, 41)		
Conocoryphe æqualis Linnarsson (67, 79, 83, 84, 86, 87)		
	C1d	Conocoryphe pustulosa Matthew
Liostracus tener (Hartt) (38-40)		
	C1d	Liostracus tener lævis Matthew
Liostracus globiceps jaculator, n. var. (86, 91)		
	C1d	Liostracus validus Matthew
	C1d2	Liostracus ouangondianus (Hartt) var.
	C1d2	Agraulos ceticephalus carinatus Matthew
Agraulos socialis Billings (37, 40, 41, 43-46, 49-58, 61, 62, 64-67, 69-77, 80-84, 86, 87)	C1d	Agraulos socialis Billings
	C1d	Solenopleura acadica Whiteaves
	C1d	Solenopleura acadica elongata Matthew
	C1d	Solenopleura robbi parva Matthew
	C1d	Solenopleura arenosa Billings
Solenopleura cf. applanata (Salter) (48, 55, 57, 67, 69, 77, 80, 83-86, 88, 91)		
	C1d	Ptychoparia adamsi Billings
	C1d	Ptychoparia limbata Matthew

	C1d	Ptychoparia linnarssoni Brögger
	C1d	Ptychoparia linnarssoni alata Matthew
	C1d2	Anomocari magnum Brögger var.
	C1d	Dolichometopus acadicus Matthew
	C1d	Dorypyge horrida Matthew
	C1d	Dorypyge quadriceps valida Matthew
Eodiscus punctatus (Salter) (40, 44, 51, 52, 54, 67, 69, 75, 81, 83, 84, 86)	C1d	Dorypyge wasatchensis acadica Matthew
	C1d	Eodiscus pulchella (Hartt)
Agnostus cf. umbo Matthew (90, 91)	C1d1	Agnostus umbo Matthew
	C1d1	Agnostus rex transectus Matthew
	C1d1	Agnostus obtusilobus Matthew
Agnostus cf. sulcatus Illing (90, 91)	C1d1	Agnostus nathorsti Brögger
Agnostus cf. gibbus Linnarsson (88, 90)	C1d1	Agnostus nathorsti confluens Matthew
Agnostus cf. gibbus hybrida Brögger (48)	C1d1	Agnostus gibbus acutilobus Matthew
Agnostus fissus Lundgren MS (41, 51, 57, 58, 64, 69, 72, 74, 77, 78, 81, 84, 85, 87-91)	C1d1	Agnostus gibbus partitus Matthew
	C1d1	Agnostus fissus Lundgren MS
	C1d1	Agnostus fissus trifissus Matthew
Agnostus cf. fallax Linnarsson (43, 45, 52, 64, 65, 81, 84, 86-91)	C1d1	Agnostus fallax Linnarsson ?
	C1d1	Agnostus fallax concinnus Matthew
Agnostus cf. acadicus declivis Matthew (40, 41, 43, 44, 48, 51-57, 70, 71, 74, 76, 77, 81, 84, 88, 92)	C1d1	Agnostus acadicus declivis Matthew
Agnostus cf. parvifrons Linnarsson (90, 91)	C1d1 & 2	Agnostus parvifrons Linnarsson
	C1d2	Agnostus cf. parvifrons nepos Brögger
Agnostus cf. parvifrons tessella Matthew (48, 50, 80)	C1d2	Agnostus parvifrons tessella Matthew
	C1d2	Agnostus parvifrons truncata Matthew
	C1d2	Agnostus punctuosus Angelin var.
Agnostus barrandei Salter (41, 43, 47, 48, 51, 55, 57, 58, 64, 65, 70, 77, 80, 81)		
Agnostus granulatus (Barrande) (43, 46, 51, 74, 80, 88, 90, 91)		
Agnostus rex (Barrande) (43, 44, 46, 52, 57, 65, 79, 88)		

Agnostus cf. nudus (Beyrich) (44, 45, 69, 70)		
Agnostus lævigatus ciceroides Matthew (81, 84, 87-91)		
Agnostus lævigatus terranovicus Matthew (90)		
Brachiopods		*Brachiopods*
Lingulella ferruginea Salter (37-41, 74)	C1d	Lingulella ferruginea Salter
Acrothele cf. matthewi (Hartt) (81)	C1d	Acrothele matthewi (Hartt)
	C1d	Acrothele matthewi lata Matthew
	C1d	Acrothele matthewi multicostata Matthew
	C1d	Acrothele prima costata (Matthew)
	C1d	Acrotreta baileyi Matthew
	C1d	Acrotreta gracia Walcott
Acrotreta misera (Billings) (48, 88, 90-92)	C1d	Acrotreta misera (Billings)
	C1d	Acrotreta sagittalis (Salter)
	C1d	Acrotreta sagittalis magna (Matthew)
	C1d	Billingsella coloradœnsis (Shumard)
	C1d	Eoorthis hastingsensis (Walcott)

COMPARISON OF THE PARADOXIDES FAUNAS OF THE MANUELS BROOK SECTION WITH THOSE OF GREAT BRITAIN

The Paradoxides faunas of Great Britain are very remarkably similar to those of Manuels. In Great Britain, as at Manuels, they can be divided into bennetti, hicksi, and davidis faunas. The trilobites and brachiopods of the faunas of the two regions are compared below. Identical and similar species are placed opposite each other in the two lists, as is done in the case of the other lists in this chapter. The lists of British species are probably not complete, but they are believed to include most, if not all, of the British forms that are identical with or very similar to the known Manuels species. Some of the British species may have been assigned to the wrong zones. It is sometimes difficult to decide whether a given form recorded in the literature has come from the hicksi or the davidis zone.

Species Found in the Paradoxides Bennetti Zone at Manuels	Species Found in the Paradoxides Bennetti Zone of Great Britain
Trilobites	*Trilobites*
Paradoxides parvoculus, n. sp.	Paradoxides hicksi Salter
	Paradoxides aurora Salter
Paradoxides eteminicus Matthew	Paradoxides harknessi Hicks
Paradoxides lamellatus Hartt	
	Paradoxides sjogreni Linnarsson
Paradoxides bennetti Salter	Paradoxides grommi Lapworth
	Plutonia sedwgicki Hicks
Conocoryphe bullata, n. sp.	
Conocoryphe elegans (Hartt)	Conocoryphe bufo Hicks
Bailiella cf. baileyi (Hartt)	Conocoryphe viola Woodward
	Conocoryphe lyelli Hicks
	Conocoryphe emarginata longifrons Cobbold
Harttella matthewi (Hartt)	Harttella solvensis Hicks
Liostracus tener (Hartt)	
Liostracus ouangondianus (Hartt)	
Ptychoparia cf. rogersi (Walcott)	
	Dorypyge lakei Cobbold
Agraulos cf. affinis Billings	
Goniodiscus dawsoni (Hartt)	Goniodiscus sculptus (Hicks)
	Agnostus sulcatus Illing
	Agnostus cf. intermedius Tullberg
Agnostus cf. fallax trilobatus Matthew	Agnostus lobatus Illing
Agnostus granulatus (Barrande)	Agnostus granulatus (Barrande)
Agnostus cf. exaratus tenuis Illing	Agnostus exaratus tenuis Illing
Agnostus cf. rex (Barrande)	Agnostus rex (Barrande)
Agnostus claræ, n. sp.	
Agnostus barlowi definitus, n. var.	Agnostus barrandei Salter

Brachiopods

Lingulella ferruginea Salter
Acrothele matthewi (Hartt)
Acrotreta gemmula Matthew
Acrotreta cf. gemmula Matthew

Micromitra (Iphidella) cf. ornatella (Linnarsson)
Eorthis cf. papias (Walcott)

SPECIES FOUND IN THE PARADOXIDES HICKSI ZONE AT MANUELS

Trilobites

Paradoxides bennetti Salter
Paradoxides cf. abenacus Matthew
Paradoxides cf. eteminicus Matthew
Paradoxides hicksi Salter
Centropleura venusta (Billings)

Conocoryphe æqualis Linnarsson
Conocoryphe elegans (Hartt)

Brachiopods

Lingulella ferruginea Salter

Acrotreta socialis von Seebach
Acrothyra comleyensis Cobbold

SPECIES FOUND IN THE PARADOXIDES HICKSI ZONE OF GREAT BRITAIN

Trilobites

Paradoxides bohemicus salopiensis Cobbold

Paradoxides hicksi Salter

Paradoxides intermedius Cobbold
Centropleura pugnax Illing
Centropleura impar (Hicks)
Centropleura salteri (Hicks)
Conocoryphe æqualis Linnarsson
Conocoryphe bufo Hicks
Conocoryphe cf. dalmani Angelin
Conocoryphe homfroyi Hicks
Conocoryphe perdita Hicks
Liocephalus impressa (Linnarsson)
Liostracus elegans Illing
Liostracus lata Cobbold
Liostracus dubia Cobbold

Liostracus globiceps jaculator, n. var.	
Liostracus tener (Hartt)	
	Arionellus longicephalus Hicks
	Agraulos cf. holocephalus Matthew
Agraulos socialis Billings	
Solenopleura cf. applanata (Salter)	Solenopleura applanata (Salter)
	Solenopleura variolaris (?) (Salter)
	Corynexochus pusillus Illing
	Corynexochus cambrensis Nicholas
	Holocephalina incerta Illing
	Hartshillia inflata Hicks
	Dorypyge reticulata Cobbold
	Dorypyge cf. richthofeni Dames
Eodiscus punctatus (Salter)	Eodiscus punctatus (Salter)
	Eodiscus punctatus scanicus (Linnarsson)
Bailiella venulosa (Salter)	Bailiella venulosa (Salter)
	Agnostus tuberculatus Illing
	Agnostus triangulatus Illing
Agnostus gracilis Illing	Agnostus gracilis Illing
Agnostus cf. parvifrons Linnarsson	Agnostus parvifrons Linnarsson
Agnostus cf. parvifrons tessella Matthew	
Agnostus cf. nudus (Beyrich)	Agnostus nudus (Beyrich)
	Agnostus regius globosus Illing
	Agnostus integer (Beyrich)
	Agnostus barlowi spinatus Illing
Agnostus cf. sulcatus Illing	Agnostus sulcatus Illing
	Agnostus corrugatus Illing
Agnostus barrandei Salter	Agnostus barrandei Salter
Agnostus fissus Lundgren MS	Agnostus fissus Lundgren MS
Agnostus cf. fallax Linnarsson	Agnostus fallax Linnarsson
Agnostus cf. gibbus Linnarsson	
Agnostus cf. gibbus hybrida Brögger	
	Agnostus cf. intermedius Tullberg
	Agnostus punctuosus Angelin
	Agnostus lobatus Illing

Agnostus granulatus (Barrande)
Agnostus cf. acadicus declivis Matthew

Agnostus rex (Barrande)
Agnostus lævigatus terranovicus Matthew
Agnostus lævigatus ciceroides Matthew
Agnostus cf. umbo Matthew

Brachiopods

Lingulella ferruginea Salter
Acrothele cf. matthewi (Hartt)
Acrotreta misera (Billings)

SPECIES FOUND IN THE PARADOXIDES DAVIDIS ZONE AT MANUELS

(The numbers in parentheses indicates the beds in which each species has been found.)

Trilobites

Paradoxides cf. hicksi (101)
Paradoxides davidis Salter (93?, 94-96, 100?, 101?, 111, 114-122, 124?, 125?)
Paradoxides rugulosus Corda (115, 116)

Centropleura pugnax Illing (99)

Agnostus granulatus (Barrande)
Agnostus exaratus Grönwall
Agnostus exaratus tenuis Illing
Agnostus rex (Barrande)

Agnostus altus Grönwall

Agnostus typicalis Nicholas
Agnostus truncatus Brögger
Agnostus longifrons Nicholas
Agnostus cambrensis Hicks
Agnostus davidis Salter

Brachiopods

Acrotreta sagittalis (Salter)

SPECIES FOUND IN THE PARADOXIDES DAVIDIS ZONE OF GREAT BRITAIN

Trilobites

Paradoxides davidis Salter

Paradoxides rugulosus Corda
Centropleura impar (Hicks)
Centropleura pugnax Illing
Centropleura salteri (Hicks)

Centropleura henrici (Salter) (115)	Centropleura henrici (Salter)
	Dorypyge cf. richthofeni Dames
Solenopleura cf. applanata (Salter) (99, 102, 105, 107-112)	Solenopleura cf. applanata (Salter)
Solenopleura variolaris (Salter) (115)	Solenopleura variolaris (?) (Salter)
Solenopleura communis Billings (115)	
	Liostracus pulchella Cobbold
	Liostracus dubia Cobbold
	Agraulos cf. holocephalus Matthew
	Agraulos quadrangularis (Whitfield)
Ctenocephalus coronatus (Barrande) (Bed unknown)	Ctenocephalus coronatus (Barrande)
	Conocoryphe cf. dalmani Angelin
	Holocephalina incerta Illing
Holocephalina primordialis Salter (115)	Holocephalina primordialis Salter
Bailiella venulosa (Salter) (109, 113)	Bailiella venulosa (Salter)
	Carausia menevensis Hicks
	Hartshillia inflata (Hicks)
Hartshillia inflata (Hicks) (111, 113)	Hartshillia spinata Illing
	Corynexochus cambrensis Nicholas
Corynexochus minor (Walcott) (109, 116?, 119?)	
Eodiscus punctatus (Salter) (99, 101-103, 106-109, 112, 115)	Eodiscus punctatus (Salter)
	Eodiscus punctatus scanicus Linnarsson
	Agnostus cf. nathorsti Brögger
Agnostus vaningeni, n. sp. (99, 100, 102)	
	Agnostus glandiformis Angelin
Agnostus bifurcatus Illing (Bed unknown)	Agnostus bifurcatus Illing
Agnostus cf. kjerulfi Brögger (99-102, 105, 107, 109)	Agnostus kjerulfi Brögger
Agnostus cf. incertus Brögger (117)	Agnostus cf. incertus Brögger
Agnostus cf. nudus (Beyrich) (95, 99-101, 107, 109, 110)	
	Agnostus nudus ovalis Illing
Agnostus lævigatus ciceroides Matthew (93, 99, 102, 109, 110, 113, 115-120)	Agnostus altus Grönwall
Agnostus lævigatus terranovicus Matthew (93, 94,	Agnostus lens Gröwall

99, 100, 102-112, 114, 115)	
Agnostus lævigatus mamilla Matthew (115)	Agnostus rotundus Grönwall
Agnostus bibullatus (Barrande) (106, 107)	Agnostus bibullatus (Barrande)
Agnostus punctuosus Angelin (95-97, 99, 106-111, 115,120)	Agnostus punctuosus Angelin
	Agnostus pulchellus Illing
	Agnostus tuberculatus Illing
Agnostus cf. parvifrons Linnarsson (99)	Agnostus parvifrons Linnarsson
Agnostus parvifrons punctifer, n. var. (101)	
Agnostus cf. parvifrons mammillata Brögger (105, 107)	
	Agnostus integer (Beyrich)
	Agnostus securiger Lake
Agnostus sulcatus Illing (93?, 94-97, 99-103, 109, 110)	Agnostus sulcatus Illing
	Agnostus barrandei Salter
Agnostus cf. fissus perrugatus Grönwall (99)	Agnostus fissus perrugatus Grönwall
Agnostus cf. fallax Linnarsson (93-97, 99-102, 104-106, 108-112, 114-116)	Agnostus fallax Linnarsson
Agnostus granulatus (Barrande) (93-95, 99-102, 106-110)	Agnostus granulatus (Barrande)
Agnostus cf. acadicus declivis Matthew (99, 107, 109, 113, 115)	Agnostus exaratus Grönwall
Agnostus cf. exaratus tenuis Illing (109)	Agnostus exaratus tenuis Illing
	Agnostus eskriggei Hicks
Agnostus rectangularis, n. sp. (Bed unknown)	
Agnostus longifrons parvulus, n. var. (109)	
Agnostus rex (Barrande) (109, 112)	

Agnostus cf. pusillus Tullberg (110)
Agnostus cf. planicauda Angelin (Bed unknown)
Agnostus barlowi Belt (Bed unknown)
Agnostus cf. umbo Matthew (93)
Agnostus gracilis Illing (109)

Brachiopods

Obolus fragilis (Walcott) (109, 115)
Lingulella ferruginea Salter (101)

Acrotreta sagittalis (Salter) (Bed unknown)
Acrotreta misera (Billings) (99-109)

Brachiopods

Lingulella ferruginea Salter
Acrothele maculata (Salter)
Acrotreta sagittalis (Salter)

Billingsella cobboldi Matley
Billingsella lindstrœmi salopiensis Matley
Billingsella hicksi (Salter MS)
Orbiculoidea pileolus (Hicks MS)

The detailed stratigraphic studies made by Mr. Illing on the Abbey Shales near Nuneaton, Warwickshire (Illing, 1914b; 1916), by Mr. Cobbold on the beds of Shropshire (Cobbold, 1911; 1913a; 1913b; 1921), and by Mr. Nicholas on those of Carnarvonshire (Nicholas, 1914; 1915; 1917), make possible a very detailed comparison of the trilobites of the Paradoxides faunas of those beds with the trilobites of the Paradoxides faunas at Manuels. The similarity of the ranges of the species of trilobites common to the Paradoxides beds of Manuels and Hartshill Hayes, Warwickshire, is shown in table VI (p 100). An examination of this table will disclose the fact that not only are most of the species of these two widely separated regions the same, but their ranges are very nearly the same. Such a correspondence as this has probably seldom been equalled in all geological time, and proves that England and Wales were in the same marine life province as southeastern Newfoundland in Paradoxidian times, and that there was a shallow water connection between them, through which the faunas could migrate.

COMPARISON OF THE PARADOXIDES FAUNAS OF THE MANUELS BROOK SECTION WITH THOSE OF SCANDINAVIA

The Paradoxides faunas of Scandinavia have been variously subdivided, but they can easily be grouped roughly into four main units, corresponding to the bennetti, hicksi, and davidis faunas, and a younger fauna, the Paradoxides forchhammeri fauna, which has not been recognized at Manuels. The bennetti, hicksi, and davidis faunas of Scandinavia are almost as much like those at Manuels as are the British ones. Their trilobites and brachiopods are compared with those at Manuels in the columns below. As the division lines between the bennetti and hicksi zones, the hicksi and davidis zones, and the davidis and forchhammeri zones have been drawn at somewhat different places by different students of the Scandinavian Paradoxides beds, it is not always possible to determine from the literature from which of these zones a species has come, and some of the Scandinavian species in the following lists may, therefore, be wrongly placed.

Species That Have Been Recognized in the Paradoxides Bennetti Zone at Manuels	Species Found in the Paradoxides Bennetti Zone of Scandinavia
Trilobites	*Trilobites*
Paradoxides lamellatus Hartt	
	Paradoxides ölandicus Sjögren
	Paradoxides sjogreni Linnarsson
Paradoxides eteminicus Matthew	
Paradoxides bennetti Salter	
Paradoxides parvoculus, n. sp.	
	Paradoxides hicksi palpebrosus Brögger
	Paradoxides aculeatus Linnarsson
	Paradoxides jemtlandicus Wiman
Harttella matthewi (Hartt)	
	Harttella exsulans (Linnarsson)
Conocoryphe elegans (Hartt)	
Conocoryphe bullata, n. sp.	
	Conocoryphe dalmani Angelin
	Conocoryphe emarginata Linnarsson
Bailiella cf. baileyi (Hartt)	
Ptychoparia cf. rogersi (Walcott)	
Liostracus ouanagondianus (Hartt)	
Liostracus tener (Hartt)	
	Solenopleura cristata Linnarsson
Agraulos cf. affinis Billings	
	Ellipsocephalus polymetopus Linnarsson
Goniadiscus dawsoni (Hartt)	
	Agnostus regius Sjögren
	Agnostus fallax Linnarsson
	Agnostus gibbus Linnarsson var.
	Agnostus atavus Tullberg
Agnostus cf. fallax trilobatus Matthew	

Agnostus granulatus (Barrande)
Agnostus cf. rex (Barrande)
Agnostus claræ, n. sp.
Agnostus barlowi definitus, n. var.
Agnostus cf. exaratus tenuis Illing

Brachiopods

Lingulella ferruginea Salter
Acrothele matthewi (Hartt)

Acrotreta gemmula Matthew
Acrotreta cf. gemmula Matthew

Micromitra (Iphidella) cf. ornatella (Linnarsson)
Eorthis cf. papias (Walcott)

SPECIES THAT HAVE BEEN FOUND IN THE PARADOXIDES HICKSI ZONE AT MANUELS

Trilobites

Paradoxides bennetti Salter ?
Paradoxides cf. eteminicus Matthew

Paradoxides hicksi Salter
Paradoxides cf. abenacus Matthew
Centropleura venusta (Billings)

Brachiopods

Lingulella ferruginea Salter

Acrothele coriacea Linnarsson
Acrothele (Redlichella) granulata (Linnarsson)

Acrotreta schmalenseei Walcott
Acrotreta socialis von Seebach

Billingsella exporrecta (Linnarsson)
Billingsella lindströmi (Linnarsson)

SPECIES FOUND IN THE PARADOXIDES HICKSI ZONE OF SCANDINAVIA

Trilobites

Paradoxides tessini Brongniart
Paradoxides hicksi Salter

Dorypyge oriens Grönwall

	Dorypyge danica Grönwall
	Corynexochus bornholmiensis Grönwall
	Ptychoparia linnarssoni (Brögger)
Liostracus tener (Hartt)	
Liostracus globiceps jaculator, n. sp.	Liostracus aculeatus Agnelin
Solenopleura cf. applanata (Salter)	Solenopleura parva Linnarsson
Agraulos socialis Billings	
Bailiella venulosa (Salter)	Bailiella breviceps (Angelin)
Conocoryphe æqualis Linnarsson	Conocoryphe æqualis Linnarsson
Conocoryphe elegans (Hartt)	Conocoryphe dalmani Angelin
	Conocoryphe tenuicincta Linnarsson
	Conocoryphe latilimbata (Brögger)
	Conocoryphe impressa Linnarsson
	Harttella exsulans (Linnarsson)
	Liocephalus impressa Linnarsson
	Liocephalus linnarssoni Grönwall
	Ellipsocephalus granulatus Linnarsson
	Ellipsocephalus muticus Angelin
Eodiscus punctatus (Salter)	Eodiscus eucentrus (Linnarsson)
	Eodiscus scanicus (Linnarsson)
Agnostus cf. fallax Linnarsson	Agnostus fallax Linnarsson
	Agnostus fallax ferox Brögger
Agnostus cf. parvifrons Linnarsson	Agnostus parvifrons Linnarsson
Agnostus cf. parvifrons tessella Matthew	Agnostus parvifrons mammillata Brögger
	Agnostus barlowi Belt
Agnostus cf. nudus (Beyrich)	Agnostus nudus scanicus Tullberg
	Agnostus nudus marginatus Brögger
Agnostus rex (Barrande)	Agnostus rex (Barrande)
	Agnostus intermedius Tullberg
Agnostus fissus Lundgren MS	Agnostus fissus Lundgren MS

	Agnostus fissus perrugatus Grönwall
Agnostus cf. gibbus Linnarsson	Agnostus gibbus Linnarsson
Agnostus cf. gibbus hybrida Brögger	Agnostus gibbus hybrida Brögger
Agnostus cf. acadicus declivis Matthew	Agnostus exaratus Grönwall
Agnostus lævigatus ciceroides Matthew	Agnostus pusillus Tullberg
Agnostus lævigatus terranovicus Matthew	Agnostus altus Grönwall
	Agnostus lens Grönwall
	Agnostus lens frontosa Grönwall
	Agnostus rotundus Grönwall
	Agnostus incertus Brögger
	Agnostus truncatus Brögger
Agnostus cf. sulcatus Illing	
	Agnostus nathorsti Brögger
	Agnostus punctuosus Angelin
	Agnostus atavus Tullberg
Agnostus gracilis Illing	
Agnostus barrandei Salter	
Agnostus granulatus (Barrande)	
Agnostus cf. umbo Matthew	
Brachiopods	*Brachiopods*
	Obolus schmalenseei (Walcott)
	Obolus (Westonia) finlandensis Walcott
Lingulella ferruginea Salter	Lingulella ferruginea Salter
Acrothele cf. matthewi (Hartt)	
	Acrothele coriacea Linnarsson
	Acrothele intermedia Linnarsson
Acrotreta misera (Billings)	
	Acrotreta sagittalis (Salter)
	Acrotreta schmalenseei Walcott

Species That Have Been Found in the Paradoxides Davidis Zone at Manuels	Species Found in the Paradoxides Davidis Zone of Scandinavia
Trilobites	*Trilobites*
Paradoxides davidis Salter	Paradoxides davidis Salter
Paradoxides rugulosus Corda	Paradoxides rugulosus Corda
	Paradoxides tessini Brongniart
	Paradoxides brachyrhachis Linnarsson
Centropleura pugnax Illing	
Centropleura henrici Salter	
Corynexochus minor (Walcott)	
	Corynexochus bornholmiensis Grönwall
	Anomocare angelini Grönwall
	Agraulos ceticephalus (Barrande)
	Agraulos depressus Grönwall
	Conocoryphe æqualis Linnarsson
	Conocoryphe sulzeri (Schlotheim)
	Bailiella breviceps (Angelin)
Bailiella venulosa (Salter)	Bailiella venulosa (Salter)
Hartshillia inflata (Hicks)	
Holocephalina primordialis Salter	Holocephalina primordialis Salter
	Ctenocephalus tumida Grönwall
Ctenocephalus coronatus (Barrande)	
	Conocephalites ornatus (Brögger)
	Liostracus globiceps Grönwall
	Liostracus aculeatus Angelin
	Ptychoparia johnstrupi Grönwall
	Ptychoparia linnarssoni Brögger
Solenopleura communis Billings	Solenopleura brachymetopa Angelin
	Solenopleura brachymetopa nuntia Grönwall
	Solenopleura bucculenta Grönwall
	Solenopleura canaliculata Angelin

Solenopleura cf. applanata (Salter)	Solenopleura holometopa Angelin
Solenopleura variolaris (Salter)	
Eodiscus punctatus (Salter)	Eodiscus eucentrus (Linnarsson)
	Agnostus elegans Tullberg
Agnostus cf. fallax Linnarsson	Agnostus fallax Linnarsson
	Agnostus fallax ferox Tullberg
	Agnostus fallax tricuspis Brögger
Agnostus cf. incertus Brögger	Agnostus incertus Brögger
Agnostus cf. pusillus Tullberg	Agnostus pusillus Tullberg
Agnostus cf. nudus (Beyrich)	Agnostus nudus scanicus Tullberg
	Agnostus nudus marginata Brögger
Agnostus punctuosus Angelin	Agnostus punctuosus Angelin
	Agnostus punctuosus affinis Brögger
Agnostus acadicus declivis Matthew	Agnostus punctuosus bipunctata Brögger
Agnostus cf. exaratus tenuis Illing	Agnostus exaratus Grönwall
	Agnostus lundgreni Tullberg
	Agnostus lundgreni nana Grönwall
Agnostus cf. planicauda Angelin	Agnostus planicauda Angelin
Agnostus parvifrons Linnarsson	Agnostus parvifrons Linnarsson
Agnostus cf. parvifrons mammillata Brögger	Agnostus parvifrons mammillata Brögger
Agnostus parvifrons punctifer, n. var.	
	Agnostus parvifrons nepos Brögger
Agnostus granulatus (Barrande)	
Agnostus barlowi Belt	Agnostus barlowi Belt
	Agnostus forfex Grönwall
Agnostus lævigatus terranovicus Matthew	Agnostus lævigatus (Dalman)
Agnostus lævigatus mamilla Matthew	Agnostus rotundus Grönwall
Agnostus lævigatus ciceroides Matthew	Agnostus altus Grönwall
	Agnostus insularis Grönwall
Agnostus kjerulfi Brögger	Agnostus kjerulfi Brögger
	Agnostus lingula Grönwall

Agnostus sulcatus Illing	Agnostus glandiformis resecta Grönwall
Agnostus gracilis Illing	Agnostus nathorsti Brögger
Agnostus vaningeni, n. sp.	Agnostus stenorrhachis Grönwall
Agnostus bifurcatus Illing	
Agnostus bibullatus (Barrande)	
Agnostus cf. fissus perrugatus Grönwall	
Agnostus rectangularis, n. sp.	
Agnostus longifrons parvulus, n. var.	
Agnostus rex (Barrande)	
Agnostus cf. umbo Matthew	
Brachiopods	*Brachiopods*
Obolus fragilis (Walcott)	
Acrotreta sagittalis (Salter)	Acrothele coriacea Linnarsson
Acrotreta misera (Billings)	Acrotreta sagittalis (Salter)

SUMMARY

The Paradoxides beds at Manuels consist of 234 feet of hard, heavy-bedded greenish and bluish gray shales, with a few thin bands of light gray nodular limestone, overlaid by 68 feet of softer, thinner-bedded, dark gray and black shales, with occasional nodules, lenses, and thin beds of dark gray limestone. These beds contain great numbers of excellently preserved fossils. The fossils can be grouped in three main faunas, which may be called, after their most characteristic species of Paradoxides, the Paradoxides bennetti, P. hicksi, and P. davidis faunas. The oldest of these faunas, characterized by Paradoxides bennetti, occupies the lower 234 feet of the section. The next fauna, characterized by P. hicksi, occurs in the succeeding 37 feet. The third fauna, that of P. davidis, occupies the uppermost 31 feet. There is no sharp faunal break between any two of the three faunas, but each succeeding fauna differs from the one before it, because of the many new types introduced, as well as because of the dropping out of many of the old forms.

The lowest Paradoxides fauna is very different from the "Metadoxides magnificus" fauna found next below it. Some 10 feet of barren manganiferous shales intervene between the beds containing the two faunas. but it seems doubtful whether there exists any distinct stratigraphic break. The beds that immediately overlie the highest bed in which Paradoxides has been found are black shales which have yielded no good index fossils, so that their age is not known. They are succeeded by black shales containing Agnostus pisiformis, Agnostus pisiformis obesus, and other fossils characteristic of an "Olenus" fauna.

The Paradoxides faunas at Manuels may be closely correlated with those of Massachusetts, New Brunswick, and northwestern Europe. Faunas very similar to the bennetti fauna found at Manuels are known at Braintree (Massachusetts), near St. John (New Brunswick), in Great Britain, and in Scandinavia; and slightly different, but closely related, faunas occur in southern France and the Spanish peninsula. Faunas very much like the hicksi fauna found at Manuels are known in Great Britain and Scandinavia, and a closely related fauna occurs in New Brunswick. Faunas very remarkably similar to the davidis fauna found at Manuels are known in Great Britain, Scandinavia, and Bohemia.

The close similarity between the Paradoxides faunas found at Manuels and those occurring in northwestern Europe is most remarkable, and has probably seldom been paralleled in all geological time. It proves that there must have been an open and easy marine highway between northeastern North America and northwestern Europe during most of known Paradoxidian time.

BIBLIOGRAPHY

Angelin, N. P. 1878. Palæontologia Scandinavica. Pars I, Crustacea formationis transitionis, fasciculi 1 et 2. Holmiæ, 1878.

Belt, T. 1868. On the "Lingula Flags," or "Festiniog Group" of the Dolgelly District, Part III. Geol. Mag., vol. 5, 1868, pp. 5-7.

Bergeron, J. 1889. Etude geologique du massif ancien situe au sud du plateau central. Annales des Sciences Geologiques, vol. 22, 1889.

Beyrich, E. 1845. Uber einige böhmische Trilobiten. Berlin, 1845.

Billings, E. 1865. Palæozoic Fossils, vol. I. Geol. Surv. Canada, 1865.

Billings, E. 1872. On some new fossils from the Primordial rocks of Newfoundland. The Canadian Naturalist, New Series, vol. 6, 1872, pp. 465-479.

Billings, E. 1874. Palæozoic Fossils, vol. II, part I. Geol. Surv. Canada, Montreal, 1874.

Brögger, W. C. 1878. On paradoxidesskifrene ved Krekling. Reprint from Nyt Magazin for Naturvidenskaberne, vol. 24, part 1, 1878.

Buddington, A. F. 1914. Reconnaissance of the Algonkian rocks of southeast Newfoundland. Bull. Geol. Soc. Amer., vol. 25, 1914, p. 40.

Buddington, A. F. 1916. Pyrophyllitization, pinitization, and silicification of rocks around Conception Bay, Newfoundland. Jour. Geol., vol. 24, No. 2, 1916, pp. 130-152.

Budington, A. F. 1919. Pre-Cambrian rocks of southeast Newfoundland. Princeton University Contribution to the Geology of Newfoundland, No. 5. Jour. Geol., vol. 27, No. 6, 1919, pp. 449-479.
Chamberlin, T. C. 1895. Notes on the glaciation of Newfoundland. Bull. Geol. Soc. America, vol. 6, 1895, p. 467.
Cobbold, E. S. 1910. On some small trilobites from the Cambrian rocks of Comley (Shropshire). Quart. Jour. Geol. Soc. London, vol. 66, 1910, pp. 19-51.
Cobbold, E. S. 1911. Trilobites from the Paradoxides beds of Comley (Shropshire). Quart. Jour. Geol. Soc. London, vol. 67, 1911, pp. 282-300.
Cobbold, E. S. 1913a. The trilobite fauna of the Comley breccia bed (Shropshire). Quart. Jour. Geol. Soc. London, vol. 69, 1913, pp. 27-44.
Cobbold, E. S. 1913b. Two species of Paradoxides from Neve's Castle (Shropshire). Quart. Jour. Geol. Soc. London, vol. 69, 1913, pp. 45-50.
Cobbold. E S. 1919. Cambrian Hyolithidæ, etc., from Hartshill in the Nuneaton district, Warwickshire. Geol. Mag., dec. 6, vol. 6, 1919, pp. 149-158.
Cobbold, E. S. 1921. The Cambrian Horizons of Comley (Shropshire) and their Brachiopoda, Pteropoda, Gasteropoda, etc. Quart. Jour. Geol. Soc. Lond., vol. 76, 1921, pp. 325-386.
Dale, Nelson C. 1914. Manganese deposits of Conception and Trinity Bays, Newfoundland. Bull. Geol. Soc. Amer., vol. 25, 1914, pp. 73, 74.
Dale, N. C. 1915. The Cambrian manganese deposits of Conception and Trinity Bays, Newfoundland. Princeton University Contribution to the Geology of Newfoundland, No. 2. Proc. Amer. Phil. Soc., vol. 54, 1915, pp. 371-456.
Dawson, J. W. 1868. Acadian Geology, 2nd edition. London, 1868.
Dawson, J. W. 1873. Annual address of the president of the Natural History Society of Montreal. The Canadian Naturalist, New Series, vol. 7, 1873, pp. 1-11.
Etheridge, R. 1881. Anniversary address of the president of the Geological Society of London, 1881. Proc. of the Geol. Soc. of London for session 1880-81, pp. 37-235, in Quart. Jour. Geol. Soc. London, vol. 37, 1881.
Frazer, Persifor, 1883. Geological notes in the several townships of Chester County. 2nd Geol. Survey of Pennsylvania, Report C4, the geology of Chester County, edited by J. P. Lesley, pp. 215-345, map. Harrisburg, 1883.
Frech, F. 1897. Lethæa geognostica, theil 1, band 2, lieferung 1. Stuttgart, 1897.
Grabau, A. W. 1900. Palæontology of the Cambrian Terranes of the Boston Basin. Occasional Papers of the Boston Soc. of Nat. Hist., IV, pp. 601-694, 1900.
Grönwall, K. A. 1902. Bornholms Paradoxideslag og deres fauna. Danmarks Geol. Undersogelse, II Række, No. 13, Copenhagen, 1902.
Hawle, I., and Corda, A. J. C. 1847. Prodrom einer Monographie der böhmischen Trilobiten. Prague, 1847.

Hayes, Albert O. 1914. Geology of the Wabana Iron Ore of Newfoundland. Bull. Geol. Soc. America, vol. 25, 1914, p. 74.

Hayes, A. O. 1915. Wabana Iron Ore of Newfoundland. Geol. Surv. Canada, Memoir 78, No. 66, Geological Series; 1915.

Hicks, H. 1872. On some undescribed fossils from the Menevian group. Quart. Jour. Geol. Soc. London, vol. 28, 1872, pp. 173-185.

Howell, B. F. 1920a. Correlation of the Middle Cambrian of Newfoundland and Great Britain. Bull. Geol. Soc. Amer., vol. 31, No. 1, 1920, p. 214.

Howell, B. F. 1920b. The Middle Cambrian beds at Manuels, Newfoundland, and their relations. Science, New Series, vol. 51, No. 1330, 1920, p. 644.

Howley, J. P. 1889. The Taconic of Eastern Newfoundland. American Geologist, vol. 4, 1889, pp. 121-125.

Howley, J. P. 1907. Geological map of Newfoundland, compiled from the most recent and authentic sources, the coast line corrected to date from the admiralty surveys, the interior chiefly from the work of the geological survey, by James P. Howley, F. G. S., Director. 1907.

Illing, V. C. 1913. Recent discoveries in the Stockingford Shales near Nuneaton. Geol. Mag., dec. 5, vol. 10, 1913, pp. 452, 453.

Illing, V. C. 1914a. Recent discoveries in the Stockingford Shales near Nuneaton. Report of the British Ass'n for the Adv. of Science, 1913 (Birmingham) meeting, 1914, pp. 498, 499.

Illing, V. C. 1914b. The Paradoxidian fauna of a part of the Stockingford shales. Geol. Mag., dec. 6, vol. 1, no. 8, 1914, pp. 379, 380.

Illing, V. C. 1916. The Paradoxidian fauna of a part of the Stockingford shales. Quart. Jour. Geol. Soc. London, vol. 71 (for 1915). 1916, pp. 386-450.

Jackson, C. T. 1859a. [On a Paradoxides from St. Mary's Bay, Newfoundland.] Proc. Boston Soc. Nat. Hist., vol. 7, 1859, p. 54.

Jackson, C. T. 1859b. [Comparison of specimens of Paradoxides from Braintree, Massachusetts, and St. Mary's Bay, Newfoundland.] Proc. Boston Soc. Nat. Hist., vol. 7, 1859, p. 75.

Jækel, O. 1909. Ueber die Agnostiden. Zeitschr. der. Deutsch. geol. Gesell., vol. 61, 1909, pp. 380-401.

Jukes, J. B. 1839. Report on the geology of Newfoundland. St. John's, Newfoundland, 1839.

Jukes, J. B. 1840a. Report on the geology of Newfoundland. Edinburg Phil. Jour., New Series, vol. 29, 1840, pp. 103-111.

Jukes, J. B. 1840b. Report of the progress of the geological survey during 1840. St. John's Newfoundland, 1840.

Jukes, J. B. 1842. Excursions in and about Newfoundland during the years 1839 and 1840. Two volumes. London, 1842.

Jukes, J. B. 1843. General report of the geological survey of Newfoundland, executed under the direction of the government and legislature of the colony during the years 1839 and 1840. London, 1843.

Keith, A. 1923. Cambrian succession of northwestern Vermont. American Journal of Science, 5th series, vol. 5, 1923, pp. 97-139.

Lake, Philip. 1906. A monograph of the British Cambrian Trilobites, part I; 1906.

Lapworth, C. 1891. On Olenellus callavei and its geological relationships. Geol. Mag., dec. 3, vol. 7, No. 12, 1891, pp. 529-536.

Linnarsson, J. G. O. 1869. Om Vestergöthlands Cambriska och Siluriska aflagringar. Kongl. Svenska Vetenskapsakademiens handlingar. Band. 8, No. 2, 1869.

Logan, W. E. 1865. Geological Survey of Canada. Report of progress from its commencement to 1863, atlas, 1865.

Marcou, J. 1889. The Taconic of Eastern Newfoundland. American Geologist, vol. 4, 1889, pp. 121-125.

Marcou, J. 1890a. The Lower and Middle Taconic of Europe and North America, I. American Geologist, vol. 5, 1890, pp. 356-375.

Marcou, J. 1890b. The Lower and Middle Taconic of Europe and North America, II. American Geologist, vol. 6, 1890, pp. 78-102, 221-233.

Matthew, G. F. 1865. On the Azoic and Palæozoic Rocks of Southern New Brunswick. Quart. Jour. Geol. Soc. London, vol. 21, 1865, pp. 422-434.

Matthew, G. F. 1885. Illustrations of the fauna of the St. John group continued: on the Conocoryphea, with further remarks on Paradoxides. Proc. and Trans. Roy. Soc. Canada for 1884, vol. 2, sec. 4, 1885, pp. 99-124.

Matthew, G. F. 1886a. Illustrations of the fauna of the St. John group continued, No. 3—Descriptions of new genera and species (including a description of a new species of Solenopleura by J. F. Whiteaves). Proc. and Trans. Roy. Soc. Canada for 1885, 1st ser., vol. 3, sec. 4, 1886, pp. 29-84.

Matthew, G. F. 1886b. Abstract of a paper on the Cambrian faunas of Cape Breton and Newfoundland. Canadian Record of Science, vol. 2, 1886, no. 4, pp. 255-258.

Matthew, G. F. 1887. On the Cambrian faunas of Cape Breton and Newfoundland. Proc. and Trans. of the Roy. Soc. of Canada for 1886, vol. 4, sec. 4, 1887, pp. 147-157.

Matthew, G. F. 1888a. On a basal series of Cambrian rocks in Acadia. Canadian Record of Science, vol. 3, 1888, pp. 21-29.

Matthew, G. F. 1888b. On Psammichnites and the early trilobites of the Cambrian rocks in eastern Canada. American Geologist, vol. 2, 1888, pp. 1-9.

Matthew, G. F. 1888c. Illustrations of the fauna of the St. John Group. No. 4—Part 1, Description of a New Species of Paradoxides (Paradoxides regina). Part 2. The smaller trilobites with eyes (Ptychoparidæ and Ellipsocephalidæ). Proc. and Trans. Roy. Soc. Canada for 1887, vol. 5, sec. 4, 1888, pp. 115-166, pls. I-III.

Matthew, G. F. 1888d. On the classification of the Cambrian rocks in Acadia. Canadian Record of Science, vol. 3, 1888, pp. 71-81.

Matthew, G. F. 1890. On Cambrian Organisms in Acadia. Proc. and Trans. Roy. Soc. Can. for 1889, vol. 7, sec. 4, 1890, pp. 135-162.

Matthew, G. F. 1891. On some causes which may have influenced the spread of the Cambrian faunas. Can. Rec. Sci., vol. 4, 1891, pp. 255-269.

Matthew, G. F. 1896. Faunas of the Paradoxides beds in eastern North America, No. 1. Trans. N. Y. Acad. Sci., vol. 15, 1896, pp. 192-247.

Matthew, G. F. 1899a. A Palæozoic terrane beneath the Cambrian. Annals N. Y. Acad. Sci., vol. 12, No. 2, 1899, pp. 41-56.

Matthew, G. F. 1899b. A new Cambrian trilobite. Bull. Nat. Hist. Soc. New Brunswick, No. 17, 1899, pp. 136-142.

Matthew, G. F. 1899c. Studies on Cambrian faunas, No. 4—Fragments of the Cambrian faunas of Newfoundland. Proc. and Trans. Roy. Soc. Canada for 1899, 2nd ser., vol. 5, sec. 4, no. 3, 1899, pp. 67-95.

Murchison, R. I. 1872. Siluria, 5th edition, London, 1872.

Murray, Alexander, and Howley, James P. 1881a. Geological Survey of Newfoundland. London, 1881. [A re-publication of the Reports of Progress of the Geological Survey of Newfoundland for the years 1864 to 1879.]

Murray, Alexander, and Howley, James P. 1881b. Map of the Peninsula of Avalon, showing distribution of formations. Scale, 4 miles to 1 inch. 1881.

Nicholas, T. C. 1914. The trilobite fauna of the Middle Cambrian of the St. Tudwal's Peninsula (Carnarvonshire). Geol. Mag., dec. 6, vol. 1, no. 8, 1914, p. 380.

Nicholas, T. C. 1915. The geology of the St. Tudwal's Peninsula (Carnarvonshire). Quart. Jour. Geol. Soc. London, vol. 71, 1915, pp. 83-143.

Nicholas, T.C. 1916. Notes on the Trilobite fauna of the Middle Cambrian of the St. Tudwal's Peninsula (Carnarvonshire). Quart. Jour. Geol. Soc. London, vol. 71, 1916, pp. 451-472.

Peach, B. N. 1913. The relation between the Cambrian faunas of Scotland and North America. Report of the eighty-second meeting of the British Association for the Advancement of Science, Dundee, 1912, pp. 448-459; 1913.

Perkins, G. H. 1908. Preliminary Report on the Geology of Franklin County. Report of the State Geologist on the Mineral Industries and Geology of Certain Areas of Vermont, 1907-1908; pp. 189-209; 1908.

Raymond, P. E. 1913. Some changes in the names of genera of trilobites. Reprint from the Ottawa Naturalist, vol. 26, 1913, pp. 137-142.

Raymond, P. E. 1914. Notes on the ontogeny of Paradoxides, with the description of a new species from Braintree. Mass. Bull. Mus Comp. Zool., Harvard, vol. 58, No. 4, 1914, pp. 225-244, 1 pl.

Raymond, P. E. 1917. Beecher's classification of trilobites after twenty years. Amer. Jour. Sci., 4th ser., vol. 43, 1917, pp. 196-210.

Raymond, P. E. 1920. The pygidium of the trilobite. Geol. Mag., vol. 57, 1920, pp. 22-25.

Rogers, W. B. 1859. [Comparison of Paradoxides bennetti with Paradoxides harlani.] Proc. Boston Soc. Nat. Hist., vol. 7, 1859, p. 86.

Salter, J. W. 1859. On the fossils of the Lingula-flags or "Zone Primordiale." Paradoxides and Conocephalus from North America. Quart. Jour. Geol. Soc. London, vol. 15, 1859, pp. 551-555.

Schuchert, C. 1910. Paleogeography of North America. Bulletin of the Geological Society of America, vol. 20, 1910, pp. 427-606. pls. 46-101.

Tullberg, S. A. 1880. Om Agnostus-arterna de kambriska aflagrin-

garne vid Andrarum. Sveriges geol. undersökning, Ser. C, No. 42, 1880.
Ulrich, E. O. 1911. Revision of the Paleozoic Systems. Bull. Geol. Soc. Amer., vol. 22, 1911, pp. 281-680.
vanHise, C. R., and Leith, C. K. 1909. Pre-Cambrian geology of North America. U. S. Geol. Surv., Bull. No. 360, 1909.
vanIngen, Gilbert. 1914a. Cambrian and Ordovician faunas of southeastern Newfoundland. Bull. Geol. Soc. Amer., vol. 25, 1914, p. 138.
vanIngen, Gilbert. 1914b. Table of the Geological Formations of the Cambrian and Ordovician Systems about Conception and Trinity Bays, Newfoundland, and their Northeastern-American and Western-European Equivalents, based upon the 1912-1913 field work. Princeton, 1914.
vonToll, E. 1899. Beitrage zur Kenntniss des Sibirischen Cambrium. I. Memoires de l'Academie Imperiale des Sciences de St. Petersburg, 8th Series, vol. 8, No. 10 et dernier, 1899, pp. I-IV, 1-57.
vonZittel, K. A., and Eastman, C. R. 1913. Text-book of paleontology, vol. 1, 1913.
Walcott, C. D. 1884. On the Cambrian faunas of North America, preliminary studies. U. S. Geol. Surv., Bull. No. 10, 1884.
Walcott, C. D. 1887. Second contribution to the studies of the Cambrian faunas of North America. Bull. U. S. Geological Survey, No. 30, 1887. (Dated 1886, but said by Dr. Walcott, in Amer. Jour. of Science, 3rd ser., vol. 37, 1889, p. 377, footnote, not to have been issued until 1887).
Walcott, C. D. 1888a. The Taconic system of Emmons and the use of the name Taconic in geologic nomenclature. Amer. Jour. of Sci., 3rd ser., vol. 35, 1888, pp. 229-242, 307-327, 394-401.
Walcott, C. D. 1888b. The Stratigraphical Succession of the Cambrian Faunas in North America. Nature, vol. 38, 1888, p. 551.
Walcott, C. D. 1889a. Stratigraphic position of the Olenellus fauna in North America and Eprope. Amer. Jour. Sci., 3rd ser., vol. 37, 1889, pp. 374-392; vol. 38, 1889, pp. 29-42.
Walcott, C. D. 1889b. Description of new genera and species of fossils from the Middle Cambrian. Proc. U. S. Nat. Mus., vol. 11, 1889, pp. 441-446.
Walcott, C. D. 1891a. The fauna of the Lower Cambrian or Olenellus zone. Tenth Annual Report of the U. S. Geol. Surv., part 1, pp. 509-774; 1891. (Report dated 1890, but not issued until 1891.)
Walcott, C. D. 1891b. Correlation Papers—Cambrian. U. S. Geol. Surv., Bull. No. 81, 1891.
Walcott, C. D. 1891c. [The stratigraphic succession of the Cambrian faunas in North America.] Congres geologique international, compte rendu de la 4me session, Londres, 1888, pp. 223-225; London, 1891.
Walcott, C. D. 1891d. The North American continent during Cambrian time. Twelfth Annual Report of the Director of the U. S. Geol. Surv., Part I—Geology, pp. 523-568; 1891.
Walcott, C. D. 1898. Cambrian Brachiopoda; Obolus and Lingulella, with description of new species. Proc. U. S. Nat. Mus., vol. 21, 1898, pp. 385-420.
Walcott, C. D. 1899. Pre-Cambrian fossiliferous formations. Bull.

Geol. Soc. Amer., vol. 10, 1899, pp. 199-244.

Walcott, C. D. 1900a. Lower Cambrian terrane in the Atlantic Province. Proc. Wash. Acad. Sci., vol. 1, 1900, pp. 301-339.

Walcott, C. D. 1900b. Random, a Pre-Cambrian Upper Algonkian Terrane. Bull. Geol. Soc. America, vol. 11, 1900, pp. 3-5.

Walcott, C. D. 1902. Cambrian Brachiopoda: Acrotreta; Linnarssonella; Obolus; with descriptions of new species. Proc. U. S. Nat. Mus., vol. 25, 1902, pp. 577-612.

Walcott, C. D. 1905. Cambrian Brachiopoda, with descriptions of new genera and species. Proc. U. S. Nat. Mus., vol. 28, 1905, pp. 227-337.

Walcott, C. D. 1910. Cambrian Geology and Paleontology, No. 6, Olenellus and other genera of the Mesonacidæ. Smithson. Misc. Coll., vol. 53, No. 6, 1910.

Walcott, C. D. 1912. Cambrian Brachiopoda. U. S. Geol. Surv., Monogr. 51; 1912.

Walcott, C. D. 1916a. Cambrian Geology and Paleontology, III, No. 3, Cambrian Trilobites. Smithson. Misc. Coll., vol. 64, No. 3; 1916.

Walcott, C. D. 1916b. Cambrian Geology and Paleontology, III, No. 5, Cambrian Trilobites. Smithson. Misc. Coll., vol. 64, No. 5; 1916.

Walcott, C. D. 1920. Cambrian Geology and Paleontology IV, No. 6—Middle Cambrian Spongiæ. Smithson. Misc. Colls., vol. 67, No. 6, pp. 261-338; 1920.

Weston, T. C. 1896. Notes on the geology of Newfoundland. Proceedings and Transactions of the Nova Scotia Institute of Science, vol. 9, 1896, pp. 150-157.

Whiteaves, J. F. 1878. On some Primordial Fossils from Southeastern Newfoundland. Amer. Jour. Sci., 3rd ser., vol. 16, 1878, pp. 224-226.

Willis, B. 1912. Index to the Stratigraphy of North America. U. S. Geol. Surv., Professional Paper 71; 1912.

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JURASSIC CEPHALOPODA FROM MADAGASCAR

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CONTENTS

INTRODUCTION

The collection of Madagascan cephalopods described in the following pages consists of some forty ammonites, two nautili, and two indeterminable belemnites, and the writer is indebted to Prof. J. Stansfield of the University of Illinois,[1] for entrusting him with the description of the material he collected.[2] The fossils evidently come from two sets of Upper Jurassic beds, and include a Callovian assemblage, preserved partly in a yellowish-brown limestone, partly as limonitic casts; further a Kimmeridgian series, the matrix of which is a glauconitic, sandy limestone of a greenish-grey colour. Six localities are represented and the specimens collected at each are listed and discussed in the concluding chapter of the present paper. Some of the ammonites have already been referred to in connection with descriptions, by the writer, of Jurassic faunas of Kachh, India, and of Somaliland, and while it will not be necessary again to go into a detailed comparison of the Jurassic ammonites of Madagascar with those of the African continent and of India, a discussion of the Madagascan forms described by Lemoine[3] and Newton[4] may prove of interest.

[1] Now of Montana State School of Mines, Butte, Montana.

[2] See Amer. Jour. Sci., Fifth Ser., vol. X, 1925, p. 1.

[3] "Ammonites du Jurassique Supérieur du Cercle d'Analalava (Madagascar)." Paléontologie de Madagascar, VIII. Annales de Pal., vol. V, 1910, pp. 1–32, pls. I–V; vol. VI, 1911, pp. 33 52, pls. VI–VIII.

[4] "Notes on Fossils from Madagascar, &c." Appendix to Baron: "Notes on the Geology of Madagascar." Quart. Journ. Geol. Soc., vol. XLV, 1889, p. 334. Also: "On a Collection of Fossils from Madagascar, &c." Ibid., vol. LI, 1895, p. 78.

II

SPECIFIC DESCRIPTIONS

A. ORDER AMMONOIDEA

Family *PHYLLOCERATIDÆ*, Zittel

Genus *PHYLLOCERAS*, Suess

Phylloceras aff. **disputabile,** Zittel

1852. *Ammonites tatricus,* Kudernatsch (*non* Pusch): "Die Ammoniten von Swinitza." Abhand. K. K. Geol. Reichsanst., vol. I, part 2, pl. I, figs. 1–4.

1869. *Phylloceras disputabile,* Zittel: "Bemerkungen über *Phylloceras tatricum* Pusch sp. und einige andere *Phylloceras*-Arten." Jahrb. K. K. Geol. Reichsanstalt, vol. XIX, pt. 1, p. 63.

This species is represented by an example (No. 7) of only about 40 mm. in diameter, somewhat corroded, but showing the suture-line, striation, and characteristic constrictions. In whorl-shape the example agrees more with the Tanganyika specimen figured by Dacque [1] than with the Kenya form, recorded by the writer as *Phylloceras* cf. *disputabile.*[2] Of Waagen's [3] Kachh examples, in the synonymy of which erroneous reference is made to Kudernatsch's figs. 4–6 of pl. I (= *Phylloceras kudernatschi,* Zittel, pars.), probably only one specimen, namely the original of pl. VI, fig. 3, can be attached to the present species. Through the kindness of Dr. E. H. Pascoe, Director of the Geological Survey of India, I have been able to study not only Waagen's types but some well preserved additional Kachh *Phylloceras* of the group to which *Ph. disputabile* belongs. Pending detailed description of these it may be briefly mentioned that the species represented by Waagen's figs. 1–2 differs from the typical *Ph. disputabile* in showing greater compression and more numerous constrictions which in the not very successfully drawn original of fig. 1 are wider than in the example of fig. 2. The constrictions are also more conspicuous across the venter in this flattened form than in the original of Waagen's fig. 3, and

[1] "Dogger und Malm aus Ostafrika." Betr. z. Pal. & Geol. Osterr.-Ung., vol. XXIII, 1910, p. 34, pl. V, figs. 3a–c.

[2] "On Jurassic Ammonites from East Africa, &c." Geol. Mag., vol. LVII, 1920, p. 318, pl. V, figs. 4a–d.

[3] "Jurassic Fauna of Kutch." I Cephalopoda. Mem. Geol. Survey India, Pal. Indica, Ser. IX, No. 2, 1875, p. 31, pl. VI, figs. 1–3.

the striation is finer. There are transitional forms, however, including the two *Phylloceras disputabile* recorded by myself [1] from bed No. 4 (of the Lower Chari Group) at Khera, Kachh, and it seems inadvisable at the present stage, to separate the two forms.

A second specimen (No. 1) in the present collection, rather poorly preserved, probably belonging to the flattened and more finely costate type above referred to, may be identical with the Madagascan form described by Lemoine [2] as *Phylloceras lodaense,* Waagen. In the Indian types of the latter species, the course of the radial line is far more sigmoidal.

Localities and Horizon. Ankidabé (localities I and II), Callovian, *macrocephalus* zone.

Phylloceras, sp. ind.

1910. *Phylloceras* sp. du groupe de *Ph. mediterraneum,* Neumayr; Lemoine: "Ammonites Jurassiques d'Analalava." *Loc. cit.,* p. 4, pl. I, fig. 4.

A small fragment of a cast (No. 28) without striation but a typical, deep rursiradiate constriction, probably belongs to the "Upper Oxfordian" form described by Lemoine as being extremely close to *Ph. mediterraneum* of the Callovian. Waagen's Indian examples [3] which are before me, together with other Kachh specimens, are probably not identical with the later species here discussed, as stated already by Lemoine. On previous occasions [4] I expressed

[1] "On the Blake Collection of Ammonites from Kachh, India." Mem. Geol. Survey India, Pal. Indica, New Series, vol. IX, No. 1, 1924, p. 22.

[2] "Ammonites du Jurassique Supér. d'Analalava." Pal. de Madagascar, VIII. Annales de Pal., vol. V, fasc. 4, 1910, p. 5, pl. I, fig. 2.

[3] Loc. cit. (1875), p. 34, pl. V, figs. 1a, b; pl. VII, figs. 3a–c.

[4] "Jurassic Ammonites from Jebel Zaghuan (Tunisia)." Quart. Journ. Geol. Soc., vol. LXIX, 1913, p. 561. Also: Geol. Mag. (loc. cit. 1920), p. 320.

doubt whether *Ph. mediterraneum* really persisted from the *macrocephalus* zone to the uppermost Jurassic, as is generally assumed. The present material, however, is insufficient for comparison with the Argovian forms recorded by de Riaz [1] and myself and the Kimmeridgian fragment described and figured by Canavari.[2]

Locality and Horizon. Antsalova, Kimmeridgian.

Family *HECTICOCERATIDÆ,* Spath [3]

This family is taken to include the genera *Hecticoceras,* Bonarelli (genotype: *Ammonites hecticus,* Reinecke, 1818, Mar. Prot. Naut. et Argon., &c., pl. IV, fig. 37) and *Lunuloceras,* Bonarelli (genotype: *Ammonites lunula,* Zieten, 1830, Verst. Würt., pl. X, fig. 11). The latter is earlier than *Hecticoceras* and cannot therefore be considered to be a subgenus of *Hecticoceras.* The genus *Brightia,* Rollier (genotype: *B. nodosa,* Quenstedt sp. = *Ammonites hecticus nodosus* Quenstedt: Amm. d. Schwäb. Jura, 1887, pl. LXXXII, fig. 10) also belongs to this family, further *Hecticoceratoides,* Spath (genotype: *H. suborientalis,* Spath = *Oppelia orientalis,* Waagen, *non* d'Orbigny sp.; Pal. Indica, 1875, pl. XI, fig. 5). This was described as probably a development of the "*subpunctata* [4] group of *Hecticoceras*" and since the latter genus must now be restricted to the group of evolute forms with typical *hecticus* ornamentation, it is necessary to separate with a new name: KHERAITES gen. nov.,[5]

[1] "Description des Ammonites des Couches à *Peltoceras transversarium* de Trept (Isère)." 1898, p. 40, pl. XVI, figs. 9, 10.

[2] "Fauna degli Strati con *Aspidoceras acanthicum* del Mte. Serra." Pal. Ital., vol. II, 1896, p. 38.

[3] "The Ammonites." Part VII of J. W. Gregory's: "Somaliland." Monographs of the Hunterian Museum, Glasgow, 1924, p. 114.

[4] This name was used in error without being marked as new and explained.

[5] Genotype: *Harpoceras crassefalcatum,* Waagen, loc. cit. 1875, pl. XII, figs. 6, 6a.

the forms grouping themselves round "*Harpoceras*" *crassefalcatum*, Waagen, and K. SUBPUNCTATUS, sp. nov. (= "*Harpoceras*" *punctatum*, Waagen *non* Stahl sp., *loc. cit.* pl. XII, fig. 9). These latter forms, however, never lose the keel entirely, whereas *Hecticoceratoides* develops an almost subconcave periphery, with costation continuous across it, in the form of forwardly directed chevrons. The genus *Putealiceras* S. S. Buckman (genotype: *Ammonites putealis*, Leckenby, 1859, Quart. Journ. Geol. Soc., vol. XV, pl. II, fig. 3; S. S. Buckman: Type Ammonites, vol. IV, 1922, pl. CCXCVII) which includes such rectiradiate Kachh species as "*Harpoceras*" *trilineatum* Waagen,[1] also belongs to this family *Hecticoceratidæ*.

Genus *LUNULOCERAS* Bonarelli

Lunuloceras cf. **lunuloides** (Kilian)

1887. *Ammonites hecticus compressus*, Quenstedt: "Ammon. d. Schwäb. Jura," pl. LXXXII, figs. 31–32.
1911. *Hecticoceras lunuloides* (Kilian) Tsytovitch: "*Hecticoceras* du Callovien de Chézery." Mém. Soc. Pal. Suisse, vol. XXXVII, p. 70, pl. VIII, fig. 7 ?

Four immature examples (Nos. 19, 21–23) with smooth inner areas and fine and close crescents on the outer half of the sides may be tentatively referred to this species though it is very doubtful whether they are identical. The largest of the specimens has a diameter of only 16 mm.

Localities and Horizon. Ankidabé (localities III and IV), *anceps* zone ?

Genus *HECTICOCERAS*, Bonarelli

Hecticoceras, sp. juv. ind.

A small ammonite (No. 17) and the fragment of another (No. 17a) represent the inner whorls of forms like *Hecticoceras svevum* Bonarelli, as figured by Mlle. Tsytovitch.[2] The ventral area is still rounded and the keel is

[1] Loc. cit. (1875), p. 71, pl. XIII, figs. 2a, b.

[2] Loc. cit. (1911), p. 51, pl. V, fig. 7.

hardly visible at the diameter of 14 mm., but the umbilicus is perhaps less open in the Madagascan examples than in the Württemberg types figured by Quenstedt.[1]

Locality and Horizon. Ankirihitra (locality V), Callovian, *anceps* zone ?

Family *BONARELLIDÆ*, Spath [2]

This family includes the genera *Bonarellia,* Cossmann (= *Distichoceras,* Munier-Chalmas; genotype: *B. bicostata* Stahl. sp. Corresp. Blatt. Württ. Landw. Ver., vol. VI, 1824, p. 49, fig. 9), *Horioceras,* Munier-Chalmas (genotype: *Amm. baugieri,* d'Orbigny, 1846, Pal. Franç., Terr. Jurass., p. 445, pl. CLVIII, figs. 5–7) and *Chanasia,* Rollier (genotype: *Hecticoceras chanasiense,* Parona and Bonarelli, "Faune du Callov. Inférieur de Savoie," Mém. Acad. Sci. Savoie (4), vol. VI, 1897, p. 134, pl. IV, fig. 2), also the new genus SINDEITES, gen. nov., proposed for a stock that has affinities with *Chanasia* as well as with *Hecticoceratoides.* Its resemblance to the latter is indicated by the inclusion, by Waagen, in his *Oppelia orientalis* (*non* Sowerby) of a doubtful, small, Kachh example (Waagen's fig. 6 of pl. XI, and figs. 8, 8a, b of pl. XII) which is distinguished from a new species of *Sindeites* before me, from Jessulmir, Sinde, India (B. M. No. C. 23545), chiefly by its rounded whorl-shape and retention of a keel. From *Bonarellia* and *Chanasia* the new genus differs in having more recticostate ornamentation and in not showing a subdivision of the lateral area into distinct inner and outer halves. The costation of the new form (and genotype) of *Sindeites* described below as *S. madagascariensis,* nov., almost resembles that of the outer whorl of *Peltoceratoides semirugosum* (Waagen).[3] In *Hecticoceratoides* also the

[1] Loc. cit. (1887), pl. LXXXII, figs. 3–5.

[2] Loc. cit. (Somaliland, 1924), p. 114. If it is considered that there was no need to change *Distichoceras* into *Bonarellia* (on account of supposed preoccupation by *Distichocera,* Kirby) the names *Distichoceratidæ* and *Distichoceras* will have to be substituted for *Bonarellidæ* and *Bonarellia* respectively.

[3] Loc. cit. (1875), p. 83, pl. XIV, fig. 1.

ribs are not rectiradiate and on the outer whorl at least they are not flattened as in the genera of the family *Bonarellidæ*.

Rollier [1] separated *Bonarellia* (including *Horioceras* as its supposed male), as an Oppelid stock, from *Hecticoceras* and its allies (comprising *Chanasia*) which were considered to be offshoots of a "Ludwigian" group. It is true that at least some of the Kachh forms comprised in Waagen's "*Oppelia subcostaria*" [2] (which I included in the genus *Alcidia*), are very close to *Chanasia* and thence to *Bonarellia*, but it seems more probable that *Bonarellidæ* are offshoots of *Hecticoceratidæ* (e. g. *Lunuloceras*). It also appears advisable to restrict the family to those genera in which the costæ show that peculiar flattening which is found again in the Lower Albian genus *Leymeriella* and to exclude del Campana's genus *Taramelliceras* (comprising the typically Callovian "*flexuosi*"), which with *Phlycticeras*, Haug, may be grouped in a family PHLYCTICERATIDÆ, nov.

Genus *CHANASIA*, Rollier

Chanasia, sp. juv. ind.

A small example (No. 20), fragmentary but well preserved and resembling similar limonitic casts from European localities, e. g., the "Ornatenthon" of Gammelshausen, Württemberg, can be attached to this genus. As its diameter is only 18 mm., specific determination is difficult, but *Ch. chanasiensis*, Parona and Bonarelli, above referred to, from the Callovian of Chanaz, Savoy, France, appears to be very close, though it is considerably less compressed.

Locality and Horizon. Ankidabé (locality IV), Callovian, *anceps* zone ?

[1] "Phylogénie des Ammonites." Eclogæ Geol. Helvet., vol. XVII, 1922, pl. XXII (table).

[2] Loc. cit. (1875), p. 48, pl. X, fig. 2, *non* fig. 1.

Genus *SINDEITES*, gen. nov.

Sindeites madagascariensis, sp. nov.

This form is based on a fragment (No. 24) showing only a portion of a septate whorl of 8.5 mm. height and 7 mm. thickness (fig. 6c, pl. I, magnified × 2) and less well preserved remains of the almost smooth next inner whorl. The sides are compressed, flattened; the whorl-section is subhexagonal, the venter subtabulate, with the median line elevated but not actually keeled. The ribs are almost rectiradiate, with distinct inner and outer tubercles and a median bulla, as indicated in fig. 6a, (pl. I). They are alternately long and short, the latter ending at the median tubercle. The outer portions of the ribs up to the peripheral clavus are flattened (see figs. 6a and 6d, pl. I). The suture-line is closely comparable to that of typical *Bonarellia* and of a new form of *Sindeites* (to be figured in the forthcoming Revision of the Jurassic Ammonites of Kachh) in which there is no trace of a keel, but costation across the ventral area as in *Kosmoceras* (pl. I, fig. 6b).

There is some resemblance to the form figured by Quenstedt[1] as *Ammonites* cf. *bipartitus,* Zieten, but its keel is distinct and the ribs have no median tubercle. On the other hand the vigorously ornamented *Hecticoceras fortocostatum,* Tsytovitch[2] from the Middle Callovian of the Hautes in the Jura, with a wide ventral area bearing three keels, appears to be a true *Hecticoceras.* The form referred by Petitclerc[3] as a variety *boginense* to *Hecticoceras hecticum* (Reinecke) also is not closely comparable to the form here described and, in any case, has a high keel.

Locality and Horizon. Ankidabé (locality IV), Callovian, *anceps* zone ?

[1] Loc. cit. (1887), pl. LXXXII, fig. 14.

[2] Loc. cit. (1911), p. 38, pl. II, figs. 10, 11.

[3] "Faune du Callovien du Department des Deux Sèvres." Contrib. à l'Etude des Terr. Jurass. dans. l'W. de la France, Vesoul, 1915, p. 26, pl. I, fig. 4, pl. XIII, fig. (4) 33.

Family *HAPLOCERATIDÆ* Zittel emend. Spath

Genus *HAPLOCERAS* Zittel

Haploceras elimatum (Oppel) Plate I, Figs. 1a–c

1868. *Ammonites elimatus,* Oppel; Zittel: "Cephalopoden der Stramberger Schichten," Pal. Mitteil. Mus. K. Bayer Staates, vol. II, pt. 1, p. 79, pl. XIII, figs. 1–7.
1924. *Haploceras deplanatum* (Lemoine, *non* Waagen) Spath: loc. cit., Pal. Indica, p. 6.
1924. *Haploceras elimatum* (Oppel) Spath: loc. cit. Monogr. Hunterian Museum, p. 160.

This form is represented by eight examples (Nos. 35–42) of which three are here figured. It seems probable that Lemoine's *"Lissoceras" deplanatum*[1] which was before him in a large number of specimens, is not identical with Waagen's Indian type. The latter is even more compressed than the figure,[2] whereas Lemoine considered the section of his Madagascan form to be very close to that of Uhlig's *Haploceras indicum.*[3] In the examples here described the umbilical border most decidedly marks the region of greatest whorl-thickness as in Zittel's Stramberg and Koniakau examples.

Locality and Horizon. Antsalova, Kimmeridgian.

Family *MACROCEPHALITIDÆ,* S. S. Buckman

Genus *MACROCEPHALITES* (Sutner MS.) Zittel

Macrocephalites aff. **madagascariensis,** Lemoine. Plate I, Fig. 7

1911. *Macrocephalites macrocephalus* (Rein.) race *noetlingi,* Lemoine, Ann. Pal. *loc. cit.,* p. 31, pl. III, fig. 3.
1911. *Macrocephalites madagascariense,* Lemoine, *ibid.,* p. 51.
1924. *Macrocephalites madagascariensis* (Lemoine) Spath: Pal. Indica, *loc. cit.,* p. 7.

The example (No. 2) of which the outline section is

[1] *Loc. cit.* (1911), p. 13, fig. 8 on p. 14.

[2] Waagen, loc. cit. (1875), pl. XI, fig. 9. (The inner whorl in fig. 9b is wrongly restored, i. e., too inflated.)

[3] "Fauna of the Spiti Shales." Mem. Geol. Surv. India, Pal. Indica, Ser. XV, Himalayan Fossils, vol. IV, fasc. 1 (1903), p. 21, pl. III, fig. 2.

here figured (pl. I, fig. 7) is completely septate and it is believed that the more rounded periphery shown in Lemoine's figure, as in all the Indian forms of the *formosus* group, characterises only the larger and outer whorls. In its whorl-section the present example closely resembles typical European examples of *M. macrocephalus* (Schlotheim), e. g. a Chanaz specimen in the British Museum (No. C. 10564).

Locality and Horizon. Ankidabé (locality I), Lower Callovian, *macrocephalus* zone.

Genus *PLEUROCEPHALITES*, S. S. Buckman

Pleurocephalites, sp. ind.

Five badly preserved examples (Nos. 3, 8, 12–14) seem to be referable to this genus, but exact identification is impossible. *Pleurocephalites folliformis,* S. S. Buckman [1] is more inflated. The largest of the Madagascan specimens has some resemblance to the Indian forms of the group of *Pl. ? grantanus* (Oppel) Waagen, and *Pl. ? chrysoolithicus* (Waagen),[2] but owing to its being crushed obliquely, and to its otherwise defective preservation, its identity with the other four examples must remain doubtful.

Localities and Horizon. Ankidabé (localities I [No. 3] and II [No. 8]) and Ankirihitra (Nos. 12–14). Lower Callovian, *macrocephalus* zone.

Genus *CATACEPHALITES*, S. S. Buckman

Catacephalites, sp. ind. Plate I, Figs. 3, 4

An example (No. 4) of which the whorl section is here figured (pl. I, fig. 4), unfortunately not well preserved, has costation resembling that of *Macrocephalites colcanapi* Lemoine [3] or of *Catacephalites durus,* S. S. Buckman.[4]

[1] Type Ammonites, vol. IV, 1922, pl. CCCXLVIII.
[2] Loc. cit. (1875), pls. XXXVI, fig. 6, and pl. XXX, fig. 1.
[3] Loc. cit. (1911), p. 33, pl. II, figs. 1, 2.
[4] Type Ammonites, vol. IV, 1922, pl. CCLXXXIII.

The suture-line represented in fig. 3, pl. I, was taken from a small example (No. 9) of only 13 mm. diameter, which has a similar whorl-section, but may not belong to the same species, and a third specimen (No. 11) is only a doubtful fragment.

Localities and Horizon. Ankidabé (localities I [No. 4] and II [No. 9]) and Ankirihitra (No. 11). Lower Callovian, *macrocephalus* zone.

Genus *KHERAICERAS*, Spath

Kheraiceras ? stansfieldi, sp. nov. Plate I, Figs. 2a, b

This species is based on a completely septate cast (No. 5) which may belong to a new genus, but is here attached to *Kheraiceras*, created [1] for the scaphitoid *Macrocephalites*, i. e. the so-called *bullati* of the Callovian. The type of *Kheraiceras* is *K. cosmopolita*, Parona and Bonarelli [2] (= *Stephanoceras bullatum*, Waagen *non* d'Orbigny sp.) and as the original example is now before me, it may be mentioned that Waagen's Indian form is even more depressed that Quenstedt's figures 21–23 of pl. LXXVIII (*"Ammonites platystoma,"* pars, *non* Reinecke) included in *K. cosmopolita* by Parona and Bonarelli, but that it has similar rectiradiate costation. In the Madagascan form, on the other hand, the ribs are very strongly prorsiradiate, the umbilical border is merely rounded, and the suture-line is extremely complex, finely divided, and interlocking, so that probably several distinct stocks within the *Macrocephalitidæ* produced these scaphitoid endforms that may eventually have to be separated. If the present form is now left in *Kheraiceras*, it is partly on account of insufficiency of comparable European material and partly because forms like *Kheraiceras ? platystomum* (Reinecke) [3] and *Kh. ? globulatum* (Quenstedt) [4] bridge the gap between the type of *Kheraiceras* and the present form.

[1] In Pal. Indica, loc. cit. (1924), p. 7.
[2] Loc. cit. (1897), p. 146.
[3] In Quenstedt, loc. cit. (1887), pl. LXXVIII, fig. 25.
[4] Ibid., fig. 2.

On the side of the Madagascan form *not* figured the remains of the umbilical suture of the (missing) outer whorl are visible, as indicated in fig. 2a, pl. I, by the white line. This is comparable to that shown in Quenstedt's fig. 1, pl. LXXVIII, but is even more eccentric. The suture-line is considerably more complex than that of *Kh. ? platystomum* (Reinecke) Quenstedt (pl. LXXVIII, fig. 25) and the saddles are deeply divided, whilst the second lateral lobe is less wide and the whole of the suture-line closely interlocking with the preceding and succeeding lines.

Kh. ? QUENSTEDTI, sp. nov. (= *Ammonites bullatus* Quenstedt *non* d'Orbigny [1]) also has a wider second lateral lobe and less individualized auxiliary elements of the suture-line, and a less strongly prorsiradiate costation, but comes close to the present species in whorl-shape. *Kh. ? globulatum* (Quenstedt) is much more inflated and differs in ribbing.

Excentrumbilicate shells somewhat similar to *Kheraiceras* were successively produced by *Sphæroceratidæ* and *Morphoceratidæ* in the Bajocian, and by *Tulitidæ* in the Bathonian (including the true *Ammonites bullatus* d'Orbigny) and correct identification of incomplete specimens is very difficult. The apertures of *Kheraiceras cosmopolita* and *Kh. ? quenstedt* have neither collar nor lip.

I have much pleasure in dedicating this species to Prof. J. Stansfield, its discoverer.

Locality and Horizon. Ankidabé (locality I), Lower Callovian, *macrocephalus* zone.

Family *PROPLANULITIDÆ*, S. S. Buckman, emend. Spath

Genus *GROSSOUVRIA*, Siemiradzki

Grossouvria, sp. ind. cf. **anomala** (Loczy)

? 1875. *Perisphinctes curvicosta* (Oppel) Waagen: Pal. Indica, *loc. cit.*, pl. XXXIX, fig. 5 (*non* 4–6).

1915. *Perisphinctes anomalus*, Loczy: "A Villanyi Callovien-Ammonitesek Monografiaja." Geol. Hungar., vol. I, p. 347, pl. VIII, figs. 8–11, pl. XIV, fig. 5.

A fragment (No. 10) is doubtfully referred to this

[1] Quenstedt, loc. cit. (1887), pl. LXXVII, figs. 7 and 8, as represented by a Neuffen specimen in the British Museum (No. 22366).

Lower Callovian form, but its mode of preservation is unsatisfactory. The rursiradiate character of the secondary costæ is pronounced but there are more single costæ than in Waagen's original of his fig. 5. It may be added that Loczy was misled by the incorrect drawings of Waagen's types. The three Indian forms are all different and only fig. 5 shows a peripheral aspect comparable to that of Loczy's fig. 10 (pl. VIII). The other two forms also differ considerably in whorl-section from the compressed form figured by Loczy (text—fig. 92, p. 346) as *Perisphinctes curvicosta.*

Locality and Horizon. Ankidabé (locality II), Callovian, *macrocephalus* zone?

Grossouvria ? cf. waageni (Teisseyre) Loczy sp.

? 1915. *Perisphinctes waageni,* Teisseyre; Loczy: Geol. Hungar., loc. cit., p. 356, pl. XIII, fig. 4.

A fragmentary example (No. 15), the whorl-section of which is figured (pl. I, fig. 10), may be tentatively attached to Loczy's *P. waageni* (*non* Teisseyre ?). Its umbilicus, however, may have been smaller since the outer whorl appears to have increased in thickness comparatively more rapidly. *Perisphinctes recuperoi* (Gemmellaro) Waagen [1] has finer secondary costation, also *P. waageni,* Teisseyre in Petitclerc.[2] The latter author's *P. cardoti,*[3] however, in coarseness of costation, resembles the form here discussed, but is too evolute and far too rounded-whorled.

Locality and Horizon. Ankirihitra. Callovian, *macrocephalus* zone ?

Grossouvria, sp. juv. ind.

1887. *Ammonites convolutus dilatatus,* Quenstedt: "Amm. des Schwäb. Jura," pl. LXXXI, figs. 1–9.

Three immature specimens (Nos. 18, 26, 27) probably

[1] Loc. cit. (1875), p. 172, pl. XLIII, fig. 1.
[2] Callovien des Deux Sèvres. II, 1915, pl. IX, fig. 1.
[3] Ibid., p. 64, pl. V, fig. 2, pl. XIII, fig. 2 (62).

belonged to forms of *Grossouvria* comparable to Quenstedt's species, but specific identification is impossible. The largest example has a diameter of only 16 mm. and is slightly more compressed and more closely costate than the smaller examples.

Localities and Horizon. Ankidabé (localities III and IV) Callovian.

Family *ATAXIOCERATIDÆ*, S. S. Buckman emend. Spath

Genus *TORQUATISPHINCTES*, Spath

Torquatisphinctes ? cf. bangei (Burckhardt) Plate I, Fig. 5

1921. *Perisphinctes (Aulacosphinctes) bangei*, Burckhardt: Faunas Juras. de Symon, &c. Bol. Inst. Geol. Mexico, No. 33, vol. II (Atlas), pl. IX, figs. 5–9.
1924. *Torquatisphinctes bangei* (Burckhardt) Spath: Pal. Indica, loc. cit., p. 15.

Four fragments of Perisphinctoid ammonites (Nos. 29–32), the whorl-section of one of which is here figured (pl. I, fig. 5), show great resemblance to the Mexican form from the Middle Kimmeridgian. Their reference to *Torquatisphinctes*, however, must remain uncertain. Some fragmentary *Lithacoceras*, another Middle Kimmeridgian genus, probably belonging to *L. ? andranosamontæ*, Lemoine, in the British Museum and included (with other forms) in Newton's *Perisphinctes polygyratus* (Reinecke),[1] are distinguished from the examples here described by their finer and tri- or multiplicate ribbing. Lemoine's "*Perisphinctes*" *colcanapi*,[2] with numerous constrictions, differs from the typical *Torquatisphinctes* and should perhaps be referred to *Subplanites* or to *Lithacoceras*, but is represented only by worn fragments (B. M. C. 3587a, C. 3580f).

Locality and Horizon. Antsalova, Kimmeridgian.

[1] Loc. cit. (Q. J. G. S., 1889), p. 334.
[2] Loc. cit., (1911), p. 43, pl. VIII, figs. 2a, b.

Family *PELTOCERATIDÆ*, Spath

Genus *PELTOCERAS*, Waagen

Peltoceras, sp. juv. ind.

A small fragment of a limonitic cast (No. 25) probably belongs to a form of *Peltoceras* but cannot be attached to any described species. The inner whorls of *Peltoceratoides*, at the same diameter are very finely costate. *P. madagascariense* Lemoine [1] does not belong to this genus, but is apparently an immature *Subdichotomoceras*. The fine and close costation of other small examples mentioned by the same writer and compared to *Amm. arduennensis*, d'Orbigny, and *A. eugenii*, Raspail, points rather to species of *Peltoceratoides*. On the other hand the same author's *Peltoceras* cf. *syriacum*, Noetling [2] may be close to the present form, though not Noetling's Argovian type [3] which like G. Boehm's *P. tjapalului* [4] is probably a *Peltoceratoides*. In the absence of outer whorls Peltoceratids are often difficult to distinguish.

Locality and Horizon. Ankidabé (locality IV), Callovian?

Family *SIMOCERATIDÆ*, Spath

Genus *HEMISIMOCERAS*, gen. nov.

This genus is established for the two Madagascan forms described below, *H. semistriatum*, nov. to be genotype. On a previous occasion [5] I referred to these forms as "peculiar (undescribed) Aspidocerates," but their resemblance to *Aspidoceratidæ* is probably quite superficial and based on the resemblances of the cross-section to that of typical

[1] Loc. cit. (1911), p. 14, pl. VII, fig. 2 (*non* 1!).
[2] Ibid., p. 15, pl. V, figs. 3a, b.
[3] "Der Jura am Hermon." 1875, p. 31, pl. V, fig. 3 only. The external saddle of this form is extremely wide and the suture-line differs also in the umbilical elements.
[4] "Beitr. z. Geol. v. Niederländ.-Indien." Pal. Suppl. (1904–7), pl. XXIX, figs. 2a–b, 3.
[5] Loc. cit. (Pal. Indica, 1924), p. 6.

forms of *Aspidoceras,* although there is also similarity in suture-line. *Sutneria,* another somewhat similar genus, though having a reduced suture-line, shows a change in ornamentation comparable to that noticed in the new forms here described, namely from merely costate or striate to tuberculate. Comparison with this genus is difficult, because both the Madagascan species are septate casts and there is no indication of a modified body-chamber. It seems possible, of course, that like *Sutneria* the new genus is an abnormal offshoot of some regular, perisphinctoid, stock, though here the resemblance ends. Both the new forms show peculiar, deep, prorsiradiate constrictions, especially where the striate ornamentation definitely changes to a tuberculate one. At the same time the whorl-thickness increases abruptly (after the deep constrictions). This points to affinity with *Simoceratidæ,* especially those early forms like *Pseudosimoceras,* Spath, which were at one time included in *Holcostephanus.* In a specimen of *Simoceras volanense* (Oppel) from Catria, Apennines (B. M. No. C. 8365) agreeing with the inner whorls of Zittel's[1] type-figure but in a better state of preservation, there can be seen the perisphinctoid inner whorls, resembling in ornamentation and whorl shape such a *Pseudosimoceras ?* as e. g. "*Perisphinctes acer*" (Neumayr). Peripheral tubercles, however, soon appear on the ribs and at a diameter of 15 mm. already, these become more blunt and distant, until finally (at 35 mm.) only very indistinct ribs but strong outer tubercles remain. The inner tubercles appear only at still larger diameters. The suture-line of *Simoceras volanense* does not show a dependent umbilical lobe, but other Simoceratids and especially *Pseudosimoceras* have suture-lines closely comparable to those of the forms here described. Since the present species, however, are quite unlike any forms previously described and so far are known

[1] "Fauna d. Alt. Cephalopoden-führenden Tithonbildungen." Palæontgr. Suppl. 1870, pl. XXXII, fig. 7.

in only two entirely septate specimens, the reference of the new genus to the family *Simoceratidæ* must remain tentative. For the same reason a Middle Kimmeridgian age is assigned to these forms merely on the strength of the associated ammonites.

Hemisimoceras semistriatum, sp. nov. Plate I, Figs. 8, b, text—Fig. 1

The holotype has dimensions 42–.30–.36–.45.[1] The inner whorls are depressed, subcoronate, with subtuberculate primary ribs and very faint and fine secondary ribbing across the broad and almost flat ventral area. Later the whorl-section becomes less depressed, with wider sides and longer primaries bearing a faint tubercle at the point of involution. Then the whorls become rounder, though remaining wider than high, the primary costæ almost disappear and only uniform single striæ remain, somewhat lytoceratid, with only at intervals a single tubercle near the ventral part of the lateral area (only developed on the side not figured). These tubercles remain and become increasingly conspicuous, whilst all striation disappears. The primary ribs, leading from the tubercles towards the umbilical suture, tend to reappear on the outer whorl.

The suture-line is characterized by its trifid lateral lobe and dependent umbilical lobe. Its saddles are less slender than those of the comparable suture-line of "*Perisphinctes*" *acer* Neumayr.[2]

[1] Diameter in mm.; whorl-height, thickness and umbilicus in percentages of the diameter.

[2] As figured in Canavari's: "Fauna d. str. con *Aspidoceras acanthicum* di Mte. Serra." Pal. Ital., vol. III (1897), p. 209, text—figs. 17, 18.

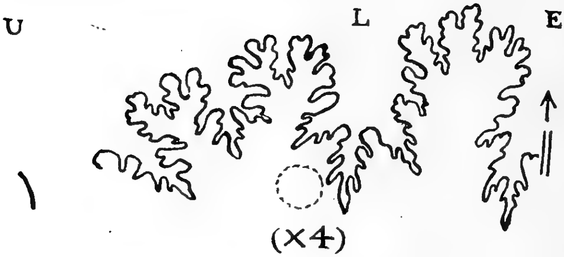


FIG. 1. *Hemisimoceras semistriatum,* gen. et sp. nov. Middle Kimmeridgian, Antsalova. Suture-line (× 4) near end of outer whorl. E = external lobe; L = lateral lobe; U = umbilical suture. (Compare fig. 8a, pl. I.)

Locality and Horizon. Antsalova, Kimmeridgian.

Hemisimoceras nodulosum sp. nov. Plate I, Figs. 9a, b

This species is closely allied to that last described but cannot be included with it. While whorl-shape and suture-line are very similar, the present species differs from *H. semistriatum* in showing a perisphinctoid type of ribbing to a diameter of 30 mm. where there is a deep constriction. The primary ribs then become distant and nodate at the outer ends, with four or five very faint secondaries to each, crossing the evenly rounded venter. The siphonal line is smooth on the last half-whorl. The costation of the earlier whorls resembles that of the forms of the *acanthicus* beds, figured by Canavari.[1]

Sutneria evoluta (Quenstedt) [2] had a flattened venter and if it is as close to *S. reineckeiana* as Quenstedt thought, its suture-line would be quite different from that of the present form. Costate forms of *Sutneria* like *S. galar*

[1] Loc. cit. (1897), pls. VII, VIII.
[2] Loc. cit. (1888), pl. CXII, fig. 19.

(Oppel), *S. cyclodorsata* (Moesch) de Loriol,[1] and *S. nusplingensis* Fischer [2] suggest that the stock here described is derived from quite a different branch of perisphinctoids.

Locality and Horizon. Antsalova, Kimmeridgian.

B. ORDER NAUTILOIDEA

Genus *NAUTILUS*, Breyn

Nautilus cf. **calloviensis,** Oppel.

1875. *Nautilus calloviensis* Oppel. Waagen: Pal. Indica, loc. cit., p. 18, pl. III, fig. 2.

A poorly preserved specimen (No. 6) seems to agree with this species which was described as the "most common of all the Kachh nautili." Waagen's type is now before me and shows a similar whorl-shape.

Locality and Horizon. Ankidabé (locality I), Callovian.

Nautilus cf. **kumagunensis** Waagen.

1875. *Nautilus Kumagunensis,* Waagen, Pal. Indica, loc. cit., p. 19, pl. III, fig. 1.

A small and fragmentary specimen (No. 16) has a subsulcate periphery and the high umbilical wall of this species. *Nautilus hexagonus,* Sowerby, with a similar whorl-shape, has a wider umbilicus.

Locality and Horizon. Ankirihitra, Callovian.

C. ORDER BELEMNOIDEA

Genus *BELEMNOPSIS* Bayle

Belemnopsis, sp. ind.

1895. *Belemnites hastatus,* Blainville. R. B. Newton: "Fossils from Madagascar." Quart. Journ. Geol. Soc., vol. LI, p. 78 (pars.).
1921 ?. *Belemnites tanganensis* (non Futterer ?) Morand: Bull. Soc. Géol. France (4), vol. XX (1920), p. 158.

[1] "Monogr. Paléont. des Couches de la Zone à *A. tenuilobatus* de Baden." Mém. Soc. Pal. Suisse, vol. V, 1878, pp. 90–93, pl. XV, figs. 3–5.

[2] "Ueber einige neue oder in Schwaben bisher unbekannte Versteinerungen d. Weiss. & Braun. Jura." Jahresb. Ver. Vat. Vaturk. Württemb., vol. LXIX (1913), p. 54, pl. V, fig. 23.

Two fragmentary examples (Nos. 43, 44) are comparable to the majority of the specimens recorded by Newton (e. g. B. M. No. C 4925–6) but specific determination is probably impossible. Mlle. Morand recorded *Belemnopsis* cf. *semisulcatus* (Mstr.), *Bel tanganensis;* Futterer and *Hastites claviger* (Waagen), from blue shales at Andranosomonta, and mentioned that *B. tanganensis* occurred already at the horizon of the sandy limestones associated with lamellibranchs of the Inferior Oolite. The identifications undoubtedly require revision, and there may be no need to invoke the aid of faults to explain apparently anomalous superposition.

Locality and Horizon. Antsalova, Kimmeridgian.

III

CONCLUSIONS

The cephalopods described in the foregoing pages may be arranged in the following assemblages:

I. From "Hill approaching hollow west of and before reaching Ankidabé":

Phylloceras aff. *disputabile,* Zittel.
Macrocephalites aff. *madagascariensis,* Lemoine.
Pleurocephalites sp. ind.
Catacephalites sp. ind.
Kheraiceras ? stansfieldi sp. nov.
Nautilus cf. *calloviensis,* Oppel.

This is clearly a Lower Callovian fauna, from the *macrocephalus* beds (sensu lato).

II. From: "Coming down the Hill from Ankidabé, going towards Maevatanana":

Phylloceras aff. *disputabile,* Zittel.
Pleurocephalites, sp. ind.

Catacephalites sp. juv. ind.
Grossouvria cf. anomala (Loczy).

This assemblage is apparently of the same age as that of Locality I.

III. From 1 Km. East of Ankidabé:
Grossouvria sp. juv. ind.
Lunuloceras cf. *lunuloides* (Kilian).

A middle Callovian age may be suggested for these forms but they are immature and no definite conclusions could be based on them.

IV. From "Approaching Ankidabé, on trail to Maevatanana":
Chanasia sp. juv. ind.
Lunuloceras cf. *lunuloides* (Kilian).
Sindeites madagascariensis sp. nov.
Peltoceras sp. juv. ind.
Grossouvria sp. juv. ind.

This assemblage also is probably of Middle Callovian age (*anceps* zone in the wider sense) but again consists merely of small and indefinite examples.

V. From "1 hr. East of Ankirihitra":
Pleurocephalites sp. ind.
Catacephalites ? sp. ind.
Grossouvria ? cf. *waageni* (Teisseyre) Loczy sp.
Nautilus cf. *kumagunensis*, Waagen.
Hecticoceras sp. juv. ind.

The first four forms are probably from the "*macrocephalus* beds," like those of localities I and II; the last, resembling the small limonitic casts from III and IV, may tentatively be grouped with the Middle Callovian (*anceps* zone).

VI. Near Antsalova:
Phylloceras sp. ind. (*mediterraneum* group).
Haploceras elimatum (Oppel).
Torquatisphinctes ? cf. *bangei* (Burckhardt).
Hemisimoceras semistriatum gen. et sp. nov.

Hemisimoceras nodulosum sp. nov.

Belemnopsis sp. ind.

This assemblage is probably of the Middle Kimmeridgian age, and would have been included in the "zone of *Amm. acanthicus*" or "Lower Tithonian" of the older authors. There is no evidence for definite reference of this fauna to one of the three corresponding zones previously listed for the Middle Kimmeridgian.[1] It is probable that it differs from Middle Kimmeridgian faunas of Kachh and Somaliland because the exact subzone or horizon to which the Madagascan forms belong is not represented in India or on the African continent; but Toucas's "Diphyakalk" of the South of France [2] which includes both *Haploceras elimatum* (the commonest ammonite in the present collection) and similar perisphinctoids may possibly comprise a corresponding and as yet undefined horizon. No zonal collecting, unfortunately, has been done in Mediterranean countries, and the more detailed subdivision of the geological time-scale given in previous papers [3] must remain somewhat speculative.

Considering, however, for the present only the larger zones, it is clear that the Jurassic sequence of Madagascar must be very incomplete.[4] Of Lemoine's list of Madagascan species, forms not already referred to above include notably *Reineckeia anceps, Obtusicostites,* and *Kinkeliniceras,* which were recorded by Waagen and myself from the Middle Callovian (*anceps* zone) of Kachh, India; further *Hildoglochiceras kobelli* (Oppel) which is an important Middle Kimmeridgian form, occurring in the Spiti shales as well as Kachh and Tanganyika. But Lemoine also re-

[1] Spath, loc. cit. (Somaliland, 1924), p. 158.

[2] See Spath: "Ammonites from New Zealand," Quart. Journ. Geol. Soc., vol. LXXIX (1923), p. 305, and loc. cit. (Somaliland, 1924), p. 160.

[3] Loc. cit. (New Zealand, 1923), p. 304 and Somaliland, 1924, p. 158.

[4] See also Spath, loc. cit. (Somaliland, 1924), p. 160.

cords a number of more doubtful forms, like *"Oppelia,"* *Lytoceras rex,* and some *Phylloceras,* which may indicate the presence of Oxfordian beds, and above all some *Mayaites* (*"Macrocephalites"* of the group of *"M." maya* and *"M." transiens,* Waagen), and *Dhosaites* (including his *"Macrocephalites" elephantinus* Waagen). These indicate beds of Argovian age. Some comparable examples in the British Museum, recorded in two papers by Mr. R. B. Newton, have already been referred to on a previous occasion.[1] The example figured in Newton's pl. XIV, figs. 1–2 (loc. cit. 1889) collected by the Rev. J. Richardson, is not in the Baron Collection in the British Museum. The *Stephanoceras macrocephalus, St. herveyi,* and *St. calloviense,* are poorly preserved, in a peculiar reddish, soapy matrix, and are probably Argovian *Mayaites* and *Dhosaites,* and not Callovian Macrocephalitids. Another specimen, from North of Andranosamonta (B. M. No. C. 3586) preserved in a sandy limestone of a light colour, I have previously described as possibly a new globose form of *Dhosaites,* with the blunt ribs that characterise the (equally Argovian) genus *Tornquistes.*

An example of *Haploceras elimatum* (B. M. No. C. 3585b) and an indeterminable fragment of a *Phylloceras* (B. M. No. C. 3585a) were not referred to by Mr. Newton. Among his twelve fragments of *"Perisphinctes polygyratus* (Reinecke) those that can be determined are referable to *Lithacoceras ? andranosamontæ* (Lemoine) (B. M. Nos. C. 3588*a* and *c*), *L.?* cf. *colcanapi* (Lemoine) (B. M. No. C. 3587a, 3588f) and doubtful *Subdichotomoceras* (C. 3587*b*, 3588*e*). The *"Perisphinctes* sp. (probably allied to *P. polygyratus,* Rein.)" recorded by Mr. Newton in 1895[2] I have previously[3] described as a *Lithacoceras* of the group of *L. eystettense—fruticans* (Schneid).

[1] Spath, loc. cit. (Pal. Indica, 1924), p. 10.
[2] Loc. cit. (Q. J. G. S., 1895), p. 78.
[3] Loc. cit. (Somaliland, 1924), p. 160.

There is, then, nothing yet recorded that would definitely indicate the presence, in Madagascar, of the Upper Callovian, the Divisian, a good deal of the Argovian, the Lower and Upper Kimmeridgian, and, of course, the uppermost Jurassic (Portlandian and Tithonian). Whilst it is improbable that the Jurassic succession of Madagascar is more complete than that of other areas and some gaps are expected, it might yet be claimed that the absence of e. g. Callovian Cosmoceratids or Argovian Cardioceratids is due to differences of "province" and not to the non-representation of strata of those ages. The discovery recently of Virgatitids in Somaliland may justify the expectation that e. g. Cosmoceratids also may yet be found in more southern deposits if there are anywhere beds that contain the true *Peltoceras athleta* and its zonal associates.

Perisphinctoids, however, are still the commonest and often only representatives of Oxfordian faunas and offer great difficulty in specific identification. Reference also has already been made to some doubtful Oppelids, recorded by Lemoine, so that the probable gaps in the Madagascan sequence, in the present state of our knowledge, cannot be definitely indicated.

In conclusion, it may be repeated that when only strictly contemporaneous formations are compared, the question as to whether there is affinity with forms of the Indian or Mediterranean Provinces ceases to have importance. Haug [1] pointed to the presence of the peculiar Sequenziceratid genus *Bouleiceras* in Madagascar as possibly indicating a separate zoölogical province. The discovery, by the writer,[2] of a specimen of *Bouleiceras nitescens*, Theve-

[1] Traité de Géologie, vol. II, fasc. 2 (1907), p. 995.

[2] "Cretaceous Cephalopoda from Zululand." Ann. South Afr. Museum, vol. XII, part VII, No. 16 (1921), p. 272.

nin, in a Domerian-Toarcian collection from the Valley of Kelat, Baluchistan, dealt the death-blow to this speculative "province," as the record of Virgatitids, from Somaliland throws doubt on the value of the "Ethiopian Province" of Neumayr, Uhlig, Dacqué, and Krenkel. Upon the analogy between the Jurassic faunas of India and Madagascar. insisted on by Boule and Lemoine, more will be said in connection with the forthcoming revision of the Ammonite Fauna of Kachh.

EXPLANATION OF PLATE

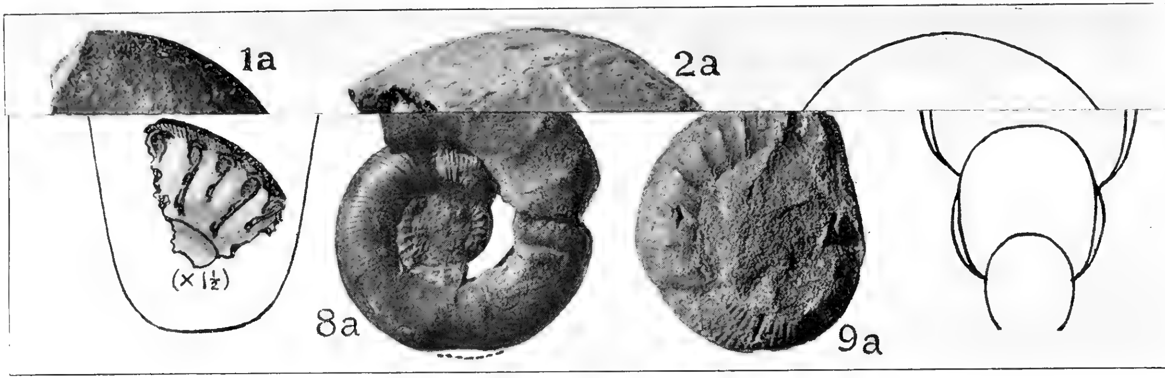
FIG. PAGE

1. *Haploceras elimatum* (Oppel). Middle Kimmeridgian, Antsalova. *a.* Side-view of a small example; *b.* septate fragment, showing suture-lines; *c.* peripheral view of another completely septate specimen 13
2. *Kheraiceras ? stansfieldi,* sp. nov. Lower Callovian, (*macrocephalus* beds) Ankidabé. *a.* side-view of holotype, with umbilical suture of (missing) outer whorl drawn in from traces on side not shown; *b.* sectional outline of outer whorl. 15
3. *Catacephalites* sp. ind. External suture-line (× 5) of a small specimen from near Ankidabé (*macrocephalus* beds). E = external lobe; L = lateral lobe; U = umbilical suture. The dotted lines represent the rib-curve. 14
4. *Catacephalites* sp. ind. Sectional outline of another example from the same bed. 14
5. *Torquatisphinctes ?* cf. *bangei* (Burckhardt). Middle Kimmeridgian, Antsalova. Sectional outline of a fragmentary example. 18

6*a, c, d.* *Sindeites madagascariensis* gen. et sp. nov. Callovian, Ankidabé. *a.* external suture-line (× 6); *c.* sectional outline (× 2); *d.* side view, diagrammatic (× 1½). . . . 10

6*b.* *Sindeites* sp. nov. Callovian, Jessulmir, Sinde, India. (British Museum, No. C. 23545.) External suture-line (× 5) for comparison with fig. 6*a.* 10

7. *Macrocephalites madagascariensis,* Lemoine. Lower Callovian, nr. Ankidabé. Sectional outline of a completely septate specimen. 13
8. *Hemisimoceras semistriatum* gen. et sp. nov. Middle Kimmeridgian, Antsalova. *a.* side-view; *b.* peripheral view of holotype (genotype). 21
9. *Hemisimoceras nodulosum* sp. nov. Same locality and bed. *a.* side-view; *b.* peripheral view of holotype. 22
10. *Grossouvria ?* cf. *waageni* (Teisseyre) Loczy sp. Callovian, Ankirihitra. Sectional outline of a fragmentary example. 17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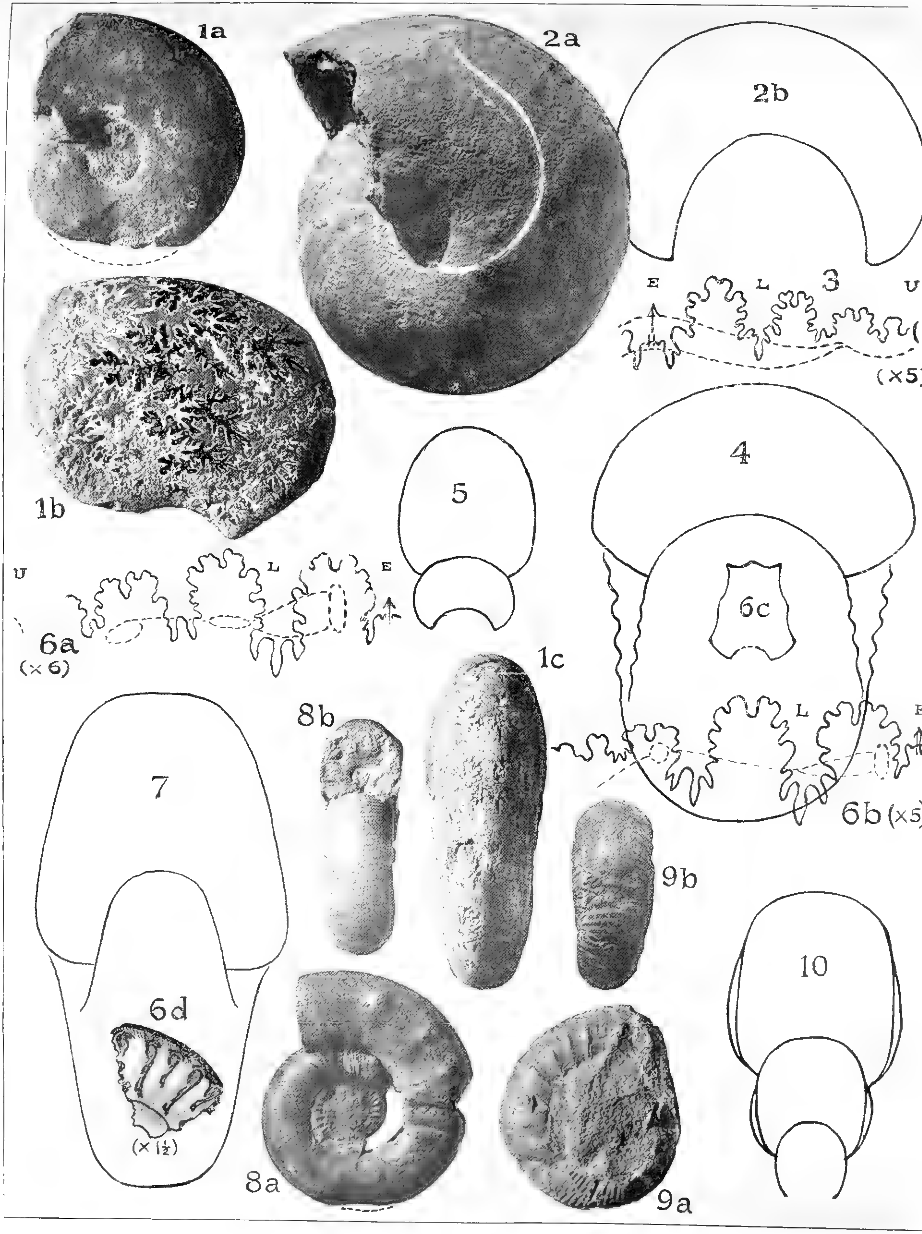
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CONTENTS AND PRICE LIST

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BULLETINS

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VENEZUELAN AND CARIBBEAN TURRITELLAS

With a List of Venezuelan Type Stratigraphic Localities

(*Presented to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy*)

By

FLOYD HODSON, A. M.

June 17, 1926

Harris Co.

Cornell University, Ithaca, N. Y.

U. S. A.

INTRODUCTION

This article is based on more than two years of field work in Venezuela unraveling the stratigraphy and paleontology of certain areas for one of the American companies operating in that country. We propose here to describe some of the new material collected during this investigation with general reference to type localities and general age determination.

At some future time when the interests of the company for whom the work was done permit, we hope to publish more definite information as to the exact locatity of each collection, the type sections, and the stratigraphic range and age determination of the species described.

Stratigraphic Formations and their Type Localities

The formations which we have found it convenient to use are recorded in alphabetical order and the type locality for each is indicated:

1. *Agua Clara series:* Chiefly black clay-shale. Type locality—around Agua Clara, District of Democracia, State of Falcón, Venezuela.

2. *Cerro Pelado series:* Alternating conglomeratic sandstones, black shales, and coals. Type locality—Cerro Pelado range, Districts of Democracia and Miranda, State of Falcón.

3. *Codera formation:* Variegated clays and sands. Type locality—just south of Codera de Dentro, District of Democracia, State of Falcón.

4. *Damsite series:* Chiefly limestones, clays and soft sandstones. Type locality—Damsite at Caujarao, south of Coro, on Río Coro, District of Miranda, State of Falcón.

5. *El Paraíso shales:* Black shales with interbedded coals and quartzitic sandstone layers. Type locality—El Paraíso, in Quebrada El Paraíso, District of Bolívar, State

of Falcón.

6. *Guarabal conglomerates:* Conglomeratic sandstones, black shales and siliceous limestones. Type locality—just southwest of Guarabal, south of Coro, on the Coro-San Luis trail, District of Miranda, State of Falcón.

7. *La Puerta series:* Variegated, gypsiferous clays and sands. Type locality—La Puerta, southeast of Dabajuro, District of Buchivacoa, State of Falcón.

8. *La Vela series:* Variegated, gypsiferous clays and sandstones; the latter are sometimes conglomeratic. Type locality—In Río or Quebrada La Vela (also called Mataruca) about one mile northeast of La Vela de Coro, District of Colina, State of Falcón.

9. *Misoa Trujillo series:* Massive sandstones, frequently conglomeratic, interbedded with black shales. Type locality—Misoa Trujillo ranges, in eastern part of State of Zulia.

10. *Querales shales:* Chiefly black clay-shales with some sandstone members. Type locality—Querales, (southwest of Sabaneta), District of Miranda, State of Falcón.

11. *Patiecitos series:* Conglomeratic sandstones, black shales and siliceous limestones. Type locality—Quebrada de Los Patiecitos, near Las Alambiques, on the Coro-Cabure trail, Districts of Petit and Miranda, State of Falcón.

12. *Paují shales:* Chiefly black shale with interbedded dense sandstone layers. Type locality—Río Paují, eastern part of State of Zulia. (Paují shales of authors in part).

13. *San Luis series:* Foraminiferal limestones, interbedded with shales and sandstones; limestones and sandstones often conglomeratic. Type locality—San Luis range at point where the Coro-Cabure trail crosses it, District of Petit, State of Falcón.

14. *Socorro series:* Gypsiferous sandstones and variegated gypsiferous clay-shales. Type locality—Socorro, south of Urumaco, District of Democracia, State of Falcón.

ACKNOWLEDGMENTS

Mr. S. H. Williston, of the Venezuelan Sun Company, brought his collection of Falcón fossils to Cornell University and described them here in the summer of 1923. His manuscript was not published, but where feasible, we have redescribed his species using his name and have given him credit for the species. Where possible, we have quoted his exact descriptions, but in most cases, due to our much larger collections, we have been able to supplement his work. In the cases where we have figured his specimens, acknowledgment is given in the explanation of plates.

Among the many people to whom acknowledgments are due for help and suggestions in this work, the following deserve special mention:

Professor G. D. Harris, for help in the field and in his splendid laboratory at Cornell University where there are extensive collections and library facilities for the study of the Tertiary formations of the Western Hemisphere.

Among the geologists to whom we are grateful for collections and help are Messrs. B. Hubbard, R. A. Liddle, C. R. Nichols, A. Andreas, Jr., W. A. Argabrite, L. G. Weeks, A. L. Owens and P. O. Olcott.

My assistant, during the latter half of the field work, Mr. G. A. Weaver, was invaluable in the instrument and map work.

Above all, I am indebted to my wife for invaluable aid in the field and in the laboratory, as well as in checking my work and manuscript.

TURRITELLA HOLOTYPES

The following holotypes are figured in this Bulletin:

LECTOTYPE

The following lectotype is figured:

DESCRIPTIONS OF SPECIES

MOLLUSCA

CLASS GASTROPODA

Order	Ctenobranchiata	Schweigger
Suborder	Platypoda	Lamarck
Superfamily	Tænioglossa	Bouvier
Family	Turritellidæ	Gray
Genus	Turritella	Lamarck

Turritella zuliana, n. sp. Pl. 1, figs. 1–6; Pl. 2, figs. 2, 3, 5, 6.

Shell of medium size, with large apical angle; whorls with scalloped carinæ, very concave in adult stages. Protoconch consists of about 1½ smooth round whorls. First two nepionic whorls are sharply medially carinate, angularly convex and almost smooth; the next three nepionic whorls become less convex, of which the first 1½ whorls carry two strong spiral threads about equally spaced behind the keel; the next 1½ whorls show sub-microscopic spiral threads in addition to four primary spirals; the primaries include,—the two spirals posterior to the keel, the thread which forms the keel in earlier whorls, and a thread which is developed on the anterior of the whorl just behind the suture. The sides of the first neanic whorls are almost flat but soon become concave; the basal or first anterior primary cord rapidly increases in size and begins to form the carina which is so conspicuous in the larger whorls; the concave neanic whorls carry four, about equally spaced, strongly beaded, large spiral cords with weaker threads of varying strength appearing in the concave portion between the posterior and anterior spirals as well as behind the posterior cord.

The adult whorls are decidedly concave with a produced scalloped flange or carina decorated with a reticulate, superficial ornamentation which likewise covers the remaining surface of the whorls; the spiral ribbing in the concave portion is less pronounced and more subdivided; the sigmoidal, close-set, prominent growth lines are strongly retractive on the upper half of the whorl, swing forward to the edge of the keel and are again strongly retractive on the base of the whorls. The sutures are compressed and rather inconspicuous, except in the gerontic stages when a wide V-shaped depression may lead down to the suture. The keel or carina in the adult whorls usually projects out straight from the base, but frequently, even in the larger whorls of the same specimen, the keel may turn down anteriorly or up posteriorly or may be moved posteriorly from the base almost a third of the whorl length. In the latter case, the base of the keel is slightly concave and ornamented with numerous spiral threads.

This is one of the most ornate of our Venezuelan species. It does not bear a very close resemblance to any other form. The large, scalloped, knobby keel is very characteristic. This species is easily distinguished from the more slender *T. montañitensis* (n. sp.) by the much longer whorl lengths of the latter, as well as by an entirely different character of spiral ribbing in all stages.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Numbers: 6, 1140.

Turritella zuliana palmeri, n. subsp. Pl. 2, figs. 1, 4.

This subspecies is characterized by the more numerous (6–7) rather prominent, heavy, spiral cords instead of 4, the number of primary spirals usually found on the closely related species.

This increase in the number of spiral cords is probably due to the fact that the second anterior cord of *T. zuliana*

(n. sp.) became divided into two primaries and to the fact that some of the secondaries have increased in strength.

Named in honor of Dr. Katherine Van Winkle Palmer.

Age: Oligocene-Miocene.

Locality: States of Zulia and Falcón. Locality Numbers: 6, 1140, 2027.

Turritella larensis, n. sp. Pl. 3, figs. 1–5; Pl. 4, figs. 1, 2, 4, 5; Pl. 5. fig. 4.

This *Turritella* is very abundant, very variable, and seldom well preserved. In examining several hundred specimens, we have found great variations in all its features; to try to establish close varieties or subspecies from the many variations would be hopeless. A few subspecies have been made to mark the limit in variation of some particular feature. Intermediate forms are considered as intergradations between species and subspecies.

Shell is rather large, heavy, and keeled in adult stages. Protoconch and first nepionic whorls were not found; later nepionic whorls are almost flat or slightly convex, with one strong, sub-medial, spiral cord, which in some specimens is double due to the appearance of a cord of variable strength just posterior to it. Immediately behind the suture, there is a faint anterior spiral which rapidly increases in strength in the succeeding whorls; there is a strong upper spiral on the posterior fifth of the whorl; on each side of the medial spiral rib there is a concave interspace in which weaker spiral lines appear; the medial or posterior intercostal area rapidly increases in size and carries 2 or 3 smaller, beaded, secondary spirals and some tertiary threads. In the adult whorls, the weak, anterior, post-sutural spiral of the younger whorls becomes a wide flange or keel of varying width, ornamented with fine revolving threads.

The adult whorls are more or less concave and the sides are ornamented with 3–5 (usually 4) stronger, beaded, spiral ribs and weaker intervening spirals; the strong sigmoidal growth lines are retractive from the suture to the medial concavity, then curving forward, are protractive to the keel or carina and retractive on the base of the whorl; the superimposition of the growth lines over the spiral ribs forms beads or nodes on all the spiral cords; the finer superficial ornamentation has usually disappeared in slightly weathered specimens; the suture is overhung by the keel which generally projects more or less straight from the base of the whorl, but may turn up or down; if the keel turns up posteriorly, it is rounded on the base; if it droops anteriorly, it is concave on the base and tends to conceal the suture; although the keel may be very pronounced, it is regular in width and does not become scalloped as in *T. zuliana* (n. sp.); well preserved specimens show fine, superimposed, spiral threads on the keel.

It slightly resembles the pagoda-like *T. cauredalitoensis filensis* (n. subsp.) but is so different that a comparison is not worth while. It is much closer to *T. systoliata* Dall [1] from the Tampa silex beds and probably is derived from the same stock. The flange or keel on our specimens is more pronounced, the shape of the whorl and sculpture is somewhat different, but the *ensemble* shows a striking similarity.

It must be remembered that there are all degrees of variation between the species and its subspecies as well as between the subspecies themselves. The subspecies are established only to mark the limit of variation in certain directions.

Age: Oligocene-Miocene.

Locality: States of Lara, Falcón and Zulia. Locality Numbers: 10 (variation), 797, 811 (slender variation), 814 (with variations), 815, 822 (with variation), 1627 (and subspecies), 1760, 1761, 1940, 1955, 1958, 2018, 2019, 2019A, 2021 (and variations), 2022 (and variations), 2023 (and variations), 2024 (with variations), 2027, 2048

[1] W. H. Dall, Bull. 90, U. S. Nat. Mus., p. 99, Pl. 9, fig. 6, 1915.

(variation).

Turritella larensis santiagana, n. subsp. Pl. 4, figs. 3, 6; Pl. 5, fig. 2.

This subspecies differs in that in the later ephebic and gerontic stages it tends to lose its spiral ribbing and to become more nearly smooth. The whorls are concave and show more or less faint spiral striation even on weathered specimens. We are figuring a few intermediate forms to show its relation to the species, otherwise, it might be hard to believe that they belong to the same stock.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1760, 1761, 2019, 2023 (a variation), 2027, 2048.

Turritella larensis carrizalensis, n. subsp. Pl. 6, figs. 1, 3, 4.

This subspecies is characterized by having three very prominent primary spirals on the adult whorls; it is the antithesis of the new subspecies *guaratarensis* in respect to the number of strong primary cords; it is a very large heavy form, however, and the anterior primary spiral tends to develop into a strong keel. It is the limit in variation of the species toward a few, very strong, pronounced spiral cords on the sides of the whorl; this subspecies is generally very similar to the species, but tends to be slightly larger and to have larger spiral cords.

Age: Oligocene-Miocene.

Locality: States of Zulia and Falcón. Locality Numbers: 10, 1290, 1398 (?), 2022, 2023, 2027, 2048, 2049 (*cf.*).

Turritella larensis guaratarensis, n. subsp. Pl. 10, figs. 1, 3.

This subspecies is coarser and heavier in size and sculpture. The whorls are more nearly flat-sided behind the basal flange. The adult whorls usually carry 5 or more strong, primary, spiral ribs and several weaker spirals of varying strength.

This subspecies marks the limit in variation toward having a large number of heavy spiral cords and developing a heavy shell.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1938, 2021 (a variation), 2023, 2027.

Turritella robusta Grzybowski **fredeai,** n. subsp.
Pl. 5, figs. 1, 3; Pl. 6, figs. 2, 5; Pl. 7, figs. 1, 6, 7; Pl. 9, fig. 7; Pl. 28, fig. 6.

The characteristics of *T. robusta* Grzybowski from Peru have been well reviewed by Spieker.[1] Our form is very closely related to this species, but is easily distinguished by the flatter, straighter-sided whorl behind the keel and by the much larger size of the shell. Depending on the size of the whorl, there are 6–9 spiral cords of varying strength and spacing behind the sharp keel; behind the anterior suture, there are 3 pre-carinal cords in the younger whorls; but in the large adult whorls there are 3 or 4 strong spirals with several weaker intervening ones in well preserved specimens. Behind the keel the growth lines are nearly straight, running diagonally from the posterior suture almost to the keel where they curve and take a vertical direction to the anterior suture; on the base of the whorl they are slightly protracted and cross about a dozen spiral threads of varying strength, giving a faint reticulate ornamentation. The pre-carinal spiral cord adjacent to the suture is rather faint in the younger whorls, but in the larger adult whorls it becomes very strong and produces a prominent shoulder which projects over the suture.

Named in honor of Mr. M. F. Fredea, of the Standard Oil Company of Venezuela, who collected some of our largest specimens.

[1] E. M. Spieker: The Paleontology of the Zorritos Formation of the North Peruvian Oil Fields, pp. 84–85, Pl. IV, fig. 5. The Johns Hopkins Press, 1922.

This subspecies somewhat resembles *T. larensis* (n. sp.) and its subspecies, but is easily distinguished by the flat straighter sides of the whorl behind the keel and by the straight growth lines. It attains a much greater size than any of the other Venezuelan species.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 70A, 70C, 72, 72C, 81, 83, 84, 86, 87, 90, 100, 149A, 149B, 169A, 210, 215, 307, 1233, 1398, 1600, 1856, 1875, 1892, 1928.

Turritella hubbardi, n. sp. Pl. 7, figs. 2–5; Pl. 8, figs. 1–6; Pl. 9, figs. 1, 5, 6.

Shell rather small, turreted, with two, strong, equal or subequal, basal, carinating, spiral cords, and a weaker primary spiral near the top of the whorl in the neanic and later stages. Between the upper spiral and the posterior basal cord, except in the youngest whorls, there is a pronounced concavity in which lie two secondary and one or more tertiary spiral threads. No protoconch was found; the nepionic whorls carry a prominent medial rib which develops into the posterior basal carina; also, a weak rib is present or suggested adjacent to the anterior suture and another one on the upper fourth of the whorls. In well preserved specimens, the whole surface of the shell is highly ornamented by numerous, strong, sub-microscopic, spiral lines, and crossed by prominent growth lines which cause transverse nodes or prominences on all the spiral cords; in the larger whorls, the strength of the nodes increases and the stronger carinæ have a decidedly beaded appearance; the strong growth lines have only a moderate curve on the posterior portion of the whorls. The nepionic portion of the shell is smoother and less ornate. The suture is not conspicuous and is slightly overhung by the anterior basal carina; the carina is ornamented with conspicuous, spiral, sub-microscopic lines (which are less strong near the suture) and crossed by forward swinging growth lines.

The ornamentation of this *Turritella* is somewhat similar to that of *T. zuliana* (n. sp.) and *T. gilbertharrisi* (n. sp.). This species is very easily distinguished from *T. zuliana* which has a wide, scalloped, basal keel, and from *T. gilbertharrisi* which has less concave whorls and a more aciculate spire. The two, strong, equal or subequal, basal cords easily distinguish this species from other Venezuelan Turritellas.

The holotype is a fragment of about 5½ whorls which measures about 3 mm. at the upper suture of the uppermost whorl and 3.7 mm. through the middle of it; maximum diameter of the largest whorl is about 8.8 mm.; the greatest length of the fragment is 22 mm.

Named in honor of Dr. B. Hubbard, Chief Geologist of the Standard Oil Company of Venezuela.

Age: Oligocene-Miocene.

Locality: Rather common in District of Buchivacoa, State of Falcón. Locality Numbers: 15, 16, 25, 1216, 1629, 1762 (*cf.*), 1943 (*cf.*), 2018, 2019, 2019A, 2040.

Turritella hubbardi weeksi, n. subsp. Pl. 8, fig. 7; Pl. 10, figs. 4, 5.

This subspecies differs in having a tendency to double the uppermost, primary, spiral cord; also, the posterior of the two basal carinæ becomes weaker in the adult whorls.

Named in honor of Mr. L. G. Weeks, Geologist for the Standard Oil Company of Venezuela, who helped collect the material.

Age: Oligocene-Miocene.

Locality: States of Zulia and Falcón. Locality Numbers. 2018, 3250.

Turritella cauredalitoensis (emended from Williston's MS.)
Pl. 6, fig. 6; Pl. 9, figs. 2, 4; Pl. 10, fig. 2; Pl. 11, figs. 1, 3, 5.

Shell of medium size and taper; whorl lengths comparatively short; whorls concave in adult stages. Later nepionic whorls are ornamented with three, strong, regularly spaced, subequal spirals; the anterior one is adjacent to the suture; the middle one is slightly stronger than the others, with a concave interspace on each side of it; the spiral ribs and interspaces even in these young whorls are ornamented with many, fine, microscopic, spiral lines and crossed by sub-microscopic, curved, growth lines which are retractive to the posterior interspace and then protractive to the suture; in all except the youngest whorls, one or two strong secondary spirals appear in the posterior concavity and several sub-microscopic spiral lines in the anterior concavity; the whorls rapidly become concave and the anterior rib forms a small keel which projects over the compressed and inconspicuous suture; at the points where the growth lines cross the spiral cords, beads or nodes are formed, but unless the specimens are well preserved, this superficial ornamentation of the spiral cords does not show; in the adult specimens, the posterior concavity of the nepionic stage has become medial and carries two or three secondary spirals; behind the posterior spiral rib on the adult whorls, there sometimes appear one or two weaker spirals; the keel is usually distinctly ornamented with fine, superficial, spiral threads and crossed transversely by elevated growth lines.

This species somewhat resembles *T. zuliana* (n. sp.) but does not have the scalloped, knobby keel of the latter. The widely concave whorls, the rather small size of this *Turritella,* the comparatively short whorl lengths easily distinguish it from *T. larensis* (n. sp.) and other Venezuelan forms.

Age: Oligocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1084, 1139, 1159, 1159A, 1159B, 1159C, 1159H, 1217, 1953 (one specimen).

Turritella cauredalitoensis liddlei, n. subsp. **Pl. 9, fig. 3; Pl. 11, fig. 6.**

This subspecies differs in the adult whorls in that the base of the keel or flange is rounded and the edge of the keel turns up posteriorly, causing the whorl to be more concave. The entire shell carries many revolving spirals of varying strength.

Named in honor of Mr. R. A. Liddle, now Divisional Geologist with the Pure Oil Company.

Age: Oligocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1159K, 1987.

Turritella cauredalitoensis dabajuroensis, n. subsp. Pl. 11, fig. 4.

This subspecies differs in having much larger and coarser primary spiral cords. It approaches some of the varieties of *T. larensis* (n. sp.) in the character of ribbing in the neanic stages, but the younger and older whorls are not confusable.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1627 (?), 2027.

Turritella cauredalitoensis filensis, n. subsp.
Pl. 11, fig. 2; Pl. 12, figs. 1, 3, 5.

This subspecies differs in having pagoda-like keels or extremely wide carinating flanges. The growth lines are prominent; the entire shell is ornamented with fine spiral threads. The concave whorls with extremely wide, pagoda-like, sharp keels make this a unique subspecies.

Age: Oligocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1217, 1979.

Turritella gilbertharrisi, n. sp. Pl. 12, figs. 2, 4, 6; Pl. 13, figs. 1–6; Pl. 14, figs. 1, 4, 7.

Shell slender, of moderate size; spire very much attenuated. Protoconch consists of $1\frac{3}{4}$ convex smooth whorls, which continue into the nepionic stage; the first 4 nepionic whorls carry a single, sharp keel near the anterior third of the whorl; the total length of the 4 whorls is about 1.7 mm. Each of the succeeding 7 whorls has a strong spiral on the upper quarter, with a posterior slope or bevel between it and the suture; in this stage, the keel of the earlier whorls becomes more nearly sub-medial with a concave interspace on each side of it; a slightly weaker spiral appears just above the suture at the base of the visible portion of these whorls; the posterior concave interspace begins to show one or more secondary spirals; the spirals even in this young stage have a tendency to be beaded at the intersection of the growth lines; the length of the 7 later nepionic whorls is slightly less than 8.5 mm., with a maximum diameter of about 2.8 mm. The neanic whorls continue with approximately the same taper; the posterior concave interspace of the nepionic whorls becomes the slightly concave medial portion of the later whorls, and usually carries two, beaded, subequal, secondary spirals, and finer, intervening, tertiary threads. In the later adult whorls, the sides are slightly concave between the two posterior cords and carry 2–4 secondary, and numerous tertiary, spiral threads; just behind the posterior cord, there sometimes appear one or two, fainter, spiral cords; the basal cord varies tremendously in strength in different specimens; usually it is low and weaker than the other two posterior, larger, primary spirals; all the larger cords and interspaces are ornamented with several, smaller, superimposed, finer spiral threads. The whole surface of the *Turritella,* in all stages except the very youngest, is covered with irregular, elevated, growth lines, which have a tendency to slightly offset the numerous, fine, microscopic or sub-microscopic, costal and intercostal threads and grooves which cover the whole surface of the whorl, including the spiral cords. The suture is compressed and inconspicuous; the close-set growth lines are strongly retractive from the posterior suture to the concave portion of the whorl, in which they curve forward and are protractive to the anterior spiral cord, which they cross at almost right angles.

This rather long, slender *Turritella* shows a wonderful microscopic ornamentation.

The species is not likely to be confused with any of the others. It has much less prominent spirals than *T. hubbardi* (n. sp.) and is, also, much more aciculate or attenuate.

Named in honor of Professor G. D. Harris of Cornell University.

Age: Oligocene-Miocene.

Locality: Rather common in the States of Falcón and Zulia. Locality Numbers: 6, 741, 777 (*cf.*), 919, 1140, 1414, 1415, 1419 (*cf.*), 1901 (one specimen only), 1944A, 2019, 2023 (?).

Turritella gilbertharrisi staufferi, n. subsp. Pl. 15, figs. 6, 9.

This subspecies differs from the species only in that the middle rib, or second anterior spiral, is doubled and is formed by two, complementary, united, spiral cords. This is scarcely more than a variation but represents a geographical difference.

Named in honor of Dr. Stauffer of the Caribbean Petroleum Company.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Number: 6.

Turritella gilbertharrisi aguavivensis, n. subsp. Pl. 15, figs. 1, 8.

This subspecies differs in having an intervening riblet between the two, anterior, primary, spiral cords. This intervening rib sometimes attains enough strength to give the appearance of three instead of two anterior primary spirals.

Age: Oligocene-Miocene.

Locality: States of Falcón and Zulia. Locality Numbers: 6, 2019.

Turritella gilbertharrisi falconensis (Williston MS.)
Pl. 14, figs. 2, 6, 8; Pl. 15, figs. 3, 4, 5, 7; Pl. 28, fig. 5.

This subspecies is much larger and coarser in appearance than the species and has larger spiral ribs. There are four, large, spiral cords instead of three in all except the younger stages; the various weaker spirals found between the two, posterior, primary cords in *T. gilbertharrisi* (n. sp.) have been replaced in this subspecies by a fairly strong spiral, which gives this *Turritella* the appearance of having four main spiral ribs; there is sometimes the suggestion of a fainter secondary spiral near the middle of the whorl. In the adult whorls, between the posterior cord and the suture, there are 1–3 weaker secondary threads (usually 2 in number). Well preserved fragments show the same kind of superficial ornamentation observed in *T. gilbertharrisi* (n. sp.), the beading being more accentuated in the larger specimens of the subspecies. The anterior spiral frequently projects over the suture as a weak keel.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 100, 101A, 104, 273, 339, 341, 342, 798 (*cf.*), 1066, 1067, 1127, 1265, 1398, 1436, 1704, 1810 (?), 1812, 1816, 1820 (poorly preserved), 1825, 1827, 1900, 1901 (also contains one specimen of *T. gilbertharrisi, sensu stricto*), 1903, 1928, 1931B, 1931C, 1932, 1934.

Turritella montañitensis, n. sp. Pl. 14, fig. 3; Pl. 15, fig. 2; Pl. 16, figs. 4, 5, 6, 8, 10; Pl. 17, figs. 3, 7, 8, 10, 11.

Shell turreted, slender, with a knobby basal carina on larger whorls. Protoconch is missing; first nepionic whorls are convex with a sub-medial, V-shaped carina; they are smooth except for faint, microscopic, posterior and anterior, spiral cords, which can be seen very early in these whorls; the posterior spiral cord is located approximately on the upper fifth of the whorl; the anterior spiral cord lies immediately behind the suture; the cords are beaded by the intersecting, curved, growth lines. In the subsequent whorls, the anterior spiral forms a strong cord, and in the adult whorls becomes a prominent, basal, knobby carina; finer, intervening, spiral threads are found on all except the youngest whorls; between the posterior primary and second anterior primary cord, there is a wide concave area with minor spiral lines which are usually beaded; the primary and secondary cords are beaded by the intersecting growth lines; the suture is moderately well exposed below the over-jutting knobby keel; the strong primary spirals, and especially the first anterior of these which forms the keel or carina, are ornamented with many, fine, revolving spirals crossed by prominent growth lines; on the sides of the whorl, the growth lines recede sharply to the middle of the concave area, then swing forward to the keel, and then retract on the base of the whorl, giving the incremental lines a sigmoid shape. The strength of the primary spirals is rather variable as well as the spacing between them. The keel is usually basal and sometimes droops anteriorly, more or less covering the suture. The scallops or knobs on the keel are more numerous but smaller than on *T. montañitensis olcotti* (n. subsp.); the knobs are more conspicuous on the base of the keel than on the posterior side of it, because they are prolonged as prominences, taking the direction of the growth lines to the suture, and giving the base a fluted appearance. The number of knobs on the keel varies, but as an average, there are about 16 knobs on a whorl 15 mm. in diameter. This species has longer whorl lengths than any of our other Venezuelan forms.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 25, 52, 56, 811 (*cf.*), 1114 (*cf.*), 1939, 1957, 1996, 2015A, 2031, 2050, 2052.

Turritella montañitensis olcotti, n. subsp. Pl. 16, fig. 12; Pl. 20, fig. 9.

This subspecies is less slender than *T. montañitensis*, and is particularly characterized by having fewer but larger knobs on the keel. The number of knobs on the keel of a whorl varies somewhat in different specimens, but as a general average, there are about 10 knobs on a whorl 20 mm.

in diameter.

Named in honor of Mr. Perry Olcott of the Standard Oil Company of Venezuela.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1639, 2050, 2051, 2052.

Turritella montañitensis saladilloensis, n. subsp. Pl. 16, fig. 2.

This subspecies differs in having more concave whorls, in having the posterior, primary, spiral weaker, and in having the second, anterior, primary, spiral cord stronger, than in *T. montañitensis, sensu stricto;* also, the two anterior primaries tend to be closer together. The carina overhangs and tends to conceal the suture.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Number: 1957.

Turritella curamichatensis, n. sp. Pl. 16, figs. 1, 3, 7, 9, 11; Pl. 17, figs. 1, 3, 4–6, 9.

Shell medium sized with strong spirals and a deeply excavated suture. Early neanic whorls carry two, strong, subequal, sub-medial, spiral cords, the lower of which gradually becomes more prominent and forms the second anterior spiral of the adult whorls, while the upper one becomes gradually weaker, changing from a primary cord in the neanic and early ephebic stages to a strong secondary one in the lower part of the medial concavity of the later ephebic and gerontic stages; the posterior part of each whorl is beveled and slopes into the excavated suture; the anterior margin of the beveled area is limited by a strong spiral cord which is found in all stages except possibly the nepionic which is not represented in our collection; the beveled area usually carries one or two, beaded, spiral threads; the anterior spiral, just behind the suture, becomes stronger in the adult whorls and forms a basal keel which projects over the excavated suture; the later nepionic and earlier neanic whorls are convex with concave interspaces between the spirals; in the adult whorls there is a wide, more or less concave, medial depression between the second anterior and the posterior primary spirals; this concavity is present in most specimens and carries two or more secondary and some tertiary threads; the whole surface of the shell is crossed by prominent growth lines which cause knobs or beads at their intersection with the spirals; the two, anterior, primary spirals are frequently covered with numerous, sub-microscopic, superimposed, fine threads with narrow intervening grooves; the crossing of these threads and growth lines gives a reticulate structure especially noticeable on the base of the first primary cord or basal flange; the growth lines are sigmoid in shape, being retractive on the upper part, protractive on the lower half of the visible portion of the whorls, and retractive on the base of the whorls; the knobby ornamentation of the ribs is emphasized by the protuberance of the growth lines over the primary spiral cords, particularly on the basal flange.

This species, when well preserved, shows somewhat the fancy, superficial ornamentation found on *T. hubbardi, T. gilbertharrisi* and other of our Venezuelan Turritellas; it is easily distinguished from these and other similar species by the deeply excavated suture. It differs from *T. larensis*, with somewhat similar ribbing, by being smaller in size, and having differently shaped whorls: in *T. larensis* the adult whorls are concave, do not have the excavated suture, and have a much wider keel.

The medial concavity is variable in this species and in a few cases, the sides of the whorls have become almost flat.

Age: Oligocene-Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 15, 440 (*cf.*, poorly preserved), 760 (*cf.*), 775 (*cf.*), 776 (*cf.*), 919, 1070, 1143, 1408, 1414 (*cf.*), 1436, 1437, 1754, 1761 (one specimen), 1944A.

Turritella gatunensis Conrad **lavelana**, n. subsp. Pl. 18, fig. 6; Pl. 19, fig. 7.

This subspecies is distinguished by slight but constant variations from *T. gatunensis* Conrad and *T. gatunensis caronensis* Mansfield. In all except the earliest whorls, this subspecies is distinguished from *gatunensis, sensu stricto,* by a stronger medial carina; the strong posterior spiral just behind it is closer and usually without the intervening spiral threads found in the species; in a few cases, we have found a very weak intervening thread; the proximity of the medial carina and the strong spiral just posterior to it gives a strong medial prominence, which causes the lower part of the whorl to be more nearly perpendicular to the base; behind the medial prominence there is a sharp uniform constriction to the suture; in front of the prominence there is a pronounced, depressed, spiral cingulation, limited anteriorly by a primary spiral which forms a shoulder overjutting the suture; this gives the *Turritella* a bicarinate appearance; the cingulation is ornamented with more numerous, smaller, subequal spirals than in the species. The visible portion of the base of the whorl usually carries one or two strong spirals with wide interspaces which sometimes carry a faint thread; the corresponding area in most of our adult specimens of *T. gatunensis* Conrad from Gatun shows three or more, more closely spaced spirals between the anterior suture and the anterior primary spiral; also, the upper fourth of the whorl tends to be slightly more concave than in our subspecies.

This subspecies is distinguished from *T. gatunensis caronensis* Mansfield [1] by the weak medial carina and the more uniformly convex whorls of the latter.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 67, 70A, 100 (?), 150A, 150B, 184, 185, 273, 298, 314 (?), 1033, 1067, 1078, 1265, 1901.

[1] W. C. Mansfield, Proc. U. S. Nat. Mus., Vol. 66, Art. 22, pp. 51–52, Plate 8, figs. 12–14, 1925.

Turritella gatunensis Conrad **willistoni,** n. subsp. Pl. 18, figs. 2–4, 8.

We have not yet found the nepionic stages of this form, but it seems to be a subspecies of *T. gatunensis* Conrad. The constriction at the top of the neanic whorls is narrower and consequently seems deeper; our subspecies is a smaller form and has fewer secondary and tertiary spiral threads; in some specimens the whorls become very roundly convex in the ephebic and gerontic stages with a rounded area between the sides and base of the whorl; in this case they approach *T. gatunensis caronensis* Mansfield (*l. c.*) in the general shape of the whorl but not in the character of the ribbing. Our subspecies has three or four strong primaries with fewer secondary and tertiary spirals than occur in either the species or any of the other subspecies. The primary spirals are stronger and the intervening threads weaker than in similar forms.

Named in honor of Mr. S. H. Williston of the Venezuelan Sun Company.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 80 (*cf.*), 93, 94, 97, 149A (?), 178, 184, 225A, 291, 303, 317 (*cf.*), 325, 1031, 1033, 1255, 1265, 1856, 1858 (*cf.*), 1866, 1900, 2054.

Turritella gatunensis Conrad **taratarana,** n. subsp. Pl. 18, figs. 5, 7.

This subspecies is a further development of the new subspecies, *lavelana*. It is characterized by gentle scallops on the primary spirals which gives a knobby or beaded appearance. The scallops or beads are elongated transversely, *i. e.*, in the direction of the spiral ribbing. All of the strong spirals may show the scalloped character, but it is more pronounced and sometimes found only on the first strong anterior spiral. The number of scallops on a spiral varies, but usually there are 16–18 on a whorl 7 mm. in diameter. The knobby character begins to appear early in the neanic whorls.

Age: Miocene.

Locality: Districts of Colina, Miranda, and Democracia, State of Falcón. Locality Numbers: 80, 93, 184, 185, 193, 291, 1033, 1231, 1255, 1507.

Turritella berjadinensis, n. sp. Pl. 18, fig. 1; Pl. 19, figs. 1, 3, 4, 6.

Shell is of medium size; sides of the whorl are almost flat except for two spiral prominences or keels, the posterior of which is a strong, medial or sub-medial, spiral rib with wide, flat or very shallow, concave areas on each side of it; the other spiral prominence forms a basal swelling on the anterior portion of the whorl, just behind and overhanging the suture; this basal prominence is decorated with several spiral ribs of varying strength; the flat or concave areas behind each of the keels, also, are ornamented with spiral ribs and on the larger whorls have weaker spiral threads alternating with the stronger; the total number of spirals on the visible portion of the whorls varies in different individuals and in different stages of the same individual; for example, the smallest whorl of the type specimen has 18 visible spirals and the largest has about 30. In some specimens there is a fairly strong spiral developed in the anterior concave area just behind the basal prominence. The base of the adult whorls is ornamented with spiral ribbing similar to that on the sides of the whorls, but usually shows a greater number of weaker intervening spirals between the stronger. The growth lines are not very conspicuous; but, on weathered specimens, they are straight and retractive on the upper portion of the whorl; they swing to an axial direction on the lower part of the whorl and cross the base at approximate right angles to the spiral sculpture. The base of the whorls is flat or slightly convex. The inside of the shell has several strong liræ which leave spiral grooves on the casts. The upper part of the whorl is sometimes more or less constricted just in front of the posterior suture.

This is an extremely variable species which grades into its subspecies, which in turn merge into each other, and sometimes approach *T. mimetes* Brown and Pilsbry [1] and similar forms which have been previously described from the Caribbean region.

T. berjadinensis, sensu stricto, most closely resembles *T. boweni* (n. sp.) but the latter is distinguished by the fewer, larger, more widely spaced spirals, which are more uniform in size on the upper half of the whorl. The whorls are shorter and flatter than in *T. mimetes* Brown and Pilsbry.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 24, 74A, 82, 90, 93, 150B, 270, 317, 830, 1000, 1078, 1111, 1115, 1231, 1232, 1447, 1630, 1757, 1855, 1856, 1858, 1861, 1892, 1911, 2036.

Turritella berjadinensis colinensis, n. subsp. Pl. 18, fig. 9; Pl. 19, fig. 8.

This subspecies is characterized by the lack of carinating spiral threads. The whorls are almost flat and have the same spiral ribbing as the species but less accentuated.

This subspecies bears a close resemblance to *T. mimetes* Brown and Pilsbry (*loc. cit.*) in all stages, but the young whorls show it to be more closely related to *T. berjadinensis.* It is distinguished from *T. mimetes* by its shorter flatter whorls and finer spiral ribbing.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 71, 74 (variation), 79, 80, 82, 83A, 84, 85, 90, 93, 97, 100, 103, 118, 149A, 150A, 150B, 180, 184, 185, 187, 189, 193, 204, 206, 215, 229, 298, 299, 300, 307 (variation), 1007 (variation), 1033, 1043, 1064, 1255, 1335, 1507, 1552, 1901, 1928.

Turritella berjadinensis warfieldi, n. subsp. Pl. 20, fig. 8; Pl. 21, fig. 6.

This subspecies differs from the species, *sensu stricto,* in that the medial portion of the whorl carries two, instead of

[1] Proc. Acad. Nat. Sciences of Philadelphia, 1911, p. 357, Pl. XXVII, fig. 1.

one, prominent spirals; also, the development of the second strong spiral on the posterior third or fourth of the whorl tends to make the upper part of the whorl more constricted than in the species. The development of a strong secondary spiral just behind the basal prominence is more common than in *T. berjadinensis, sensu stricto.*

The adult whorls approach *T. mimetes* Brown and Pilsbry (*loc. cit.*) in general appearance; the ribbing on the lower half of the whorl is, indeed, very similar, but on the upper part of the whorl, *T. mimetes* has three or more strong spirals, instead of two.

T. mimetes has longer adult whorls and the younger whorls are much more convex than in *T. berjadinensis warfieldi.*

Named in honor of Mr. Wm. Warfield, formerly with the Standard Oil Company of New Jersey.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 83B, 84, 88, 93, 96, 98, 118, 137, 150B, 152, 155, 169A (*cf.*), 178, 184, 185, 187, 193 (*cf.*), 206, 215, 225, 270, 307, 830, 1007, 1033, 1043, 1066, 1111 (*cf.*), 1232, 1335, 1447, 1449, 1450, 1509, 1552, 1757, 1870 (*cf.*), 1892, 1905.

Turritella berjadinensis socorroensis (Williston MS.)
Pl. 21, fig. 3; Pl. 23, fig. 8; Pl. 27, fig. 2.

This subspecies is a further development in the direction taken by the new subspecies, *T. berjadinensis warfieldi.* It tends to be a larger, heavier variety, having three, strong, spiral cords and a fourth weaker spiral between the two anterior primaries. There is a pronounced constriction around the upper fourth of the whorl in front of the posterior suture. The spiral ornamentation of the base is poorly preserved. This subspecies is retained because it marks the limit in the variation of this stock of *Turritella* toward a large, heavy, strongly ribbed shell.

Age: Miocene.

Locality: Principally in the Districts of Democracia and

Miranda, State of Falcón. Locality Numbers: 100, 103 (*cf.*), 104 (variation), 122B (*cf.*), 149A, 149B, 169A, 171, 172, 174, 270 (*cf.*), 301, 314, 325, 1017, 1127, 1931, 1932, 1934 (*cf.*).

Turritella berjadinensis cocoditana, n. subsp. Pl. 19, fig. 5; Pl. 20, figs. 3, 7, 10.

This subspecies is distinguished by having the upper half of the whorl much more constricted and by having a wider basal flange just behind the suture. The whole surface of the shell, when well preserved, bears more numerous and finer intervening spiral threads. The young stages show nodes on the upper half of the whorls elongated in the direction of the growth lines. The base bears about eight equally spaced spiral "welts" with three or more smaller intervening threads.

Age: Miocene.

Locality: District of Falcón, State of Falcón. Locality Number: 2207.

Turritella planigyrata Guppy Pl. 19, figs. 2, 9.

Turritella planigyrata Guppy, Sci. Assoc. Trinidad Proc., Vol. 1, Pt. 3, pp. 169–170, 1867.
Turritella planigyrata Guppy, Geol. Mag., London, Vol. 1, N. S., p. 408, pl. 18, fig. 5, 1874.
Turritella planigyrata Guppy, Quart. Journ. Geol. Scc., London, Vol. 32, p. 519, 1876.
Turritella planigyrata Guppy, Agr. Soc. Trinidad and Tobago (Society Paper No. 440) p. 11, 1910.
Turrritella plangyrata Guppy, Agr. Soc. Trinidad and Tobago, Society Paper No. 444), Vol. 10, p. 451, 1910. (*fide* Mansfield).
Not *Turritella planigyrata* Guppy, Maury, Bull. Amer. Pal., Vol. 5, pp. 293–294, pl. 48, fig. 14, 1917.
Turritella planigyrata Guppy, Maury, Bull. Amer. Pal., Vol. 10, p. 232, pl. 42, figs. 6, 7, 8, 1925.
Turritella planigyrata Guppy, Mansfield, Proc. U. S. Nat. Mus., 1925, No. 2559, Vol. 66, Art. 22, pp. 55–57, pl. 9, figs. 1, 9.

We have a single, small, young specimen of this species. It shows a slight variation in the early neanic whorls in developing slightly stronger spirals than are found in the corresponding whorls of our specimens from Trinidad. It is the only Venezuelan specimen which we can refer unquestionably to *T. planigyrata* Guppy.

Age: Miocene.
Locality: State of Delta Amacuro, Eastern Venezuela. Locality Number: 1131.

Turritella mauryæ, n. sp. Pl. 23, fig. 11.
Turritella planigyrata Guppy, Maury, Bull. Amer. Pal., Vol. 5, 1917, pp. 293–294, Pl. 48, fig. 14.

Shell rather small, turreted; spirals scalloped or beaded. Protoconch consists of about 1¾ smooth convex whorls; the first 3 nepionic whorls are convex with a medial carinating spiral; in front of the carina, there are about three equally spaced primary spirals with intervening spiral threads; between the medial carina and the posterior suture there are about three primaries, the middle one of which is stronger than any of the other spirals on the whorl except the medial carina; between the primaries, there are intervening, weaker, spiral threads. The number of spirals increases on the succeeding whorls, and all of them, especially the primary ones, become scalloped or knobby; the number of scallops varies, but on the last whorl (8.5 mm. in diameter) there are about 17 or 18 small scallops. On the larger whorls, there are three about equally spaced spirals which are stronger than the others; between these, there are intervening, secondary spirals, with still weaker tertiary threads; on the posterior slope, there are three or four less prominent spirals. The sides of the larger whorls are moderately convex; the base is almost flat and is spirally striate with 2–5 weaker spirals between the stronger ones. The growth lines are not conspicuous. The inside of the shell is reinforced by about eight spiral liræ of varying strength.

Attention was drawn to this species in the synonymy given by Mansfield [1] for *T. planigyrata* Guppy.

The finely scalloped spirals easily distinguish this species from *T. planigyrata* Guppy from Trinidad.

Named in honor of Dr. C. J. Maury.

[1] W. C. Mansfield: Proc. U. S. Nat. Mus., Vol. 66, 1925, Article 22, p. 256.

Age: Miocene.

Locality: Bluff 2, Cercado de Mao, Santo Domingo. Collected by Dr. Maury, expedition of 1916.

Turritella variegata Linné **paraguanensis,** n. subsp. Pl. 21, figs. 2, 7.

This subspecies is very close to *T. variegata* Linné which is so common in the recent faunas along the north coast of Venezuela. It differs in having stronger ribbing, especially on the base of the whorls, which are corrugated with about six very prominent ridges; the corrugations and interspaces are overridden with numerous, finer, spiral threads. This subspecies increases in size more rapidly than the recent species shown in Pl. 22, fig. 7.

Age: Quaternary.

Locality: District of Falcón, State of Falcón. Locality Number: 1504.

Turritella plebeia Say **A-L-Owensi,** n. subsp. Pl. 20, figs. 1, 2, 5, 6; Pl. 23, fig. 2; Pl. 28, fig. 1.

This subspecies differs principally in attaining a much greater size; the larger whorls are less convex; the posterior slope is much longer and less inclined. The spirals become more nearly equal in size, the channeled interspaces being as wide or wider than the spirals. The base of the whorls is somewhat flattened and ornamented with many fine spirals. *T. plebeia* Say from Jones Wharf, Maryland, is figured for comparison, Pl. 21, fig. 5.

Named in honor of Mr. A. L. Owens, Geologist for the Standard Oil Company of Venezuela.

Age: Miocene.

Locality: Districts of Colina and Democracia, State of Falcón. Locality Numbers: 71, 84, 90, 96, 150A-B, 150B, 171 (?), 193 (and variations), 225A, 298.

Turritella matarucana, n. sp. Pl. 20, fig. 4; Pl. 21, figs. 1, 9.

Shell turreted, with long flattened whorls, ornamented with many spirals. Protoconch and nepionic whorls are missing. Neanic whorls are roundly convex; the posterior slope is more gentle than the anterior; whorls are ornamented with about twelve flattened spiral ribs of varying strength, wider than the interspaces. The succeeding whorls become less convex and almost flat-sided except for the rounded posterior and anterior slopes. In the large adult whorls the number of spirals increases due to the interpolation of intervening spirals, or the width of the spirals increases, or both may occur on the same whorl; that is, some of the flat spirals become uniformly wider on the succeeding whorls, or narrower, intervening, secondary spirals may appear, or the ribs may become wider with only a few intervening weaker spirals; the proportion of the wide ribs to the narrow is not at all constant, but in well preserved specimens all of the ribs are flat, and they are wider than the groove-like interspaces; in the adult whorls the number of ribs varies from 15–22 depending on their width. The growth lines are decidedly curved on the visible portion of the whorls, but we have not seen the sculpture on the base. The suture is excavated.

The wide spirals with narrow interspaces on almost flat-sided whorls make this a distinctive species.

Age: Miocene.

Locality: Districts of Colina and Democracia, State of Falcón. Locality Numbers: 71, 194A, 197, 199, 1027, 1250.

Turritella venezuelana, n. sp. Pl. 21, figs. 4, 8; Pl. 22, figs. 1, 6.

Shell is small, turreted, and rather slender. Protoconch consists of 1¾ small round whorls. Nuclear whorls are continuous with the nepionic whorls which are sub-medially bicarinate, with a slightly convex, long, posterior slope; anterior slope, short, steep, and slightly concave; the second nepionic whorl shows a trace of a microscopic spiral on the anterior third of the posterior slope; the later nepionic whorls develop another spiral thread on the upper third of the posterior slope; the spiral ribs are sharply elevated; the interspaces are wide and concave. The neanic and succeeding whorls of this abundant species begin to show many variations in the shape of the whorl, and in the character and spacing of the spirals. The commonest form has a rather flat tapering whorl with an overjutting beveled base sloping down sharply to the suture; the second anterior primary spiral forms the apex of the angle between the long, tapering, posterior part of the whorl and the narrow, steep, anterior slope leading down to the suture; the long posterior part of the whorl carries four elevated spirals with wide concave interspaces; the interspace between the 2 large posterior primaries is usually wider than the others; just in front of the suture on the posterior slope, there are one or two secondary spiral threads; about the middle of the steep anterior slope there is a fairly strong spiral. The surface of the shell is usually covered with a shiny enamel. The growth lines are very inconspicuous, but are slightly retractive on the sides and base of the whorl. The base is flattened and ornamented with numerous fine spirals.

There are innumerable variations in this species. The shape of the adult whorls varies tremendously, even in the same individual. The larger whorls frequently become roundly convex instead of being angulated behind the anterior slope. In some specimens, secondary threads appear in some of the wide interspaces, and other threads near the sutures.

This small form somewhat resembles the much larger species, *T. subgrundifera* Dall [1] from the Chipola beds, which has its nuclear whorls oblique to the axis of the shell.

The inside of the shell gives very faint traces of internal liræ.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Numbers: 6, 810 (?), 811, 814, 815, 822, 1628, 1754 (*cf.*),

[1] Wm. H. Dall: Trans. Wagner Free Inst. of Science, Vol. III, Part 2, 1892, pp. 313–14, Pl. 22, fig. 23.

1761, 1942, 1955, 2010, 2019, 2019A, 2021, 2022, 2023, 2027.

Turritella venezuelana quirosana, n. subsp. Pl. 22; figs. 9, 10; Pl. 24, fig. 1.

This subspecies is characterized by the tendency to interpolate an intervening secondary spiral thread between the primaries. The whorls vary tremendously in convexity; the moderately flattened, convex, tapering, adult whorls, are more common than the very roundly convex ones; the secondary threads may appear between most or all of the primary spirals. Fig. 1 on Pl. 24 shows a freak in which intervening secondary spirals suddenly appear after an injury to the shell.

Age: Oligocene-Miocene.

Locality: States of Falcón, Lara, and Zulia. Locality Numbers: 6, 814, 815, 822, 2019, 2022, 2027.

Turritella venezuelana watkinsi, n. subsp. Pl. 22, fig. 8.

This subspecies represents a common variation toward roundly convex whorls without intervening secondary threads between the primaries. Adult whorls become less convex than the younger but do not show intervening spirals.

Named in honor of Mr. W. A. Watkins, formerly of Cornell University, who helped collect some of this material.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Number: 6.

Turritella G-A-Weaveri, n. sp. Pl. 22, figs. 3, 5; Pl. 23, fig. 9; Pl. 24, fig. 4.

Shell rather small, slender, with convex whorls in young stages, and somewhat flattened whorls in adult stages. Protoconch and first nepionic whorls are missing; succeeding nepionic whorls have a medial carina with the anterior and posterior slopes about equal in length and steepness; posterior slope carries 2 (and later 3) about equally spaced spiral threads; anterior slope carries 3 (and later 4) spirals of which the middle one soon becomes stronger than the others and approaches the strength of the medial carina. The convex neanic stages are bicarinate, one keel being medial and the other weaker one half way between it and the anterior suture; secondary spirals appear between the primaries; typically, the intervening thread just behind the medial keel is very faint or lacking. The spiral sculpture of the neanic whorls resembles that mentioned in the nepionic stage with additional threads of varying strength appearing on the upper half of the whorl. The succeeding whorls become less convex with flattened sides, and bear 7 or 8 subequally spaced strong spirals, some of which are larger than others. The base of the whorl, ornamented with several revolving lines, is rather flat and projects over the succeeding whorl. Growth lines are inconspicuous. Largest whorl found measures 10 mm. in diameter.

This *Turritella* most closely resembles some of the flat-sided adult whorls of *T. venezuelana* (n. sp.). It is easily distinguished by the single medial carina of the nepionic whorls in place of the double of the latter species.

Named in honor of Mr. G. A. Weaver who was an invaluable collaborator in the field work during 1924–5.

Age: Oligocene-Miocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 47, 51, 52, 2010.

Turritella cornellana, n. sp. Pl. 22, figs. 2, 4; Pl. 24, figs. 11, 14.

Shell is very slender, ornamented with many spirals of varying strength; shape of whorl and prominence of ribbing are very variable. Protoconch and earliest whorls are missing. Later nepionic whorls are convex and medially carinate; posterior slope is flat or convex and ornamented with several spiral striæ of varying strength; anterior slope, flat or concave with spiral ornamentation similar to that on the posterior slope. On the neanic and succeeding whorls the sides become almost flat and carry four about equally spaced primaries with two or more intervening secondary threads; anterior slope is shorter and steeper than the posterior; both slopes carry a spiral ornamentation similar to that on the sides; the suture is excavated; in the adult whorls, the overjutting base eliminates an anterior slope; the base of the whorl is flattened and seems to have a spiral sculpture similar to that on the sides of the whorl. The growth lines are retractive on the upper half of the whorl and take an axial direction over the lower half; prominent beads or nodes are formed on the upper half of the whorl at the intersection of the spirals and the growth lines; depressions in the spirals and interspaces are sometimes noted on either side of the elevated growth lines which cause the nodes.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Number: 3222.

Turritella cornellana bolivarensis, n. subsp. Pl. 24, figs. 2, 3, 13.

This subspecies is less slender, more strongly ribbed, and has a more pronounced overjutting shoulder at the base of the whorl. The posterior slope is slightly concave in the adult whorls; all the spirals may be strongly beaded in this subspecies.

Age: Oligocene-Miocene.

Locality: District of Miranda, State of Zulia. Locality Number: 3222.

Turritella boweni, n. sp. Pl. 24, figs. 5, 6, 10; Pl. 25, fig. 3.

Shell small, bicarinate except in the younger stages; adult whorls almost flat with about 5 equally spaced primaries on the upper half of the whorl. Protoconch and early nepionic stages are missing. Later nepionic whorls are submedially carinate; the posterior slope is longer and more gentle than the anterior; both are ornamented with a few spirals. Neanic whorls are convex and bicarinate; the anterior carina is less prominent and located just behind the anterior suture; there is a wide concave interspace between the 2 carinæ, which usually shows a secondary intervening thread; posterior slope is almost flat and carries 4 equally spaced, elevated, primary spirals behind the medial carina. Succeeding whorls have about the same sculpture as the neanic, but are less convex and become nearly flat-sided; the bicarinating spirals of the earlier whorls are not so prominent in the adult stages, and form the 2 anterior primary spirals with a wide flat interspace between them; this interspace usually carries one intervening secondary spiral; between the anterior primary and a secondary thread that lies near the anterior suture, there is a narrow, beveled or slightly concave, steep, anterior slope with a faint spiral near its middle. The growth lines are seldom seen, but are slightly retractive on the visible portion of the whorl. The sculpture on the base of the whorl has not been seen.

This species somewhat resembles *T. venezuelana* (n. sp.) and *T. berjadinensis* (n. sp.); it is distinguished from the former by the wide flat interspace between the 2 anterior primaries of the adult whorls; from the latter, by the absence of the numerous, intervening, secondary threads and by the fewer spirals in the adult.

Named in honor of Mr. C. F. Bowen, Chief Geologist of the Standard Oil Company of New Jersey.

Age: Oligocene-Miocene.

Locality: Districts of Buchivacoa and Acosta, State of Falcón. Locality Numbers: 725, 1217.

Turritella andreasi (Williston MS.) Pl. 24, figs. 7–9, 12; Pl. 25, fig. 2.

Shell is of moderate size with convex whorls. Protoconch and nepionic whorls were not found; earliest whorls preserved have a diameter of about 2.3 mm.; they are convex, ornamented with about seven primary and secondary spirals with some weaker microscopic intervening threads; the anterior slope is slightly steeper than the posterior and carries several fine spiral threads. The adult whorls are almost uniformly moderately convex, with 9–11, subequally spaced, primary spiral cords of varying strength; there are usually one or two intervening threads between the spirals on the lower half of the whorl; in some specimens an intervening thread is found between some of the spirals on the upper part of the whorl; the primaries tend to be somewhat more closely spaced on the posterior than on the anterior slope; the anterior slope always carries at least one primary spiral about midway between the anterior suture and the first anterior primary on the sides of the whorl; the wider interspaces frequently carry two or more intervening, sub-microscopic, spiral threads. The growth lines are sickle-shaped, being strongly curved on the upper half of the whorl and crossing the lower half and base of the whorl more or less at right angles to the spiral ribbing. Sutural line is rather inconspicuous. In the intermediate stages it is sometimes difficult to tell this species from *T. filacarmenensis* (n. sp.) but the young and adult stages are easily distinguished; in the young stages, *T. filacarmenensis* is much more convex and has stronger, fewer, primary spirals; in the adult whorls, *T. filacarmenensis* has a pronounced excavated anterior slope without prominent spiral ribbing.

Named in honor of Mr. A. Andreas, Jr., Geologist for the Standard Oil Company of Venezuela.

Age: Oligocene.

Locality: Common in the State of Falcón. Locality Numbers: 31, 32, 40, 66, 508 (and variation), 802, 1048, 1058, 1061, 1084, 1130 (?), 1135 (variation), 1139, 1159, 1159B, 1217, 1638 (variation), 1664 (and variation), 1664B (variation), 1951 (variation), 1953, 1963, 1964, 1987.

Turritella filacarmenensis, n. sp. Pl. 23, figs. 1, 5; Pl. 25, figs. 4, 6, 10, 12.

This *Turritella* closely resembles *T. andreasi* (Williston MS.) in the intermediate whorls, but is very different, especially in the younger stages. Protoconch is missing: nepionic whorls are sub-medially bicarinate, with a long gentle posterior slope carrying a faint spiral, which later forms a third primary spiral on the upper part of the neanic whorls; in the later neanic whorls there are four, about equally spaced, strong, primary spirals with an intervening sub-microscopic spiral thread in the interspaces; some weak secondary spirals appear on the posterior slope and the deeply concave anterior area carries very faint spiral threads. The number of primaries increases in the adult stages and the whorls become more gently convex. In the larger whorls there are about 9 primaries of varying strength and many weaker intervening threads; the visible portion of the base of the whorl forms a concave, narrow, anterior slope which does not carry any prominent spiral ribbing and is limited anteriorly by a faint spiral just behind the inconspicuous suture; this spiral forms a sharp shoulder between the flat concealed base of the whorl and the sides. The sculpture on the base of the whorls is not well preserved but has spiral ribbing more or less like that on the sides of the whorl. The growth lines are not conspicuous, but on our weathered fragments they seem to resemble the incremental lines of *T. andreasi* (Williston MS.).

It is distinguished from *T. andreasi* (Williston MS.) which it most closely resembles, by the absence of any strong spiral ribbing in the anterior concave area in the adult stages and by the fewer and stronger spirals in the younger stages.

Age: Oligocene.

Locality: District of Buchivacoa, State of Falcón. Locality Numbers: 1953, 1964, 1987, 2000.

Turritella buchivacoana, n. sp. Pl. 23, fig. 7; Pl. 25, figs. 7–9.

Shell is small; whorls are ornamented with crowded minute spirals and 3 strong primary spirals,– the first of which forms the basal carina, the other two are on the convex portion of the whorl. Protoconch consists of about 2 smooth round whorls, continuous with the succeeding stages. Nepionic whorls are medially carinate, with a posterior spiral appearing on the middle of the posterior slope and an anterior spiral at the base of the visible portion of the whorl just behind the suture; the whole surface of these and succeeding whorls is covered with minute or microscopic spirals of varying strength. In weathered specimens a deep groove frequently is seen at the posterior base of the anterior spiral. The neanic and succeeding adult whorls change in shape due to the development of a sharp basal carina which juts over the sutural line at the base of the whorl; the sides of the whorls are slightly convex with two primary spirals occurring near the medial line; the interspaces between the spirals are concave; the area between the posterior primary spiral and the posterior suture is somewhat concave and about equal in width to the anterior concave interspace between the middle and basal primary spirals; the medial concavity is slightly narrower than the others; a strong secondary spiral is sometimes developed in the anterior concavity. Weathered specimens often seem to have four primaries, instead of three (with a strong secondary in the anterior interspace); the sutures frequently appear deeply excavated in weathered specimens.

This species does not closely resemble any of the others. It bears a superficial resemblance to *T. gatunensis* Conrad, but the numerous fine spirals easily distinguish it, as does the sharper basal flange.

Age: Oligocene-Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 257, 400, 1042, 1070, 1282, 1408, 1627, 1628, 1629, 1722, 1761, 1935 (*cf.*), 1936, 1942, 1955, 2018, 2019, 2019A, 2022, 2023, 2027, 2031.

Turritella buchivacoana cañonensis, n. subsp. Pl. 25, figs. 1, 5.

This subspecies differs in having less prominent microscopic spiral striation, in having a less pronounced basal keel and in having a less deeply excavated suture. The diminutive basal keel is the most characteristic and distinctive feature. The sides are somewhat more convex than in *T. buchivacoana, sensu stricto.*

Age: Miocene.

Locality: District of Miranda, State of Falcón. Locality Numbers: 341, 1630, 1792.

Turritella elmenensis, n. sp. Pl. 25, fig. 11.

Whorls finely striate; the strong spiral on the anterior third of the whorls gently scalloped; apical angle large; protoconch and earliest whorls missing. Smallest whorl on the holotype is 2 mm. in diameter; it carries a strong, sub-medial, carinating spiral, with a concave interspace on each side; the posterior of these interspaces is wider than the anterior and is limited by a spiral on the posterior fourth of the whorl; the anterior concave interspace is limited by a spiral which is adjacent to the sutural line. The posterior slope is steeper in the young stages. In the succeeding whorls the medial carina increases in relative strength; it moves forward to the anterior fourth of the larger whorls where it becomes gently scalloped; the posterior primary remains on the posterior fourth of the whorls and the anterior one remains just behind the suture. The whole surface of the *Turritella,* including the primaries, is covered with minute spirals of varying strength; there are about 50 of these minute spirals on a whorl 9 mm. in diameter.

In the largest whorls, some of the minute spirals have become relatively stronger than the others, and might be termed secondary spirals. The base of the whorl is slightly concave and ornamented with numerous, fine, revolving lines.

The abundant, fine, spiral striation and the gently scalloped sub-medial keel make this a unique species.

Collected by the Miranda Exploration Company. Only one specimen has been found.

Age: Oligocene-Miocene.

Locality: Near Quirós, District of Miranda, State of

Zulia.

Turritella guppyi Cossmann **morantensis,** n. subsp. Pl. 26, figs. 3, 5, 6, 8; Pl. 28, fig. 4.

Protoconch consists of 1½ smooth convex whorls, followed by two mono-carinate nepionic whorls in which the carina is located on the anterior third of the whorl; the posterior slope is longer and more gentle than the anterior; length of the first eleven whorls, 7.7 mm.; all the succeeding whorls are bicarinate with single, beaded ribs; the upper half of the wide medial concavity carries three or four spirals of varying strength; the lower half of the concavity seldom shows any prominent spiral ornamentation. The posterior slope carries a secondary spiral thread about midway between the upper cord and the posterior suture. The shell is thin, and rather attenuate; the growth lines are not very prominent, but are retractive to the middle of the whorl and protractive on the lower half; the beads on the spiral ribs and threads are at the points where the growth lines cross them and are elongated in the direction of the growth lines. Well preserved specimens show minute spirals over the whole surface of the shell including the tops of the spiral carinæ.

This subspecies seems to differ very little from the cast and photograph (Pl. 27, fig. 1) which Dr. R. S. Bassler of the U. S. National Museum very kindly made for us of the type of *T. guppyi* Cossmann[1] (equals *T. tornata* Guppy) from Cumaná, Venezuela. It may be that they are identical but we believe it advisable to consider this Bowden form as a subspecies until better material is collected from Cumaná.

The distinctive characters are very slight, but the posterior slope in *T. guppyi* is more gentle and is not as concave as in the subspecies *morantensis*. The shell of the subspecies seems to be more delicate and attenuate than suggested by the cast of the type of *T. guppyi*.

[1] M. Cossmann: Revue Critique de Paléozoologie, 1909, p. 225.

Age: Miocene.
Locality: Bowden, near Bowden Wharf, Morant Bay, Jamaica. Locality Number: 1109.

Turritella carlottæ, n. sp. Pl. 26, fig. 2; Pl. 27, fig. 11.

Turritella tornata Guppy, Maury, Bull. Amer. Pal., 1917, Vol. 5, p. 294, Pl. 48, fig. 15.

Shell is thin, turreted, rather small, with two spiral carinating prominences. Protoconch is missing; first two nepionic whorls, smooth, very convex due to a strong angulated carina on the basal third of the whorls; on each side of the carinating ridge, there is a slope to the sutures; the posterior slope is much more gentle than the anterior; the two succeeding nepionic whorls are not angulated but are roundly convex with a strong spiral on the basal third, and with two or three fainter intervening ones distributed between it and the posterior suture; all the succeeding whorls carry a medial, concave, spiral depression with a prominence on each side of it; the anterior prominence is a single, spiral, carinating rib near the anterior third of the whorls; it is higher and sharper than the posterior prominence which is a wide, rounded ridge occupying most of the upper half of the whorl and surmounted by two separate beaded spirals of about equal strength; near the middle of the medial concave area, there are two or three secondary spirals; between the lower cord and the anterior suture there is a concave area. The whole shell carries microscopic spiral ribbing, which is especially noticeable in the anterior concave area and on the posterior slope. In the larger whorls, there is a spiral formed at the base of the anterior concave area, just behind the anterior suture. The growth lines are inconspicuous.

This *Turritella* is distinguished from *T. altilira* Conrad by having a greater apical angle and by having a lower, wider, rounded, posterior, carinating prominence surmounted by two weak spirals. It is distinguished from *T. guppyi* Cossmann and its new subspecies *morantensis* by carrying two equal spirals on the rounded upper prominence, instead of one strong spiral with a weaker one on the posterior slope. It further differs from *T. guppyi* Cossmann *morantensis* (n. subsp.) in having a greater apical angle.

Named in honor of Dr. C. J. Maury.

Age: Miocene.

Locality: Río Gurabo at Los Quemados, Santo Domingo. Specimens collected by Dr. Maury, expedition of 1916.

Turritella altilira Conrad **urumacoensis,** n. subsp. Pl. 26, figs. 4, 7; Pl. 27, figs. 3, 7, 10.

This abundant *Turritella* differs so much from our adult specimens of *T. altilira* Conrad collected from Gatun, C. Z., that we were inclined at first to make it a new species. Unfortunately, these long slender forms are seldom preserved except as fragments. We did not find the protoconch or the earlier nepionic whorls of the Venezuelan form, but the later nepionic whorls agree so closely with some of the Gatun specimens that we are considering this as a subspecies of *T. altilira* Conrad until the young stages are found to establish its relationship with certainty. The adult whorls show a closer similarity to *T. guppyi* Cossmann or its new subspecies *morantensis* than to *T. altilira* Conrad, but it is distinct from each of them.

The greatest diameter of the smallest well preserved whorl in our collection is about 3.7 mm.; the posterior spiral rib has an auxiliary spiral about the middle of its lower side and this tends to make it somewhat larger than the anterior keel in the young stages; there is a secondary spiral in the center of the concave area in the middle of the whorl; near the posterior base of the anterior spiral there is another secondary spiral; in addition to the two primary carinating ribs, there are three secondary spirals with fainter intervening threads in the medial concave area; submicroscopic spirals are to be found over the entire surface of the whorl in well preserved specimens; the later nepionic whorls bear a close resemblance to the corresponding stages of *T. altilira* Conrad, *sensu stricto*. For comparison we are figuring specimens of *T. altilira* from Gatun, C. Z. (Loc. No. 1101) in Pl. 26, fig. 1; Pl. 28, fig. 3; Pl. 29, fig. 1.

The neanic and ephebic stages of the subspecies do not show a very close similarity to the species because in the former the two carinating spirals are always single; the posterior cord does not show any tendency to become double or to be strengthened by a strong auxiliary cord on its lower side; the two large spiral keels are about equal in size, but the anterior one tends to be slightly smaller. The medial concavity is slightly wider because the upper rib is narrower than in *T. altilira* Conrad; three or four weaker secondary spirals are found in the middle of this concavity and on the lower part of the posterior keel; the upper side of the anterior keel does not seem to bear any prominent spiral ornamentation.

It differs from *T. guppyi* Cossmann in having a larger and heavier shell, in being more strongly beaded, and in lacking the spiral thread on the posterior slope. It is like *T. guppyi* in having two single keels.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 78, 79, 83, 84, 90, 93, 96, 118, 120A, 120B, 121, 122A, 122B, 123, 127, 129, 130, 131, 138, 150, 150A, 154, 159(?), 162, 163, 176, 178, 180, 189, 204, 205A, 206, 206A, 219A, 220, 222, 261, 290, 295, 297, 325, 354, 719 (?), 1004, 1007 (?), 1012, 1034, 1067, 1233, 1322, 1447, 1450, 1852, 1856, 1858, 1863 (*cf.*), 1870, 1892, 1908.

Turritella altilira Conrad **mirandana,** n. subsp. Pl. 23, fig. 10; Pl. 28, fig. 2.

This subspecies stands very close to *T. altilira* Conrad, *sensu stricto*, and to its variety *chiriquiensis* Olsson,[1] but there is a slight difference which is constant in the Venezuelan forms, *viz.*, the components of the double upper

[1] A. A. Olsson, Bull. Amer. Pal., Vol. 9, pp. 322–323, Pl. 17, fig. 4, 1922.

spiral rib are almost equal, or the weaker supplementary cord is posterior to or above the larger anterior one. In all of our specimens from Gatun, C. Z., the upper rib, if double, has the weaker cord below, or just anterior to the larger posterior cord. The two main cords forming the strong posterior rib vary in strength; frequently, the two cords attain an almost equal size but in no case does the posterior component become stronger than the lower component, as is the general case in typical *T. altilira* Conrad.

This subspecies differs from variety *chiriquiensis* Olsson in that the upper carinating rib is double; in variety *chiriquiensis*, it is single; in the latter, there occurs on the posterior slope a weaker spiral thread which is not a supplementary cord of the upper keel. The posterior slope is much steeper than in variety *chiriquiensis* due to the greater width of the upper double keel.

Age: Miocene.

Locality: Common in the States of Falcón and Zulia, Venezuela, and at Cartagena, Columbia. Locality Numbers: 103 (?), 122B, 149, 154, 171 or 172 (variation), 178 (variation), 179, 277, 304, 1004, 1031 (?), 1100, 1799 (*cf.*), 1800, 1802, 1805, 1859 (*cf.*), 1860 (?), 1901, 1905, 1931B, 1931C, 1934, 3222.

Turritella vistana, n. sp. Pl. 23, figs. 3, 4; Pl. 27, figs. 8, 9, 12; Pl. 28, fig. 4.

Shell is turreted, bicarinate, attenuate. Protoconch and early nepionic whorls are missing. Later nepionic whorls are bicarinate; upper spiral rib is weaker than the lower; the concave interspace between the keels is ornamented with about three secondary spirals; all the spirals are beaded in well preserved specimens. In the neanic stages, the two single keels are almost equal in size, and later, the posterior finally becomes the larger of the two. In the succeeding whorls, the keels are always single, very pronounced in transverse height, rather narrow in axial width, with deep, narrow, concave interspaces; when the keels are much extended, they are frequently concave on either side, but more so on the sides facing the sutures; the deeply excavated area between the keels usually is ornamented with about three beaded secondary spirals and occasionally finer spiral threads; one of the spirals usually lies on the lower side of the upper rib; the sigmoid growth lines cause heavy beads or oblique nodes elongated in the direction of the lines of growth over the keels.

In well preserved specimens, the whole surface of the shell shows minute spiral ornamentation; in the adult whorls below the concavity under the anterior keel, there is a strong prominence or shoulder, ornamented with sub-microscopic threads, which juts over the excavated suture.

This species closely resembles *T. altilira* Conrad but differs in having the upper keel weaker than the lower in the young stages; in having single carinating ribs, the posterior of which becomes stronger in adult stages; and in having deeper, narrower interspaces between the carinating spirals. It is not confusable with *T. perattenuata* Heilprin or *T. altilira* Conrad *mirandana* (n. subsp.), both of which have a double upper keel. It differs from *T. guppyi* Cossmann *morantensis* (n. subsp.), and from *T. altilira* Conrad *urumacoensis* (n. subsp.) in having the weaker posterior keel of the young stages become the stronger in the adult whorls, and in having more pronounced keels with a deeper, narrower, medial concavity between them. It further differs from *T. guppyi* Cossmann and its new subspecies *morantensis* in lacking the spiral thread on the posterior slope of the latter species and subspecies.

Age: Miocene.

Locality: Common in the State of Falcón. Locality Numbers: 83B, 93 (*cf.*), 97, 121 (*cf.*), 122B, 146 (or var.), 149, 149B, 154, 155, 163, 169A, 171, 174, 180, 182, 185, 187, 193, 194A (*cf.*), 204, 216, 229, 270, 277 (or subsp. *nicholsi*), 317, 1007 (*cf.*), 1017, 1031, 1033, 1043, 1111, 1255, 1335, 1552, 1850, 1855, 1856, 1866, 1867, 1873, 1911, 1928.

Turritella vistana nicholsi (Williston MS.) Pl. 23, fig. 6; Pl. 29, figs. 2, 5.

This subspecies is distinguished by the pronounced size of the extended keels which cause them to become unwieldy, irregular in spacing, and slovenly in appearance. The keels may droop down anteriorly or turn up posteriorly on even a single volution.

Age: Miocene.

Locality: Districts of Colina and Miranda, State of Falcón. Locality Numbers: 140, 148, 148BB, 149A, 149B, 210, 212, 301, 412, 1056 (?), 1118, 1833 (*cf.*).

Turritella bifastigata Nelson **maracaibensis,** n. subsp. Pl. 30, figs. 2, 4, 6.

This subspecies is very close to *T. bifastigata* Nelson and we would refer it to this species, *sensu stricto,* except for slight but constant differences which make it advisable to separate it as a distinct subspecies.

Dr. Carl O. Dunbar of the Peabody Museum at Yale University very obligingly sent us Nelson's specimens from which *T. bifastigata* was originally described. Two of these Nelson [1] mentioned especially, giving the dimensions. The first one mentioned (length 61 mm., greatest diameter 19.1 mm., diameter of smallest whorl 7 mm.) we have selected for the lectotype of the species; Spieker [2] reviewed these species quite thoroughly and figured one of the specimens, but did not state whether it was Nelson's specimen or not. Upon examining the lectotype, we find it to be the one which Spieker figured, but for clearness we are refiguring it, Pl. 30, fig. 1. There is only one specimen in Nelson's collection which corresponds to each he described and measured. As Spieker states (*loc. cit.*), Grzybowski described and figured this *Turritella* as a new species which

[1] Trans. Conn. Acad., Vol. 2, p. 189, 1870.

[2] E. M. Spieker. The Paleontology of the Zorritos Formation of the North Peruvian Oil Fields, pp. 63–65, Pl. 3, fig. 1, The Johns Hopkins Press, 1922.

he called *T. gothica.*[1]

In 1912, Pilsbry and Brown [2] described as a new species three whorls of a *Turritella* from Cartagena, Columbia, which is evidently of the *T. bifastigata* type, under the name of *T. cartagenensis;* as described, it is somewhat larger than most of our specimens and in the description of the base they say:

"The base is somewhat convex, and shows four very low, wide spiral welts, with the same finer spirals as the upper surface." [3] This would seem to indicate that it is intermediate between the Peruvian and Venezuelan forms, as the typical *bifastigata* shows about six sharp spirals or "welts" on the base, while our form is almost smooth and ornamented by numerous finer spirals of varying strength.

In 1922, Olsson [4] described as a new species, a form occurring in Costa Rica which is very similar to *T. bifastigata* Nelson, but until more specimens are collected to show its genetic relationship, it is hard to say whether this is of specific or subspecific rank. It differs chiefly in having a very prominent posterior swelling which overlaps the anterior suture of the preceding whorl.

The distinguishing feature in the new subspecies *maracaibensis* is the ornamentation of the base. The typical Peruvian form has five or six very prominent folds on the base of the adult whorls which in this subspecies have been changed to many small spiral threads of varying strength. On the part of the base covered by the succeeding whorls there are six or seven widely spaced spirals, somewhat stronger than the weaker intervening spiral threads. This change is probably due to a locality difference. It is easy to separate the Venezuelan forms of the *bifastigata* stock by this difference alone, because *T. bifastigata*

[1] Neues Jahrbuch für Min. Geol. etc., Beil. Bd. 12, p. 645, Pl. 20, fig. 10, 1899.

[2] Proc. Acad. Nat. Sciences of Philadelphia, 1917, pp. 34–35, Pl. 5, fig. 13.

[3] *loc. cit.*, p. 35.

[4] A. A. Olsson, Bull. Amer. Pal., Vol. 9, pp. 324–325, Pl. 17, fig. 1, 1922.

Nelson, *sensu stricto,* has the base of the whorls corrugated by very strong spiral ribs; this ornamentation makes the Peruvian form quite distinct from ours which has a smoother base with more numerous weaker spirals. The base of the whorl is somewhat convex with a rounded, carinating, anterior prominence just behind the anterior suture.

The posterior shoulder tends to be prominent and to overlap the suture to a certain extent, but less than is commonly found in the Peruvian form. In other words, the suture in this subspecies tends to be slightly more open or gaping than in *bifastigata, sensu stricto,* and less gaping than in the new subspecies *democraciana.*

Age: Miocene.

Locality: Common in the northern part of the State of Falcón. Locality Numbers: 70A, 70B, 71, 72, 81, 83, 86, 87, 90, 1233, 1757, 1856, 1858 (*cf.*), 1872, 1874, 1875, 1883, 1884, 1892, 2036.

Turritella bifastigata Nelson **democraciana,** n. subsp. Pl. 28, fig. 3; Pl. 30, figs. 3, 5.

This subspecies differs from the other subspecies, *maracaibensis,* in having a nearly flat base, slightly concave in some specimens, slightly convex in others, which projects a little beyond the sides of the whorls as a basal keel; the base is almost at right angles to the sides of the whorls; the rounded area between the base and sides of the whorls in *maracaibensis* is lacking in this subspecies and replaced by the angulated anterior keel. The base of the whorl is ornamented with twenty or more small spirals of varying strength; usually there is one or more weaker, intervening, spiral threads between the stronger. The sutures are more open and gaping than in any of the similar forms.

Age: Miocene.

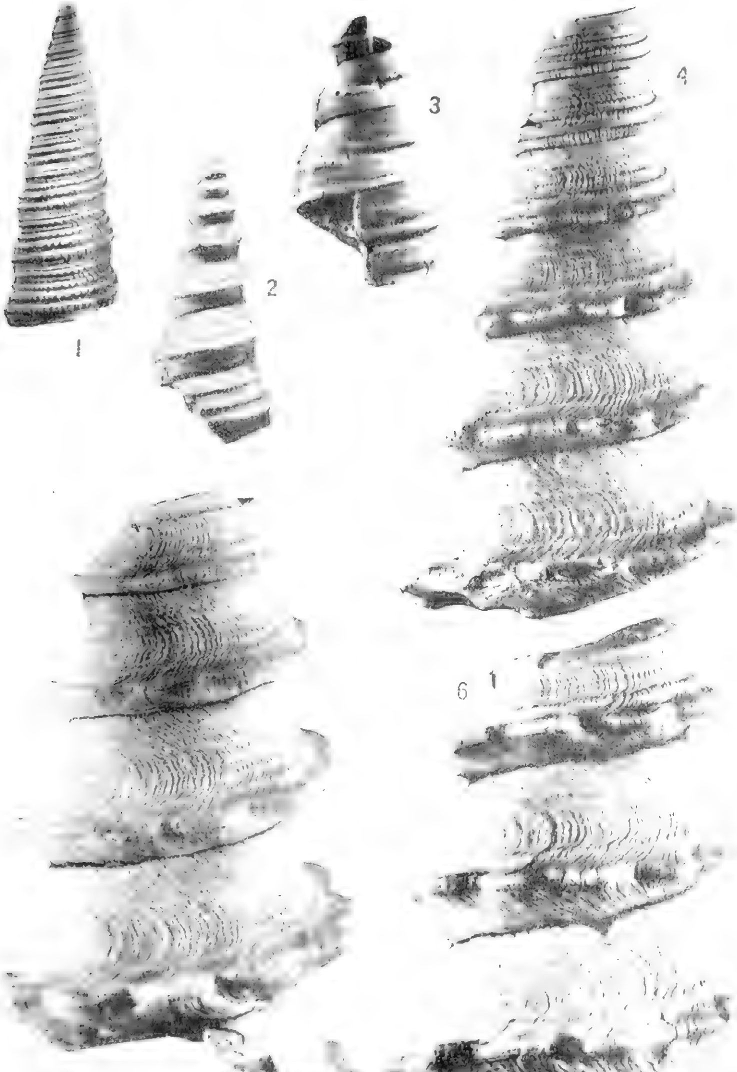
Locality: Common in the northern part of the State of Falcón. Locality Numbers: 70A, 70B, 70C, 80, 81, 82, 83, 83B, 84, 85, 86, 87, 90, 94, 96, 97, 103, 149B, 150B, 163, 184, 219, 1117, 1231, 1233, 1335, 1757, 1850, 1852, 1856, 1858, 1859, 1860, 1861, 1862, 1869 (?), 1872, 1883, 1908, 1911.

PLATES

Photographs by the author; engravings by the Hurst Engraving Co.

PLATE 1.

Fig.		Page
1.	**Turritella zuliana,** n. sp. Paratype from Loc. No. 6, collected by Mr. W. A. Watkins, length 20 mm., greatest diameter 7.3 mm.	8
2.	**Turritella zuliana,** n. sp. Paratype from Loc. No. 6, protoconch, length 3.7 mm., greatest diameter of next to last whorl 1.38 mm.	8
3.	**Turritella zuliana,** n. sp. Paratype from Loc. No. 6, young whorls, length 3 mm., greatest diameter 1.9 mm.	8
4.	**Turritella zuliana,** n. sp. Holotype, from Loc. No. 6, length 60 mm., greatest diameter 22.5 mm.	8
5.	**Turritella zuliana,** n. sp. Paratype from Loc. No. 6, length 38 mm., greatest diameter 22 mm.	8
6.	**Turritella zuliana,** n. sp. Paratype from Loc. No. 6, collected by Mr. W. A. Watkins, length 33 mm., greatest diameter 24.1 mm.	8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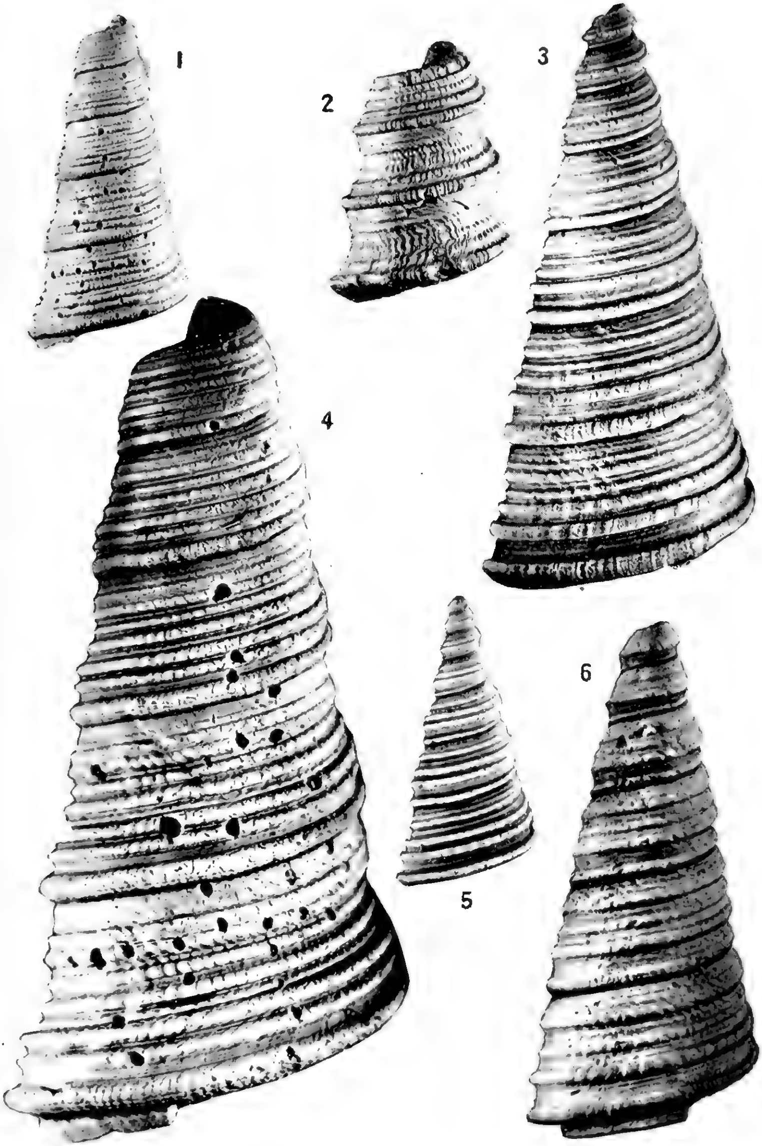
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PLATE 3.


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PLATE 4.

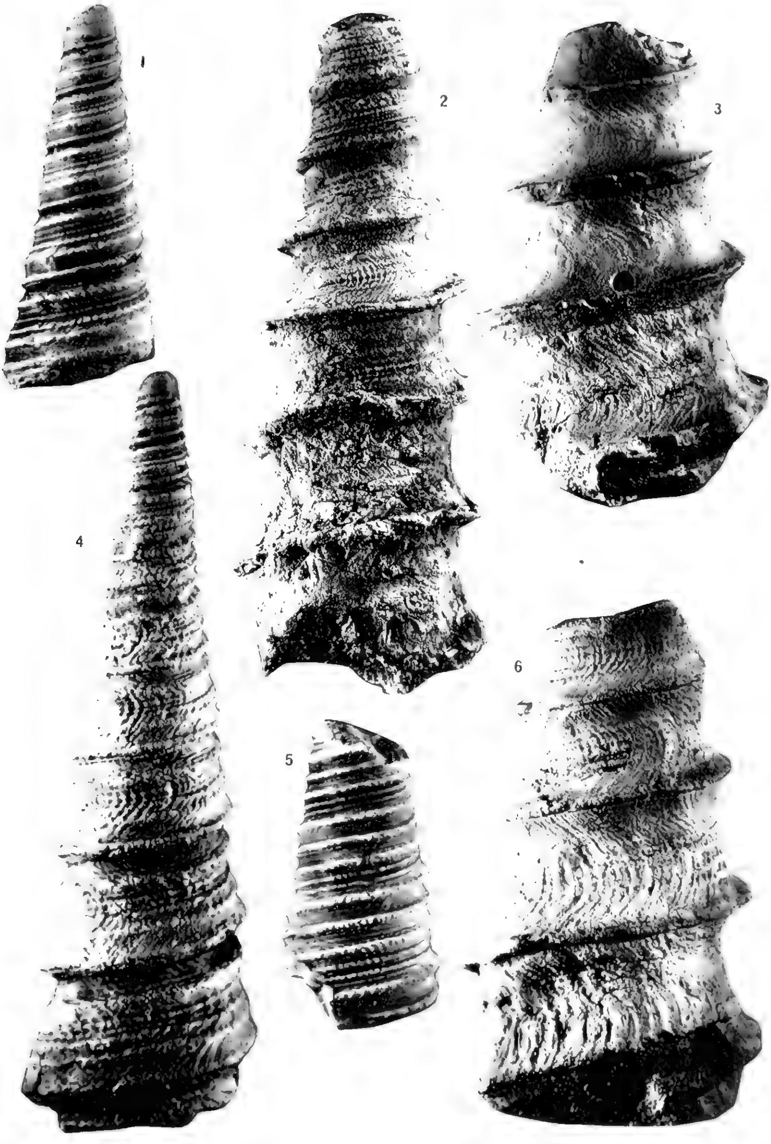
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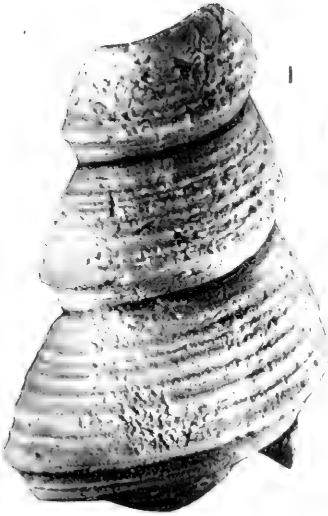
PLATE 5.

FIG. PAGE

1. **T. robusta** Grzybowski **fredeai,** n. subsp. Paratype from Loc. No. 72, young whorls enlarged, length 12.6 mm., greatest diameter 8.6 mm. ... 13
2. Form intermediate between **T. larensis,** n. sp. and **T. larensis santiagana,** n. subsp. Length 26 mm. From Loc. No. 2027. 12
3. **T. robusta** Grzybowski **fredeai,** n. subsp. Paratype from Loc. No. 70A, enlarged, length 41 mm. ... 13
4. **T. larensis,** n. sp. Paratype from Loc. No. 2027, length 34 mm., greatest diameter 20.5 mm. For comparison with Pl. 4, fig. 3, and fig. 2 on this plate ... 10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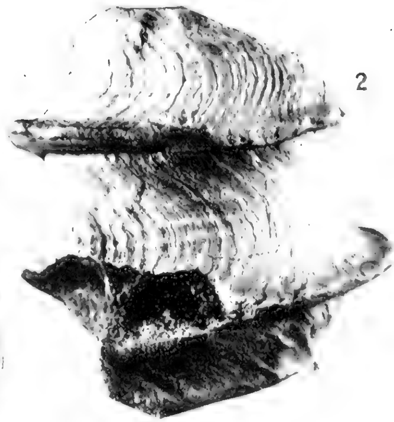
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3

4

PLATE 6.

FIG.		PAGE
1.	**T. larensis carrizalensis,** n. subsp. Paratype from Loc. No. 2022, length 36.5 mm., greatest diameter 20.5 mm.	12
2.	**T. robusta** Grzybowski **fredeai,** n. subsp. Paratype from Loc. No. 72, youngest whorls found, enlarged; length 21.5 mm., greatest diameter of second largest whorl 10.2 mm.	13
3.	**T. larensis carrizalensis,** n. subsp. Holotype from Loc. No. 2027, length 41 mm., greatest diameter 21 mm.	12
4.	**T. larensis carrizalensis,** n. subsp. Paratype from Loc. No. 2023, length 64 mm., greatest diameter 23 mm.	12
5.	**T. robusta** Grzybowski **fredeai,** n. subsp. Paratype from Loc. No. 70A, very large whorl, greatest diameter 50 mm.	13
6.	**T. cauredalitoensis** (Williston MS.). Paratype from Loc. No. 1217, length 14 mm., greatest diameter 6 mm.	15


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6
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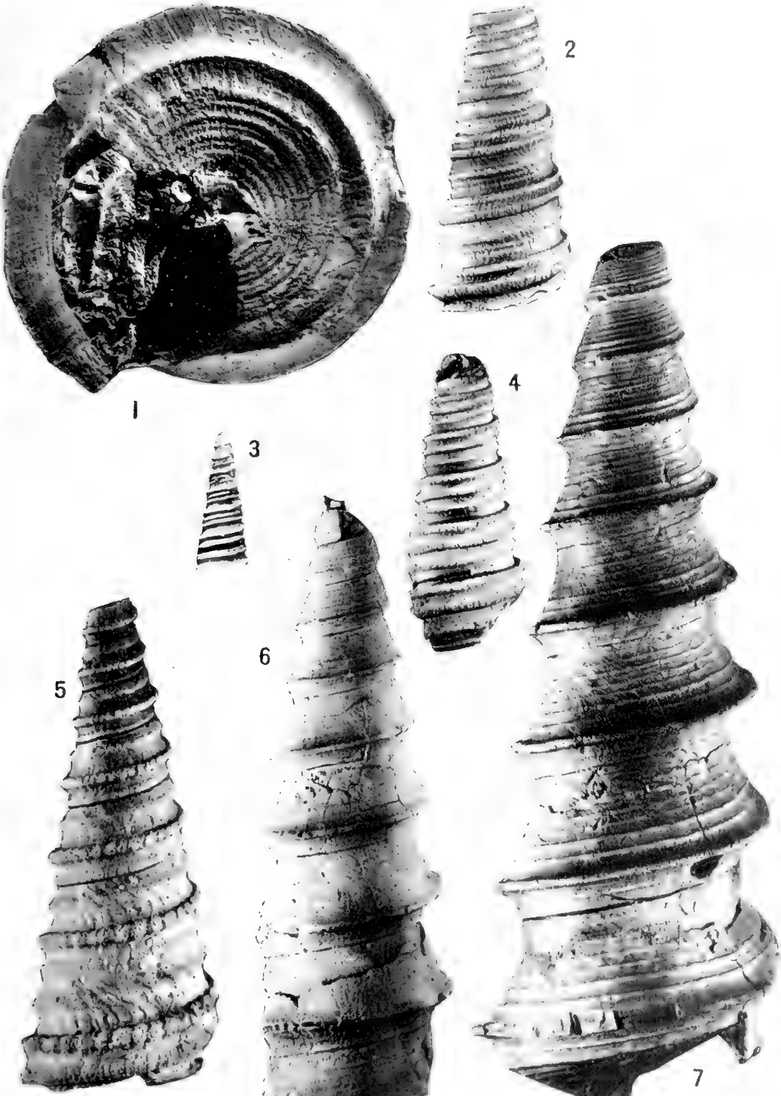
PLATE 7.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7

PLATE 8.

FIG. PAGE

1. **T. hubbardi,** n. sp. Paratype from Loc. No. 2040, greatest diameter 13 mm. Shows ornamentation on lower part of basal carina and slightly knobby character of the lower cord. 14
2. **T. hubbardi,** n. sp. Paratype from Loc. No. 2019A, young whorls enlarged, length 8.8 mm., greatest diameter 4 mm..... 14
3. **T. hubbardi,** n. sp. Holotype from Loc. No. 2040, length 30 mm., greatest diameter 10 mm... 14
4. **T. hubbardi,** n. sp. Same specimen as fig. 6, enlarged......... 14
5. **T. hubbardi,** n. sp. Paratype from Loc. No. 2040, length 18.7 mm., greatest diameter 6.5 mm.................................... 14
6. **T. hubbardi,** n. sp. Paratype from Loc. No. 2019A, length 20 mm., greatest diameter 8 mm... 14
7. **T. hubbardi weeksi,** n. subsp. Paratype from Loc. No. 3250, collected by Mr. L. G. Weeks. A slender variation, length 26 mm., greatest diameter 9.4 mm... 15

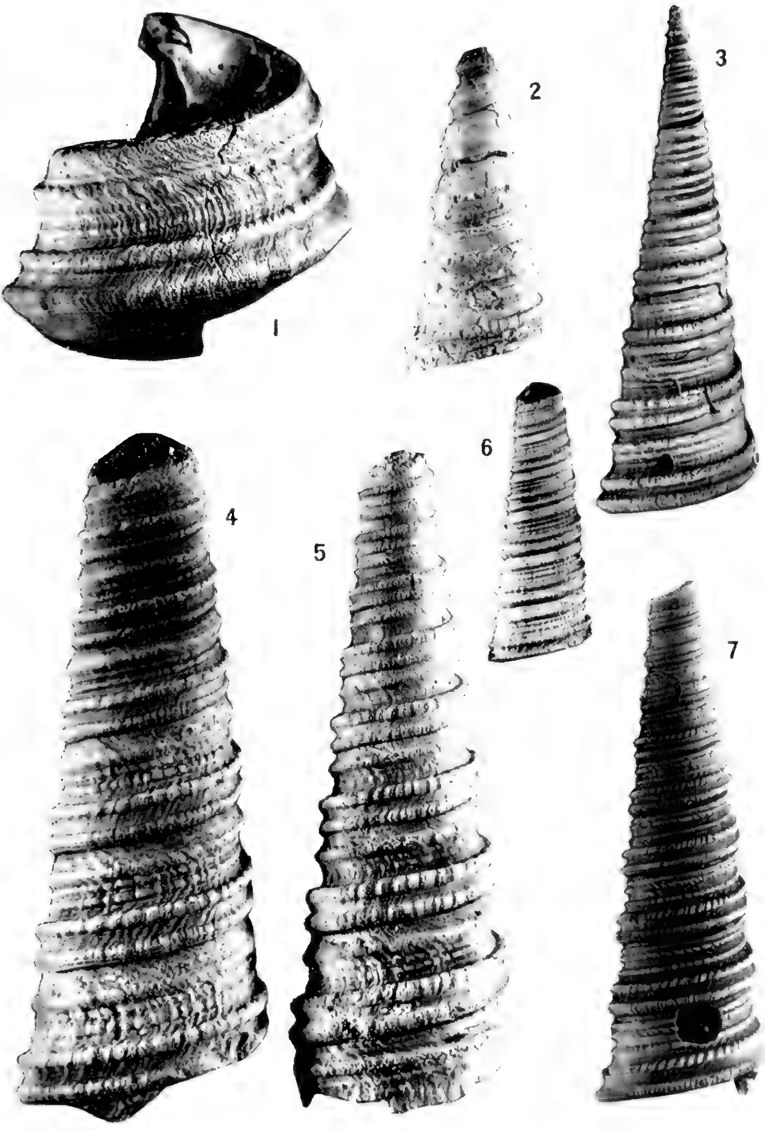
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PLATE 9.


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4
5
6
7

PLATE 10.

FIG. PAGE

1. **T. larensis guaratarensis,** n. subsp. Paratype from Loc. No. 1938, length 17.5 mm., greatest diameter 13.1 mm......... 12
2. **T. cauredalitoensis** (Williston MS.). Paratype collected by Mr. S. H. Williston, length 21 mm., greatest diameter 9 mm. 15
3. **T. larensis guaratarensis,** n. subsp. Holotype from Loc. No. 1938, length 40 mm., greatest diameter 19 mm........................ 12
4. **T. hubbardi weeksi,** n. subsp. Holotype from Loc. No. 3250, collected by Mr. L. G. Weeks, length 37.3 mm., greatest diameter 9.5 mm.. 15
5. **T. hubbardi weeksi,** n. subsp. Paratype from Loc. No. 3250, collected by Mr. L. G. Weeks, length 04 mm., greatest diameter 15 mm.. 15

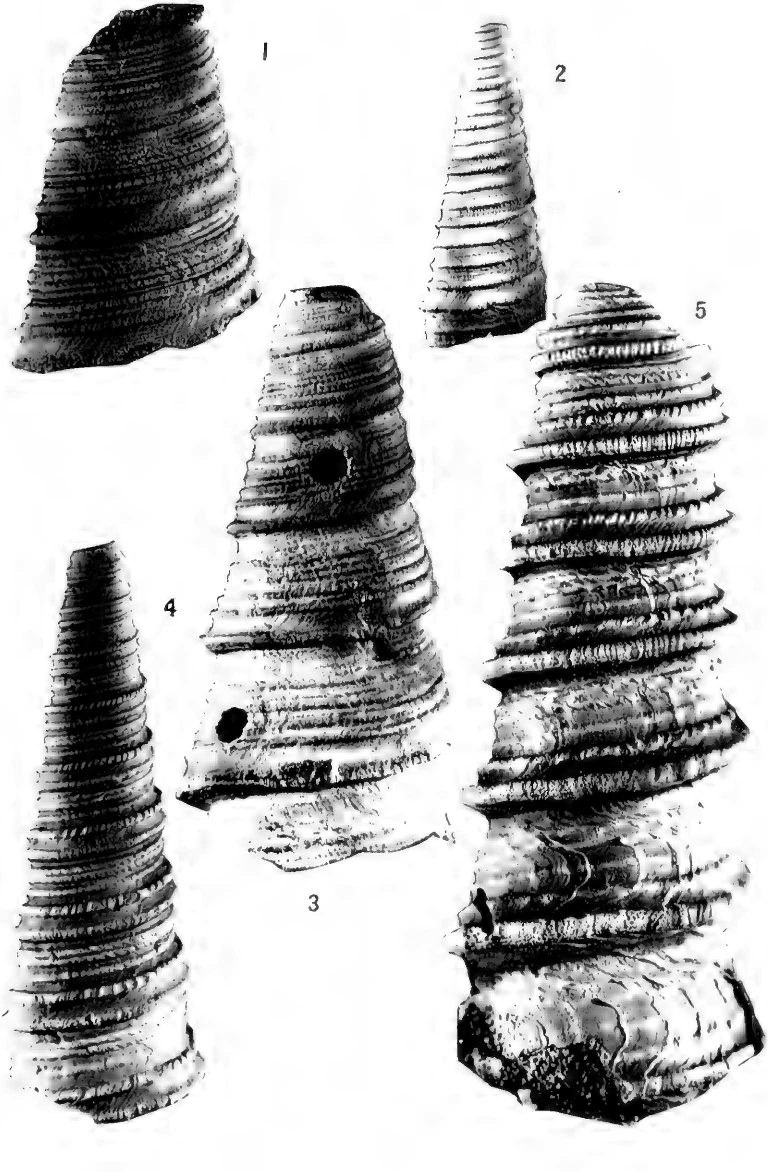
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PLATE 11.

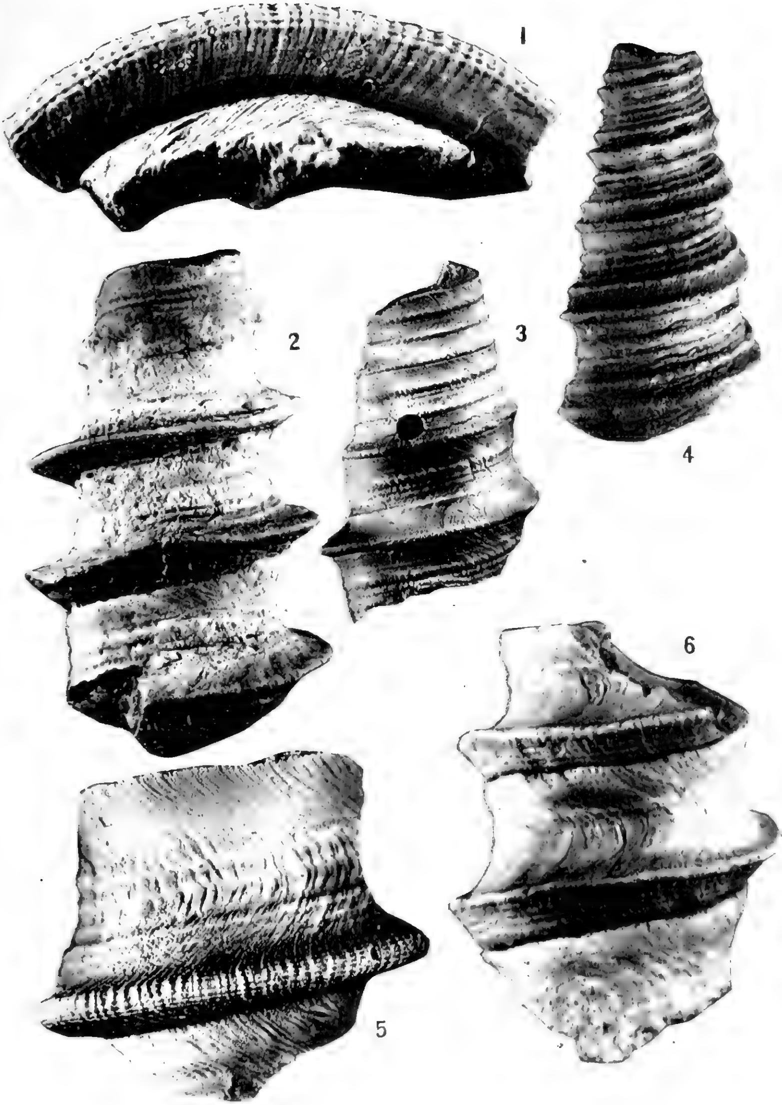

PLATE 12.

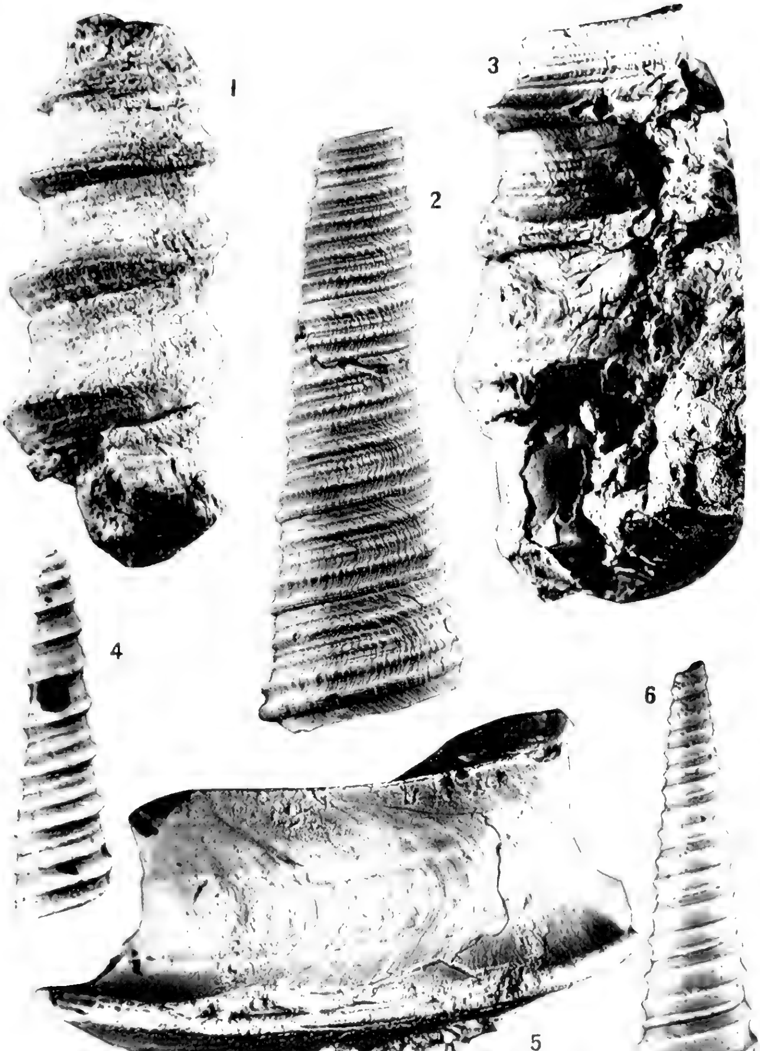
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PLATE 13.

FIG. PAGE

1. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 6, length 18 mm., greatest diameter 9 mm. 17
2. **T. gilbertharrisi,** n. sp. Same specimen as fig. 1, enlarged 17
3. **T. gilbertharrisi,** n. sp. Holotype from Loc. No. 6, length 60 mm., greatest diameter 15 mm. The longest single specimen found. (The part that had been hopelessly crushed is replaced with modeling wax) 17
4. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 6, length 20 mm., greatest diameter 7 mm. 17
5. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 6, protoconch, length 4.13 mm., greatest diameter 1.22 mm. 17
6. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 6, length 32 mm., greatest diameter 9 mm. 17

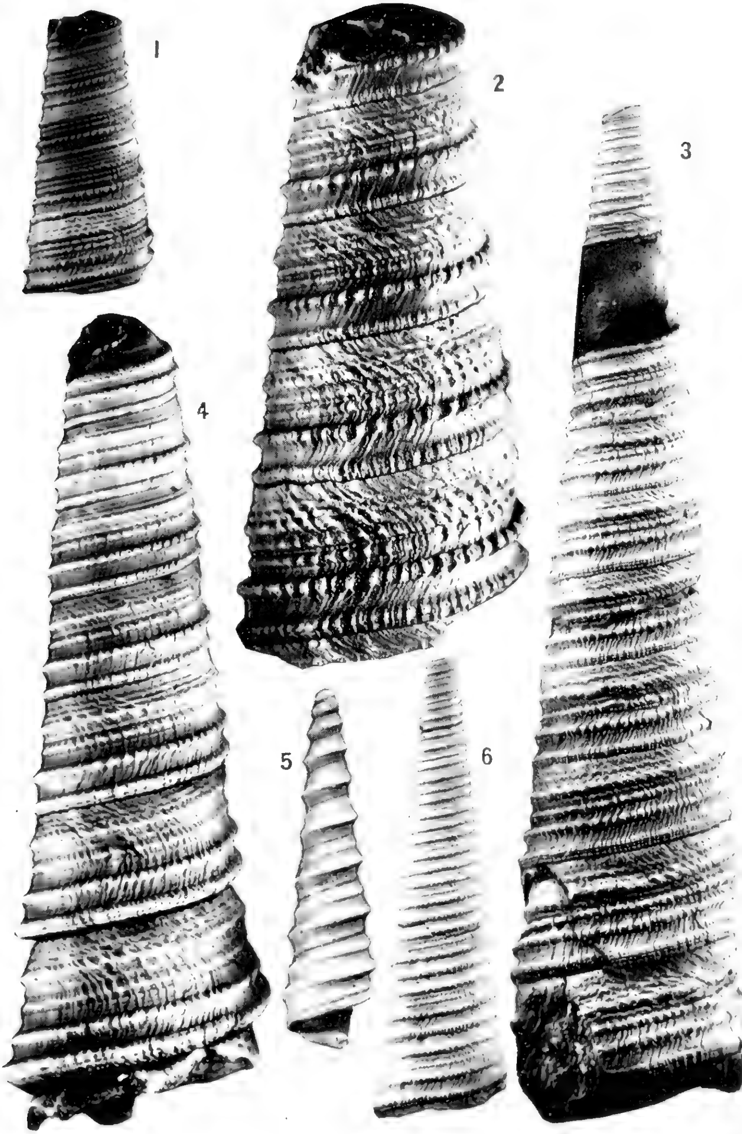
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PLATE 14.

FIG. PAGE

1. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 1415, young whorls enlarged, length 14.5 mm., greatest diameter 6 mm. 17
2. **T. gilbertharrisi falconensis** (Williston MS.). Paratype from Loc. No. 1928, showing common appearance, length 52 mm., greatest diameter 23.2 mm.......... 19
3. **T. montañitensis,** n. sp. Paratype from Loc. No. 1939, young whorls enlarged, length 13.5 mm., greatest diameter 7.2 mm. 20
4. **T. gilbertharrisi,** n. sp. Same specimen as Plate 13, fig. 6. Length 32 mm.......... 17
5. **T. hubbardi,** n. sp. Paratype from Loc. No. 2040, young whorls enlarged, length 9.5 mm., greatest diameter of smallest whorl 1.4 mm., greatest diameter of largest whorl 3.9 mm. 14
6. **T. gilbertharrisi falconensis** (Williston MS.). Holotype from Loc. No. 1928, length 59 mm., greatest diameter 20 mm. 19
7. **T. gilbertharrisi,** n. sp. Paratype from Loc. No. 1415, enlarged to show sculpture, length 21 mm., greatest diameter 12 mm.......... 17
8. **T. gilbertharrisi falconensis** (Williston MS.). Paratype from Loc. No. 1127, length 38.5 mm., greatest diameter 18.7 mm. 19

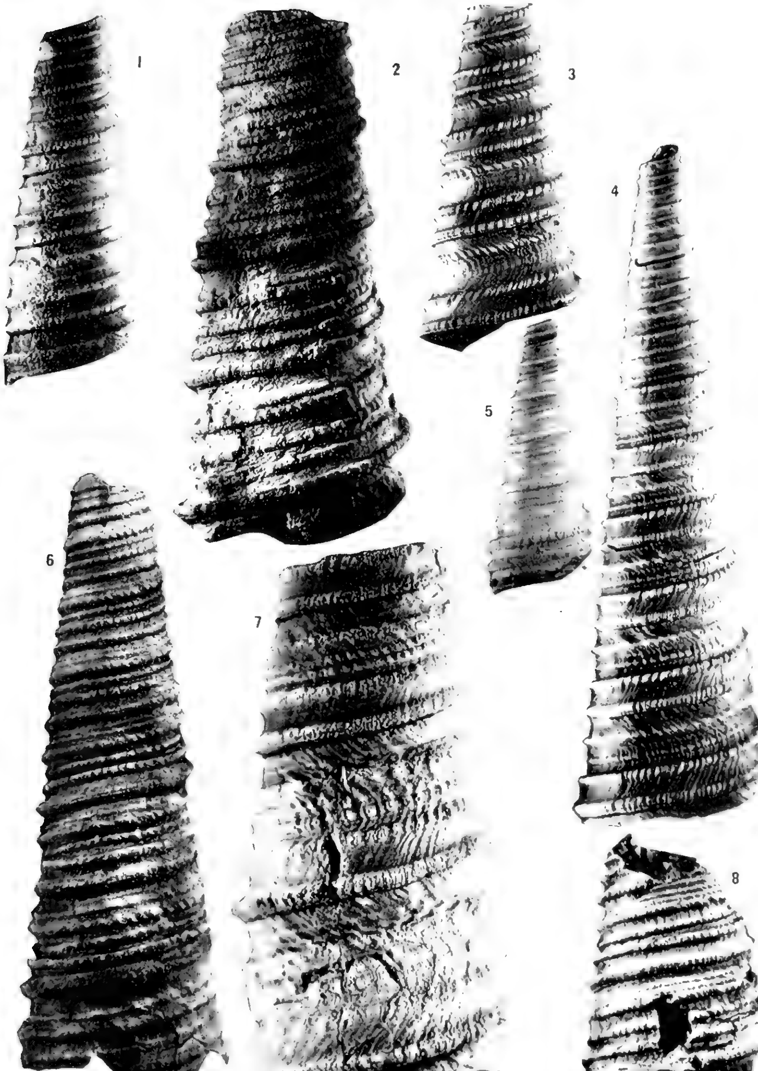
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PLATE 15.

Fig.		Page
1.	**T. gilbertharrisi aguavivensis,** n. subsp. Holotype from Loc. No. 2019, length 22 mm., greatest diameter 11 mm.	19
2.	**T. montañitensis,** n. sp. Paratype from Loc. No. 1939, length 20.5 mm., greatest diameter 9.5 mm.	20
3.	**T. gilbertharrisi falconensis** (Williston MS.). Paratype from Loc. No. 341, length 29.5 mm., greatest diameter 12.3 mm.	19
4.	**T. gilbertharrisi falconensis** (Williston MS.). Paratype from Loc. No. 1067, length 41.1 mm., greatest diameter 15 mm.	19
5.	**T. gilbertharrisi falconensis** (Williston MS.) Paratype from Loc. No. 1265, length 17 mm., greatest diameter 8.2 mm.	19
6.	**T. gilbertharrisi staufferi,** n. subsp. Holotype, length 17 mm., greatest diameter 7.5 mm.	19
7.	**T. gilbertharrisi falconensis** (Williston MS.). Paratype, from Loc. No. 1436. Enlarged to show sculpture, length 31.5 mm., greatest diameter 16 mm.	19
8.	**T. gilbertharrisi aguavivensis,** n. subsp. Paratype from Loc. No. 6; intervening riblet is weaker than in holotype, length 21 mm., greatest diameter 14 mm.	19
9.	**T. gilbertharrisi staufferi,** n. subsp. Same specimen as fig. 6.	19

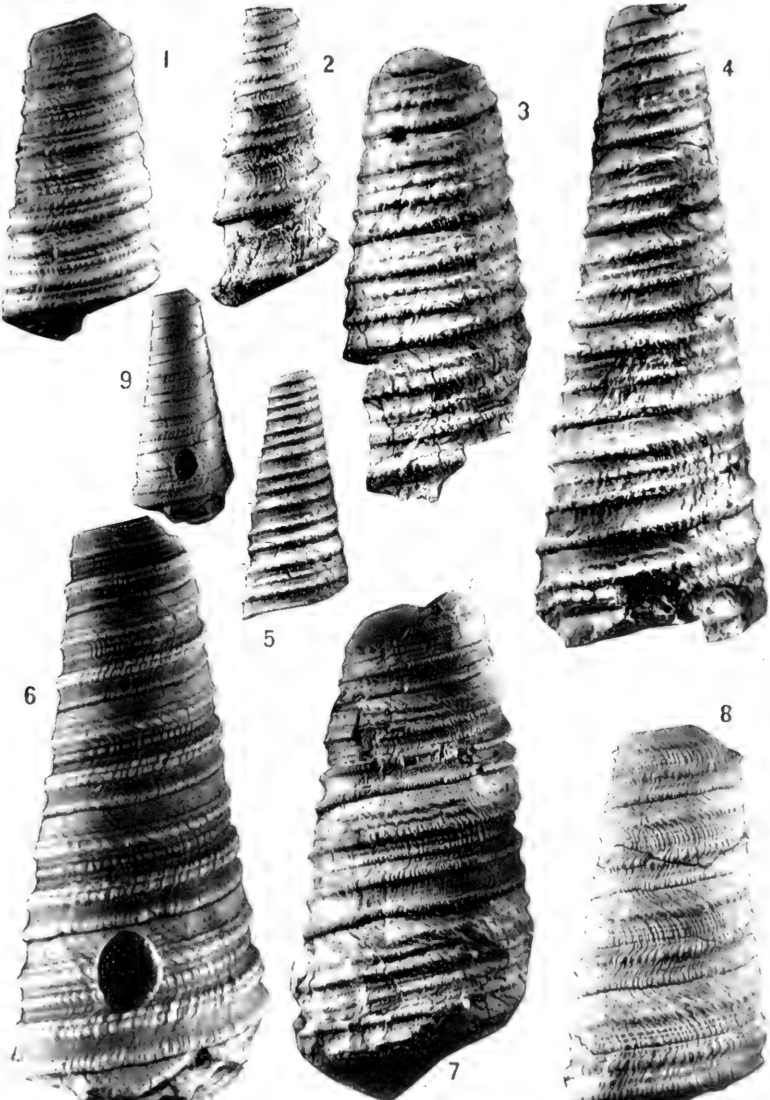
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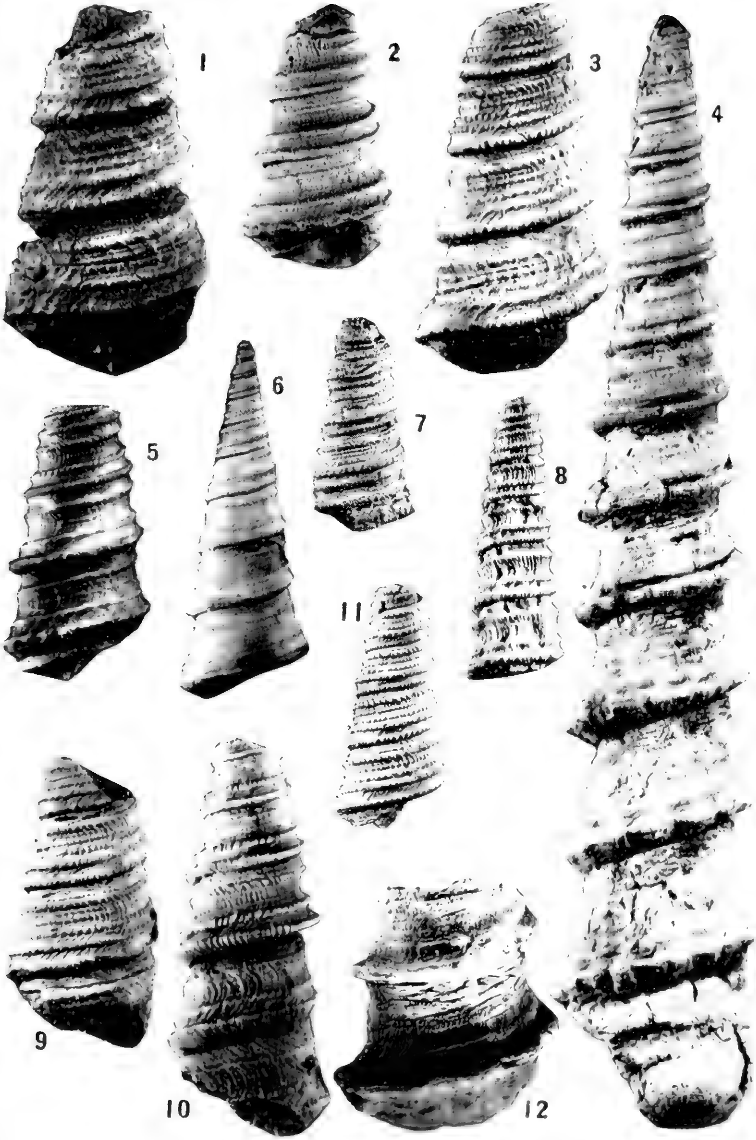
PLATE 16.

FIG. PAGE

1. **T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, length 30 mm., greatest diameter 13.5 mm........................... 22
2. **T. montañitensis saladilloensis,** n. subsp. Holotype from Loc. No. 1957, length 16 mm., greatest diameter 8.2 mm..... 22
3. **T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, length 25 mm., greatest diameter of smallest whorl 8.2 mm. 22
4. **T. montañitensis**, n. sp. Paratype, a slender variation from Loc. No. 52, length 80 mm., greatest diameter 16 mm......... 20
5. **T. montañitensis,** n. sp. Paratype from Loc. No. 1939, length 17.8 mm., greatest diameter 11 mm............................ 20
6. **T. montañitensis,** n. sp. Paratype from Loc. No. 1939, length 23.5 mm., greatest diameter 9 mm............................... 20
7. **T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, length 15.1 mm., greatest diameter 6.8 mm.......................... 22
8. **T. montañitensis,** n. sp. Paratype from Loc. No. 2031, common appearance when weathered, length 18 mm., greatest diameter 6.8 mm.. 20
9. **T. curamichatensis,** n. sp. Paratype from Loc. No. 1070, length 18 mm., greatest diameter 10.7 mm............................ 22
10. **T. montañitensis,** n. sp. Holotype from Loc. No. 1939, length 25 mm., greatest diameter 10 mm.............................. 20
11. **T. curamichatensis,** n. sp. Paratype from Loc. No. 1408, length 17 mm., greatest diameter 7.3 mm............................ 22
12. **T. montañitensis olcotti,** n. subsp. Paratype from Loc. No. No. 2052, length 24 mm., greatest diameter 18.6 mm........... 21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11
12

PLATE 17.

Fig.		Page
1.	**T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, showing a variation with flatter whorls. Length 16.5 mm.	22
2.	**T. curamichatensis,** n. sp. Holotype from Loc. No. 1070, length 27 mm., greatest diameter 13 mm.	22
3.	**T. montañitensis,** n. sp. Paratype from Loc. No. 1939, length 27 mm., greatest diameter 11 mm.	20
4.	**T. curamichatensis,** n. sp. Paratype from Loc. No. 1408, length 9 mm., greatest diameter 5 mm.	22
5.	**T. curamichatensis,** n. sp. Paratype from Loc. No. 1754, length 10 mm., greatest diameter 5.5 mm. Young whorls enlarged.	22
6.	**T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, length 34 mm., greatest diameter of smallest whorl 6 mm.	22
7.	**T. montañitensis,** n. sp. Same specimen as Plate 16, fig. 6. Length 23.5 mm.	20
8.	**T. montañitensis,** n. sp. Holotype from Loc. No. 1939, length 25 mm., greatest diameter 10 mm. Same specimen as Pl. 16, fig. 10.	20
9.	**T. curamichatensis,** n. sp. Paratype from Loc. No. 1436, length 22 mm., greatest diameter 12.5 mm.	22
10.	**T. montañitensis,** n. sp. Same specimen as fig. 3.	20
11.	**T. montañitensis,** n. sp. Paratype from Loc. No. 1939, length 13.5 mm., greatest diameter 7.2 mm. Same specimen as Pl. 14, fig. 3.	20


1
2
3
4
5
11
6
9
7
10
8

PLATE 18.

Fig.		Page
1.	**T. berjadinensis,** n. sp. Paratype from Loc. No. 67, length 15 mm., greatest diameter 8 mm.	26
2.	**T. gatunensis willistoni,** n. subsp. Holotype from Loc. No. 1033, length 28.8 mm., greatest diameter 7.6 mm.	25
3.	**T. gatunensis willistoni,** n. subsp. Paratype from Loc. No. 1033, length 20.5 mm., greatest diameter 8 mm.	25
4.	**T. gatunensis willistoni,** n. subsp. Paratype from Loc. No. 1856, length 18.7 mm.	25
5.	**T. gatunensis taratarana,** n. subsp. Paratype from Loc. No. 1033, length 30 mm., greatest diameter 9.1 mm.	25
6.	**T. gatunensis lavelana,** n. subsp. Paratype from Loc. No. 183, length 17.5 mm., greatest diameter 10 mm.	23
7.	**T. gatunensis taratarana,** n. subsp. Holotype from Loc. No. 185, length 27.3 mm., greatest diameter 10 mm.	25
8.	**T. gatunensis willistoni,** n. subsp. Variation with shallower constriction at top of whorl, from Loc. No. 93, length 19 mm., greatest diameter 7 mm.	25
9.	**T. berjadinensis colinensis,** n. subsp. Paratype from Loc. No. 1033, length 43 mm., greatest diameter 15 mm.	27

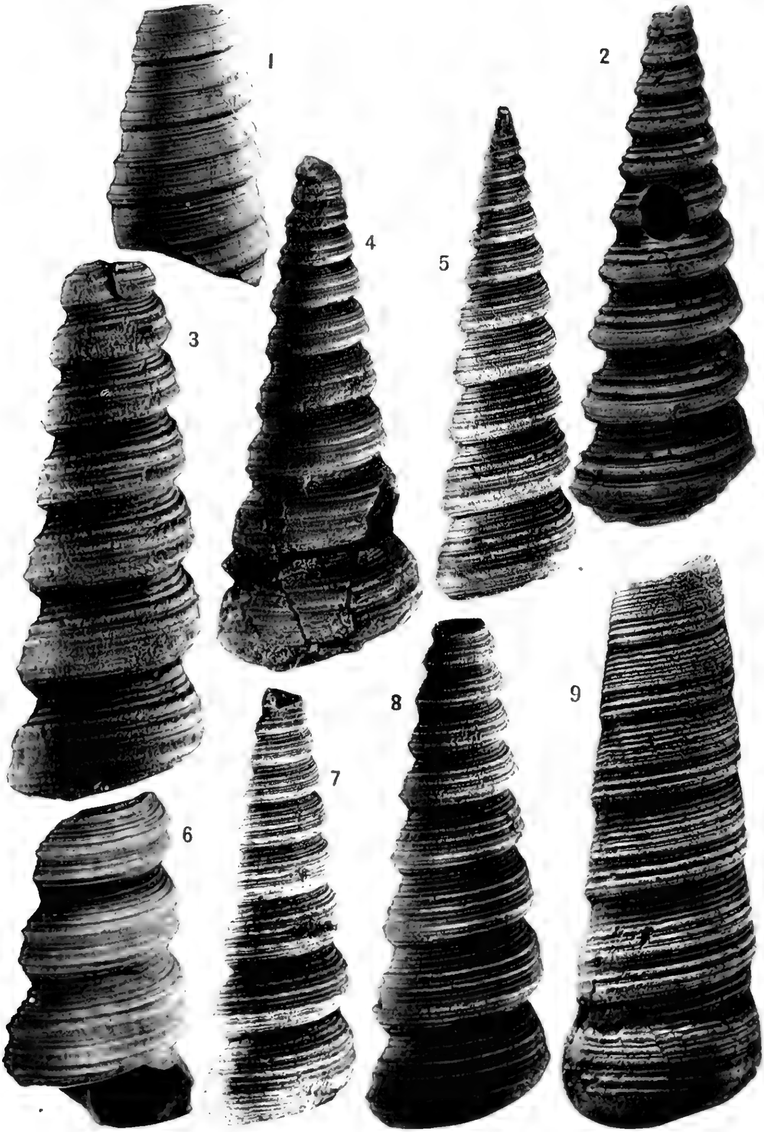
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PLATE 19.


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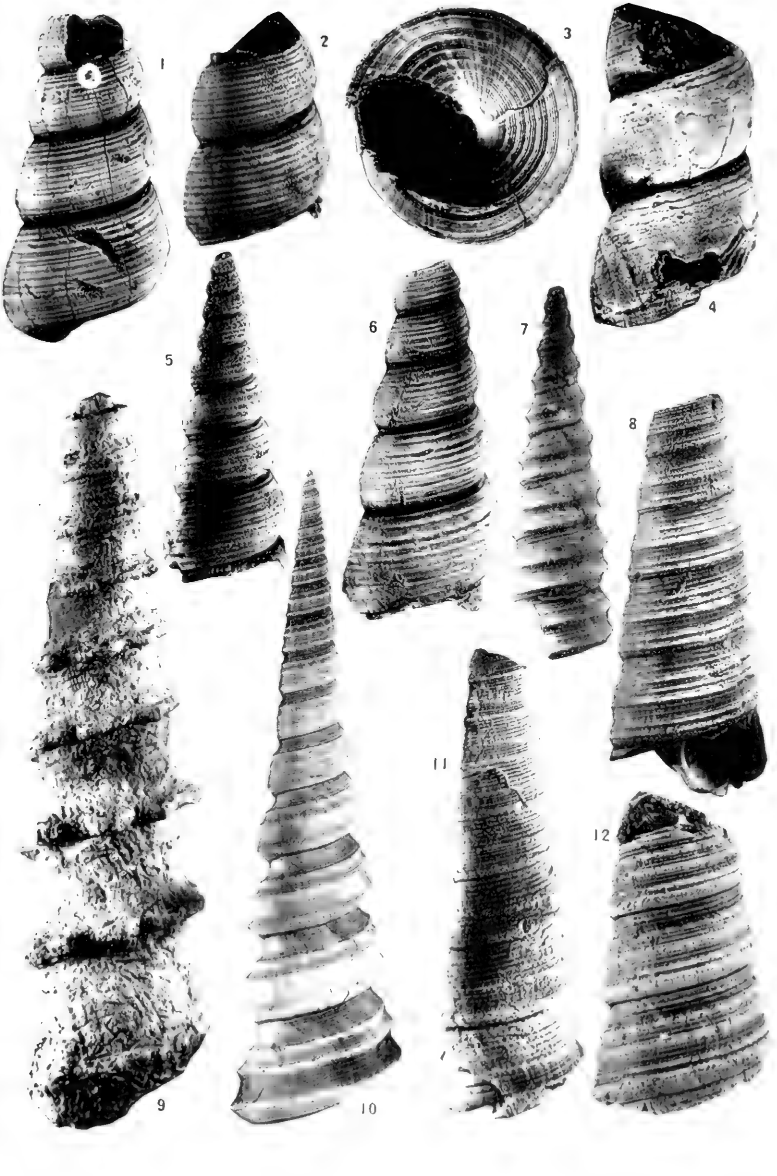
PLATE 20.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7
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9
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11
12

PLATE 21.

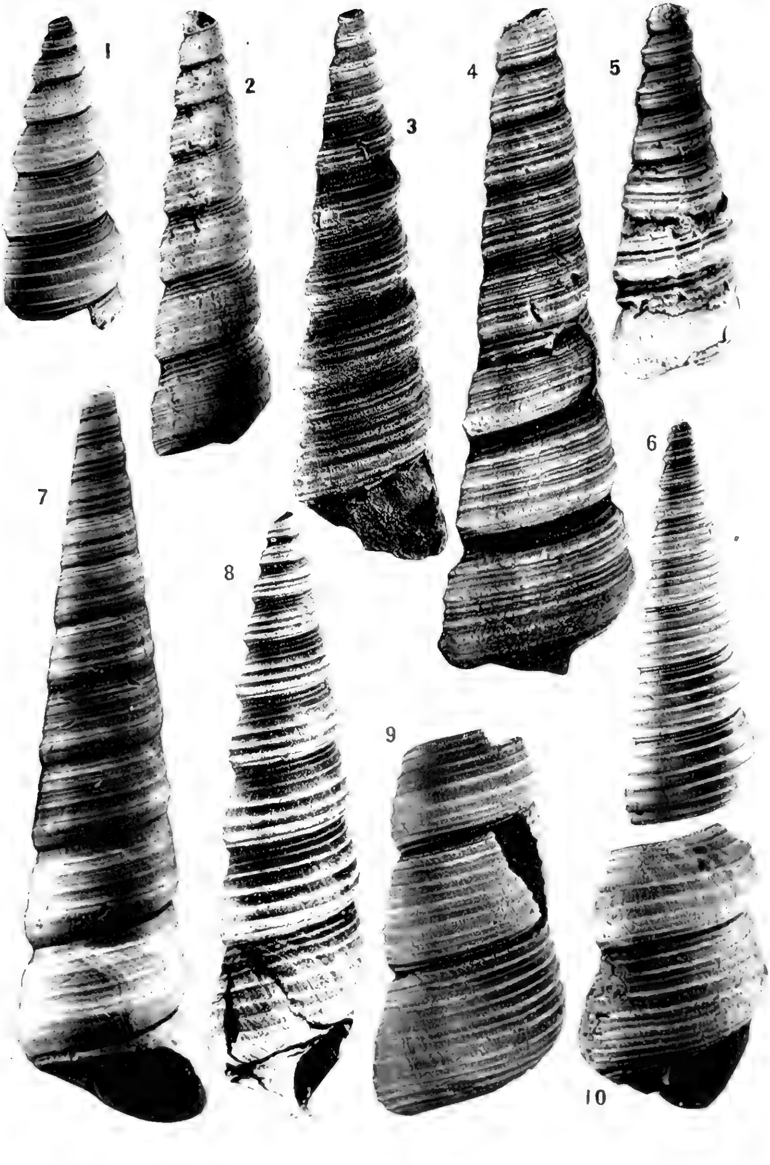
FIG.		PAGE
1.	**T. matarucana,** n. sp. Paratype from Loc. No. 197, greatest diameter 14 mm	31
2.	**T. variegata** Linné **paraguanensis,** n. subsp. Paratype from Loc. No. 1504, base enlarged to show sculpture, greatest diameter 19.5 mm	31
3.	**T. berjadinensis socorroensis** (Williston MS.). Holotype, collected by Mr. S. H. Williston. Length 31 mm., greatest diameter 12 mm	28
4.	**T. venezuelana,** n. sp. Paratype from Loc. No. 6, length 18 mm., greatest diameter 7 mm	32
5.	**T. plebeia** Say from Jones Wharf, Md. Figured for comparison. Length 27.3 mm., greatest diameter 9 mm	31
6.	**T. berjadinensis warfieldi,** n. subsp. Holotype from Loc. No. 118, length 26 mm., greatest diameter 10 mm	27
7.	**T. variegata** Linné **paraguanensis,** n. subsp. Holotype from Loc. No. 1504, length 78.5 mm., greatest diameter 21 mm	31
8.	**T. venezuelana,** n. sp. Paratype from Loc. No. 6, showing protoconch. Length 2.07 mm., greatest diameter 1 mm	32
9.	**T. matarucana,** n. sp. Holotype from Loc. No. 197, length 63.5 mm., greatest diameter 15 mm	31


1
2
3
4
5
6
7
8
9

PLATE 22.

FIG. PAGE

1. **T. venezuelana,** n. sp. Paratype from Loc. No. 6, length 16.5 mm., greatest diameter 7 mm. 32
2. **T. cornellana,** n. sp. Paratype from Loc. No. 3222, length 16 mm., greatest diameter 4.5 mm. 35
3. **T. G-A-Weaveri,** n. sp. Holotype from Loc. No. 52, length 27 mm., greatest diameter 7.9 mm. 34
4. **T. cornellana,** n. sp. Paratype from Loc. No. 3222, length 20.5 mm., greatest diameter 6.3 mm. 35
5. **T. G-A-Weaveri,** n. sp. Paratype from Loc. No. 2010, length 19.5 mm., greatest diameter of next to last whorl 7 mm. 34
6. **T. venezuelana,** n. sp. Holotype from Loc. No. 6, length 19 mm., greatest diameter 7 mm. 32
7. **T. variegata** Linné. Recent from north coast of Venezuela. Figured for comparison. Length 75 mm., greatest diameter 17 mm. 31
8. **T. venezuelana watkinsi,** n. subsp. Holotype from Loc. No. 6, length 29 mm., greatest diameter 8.2 mm. 34
9. **T. venezuelana quirosana,** n. subsp. Holotype from Loc. No. 6, length 20 mm., greatest diameter 11 mm. 34
10. **T. venezuelana quirosana,** n. subsp. Paratype from Loc. No. 6, length 14.6 mm., greatest diameter 9.8 mm. 34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9
10

PLATE 23.

Fig.		Page
1.	**T. filacarmenensis,** n. sp. Paratype from Loc. No. 1964, length 13 mm., greatest diameter 8 mm.	38
2.	**T. plebeia** Say **A-L-Owensi,** n. subsp. Holotype from Loc. No. 90, length 27 mm., greatest diameter 16 mm.	31
3.	**T. vistana,** n. sp. Holotype from Loc. No. 185, length 25 mm., greatest diameter 11.9 mm.	46
4.	**T. vistana,** n. sp. Paratype from Loc. No. 1552, length 22.2 mm., greatest diameter 19.5 mm.	46
5.	**T. filacarmenensis,** n. sp. Paratype from Loc. No. 1987, length 22, greatest diameter 11.8 mm.	38
6.	**T. vistana nicholsi** (Williston MS.). Composite of 2 specimens collected by Mr. S. H. Williston. Upper specimen: length 44 mm., greatest diameter 15.5 mm. Lower specimen: length 50 mm., greatest diameter 21 mm.	48
7.	**T. buchivacoana,** n. sp. Paratype from Loc. No. 1761, young whorls enlarged, length 7.7 mm., greatest diameter 2.8 mm.	39
8.	**T. berjadinensis socorroensis** (Williston MS.). Paratype from Loc No. 100, length 32 mm., greatest diameter 19.5 mm.	28
9.	**T. G-A-Weaveri,** n. sp. Paratype from Loc. No. 52, length 11.6 mm., greatest diameter 5.4 mm.	34
10.	**T. altilira mirandana,** n. subsp. Holotype from Loc. No. 154, length 22.5 mm., greatest diameter 13 mm.	45
11.	**T. mauryæ,** n. sp. Holotype, collected by Dr. Maury from Cercado de Mao, Santo Domingo. (Same specimen as in Bull. Amer. Pal., Vol. 5, Pl. 48, fig. 14.). Length 22.5 mm., greatest diameter 8 mm.	30

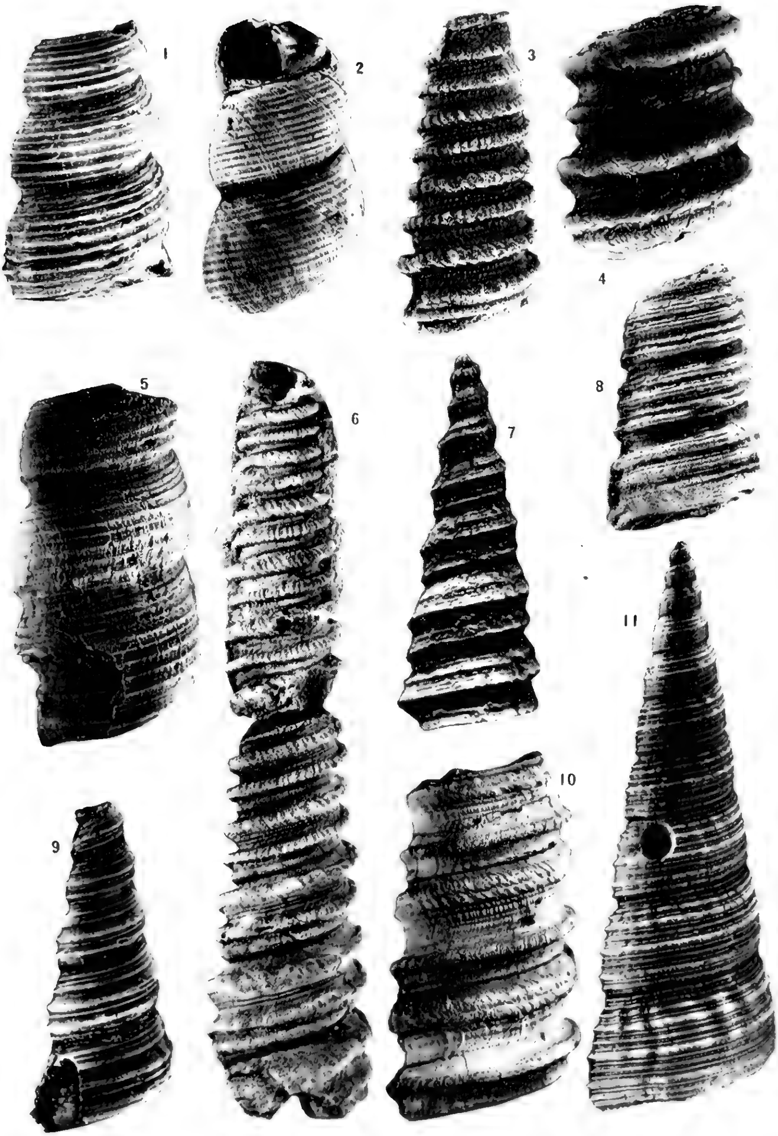
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PLATE 24.

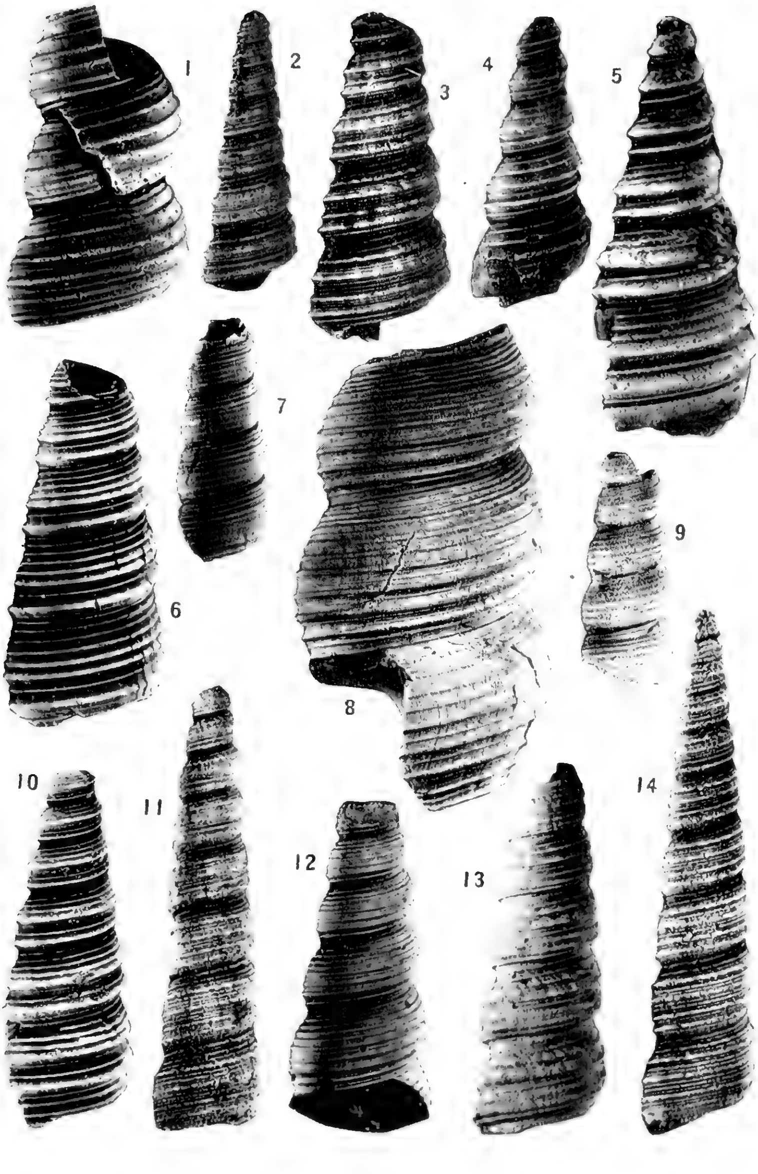
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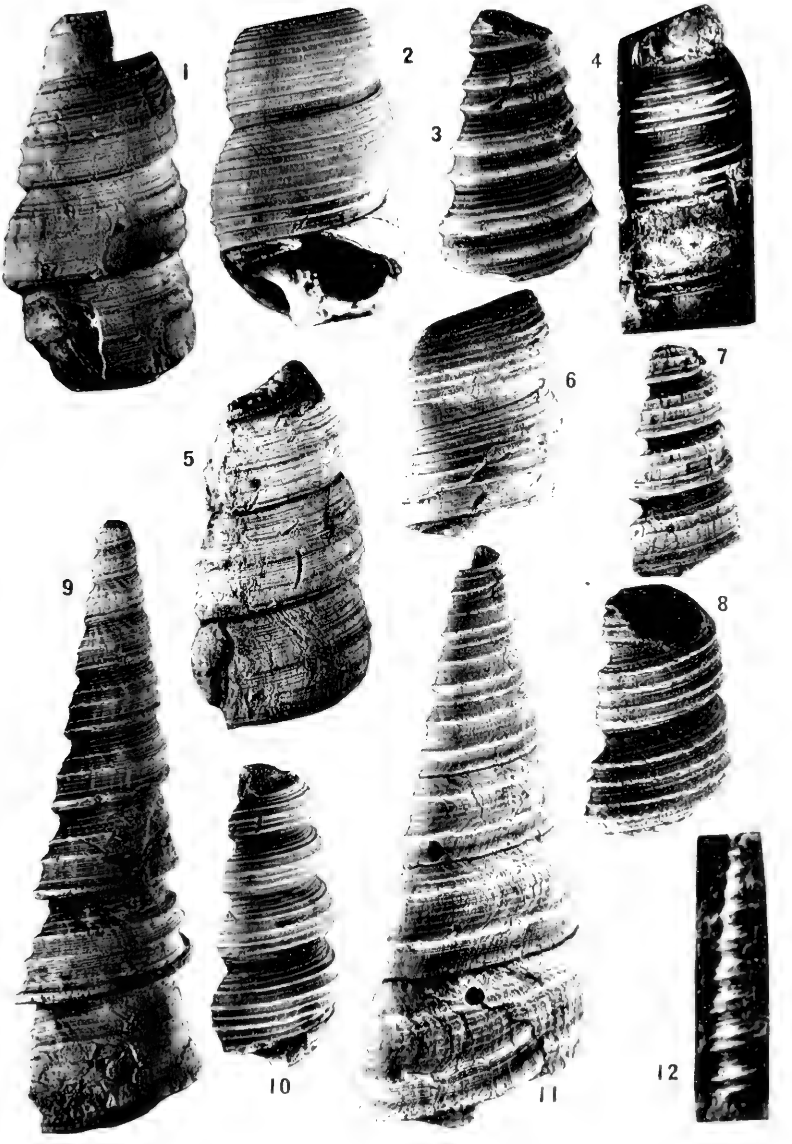
PLATE 25.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11
12

PLATE 26.

FIG. PAGE

1. **T. altilira** Conrad, from Gatun, C. Z., Loc. No. 1101, figured for comparison. Length 25 mm., greatest diameter 5.1 mm. 45
2. **T. carlottæ,** n. sp. Paratype collected by Dr. Maury from Río Gurabo at Los Quemados, Santo Domingo. Length 21 mm., greatest diameter 7 mm.......... 43
3. **T. guppyi** Cossmann **morantensis,** n. subsp. Paratype with protoconch from Bowden, Morant Bay, Jamaica, Loc. No. 1109. Length 7.35 mm., greatest diameter 1.7 mm.......... 42
4. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 206A, length 14.8 mm., greatest diameter 8 mm. 44
5. **T. guppyi** Cossmann **morantensis,** n. subsp. Paratype from Bowden, Morant Bay, Jamaica, Loc. No. 1109. Length 22.2 mm., greatest diameter 4.9 mm.......... 42
6. **T. guppyi** Cossmann **morantensis,** n. subsp. Paratype from Bowden, Morant Bay, Jamaica, Loc. No. 1109. Length 27 mm., greatest diameter 12.3 mm.......... 42
7. **T. altilira** Conrad **urumacoensis,** n. subsp. Holotype, collected by Mr. S. H. Williston, length 72 mm., greatest diameter 18.8 mm.......... 44
8. **T. guppyi** Cossmann **morantensis,** n. subsp. Holotype from Bowden, Morant Bay, Jamaica, Loc. No. 1109. Length 59 mm., greatest diameter 12.6 mm.......... 42

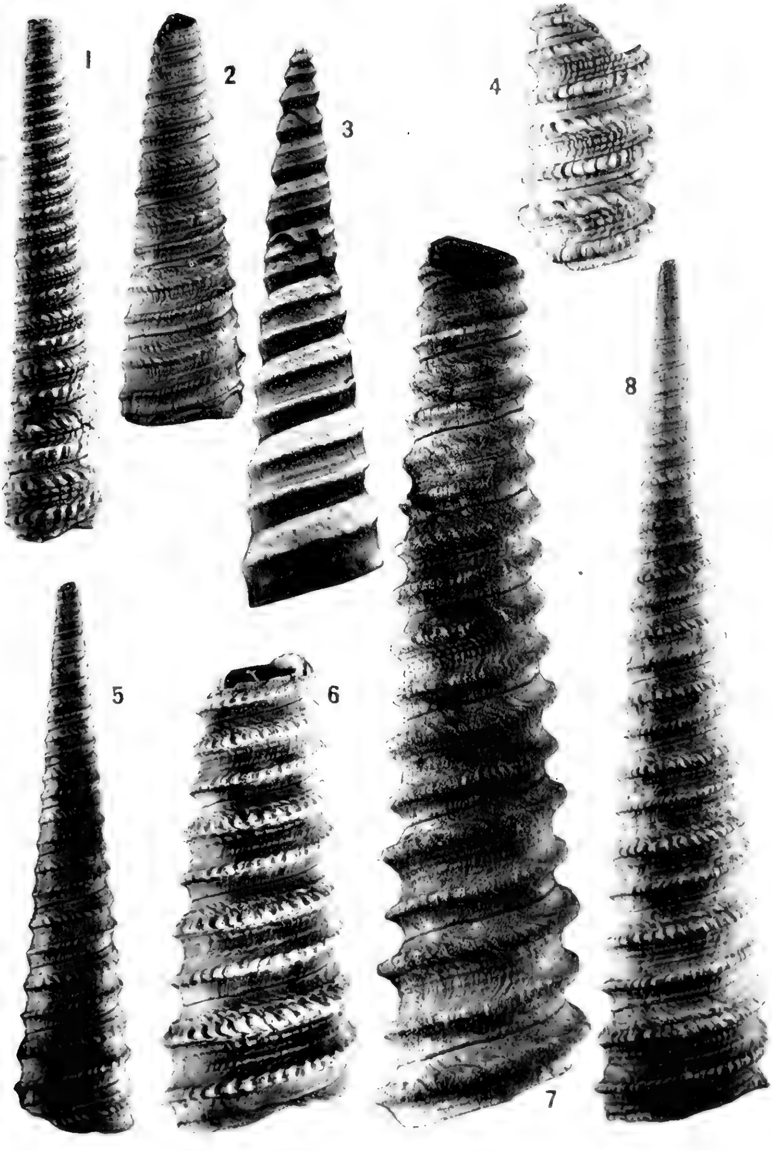
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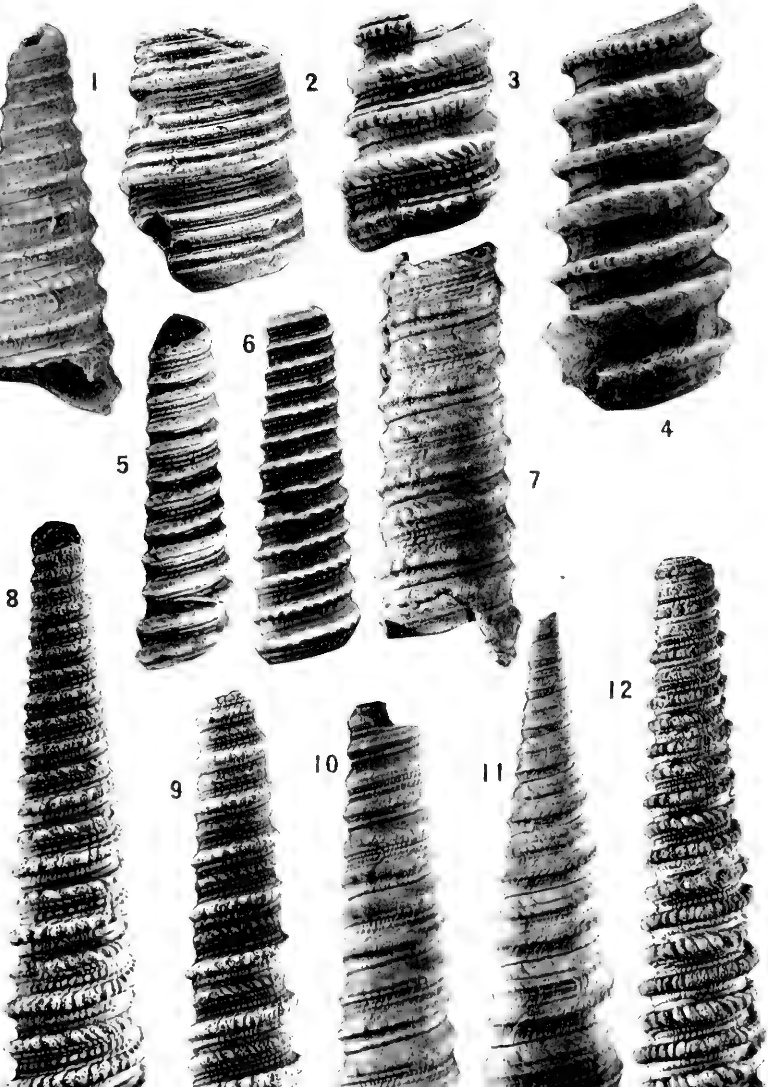
PLATE 27.

FIG. PAGE

1. **T. guppyi** Cossmann. Holotype, photograph by Dr. R. S. Bassler of the U. S. National Museum. Length of cast 17.5 mm., greatest diameter 8 mm. 42
2. **T. berjadinensis socorroensis** (Williston MS.). Paratype, collected by Mr. S. H. Williston, length 23 mm., greatest diameter 13 mm. 28
3. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 118, length 19 mm., greatest diameter 13.5 mm. 44
4. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 118, length 31 mm., greatest diameter 16 mm..... 44
5. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 118, length 38.5 mm., greatest diameter 8 mm..... 44
6. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 121, length 28 mm., greatest diameter 9 mm......... 44
7. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 121, length 14 mm., greatest diameter 5 mm......... 44
8. **T. vistana,** n. sp. Paratype from Loc. No. 1033, length 30 mm., greatest diameter 8 mm. 46
9. **T. vistana,** n. sp. Paratype from Loc. No. 1033, length 22 mm., greatest diameter 6 mm. 46
10. **T. altilira** Conrad **urumacoensis,** n. subsp. Paratype from Loc. No. 121, length 22 mm., greatest diameter 6.2 mm......... 44
11. **T. carlottæ,** n. sp. Holotype, collected by Dr. Maury from Río Gurabo at Los Quemados, Santo Domingo. (Same specimen as figured in Bull. Amer. Pal., Vol. V, Pl. 48, fig. 15.) Length 20.5 mm., greatest diameter 5.5 mm....... 43
12. **T. vistana,** n. sp. Paratype from Loc. No. 122B, length 34 mm., greatest diameter 7.5 mm. 46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11
12

PLATE 28.

FIG. PAGE

1. **T. plebeia** Say **A-L-Owensi,** n. subsp. Paratype from Loc. No. 298, length 12 mm., greatest diameter 7.3 mm.............. 31
2. **T. altilira** Conrad **mirandana,** n. subsp. Paratype from Loc. No. 154, length 18 mm., greatest diameter 9.1 mm....... 45
3. **T. altilira** Conrad. Collected from Gatun, C. Z., Loc. No. 1101. Figured for comparison. Length 47 mm., greatest diameter 11 mm.. 45
4. **T. guppyi** Cossmann **morantensis,** n. subsp. Paratype from Loc. No. 1109, Bowden, Morant Bay, Jamaica. Length 60 mm., greatest diameter 14.6 mm.. 42
5. **T. gilbertharrisi falconensis** (Williston MS.). Holotype. Same specimen as Pl. 14, fig. 6. Length 59 mm.................... 19


1
2
3
4
5

PLATE 29.

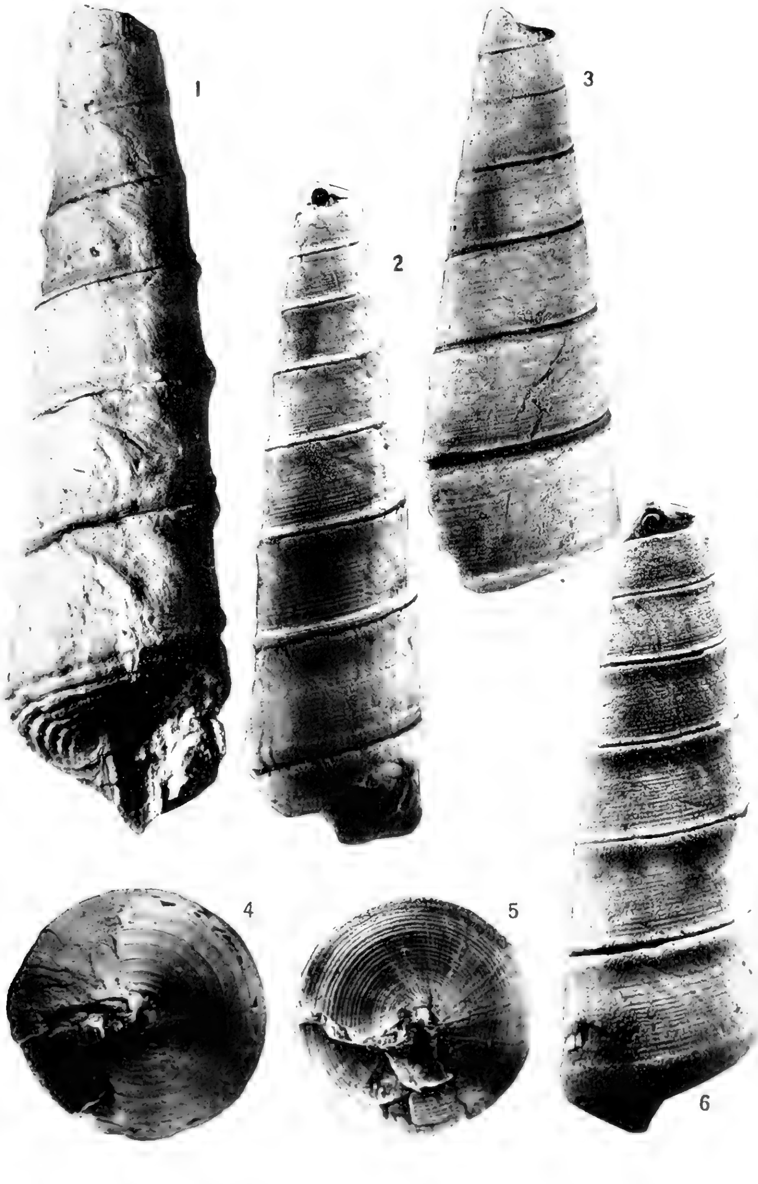
Fig.		Page
1.	**T. altilira** Conrad, from Gatun, C. Z., Loc. No. 1101. Figured for comparison. Length 23 mm., greatest diameter 29.7 mm.	45
2.	**T. vistana nicholsi** (Williston MS.). Paratype from Loc. No. 1552, length 27.5 mm., greatest diameter 17 mm.	48
3.	**T. bifastigata** Nelson **democraciana,** n. subsp. Paratype from Loc. No. 86. Base enlarged showing scultpure; greatest diameter 16.9 mm.	50
4.	**T. vistana,** n. sp. Paratype from Loc. No. 1033, length 10 mm., greatest diameter 3.8 mm.	46
5.	**T. vistana nicholsi** (Williston MS.). Holotype from Loc. No. 140, length 33 mm., greatest diameter 21.5 mm.	48
6.	**T. robusta** Grzybowski **fredeai,** n. subsp. Paratype from Loc. No. 1600, length 157 mm., greatest diameter 51 mm.	13


1
2
3
4
5
6

PLATE 30.

FIG. PAGE

1. **T. bifastigata** Nelson. Lectotype kindly lent by Dr. Carl O. Dunbar of the Peabody Museum at Yale University. Length 61 mm., greatest diameter 19.1 mm. 48
2. **T. bifastigata** Nelson **maracaibensis,** n. subsp. Paratype from Loc. No. 70A, length 62 mm., greatest diameter 18 mm. 48
3. **T. bifastigata** Nelson **democraciana,** n. subsp. Holotype from Loc. No. 1233, length 46 mm., greatest diameter 16 mm. 50
4. **T. bifastigata** Nelson **maracaibensis,** n. subsp. Paratype from Loc. No. 86, base enlarged, greatest diameter 21 mm. 48
5. **T. bifastigata** Nelson **democraciana,** n. subsp. Paratype from Loc. No. 1233. Base enlarged to show sculpture; greatest diameter 14.5 mm. 50
6. **T. bifastigata** Nelson **maracaibensis,** n. subsp. Holotype from Loc. No. 72, length 58 mm., greatest diameter 20 mm. 48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BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. II

No. 46

VENEZUELAN DEVONIAN FOSSILS

(Presented to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Master of Arts)

BY

NORMAN E. WEISBORD

December 9, 1926

Harris Co.

Cornell University, Ithaca, N. Y.

U. S. A.

INTRODUCTION AND ACKNOWLEDGMENTS

Although Mesozoic and Cenozoic deposits are well represented in northern Venezuela, knowledge of Paleozoic history has hitherto been quite obscure. Rather recently, however, and mainly through the efforts of Mr. Charles W. Yeakel, a collection of Devonian fossils was secured near the headwaters of the Cachiri River in the northwestern part of Venezuela near the Colombian border. Inasmuch as the literature is nearly barren of information concerning these older deposits, this provides a comparatively new field of investigation in Venezuela for Paleozoic sedimentation.

That the Devonian series were found in place I am assured by various investigators, though I am informed in a communication from Mr. Liddle, who accompanied Mr. Yeakel, that the majority of our fossils were collected from float, and that many of the specimens are from the shale phases in the series. A number of the specimens are in a fairly good state of preservation, but often the inaccessibility of the cardinal areas and other diagnostic parts, whose characters define criteria for identification, prevents precise determination. There is some variation in the rock matrix containing the fossils and in the absence of any notes relative to the stratigraphic succession of the beds, I cannot be assured of the homogeneity of the entire fauna, though as a general statement it seems reasonable to assert that the fossils show closest relationships to upper lower and lower middle Devonian species from the type localities of eastern United States.

The types of rock represented are:

1. A gray, fine-grained sandstone, containing fine flakes of mica and occasional patches of bright brown iron stains.
2. A dirty gray, rather compact shale, weathered to a dull brown color with numerous Bryozoa.
3. A gray-black, semi-crystalline limestone.

These various rocks are all fossiliferous, and the fact that the lithological characters of some tend to grade into that of the others, together with the occurrence of some of the same species in the different matrices, warrants the temporary assumption that the beds may be considered as a stratigraphic unit. In addition to the above named rocks, a few fragments of a hard, rather coarse-grained, metamorphosed sandstone are included in the collection, but it contains very few specifically identifiable forms. In the paleontological discussion, the type of rock in which each species occurs will be noted.

To Prof. Harris of Cornell University, for whose interest and co-operation I have always been indebted, I tender my sincerest gratitude. I am also under obilgations to Mr. J. E. Brantly and Mr. C. R. Rider of the Venezuelan Atlantic Refining Company for their many kindnesses in facilitating the shipment of the fossils to me and for permission to publish this article. And finally to Mr. Yeakel, whose loss is keenly felt by all who knew him, we offer our belated appreciation.

DESCRIPTION OF SPECIES

COELENTERATA

ANTHOZOA

Cyathophyllum venezuelense, n. sp. Pl. 1, Figs. 1–5

Corallum simple, varying somewhat in outline. Some specimens are sub-cylindric, curved, elongated, while others are broadly conical in shape. The more elongate specimens bear slight circular irregularities or swellings at distant intervals; epitheca thin; calice ovate, circular, or elliptical, probably with a moderately deep cavity, the depth of which cannot be ascertained on our specimens because of adhering material; septa rather numerous, varying with the size of the calix, almost equal, straight or slightly bent, extending nearly to the center where they twist together to produce the appearance of a pseudo-columella. A longitudinal section shows that the tabulæ are quite prominent, their proximity to each other varying in different specimens. The distance between septa in vertical section averages slightly less than a millimeter.

Dimensions:

Alt. 105 mm., diam. of calice 50 mm.
Alt. 55 mm., diam. of calice 46 mm.
Alt. 45 mm., diam. of calice 32 mm.; 25 mm.

In many respects this species is rather closely akin to *C. pocillum* Davis from the middle Devonian of Kentucky. One specimen suggests a relationship to the *C. zenkeri* Billings from the Onondaga formation of New York, while *C. robustum* and *C. galerum* Hall from the Hamilton formation of western New York also exhibit similarities. Despite this seeming relationship to middle Devonian forms, there are also a number of lower Devonian corals, especially from Kentucky, that are not unlike this in their characters.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Diphyphyllum vermetum, n. sp. Pl. 1, Figs. 6, 7; Pl. 2, Fig. 1

This species virtually comprises the limestone in which it is found imbedded. Coralla occurring in clusters, but as far as observed they are simple and not branching, subvermiculate in appearance, with numerous growth lines and irregular constrictions and swellings of low relief; longitudinal sculpture consisting of rather numerous septal furrows; longitudinal sections show the visceral chambers crossed by subequally spaced tabulæ; calyx probably shallow.

Dimensions. Diameter of average corallum 4–6 mm.

There seems to be no alliance between this species and any hitherto described from South America, though in North America the form *D. verneuilanum* from the middle Devonian has a suggestive relationship. From the latter, the present species is distinguished in the smaller size of the coralla.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Pleurodictyum venezuelense, n. sp. Pl. 1, Figs. 8, 9

Corallum massive, rather small, subhemispherical, the upper surface somewhat unevenly convex, the under side slightly concave; in the superficial characters of the exterior it resembles *Favosites forbesi* of England, but differs in its internal composition. In polished section, the center of the base presents an irregular, undefined mass, recrystallized by secondary calcite which seems to indicate that the corallum may have been attached to some foreign body during life. Before polishing the base it was seen to have a thin epitheca, but so weathered as to obscure its structure; corallites polygonal, in close contact throughout, not surrounded by thickened margins; septa fairly numerous, about 35 on our specimen, which in longitudinal section diverge somewhat and rather frequently bifurcate; tabulæ faintly displayed, extending across the visceral chambers, sometimes slightly flexuous, at other times straight, but not vesicular in character; mural pores small, arranged in a single irregular row upon each of the prismatic faces of the corallites.

Dimensions. Long diameter of corallum, 26 mm.; short diameter, 16 mm.

I am not entirely satisfied with the generic determination of this form, though its characteristics indicate a Favositic relationship.

Specifically, this tabulate coral seems not unlike the Argentinian *Pleurodictyum* sp. Thomas (Zeit. Deut. Geol. Gesell., Vol. 57, p. 267, pl. 12, figs. 21, a, 1905) from the beds at Cerro del Fuerte, but neither the description nor figure of his poorly preserved form warrant accurate comparison. The Brazilian *P. amazonicum* Katzer (Geol. Unt. Amazon., p. 192, pl. 2, figs. I-Id, 1903) has larger *Michelinia*-like calices. The shape of the corallum of *Favosites argentina* Thomas (op. cit., p. 268, pl. 12, figs. 20, a, b, and plate accompanying p. 268, 1905) is quite unlike this species, though *F. forbesi,* with which Thomas compared his form, is much more alike, the present species differing in its septal arrangement. *Michelinia transitoria* Knod (N. Jahr. f. Min., Geol. u. Pal., Beil. Bd. 25, p. 561, pl. 30, figs. 1–4, 1908) from the Icla beds of Bolivia is another South American species, but here again the Venezuelan form is at variance in the chaarcters of the septa and in its smaller corallites.

The small size of the calices distinguish this species from such Devonian forms as the Hamiltonian *P. stylophorum* Eaton, and *P. problematicum* Goldfuss from the Coblentzian of the Rhine region and Onondaga of Illinois (Meek and Worther).

Occurrence. In the limestone series.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

MOLLUSCOIDEA

BRYOZOA

Fenestella venezuelensis n. sp. Pl. 2, Figs. 2, 3

Zoarium a somewhat undulating flabellate expansion;

fronds large, compact; branches very slender, ridge-shaped, gently curved, bifurcating at distant intervals; dissepiments short, horizontal or arched, from half to less than half the width of the branches. Zoecia in two ranges. Fenestrules tabulate, rectangular, about 20 in one centimeter, the measurements taken in the direction of the longer axes; cell apertures, as indicated by the filling of the cells, somewhat irregular in shape, about three to each fenestrule; the non-celluliferous faces of the fronds have a fibrous structure composing the more solid portions of the branches, and these branches are occasionally nodose, and carinated.

Dimensions. A fairly complete frond measures 50 mm. in altitude and 30 mm. in width.

This species closely resembles the Upper Heldebergian (Onondaga) *F. parallela* Hall (Geol. Sur. N. Y., Vol. 6, p. 107, pl. 44, figs. 8–18, 1887) from the vicinity of Buffalo, N. Y., and may subsequently prove to be identical, but in the absence of branches showing the celluliferous faces intact, and in the occasional nodosity of the non-celluliferous faces (which feature is not mentioned or figured by Hall) it seems advisable to consider this as new. In his list of fossils from the Devonian of Curua, Brazil, Katzer mentions the presence of *F. parallela* but does not figure it, though it is probably a very similar species to the present one described.

Occurrence. In the gray shale. Occasional impressions of a similar or identical form is also found in the dark-gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Polypora cachirita n. sp. Pl. 2, Figs. 4–6

Occurs with the preceding and differentiated from it by its broader branches and with a gerater number of ranges of cell apertures; zoarium an undulating expansion, infundibuliform, fronds large; branches strong, angular and generally carinate, with an average width of .6 of a millimeter; bifurcations distant. Interstices slightly wider than the branches. Dissepiments somewhat narrower than the branches. Fenestrules subquadrangular to subovate; cell apertures usually in three to five ranges as indicated by the fillings impressed on occasional specimens. There are about nine fenestrules in the length of one centimeter.

Dimensions. An incomplete portion of a frond measures 40 mm. in altitude and about 20 mm. in width.

This species suggests a relationship to a number of Onondaga *Polyporid* forms in western New York, of which we may cite *P. robusta* Hall as a typical representative (Geol. Sur. N. Y., Vol. 6, p. 156, pl. 34, figs. 4–7, 1887). Not unlike this in all probability is a specifically unidentified *Fenestella* recorded by Katzer (Bol. Mus. Paraense, Vol. 2, p. 210, 1897–98) as an impression in the Devonian rocks of the Maecurú River of Brazil, which he says is somewhat of the same type as *P. cultella* Hall. This is of the same group as *robusta* previously mentioned above.

Occurrence. In the gray shale. The cell impressions have afforded easy access of weathering agents and hence many of the specimens are largely stained with iron.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

BRACHIOPODA

Dalmanella (?) venezuelensis n. sp. Pl. 2, Fig. 7

Shell quite small, suborbicular. Cardinal angles rounded. Greatest width of shell somewhat greater than length of the hinge-line. Beak small, projecting slightly above the cardinal area. Dorsal valve from which the specimen is described is depressed-convex, with a shallow mesial depression extending the length of the shell, rapidly widening anteriorly. Surface covered by 24 strong longitudinal riblets.

Dimensions. Alt. 5 mm., long. 6 mm.

The generic position of this species is doubtful. The form is characterized by its broadly circular outline and unusually strong ribbing. It is somewhat the same type of shall as *Orthis ?* sp. Reed (Ann. S. Afr. Mus., Vol. 4, p. 175, pl. 21, fig. 6, 1908) from the Bokkeveld beds of Africa, but differs in its broader medial sinus and short, straighter hinge-line, though from Reed's figure it would appear as if the Bokkeveld shell were weathered posteriorly, hence accounting for the apparently sloping hinge-line.

Occurrence. In the gray, micaceous, fine-grained sandstone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Stropheodonta (Leptostrophia) caribbeana n. sp. Pl. 3, Fig. 1

Shell semi-elliptical; pedicle valve slightly inflated, the maximum inflation coming at the umbos; length somewhat less than the width; hinge-line equal to the width of the shell below; anterior margin well rounded, the lateral margins nearly straight; cardinal angles sub-acute; beak appressed, scarcely rising above the hinge-line.

The surface is covered with a series of fine, unequal, radiating threads, gently undulating, increasing by bifurcation, and crossed by fine, even, concentric striæ; in addition there are about 16 subregular, concentric undulations which follow the outline of the valve; these are weaker at the apex but become more prominent anteriorly. Of the fine, radial riblets there are about two hundred in number. Dorsal valve partially and obscurely represented.

Dimensions. Alt. 24 mm., long. 31 mm.

To South American species, this is closest perhaps to *S. argentinus* Thomas (Zeit. Deut. Geol. Gesell., Vol. 57, p. 261, pl. 13, figs. 27, 28, a, 1905) from Cerro del Fuerte; the latter differs in its weaker concentric undulations, and in its rather pronounced anterior genuflection, though this may have been caused by distortion. This is also like the form Knod referred to as *S. perplanas* (probably not of Conrad) from the Icla and *Conularia* beds of Bolivia (N. Jahr. f. Min., Geol. u. Pal., Beil. Bd. 25, p. 540, pl. 27, fig. 4, 1908) but here again the strong concentric undulations are wanting; the Bolivian form is also more finely ribbed. Nevertheless the relationship is very close, as is that of *Strophomena* sp. Ulrich also from Bolivia, which Knod considers syonymous with his *S. perplana*. In North America this species stands intermediate between the Lower Heldebergian *S. becki* Hall and the typical Hamiltonian *S. perplana* (Conrad). The concentric undulations are very similar to those on *becki*, but the latter has coarser radial striæ than has the Venezuelan species. To *perplana* this exhibits a striking resemblance, but the North American form is generally less strongly undulate and with somewhat finer radial striæ. Still, the Venezuelan species may be particularly well developed in its sculptural details and a more complete suite of specimens might prove it to be identical with forms of *perplana*. In South Africa, *S.* cf. *concinna* (Morris and Sharp) reported by Reed, is a similar species but lacks the undulations of the surface.

Occurrence. In the gray weathered shale. The dark gray limestone also has a form that may be the brachial valve of this species.

Locality. Upper course of the Cachiri River.

Type. Cornell University Paleontological Laboratory.

Stropheodonta zuliana n. sp. Pl. 2, Fig. 8

Species represented by several external molds of the brachial valve; shell rather small, nearly flat, hemispheral, with a well rounded anterior margin and straight hingeline having the full width of the shell; cardinal area very narrow; sculpture consisting of a series of distant, subregular, rather fine, elevated filiform striæ, between which are still finer threads with an occasional coarser one. The major radii are more pronounced in the center of the valve than laterally, especially near the hinge where they become obsolete.

Dimensions. Alt. 6 mm., long. 9 mm.

This very pretty species at once recalls the Oriskanian *Brachyprion majus* Clarke from Becraft Mountain, N. Y. (See Mem. N. Y. State Mus., No. 3, Vol. 3, p. 56, pl. 8, figs. 1–7, 1900). Comparison with the brachial valve, however, recalls that the Oriskanian species is more elongate than the Venezuelan shell, and considerably larger. Occasional forms of *Leptostrophia interstrialis* (Vanuxem) of the Portage (Upper Devonian) are not unlike this species as illustrated in the Maryland Geological Survey Report, p. 554, pl. 48, fig. 7, 1913.

Occurrence. In the gray, fine-grained, micaceous, sandstone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Schuchertella (?) sp. aff. **sullivani** (Morris and Sharpe) Pl. 3, Fig. 2

Orthis Sullivani Morris and Sharpe. Quart. Journ. Geol. Soc. London, Vol. 2, p. 275, pl. 10, fiig. 1, 1846.

Strophomena sullivani Sharpe. Trans. Geol. Soc. London, Vol. 7, p. 209, pl. 26, figs. 18, 19, 1856.

Strophomena sullivani Reed. Ann. S. Afr. Mus., Vol. 4, p. 170, pl. 20, fig. 8, 1903.

Schuchertella sullivani Clarke. Foss. Dev. Parana, p. 279, pl. 23, figs. 16–23, 1913.

A fragment of the basal part of a large subovate form closely resembles the above named species in the character of its ribbing. *S. sullivani* has been reported from the Falkland Islands, the Bokkeveld beds of South Africa and from Paraná, Brazil.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimen. Cornell University Paleontological Laboratory.

Chonetes (?) zuliensis n. sp. Pl. 3, Fig. 3

Shell small, subelliptical, wider than high; hinge-line straight, equal to or greater than the width of the shell below; cardinal angles subacute, anterior margin well rounded; pedicle valve very convex umbonally, flattening somewhat toward the front; umbos broad and full, beaks projecting slightly over the hinge line, the spines of which are obscured (if any). Surface ornamented with about twenty-five strong, subequal, radiating ribs which seem to increase by bifurcation. The ribs are high, subangular, separated by well channeeld interspaces. Careful inspection reveals in addition a very fine series of concentric growth striæ. Dorsal valve missing.

Dimensions. Alt. 7.5 mm., long. 10 mm.

This rather scantily ribbed form very strongly suggests a more than casual relationship to *Chonetes stubeli* Ulrich [1] from the sandstone of the Rio Sicasica between Oruro and La Paz, Bolivia. Both Ulrich's description and figure of the species, however, show a medial sinus on the pedicle valve, which is lacking on the present species. The convexity of the Venezuelan form is also greater than that of the Bolivian but in other respects the two are nearly identical. From the Bokkeveld beds of Africa, Reed's *C.* aff. *settiger* [2] Hall, is also allied to *zuliensis,* but here again the presence of a median depression and less gibbosity of the pedicle valve serve to temporarily differentiate the two. The South African form also has a few more ribs than our shell. With the exception of its somewhat greater number of ribs, Reed's species compares very favorably with Ulrich's.

In Brazil, the Erere sandstone produces a small *Chonetes,* named *herbert-smithi* [3] which is not unlike *zuliensis,* but is

[1] N. Jahr. f. Min., Geol. u. Pal., Beil. Bd. 8, p. 80, pl. 5, figs. 3, 4, 1902.

[2] Ann. S. Afr. Mus., Vol. 4, p. 174, pl. 21, figs. 4, 5, 1908.

[3] Bull. Buff. Soc. Nat. Hist., Vol. 1, p. 251, pl. 10, figs. 39–42; 44–47, 1874.

more finely ribbed and less robust. Clarke's figure 4, pl. 24, of *Chonetes falklandicus* (Dev. Foss. Parana, 1913) is very much like the present shell except for its more numerous ribs, but I am not prepared to call the Venezuelan species *falklandicus,* for even though it is much like one of the varietal phases of what Clarke interpreted as *falklandicus,* it is clearly different than the original portrayal of that species by Morris and Shape. True, there may be the gradations from finely to coarsely ribbed forms of *falklandicus,* but in the absence of intergrading shells of the Venezuelan species I proposed for ours the new name *zuliensis.* Haug (Doc. Scientifiques Saharienne, pl. 14, figs. 4, 5, *partim,* 1905) has figured an unnamed form on a slab of rock also containing *Stropheodonta* (*Leptostrophia*) *oriskania* Clarke from the lower ? Devonian sandstone of Tassili which superficially compares favorably with this species.

Occurrence. In the gray to black limestone and in the gray, weathered shale.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Chonetes venezuelensis n. sp. Pl. 3, Figs. 4, 5, 6, 7, 8 ?

Shell of medium size, hemispherical in outline, with evenly rounded margins and straight hinge line equal to the width of the shell below or slightly shorter; cardinal extremities obtusely angular; pedicle valve strongly convex, with or without a slight medial depression; the beak rises barely above the hinge-line, is small and appressed; hinge area very narrow. The sculpture consists of about eighty radial riblets, subequal to equal in size, separated by interspaces equally as wide. Where a portion of the original shell has been retained at the sides, the intercostal spaces are observed to be punctate, while the ribs, which reflect the sculpture of the interior of the valve, are with small spicules. The punctations and spinosities are better developed laterally than centrally; cardinal spines of hinge-line obscured, if any are present. Brachial valve nearly flat with a slight central inflation which is barely sulcate. An impression of the internal mold shows the ribs to bear small spines as on the opposite valve.

Dimensions. Alt. 14 mm., diam. 17.5 mm.

It seems probable that the specimens figured as *C.* cf. *coronatus* Conrad by Reed (Ann. S. Afr. Mus., Vol. 4, p. 172, pl. 20, figs. 11, 12; pl. 21, 1908) is somewhat similar to our species. The Venezuelan form, however, is much more nearly allied to the species Reed has doubtfully referred to as *coronatus* than to typical forms of *coronatus* from New York which are accessible to me for comparison. Fig. 8, pl. 3 shows a slightly distorted mold with a medial incision suggesting the characters of *Eodevonaria.* I am not sure, however, that the specimen represents this species.

Occurrence. In the gray, fine-grained, micaceous sandstone. A similar form also occurs both in the limestone and shale but their identification is uncertain.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Chonetes (Eodevonaria) subhemispherica n. sp. Pl. 3, Figs. 9; 10 ?

Shell semi-elliptical to semi-circular. Ventral valve extremely gibbous, especially below the beak; anterior margin well rounded; hinge-line straight, apparently denticulate on the external border; umbo more or less gibbous. beak appressed and incurved. Dorsal (?) valve (Fig. --) nearly flat, with a medial elevated rib extending from the beak down the center of the valve. External border of hinge clearly crenulate.

Surface marked by about fifty low, equal, evenly rounded riblets, crossed perhaps by concentric striations which are not clearly visible on the specimen. There seems to be a tendency for the extremities of the hinge-line to become extended or auriculate.

Dimensions. Ventral valve, alt. 14 mm., long. 16 mm.

This species shows unmistakable affinities to the Oriskanian and Onondagan *C. hemispherica* and *C. arcuata* Hall, though it is somewhat smaller than mature specimens of these two forms. The presence of the genus *Eodevonaria* is rather good evidence of the upper lower or lower middle position of the Venezuelan Devonian.

Occurrence. In the dark gray to black limestone. The dorsal valve of what seems to be this species is found in the gray shale.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Conchidium (?) sp. indet. Pl. 3, Fig. 11

General characteristics as figured. The valve is strongly convex, and ornamented with a series of strong, elevated plications which become nearly obsolete laterally. Below the umbo, some concentric wrinkles suggest the assumption that the radial plications are crossed by rather strong concentric striations. A rather wide sulcus appears umbonally but the appearance may be deceptive due to crushing of the valve. Cardinal area partially weathered and obscured on one side of the beak and broken on the other making even the generic identification doubtful.

Dimensions. Alt. 29. mm., long. 34 mm.

Occurrence. In the dark gray limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Amphigenia (?) sp. indet. Pl. 4, Fig. 1

The umbonal portion of a large species is very doubtfully referred to this genus. The partial contour of the shell indicates that it is probably triangularly elliptical in outline. Beak low, appressed; cardinal margins sloping rather acutely from the beak and making an angle of about 120 degrees with each other. The ventral (?) valve is strongly convex, especially umbonally where it is subangularly elevated into a rather high, rounded prominence. Although this eminence continues with undiminished strength to the anterior portion of our specimen, it probably becomes depressed anteriorly on a complete shell. Cardinal area obscured by adhering material, but rather broad for the genus. The surface is marked by rather distant concentric weak lamellæ which are broadly V-shaped, and a series of radiating riblets which are just barely discernible on our specimen.

Dimensions. Alt. ?, long. 50 mm.

This very interesting shell very unfortunately has the cardinal area partially broken and obscured, hence making the generic determination extremely doubtful. From the general contour of the cardinal area, it would seem entirely too broad for the genus, but the characteristic angulation of the valve, and the radial ribbing (unfortunately nearly all weathered) suggests a *Rensselarid* relationship of the form. We await better material for more accurate identification.

Atrypa cf. **reticularis** (Linne) Pl. 4, Figs. 2, 3

Anomia reticularis Linne. Syst. Nat., ed. 12, p. 1132, 1767.
Terebratula reticularis De Verneuil. Geol. of Russia and Ural Mts., Vol. 2, pl. 10, fig. 12, 1845.
Atrypa reticularis Morris. Cat. British Fossils, p. 132, 1854.
Atrypa reticularis Hall. Nat. Hist. N. Y., Vol. 4, pt. 1, p. 316, pls. 51–53a, 1867.
Atrypa reticularis Schuchert. Bull. 87, U. S. G. S., p. 154, 1897. See also for complete bibliography up to 1897.
Atrypa reticularis Weller. Geol. Surv. N. J., Vol. 3, p. 236, pl. 21, figs. 35–37, 1903.
Atrypa reticularis Schuchert and Maynard. Md. Geol. Surv., p. 392, pl. 67, figs. 26–28, 1913.

Venezuelan shells rather large, subcircular; pedicle valve moderately gibbous about the umbo, depressed anteriorly; cardinal angles well rounded; beak fairly prominent, rising somewhat above the hinge; Brachial (?) valve similar to the preceding but somewhat less inflated. Surface of valves marked by coarse, subequal, radiating riblets, of which there are about five to five millimeters at the base of the shell. These are somewhat rounded and separated by interspaces of nearly equal width. Though not distinctly shown, the valves are crossed by concentric, lamellose extensions of the shell which have been partially obliterated by weathering. Interior of valves inacessible.

Dimensions. Alt. 32 mm., long. 35 mm. Alt. 36 mm., long. 39 mm.

Curiously enough, this is the first time this widespread and cosmopolitan species has been recorded from South America, and is as yet unknown in the Bokkeveld beds of South Africa as far as I am aware. Our specimens, though somewhat the worse for wear, appear to be the normal type of *reticularis,* but in the absence of stronger sculptural details and with the interior inaccessible, identity with the above is provisional. Geographically and stratigraphically, this form is known for its efflorescence. Ranging from England, the Continent, North and now South America, with a vertical span from Silurian to uppermost Devonian (Chemung), this species is of little value in discriminating horizons.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimen. Cornell University Paleontological Laboratory.

Spirifer meridioamericana n. sp. Pl. 4, Figs. 4, 5

This species is represented by a poorly preserved ventral valve and a fragment of another specimen which shows to better advantage the sculpture of the form. Shell of medium size, transversely subelliptical, rather compressed; beak fairly high, prominent, but small and slightly incurved; anterior margin of the valve broadly rounded; cardinal margins concavely sloping from the beak; cardinal angles rounded; sinus shallow but well defined, broadening anteriorly. The major radial plications are relatively low, rounded, broad, about five or six in number, decreasing in prominence from the sinus to the periphery. On the more complete specimen which seems to be fairly mature, a series of fine, but rather strong striæ longitudinally traverse the valve and are interrupted occasionally by small nodular growths. In addition to these secondary threads, numerous, fine, concentric growth lines cross the valve.

The sculpture on the fragment is as follows: (1) a number of strong, radial undulations like those described above; (2) these major plications are crossed by widely spaced, overlapping, concentric lamellæ, and (3) a finer series of concentric growth striæ; (4) on the lamellae are a number of elongated pustules or spiny processes. Although these latter radial lineations are disconnected from those on the lamella above they are in alignment, and it seems probable that it is the growth of these that form the secondary radial lines observed on the larger specimen.

Dimensions. Alt. 15 mm., long. 23 mm.

This is a very interesting species, and I am by no means satisfied that my diagnosis is entirely correct, having to reconstruct the whole from unsatisfactory fragments. It is apparently of much the same type as *S. kayserianus* Clarke (Foss. Dev. Paraná, p. 252, pl. 19, figs. 1–15, 1913) from Brazil, a species which presents numerous different aspects, depending upon its stage of growth.

Occurrence. In the gray weathered shale.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Museum.

Spirifer venezuelensis n. sp. Pl. 4, Fig. 6

Shell transversely subelliptical, of medium size, moderately gibbous, with a straight hinge-line which represents the greatest width of the shell. Ventral valve (from which this species is described) inflated centrally, regularly curving to the front and sides; sinus well defined, rather deep and rounded or subangular; beak small but sharp, rather high, somewhat incurved over the narrow cardinal area. Surface marked by five strong plications on either side of the medial sinus; the plications are high, rounded, separated by narrow interspaces, and become weaker laterally; these are crossed by imbricating lamellose striæ rather closely spaced and studded with very fine, sometimes slightly vermicular lines, arranged in parallel bands according to the distance of the concentric lamellæ. The sculpture is very similar to that of *Reticularia fimbriata* (Conrad) from the Hamilton formation of North America, but the shape of the shell and strong longitudinal folds serve to differentiate the South American species.

Dimensions. Alt 16 mm., long. 19 mm.

This beautifully sculptured species may be identical with the previous form, but it seems advisable to consider them distinct for the present. Strikingly similar in sculptural details is the Eifelian *S. aculeatus* of Europe.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Spirifer audaculus zulianus n. subspecies

Pl. 4, Figs. 7, 8; Pl. 5, Figs. 1–8

The most characteristic form of the Venezuelan Devonian in our collection is a species very closely allied to the *S. audaculus,macronata* type of shell from the middle Devonian deposits of eastern United States.

Ventral valve larger and deeper than the dorsal, with a high, prominent, slightly incurved beak. Cardinal area high, triangular, slightly concave, divided in the middle by a deltoid fissure which is twice as high as wide, and reaches the apex of the area. Cardinal line straight; mesial sinus rather wide, of moderate depth, widening fairly rapidly from the apex to the anterior margin, and generally rounded. Cardinal margins obtusely sloping from the beak.

Dorsal valve less convex than the pedicle valve and not as high; beak small, appressed, and slightly incurved; area obscured but probably linear. Mesial fold well defined, convex, rounded on top (sometimes angular), rapidly expanding from the apex.

Sculpture of both valves consisting of an average of about twenty to thirty equal plications on each half of the valve, rounded, separated by narrow interspaces, and probably crossed by numerous growth striæ which are not visible on the specimen. Both valves are occasionally interrupted by heavier concentric growth bands.

Dimensions. Ventral valve: alt. 31 mm., long. 46 mm; alt of cardinal area 15 mm. Dorsal valve of another specimen: alt. 30 mm., long. 58 mm.

This species closely resembles the Marcellus to Hamiltonian *S. audaculus* Conrad, and indeed some of the dorsal valves are practically identical. The ventral valves of the Venezuelan specimens, however, have a somewhat higher cardinal area and slightly less incurved beak than the typical *audaculus.* Nevertheless there are varietal forms of the latter with high areas that are closely allied to the present species such as the form known as the variety *eatoni.* In the height of its cardinal area our form recalls such species as *S. manni* and *S. granulosus* but the fewer ribs of the latter two forms, and the bipartite mesial fold of *granulosus* serve to differentiate them.

Figure 7, Plate 5, shows a form which apparently grades into this species, but also resembles the Brazilian *S. pedroanus* Hartt and Rathbun from the Erere Devonian of Brazil. Of *pedroanus,* Rathbun (Bull. Buff. Soc. Nat. Hist., Vol. 1, p. 237, pl. 8, figs. 1–9, 13, 14, 16–20, 1974) writes this interesting conclusion: "Prof. Hall, who examined a small number of specimens of this species of Spirifer after the above description was written, thinks that in its different varieties it is very closely related to several American Devonian Spiriferæ; *S. varicosus,* Corniferous limestone; *S. medialis* (*audaculus*) Hamilton group, which varies much in form; *S. angusta,* Hamilton group, perhaps only a variety or young form of *S. medialis;* and *S. macrus* of the Corniferous limestone, which last species, however, has generally a narrower and more curved hinge area. *S. pedroanus,* therefore, appears almost like a connecting link, uniting the above named species in a single series."

Occurrence. In the dark gray to black limestone; in the gray micaceous sandstone; and possibly in the weathered shale.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Spirifer sp. indet. Pl. 3, Fig. 12

General features as figured. The obliteration of the sculptural details does not allow specific characterization.

Dimensions. Alt. 14 mm., long. 22 mm. (approximation).

Unlike the majority of the other forms, this shell occurs in the metamorphosed sandstone.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimen. Cornell University Paleontological Laboratory.

Vitulina (?) venezuelensis n. sp. Pl. 5, Figs. 9–13

This very interesting little species does not adequately fit into any well known genus of Brachiopod, and may possibly be a new genus, in which case I propose the new name of *Venezuelia.* In its general aspects it appears to belong to the *Coelospiridæ* showing affinities to such genera as *Leptocoelia* and *Anoplotheca,* though its straight hinge-line more strongly suggests *Vitulina*. Here again, however, the character of the ribbing is somewhat discrepant and makes reference to that genus temporary.

The form is relatively abundant but is represented in the collection only by pedicle valves. These vary in gibbosity, some being very ventricose, others less so. The shells are generally hemispherical in outline with well rounded anterior margins, and relatively long, straight hinge-lines; cardinal margins depressed; umbos generally full, beaks small. Surface marked with eight to eleven strong, rather distant, angular plications. There is generally one medial plication, flanked by others of equal size, which play out rather sharply toward the lateral margins; concentric lamellæ and a few unusually strong concentric riblets traverse the radial ribs. The pustular markings characteristic of the genus may be present but have not been observed.

Dimensions. Alt. 6.5 mm., long. 7.5 mm.

This species is quite different from the well known North and South American *V. pustulosa* or *Leptocoèlia flabellites*. It is readily recognized by its straight hinge, heavy radial and centrally located ribs, and strong concentric sculpture.

Occurrence. In the gray, micaceous, fine-grained sandstone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Athyris aff. spiriferoides (Eaton) Pl. 6, Fig. 1

Terebratula spiriferoides Eaton. Amer. Journ. Sci., Vol. 21, p. 137, 1831.

Spirifera spiriferoides Hall. Tenth Rep. N. Y. State Cab. Nat. Hist., p. 153, figs. 1, 2, 1857.

Athyris spiriferoides Hall. Pal. N. Y., Vol. 4, pt. 1, p. 285, pl. 46, figs. 5–31, 1867.

Athyris spiriferoides Schuchert. Bull. 87, U. S. G. S., p. 149, 1897.

Athyris spiriferoides Schuchert and Maynard. Md. Geol. Surv., p.

211, pl. 21, figs. 1, 2, 1913.

Two shells in our collection may be compared with the common *spiriferoides* of the Onondaga and Hamilton groups of North America. One of our specimens is an extremely broad and somewhat distorted individual but is probably the same species as portrayed in Fig. 1, which is a normal shell. The valve is transversely ovate, well inflated, with a short hinge line and rounded cardinal extremities. Maximum convexity umbonally and medially, the valve exhibiting a tendency to become widely sulcate toward the front. Beak small, somewhat incurved. Surface marked by concentric lamellæ.

Dimensions. Alt. 17 mm., long. 22 mm. Alt. 19 mm., long. 32 mm.

This genus has hitherto been unrecorded from South American Devonian deposits. The species is not unlike *S. fultonensis* (Swallow) which has the same stratigraphic range as *spiriferoides*. The relationships of this Venezuelan shell again show the probable lower middle Devonic affinities of the fauna.

Occurrence. In the gray shale.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimens. Cornell University Paleontological Laboratory.

MOLLUSCA

PELECYPODA

Aviculopecten yeakeli n. sp. Pl. 6, fig. 3

Shell rather large, sub-ovate, slightly oblique, length and height nearly equal; anterior and ventral margins regularly rounded; posterior margin of the disk proper forms a nearly even, oblique line to the beak. Left valve slightly inflated in the umbonal region, flatter ventrally. Hinge-line straight, approximately two-thirds the length of the shell. Umbo slightly elevated, sloping rather abruptly to the wings, the umbonial line forming an angle of somewhat more than ninety degrees; ears unequal, the anterior smaller, the posterior alate and triangular; beak located anterior to the middle of the cardinal line; terminal margins of the ears missing but probably somewhat concave.

Sculpture consisting of about thirty-eight strong, elevated, subtriangular, radiating ribs, subequal in size with perhaps an occasional weaker riblet, separated by equally wide interspaces; on the posterior area of the valve there are about twelve fine, radiating riblets, more closely spaced and less pronounced than those on the disk proper. In addition the valve is crossed by numerous concentric growth striæ, but these are only faintly suggested on the specimen.

Dimensions. Alt. 44 mm., long. 46 mm.

This species is very closely allied to Katzer's *A. coelhoanus* from the "*Spirifer* sandstone" of the Rio Maecuru, Brazil, the latter differentiating primarily in having alternating stronger and finer ribs, and wide, flat interspaces. To *A. pecteniformis* and *A. princeps* (Conrad) the present species shows similar characteristics, but its broadly ovate outline and stronger ribs differentiate it from the aforementioned middle Devonian species of North America.

Named in honor of Mr. C. Wesley Yeakel.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Aviculopecten sp. indet. Pl. 6, Fig. 2

A partial specimen doubtfully referred to *Aviculopecten*, shows surface markings of numerous, subequal, radiating riblets crossed by a series of fine, regular, closely spaced concentric striæ. Characters of the upper portion of the valve not observable. The specimen probably represents an immature shell.

Dimensions. Alt. 9 mm., long. 9 mm. (approximately).

The form appears to be of the same general character as *A. coelhoanus* Katzer (right valve) from the Brazilian Devonian of the Río Maecurú, but is very much smaller.

Occurrence. In the gray weathered shale.

Locality. Upper course of the Cachiri River.

Specimen. Cornell University Paleontological Laboratory.

Conocardium sp. Pl. 6, Figs. 4, 5

Two partial specimens, indicating a shell of generous proportions; is probably subovate-trigonal in outline when complete. Length greater than the height; beak very high, rather narrow, situated on the posterior two-fifths of the valve, and is strongly recurved as well as sharply keeled medially. Posterior area of the shell rather acutely truncated; umbonal slope continuing to the ventral margin; anterior dorsal margin acutely sloping to form the cuneate anterior. Markings consist of unequal to subequal radiating ribs, not clearly defined on our specimens, and numerous, fine, concentric growth striæ.

Probable dimensions. Alt. 50 mm., long. 60 mm.

This genus has hitherto been unrecorded from other Devonian deposits of South America. The obscurity of certain features and distortion of the shell, however, render the determination doubtful.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimen. Cornell University Paleontological Laboratory.

Cypricardinia subindenta n. sp. Pl. 6, Fig. 6

Cypricardinia indenta (Conrad) Hall. Geol. Surv. N. Y., Vol. 5, pt. 1, p. 485, pl. 79, figs. 6–16, 1885.

Specimen small, subrhomboidal in outline, anterior margin sharply rounded, ventral border nearly straight, with a slight sinuosity; posterior extremity acutely curved below, obliquely truncate above. A well defined but rounded umbonal ridge extends from behind the beak to the posterior margin, marking off the post-cardinal depression; dorsal margin straight. Left valve slightly inflated umbonally, flattening out below. Beaks anterior, small, appressed, probably rising slightly above the hinge-line. Sculpture consisting of about ten or twelve rather distant, concentric undulations, which, anterior to the middle of the valve, curve slightly toward the umbo, and which follow the contour of the valve's outline on the depressed area behind; though not distinctly visible on the specimen, a series of finer concentric striæ occur between the major undulations; some oblique radial markings are also barely discernible.

Dimensions. Alt. 6.5 mm., long. 9.5 mm.

In many particulars this shell closely resembles *C. indenta* Conrad which ranges from the Oriskanian to Hamiltonian horizons in North America. Characteristic of the latter species, however, is its chevron-like sculpture visible under conditions of suitable preservation; although the South American form shows some indistinct radial markings, which may suggest the ornamentation of *indenta,* they are not clear enough to warrant positive comparison with the North American species, and hence I suggest the name *subindenta* until a later collection affords better material for comparison. Though Clarke's *Macrodon ?* sp. from Paraná (Foss. Dev. Paraná, p. 184, pl. 16, fig. 8, 1913) has fewer major undulations, is more visibly depressed centrally and has a less oblique posterior margin, the natural variability of such a form as this, may indicate a closer relationship to our form than comparison of only one shell indicates.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

GASTEROPODA

Diaphorostoma neveritanum n. sp. Pl. 6, Fig. 7; Pl. 7, Figs. 1–3

Shell subovate, globose, rather large, naticoid in outline;

spire slightly elevated, obtuse; sutures linear, weakly incised; whorls about four, convex, increasing rapidly in size, the apical volution seemingly papilliform; body whorl globose, convex laterally but with an apparent slight flattening below the suture on what would ordinarily correspond to the shoulder of the whorl; aperture nearly ovate, large; columellar lip thickened and folded, and seemingly reflexed over the umbilicus which is closed to view.

Surface marked by a series of fine, subequal, flexuous, longutudinal, thread-like striæ, much like those often occurring on the genus *Pleurotomaria,* and in addition crossed by equally fine, but perhaps slightly wider spaced revolving lines giving a beautiful reticulate appearance to the whorls. This latticed sculpture is observable on the less weathered portions of the shell, the longitudinal markings being otherwise the more prominent; as the longitudinal striæ leave the suture they are curved convexly toward the aperture, but upon approaching the madial portion of the body whorl they are flexed rather sharply inward, again suggesting a relationship to the sculpture of *Pleurotomaria.* The species, then, is at once distinguished by its *Neverita*-like shape, obtuse spire, globose whorls, reticulate sculpture and ovate aperture.

Dimensions. Alt. 32 mm., diam. 30 mm.

In affinities, the species is most nearly related to the Oriskanian *D. desmatum* Clarke of eastern United States, the latter differing, however, in its shorter and wider body whorl. The sculpture of the two forms, on the other hand, is very similar. In shape, the present species would appear somewhat allied to *Holopea furmaniana* Hartt and Rathbun from the Ereré Devonian of Pará, Brazil, but the diagnosis "surface as determined by external molds, smooth," of that species does not harmonize with the latticed ornamentation of the Venezuelan species. Examination of the type specimens of *furmaniana* show also that the shape of the shell is discrepant from that of our species. *Littorina ? (Holopea) bainii* Sharpe from the Devonian of

South Africa is higher and more prominently spired. In Argentina, a weathered *Naticopsis ?* sp. Kayser, is a form of this type of shell. From Pebble Island, West Falkland, Clarke's *D. allardycei,* though of the same order, is a less compact and less prominently reticulate species.

In many characteristics this form is also like *Pleurotomaria keyseri* Ulrich from the *Conularia* beds of Bolivia, but the latter has a rather angulate body whorl with a narrow circumventing band. Finally, there is a suggestion of similarity to *Platyostoma lineatum* (Conrad) which ranges from the Onondaga formation to the Chemung in New York, but *lineata* differs in being more finely sculptured.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

Pleurotomaria venezuelensis n. sp. Pl. 7, Figs. 4, 5

Shell poorly preserved and somewhat distorted, depressed-trochiform; spire probably moderately elevated, but subdued in this particular specimen; apex small. Volutions about five, depressed-convex on the upper side; last whorl ventricose and angulate; sutures incised, but probably not as much as the weathered specimen indicates; surface ornamentation very obscure, but there seems to be a narrow peipheral sulcus on the spire whorls at the sutures; the penultimate whorl shows a slight revolving sulcus medially, but this, however, is obsolete on the other whorls and may simply represent an irregularity in the shell. There are evidences, nevertheless, of regular, rather strong radiating striæ visible near the sutures, which bend back at the angulation of the whorl.

Body volution with a rather large, subcircular and deep umbilicus underneath; aperture subquadrate.

Dimensions. Alt. 13 mm., diam. 22 mm.

There is much to be desired in the description of the species, but it seems advisable to include any generically recognizable forms in a treatise dealing with a new area.

Occurrence. In the gray, fine-grained, micaceous sandstone.

Locality. Upper course of the Cachiri River, State of Zulia.

Type. Cornell University Paleontological Laboratory.

ARTHROPODA

Phacops argentinus ? Thomas. Pl. 7, Figs. 6, 7

Phacops cf. *rana* Kayser. Zeit. Deut. Geol. Gesell., Vol. 49, p. 284, pl. 11, figs. 8–10, 1897.

Phacops argentinus Thomas. Ibid, Vol. 57, p. 246, pl. 11, figs. 8–9b, 1905.

A coiled form showing some of the thoracic segments and the pygidium appears to be closely allied to *argentinus,* though the imperfect preservation and absence of parts of both this and the Argentine specimens do not assure undoubted identity. Discussing the characteristics of his species, Thomas mentions the pentahedral shape of the glabella, the well developed and projecting eyes, and the subtriangular shape of the pygidium with its six segments on the axis and on the sides.

Unfortunately the cephalic portion of the Venezuelan specimen is missing; the thorax shows about seven segments, which on the moderately broad, gently arched axis are rather strongly elevated, of moderate width, separated by well channeled furrows and firmly anchylosed with the pleura by articulations visible on the peeled carapace; dorsal furrows not as pronounced as the distortion of the specimen indicates; pleural areas somewhat wider than the axis; the maximum width of the thorax comes at the fourth or fifth segment from the pygidium.

Pygidium subtriangular, rather short and of moderate breadth, with a characteristic narrow, depressed-convex, rather rapidly tapering axis, sculptured with about six or seven segments, of which the anterior four are the more prominent, the posterior members being indistinctly developed; pleura broad, convex, carrying about seven segments, the upper four well defined, flattened, rather broad, and separated by narrow sulci, the remaining smaller, narrower and indistinctly divided; border narrow and flat.

Dimensions. Probable length of specimen 25 mm., diam. 18 mm. Pygidium, length 7 mm., width 14 mm.

The thorax and pygidium of this species is similar to that of a number of *Phacopidæ,* and this taken in conjunction with the absence of the cephalon, makes differentiation difficult. To *P. rana* Green (Onondaga and Hamilton of North America) this form shows a striking similarity and indeed it was originally referred to it by Kayser (op. cit.); Thomas, however, recognizes that *argentinus* has the frontal part of the glabella flatter, but I cannot attest to this difference because of the absence of the glabella on my single specimen. At present it seems best to separate *argentinus* from *rana* until more complete specimens are available, though it is interesting to note that Groth (Bull. Geol. Soc. France, (4), Vol. 12, p. 607, pl. 19, figs. 2, 2a, 1912) has referred to *Phacops* from the Icla beds of Bolivia to *rana.* Other allied species are *P. latifrons* Bronn from the Eifelian of Europe. This form has also been reported by Salter from Oruro, Bolivia, but Thomas conjectures it may be his *argentinus.* *P. africanus* Salter (*pars*) as figured by Lake differs in its much broader pygidial axis, as does *P. scirpeus* Clarke from the Rio Macurú, Brazil. Again, as far as the parts are comparable, the Venezuelan species is similar to the Oriskanian *P. logani* of North America. In its affinities, then, it would seem to appertain to the upper lower or middle Devonian series of rocks.

Occurrence. In the dark gray to black limestone.

Locality. Upper course of the Cachiri River, State of Zulia.

Specimen. Cornell University Paleontological Laboratory.

CONCLUSIONS

That the Venezuelan fossils have a Devonic expression seem unmistakable, though at present it is somewhat premature, with the limited number of forms we have studied, to state definitely with what known horizon they may be correlatable. Considering the fossils as a whole, however, and assuming the homogeneity of the fauna despits its occurrence in somewhat varying rock matrices, it would seem as if the stratigraphic position of the beds ought to come between the Oriskanian and Onondagan formations as known from the type section in New York. Of the ascertained relationships with described species whose stratigraphic range is known, our fauna shows that the greater number of species are related to Onondaga forms, a somewhat smaller have both Oriskanian and Onondagan affinities, while a few are akin to Hamiltonian species.

The Corals, *Cyathophyllum venezuelense* and *Diphyphyllum vermetum,* exhibit resemblance to known forms in the middle Devonian beds of eastern United States. The tabulate *Pleurodictyum venezuelense* contributes nothing definite toward ascertaining the age of our fauna, but the Bryozoa *Fenestella venezuelensis* and *Polypora cachirita* which occur abundantly in the shale phase of the series, seem to be strongly suggestive of the Onondaga formation, the former being nearly identical with *F. parallela* Hall, the latter representing the *P. robusta* type. In the Brachiopods, *Leptostrophia caribbeana* seems to lies between the Heldebergian *becki* and the Hamiltonian *perplana,* while *Stropheodonta zulianum* seems to be akin to *Brachyprion majus* from the Oriskany of Becraft Mountain, New York. The *Eodevonaria* division of the *Chonetes* group strongly reminds one of such characteristic Oriskany and Onondaga forms as *C. hemispherica* and *C. arcuata* Hall. *Chonetes zuliensis* suggests more than a casual relationship to the Bolivian *C. stubeli* described to be lower-middle Devonian in age. *Atrypa reticularis* is of no diagnostic value because of its great stratigraphic range, but it is of interest in being recorded for the first time in South America, giving it a further known geographical distribution. *Spirifer meridioamericana* and *S. venezuelensis* are fimbriate forms much like *S. kayserianus* Clarke from the Devonian of Paraná, Brazil, and like the Eifelian *S. alculeatus* of Europe. It is in this genus that we get the closest affinity to Hamiltonian species, for *S. audaculus zulianus* is nearly identical with *S. audaculus*, the well known middle Devonian form of eastern United States, *Vitulina* (?) *venezuelensis* is a very distinct form whose relationships have not been ascertained. *Athyris* aff. *spiriferoides* ranges from Onondaga to Hamilton in North America.

The representatives of the Pelecypods are four in number—*Aviculopecten yeakeli* is of the same order as *A. coelhanus* Katzer from the Maecurú beds of Brazil. If the generic determination of *Conocardium* is correct, this will be the first notification of this genus from South America, though the distortion and obscurity of the specimen makes its identification uncertain. The most characteristic of the lamellibranchs, however, is the small *Cypricardinia subindenta* which may subsequently prove to be identical with *C. indenta* (Conrad), a shell which ranges from Oriskanian to Hamiltonian in the United States. Because of the weathering of the sculptural details which prevents close identification, I have deemed it advisable to consider the Venezuelan species temporarily distinct.

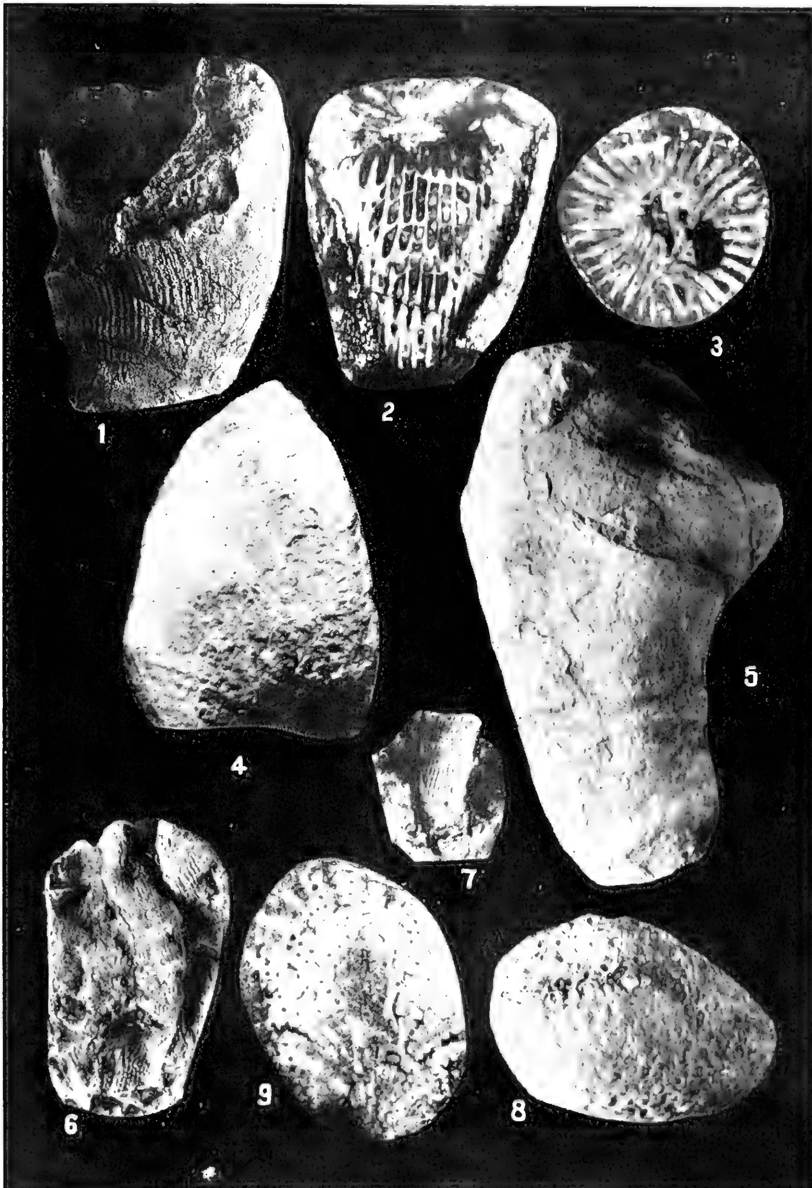
The Gasteropod *Diaphorostoma neveritanum* seems to come between the Oriskanian *D. desmatum* Clarke and the middle Devonian *Platyostoma lineatum* (*Conrad*). With its regularly globose body whorl and beautiful sculpture it makes a most outstanding form. *Pleurotomaria venezuelensis* is too poorly preserved for satisfactory comparison.

The single imperfect Trilobite, *Phacops argentinus* ? Thomas has been found in the middle Devonian of Argentina, but the Venezuelan shell awaits better material for more accurate identification.

The facies of the Venezuelan fauna indicates that the deposits are of a marine, littoral type, laid down in warm waters of rather shallow depth. The abundance of Corals and Bryozoa together with the occurrence of certain types of Brachiopods lend themselves to this supposition. Such forms as *Vitulina pustulosa, Tropidoleptus carinatus* and *Leptocoelia flabellites* which are so common in the other Devonian deposits of South America, have not as yet been found, nor have other rather characteristic forms made their appearance, but it is to be hoped that further exploration and collection will afford sufficient material to aid us in correlating the Venezuelan deposits not only with those in North America but with the scattered deposits in South America, and with the Bokkeveld beds of South Africa.

PLATES

PLATE 1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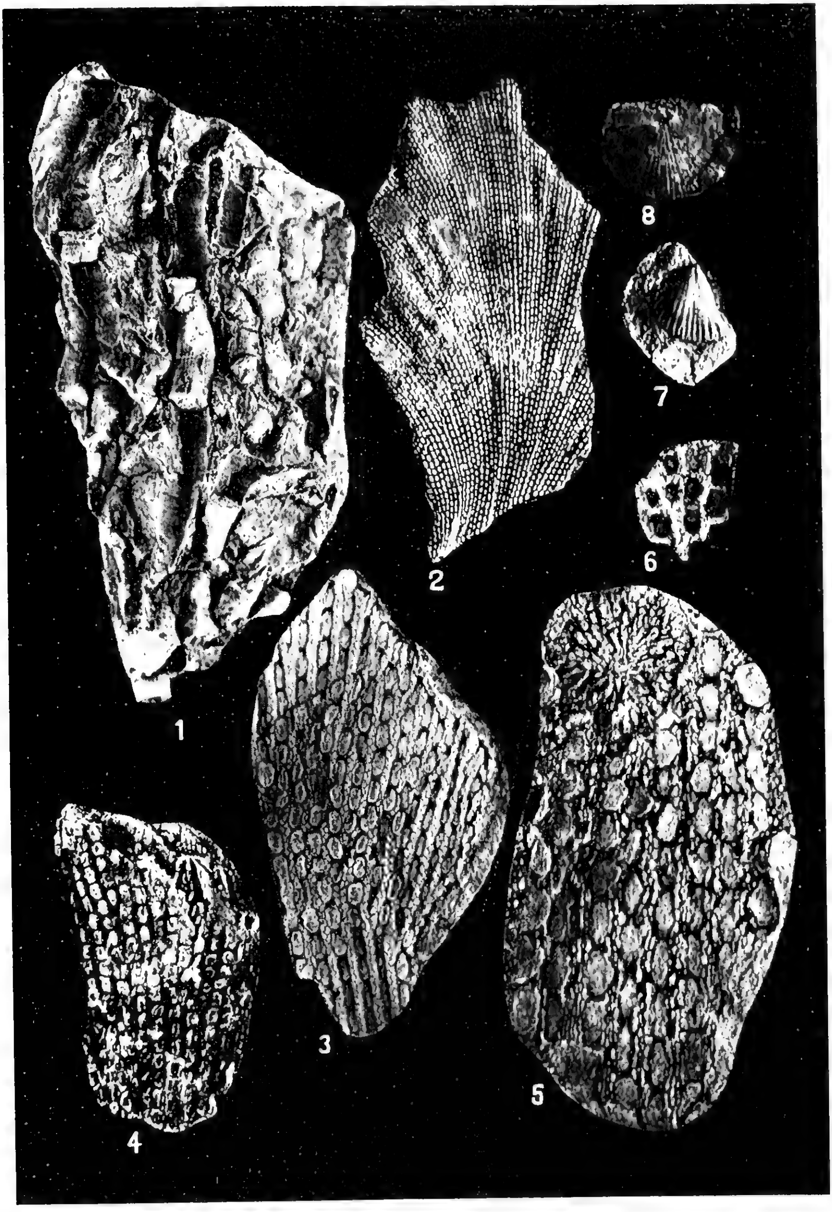
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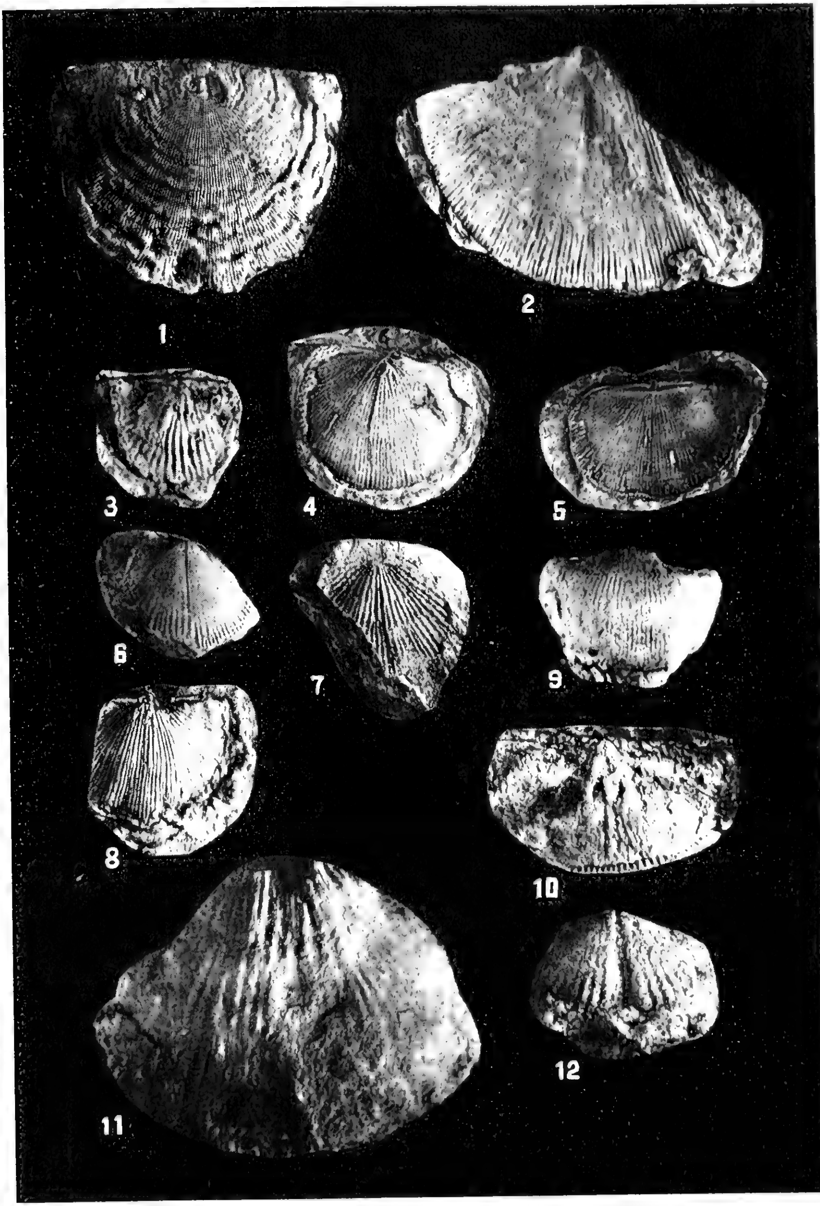
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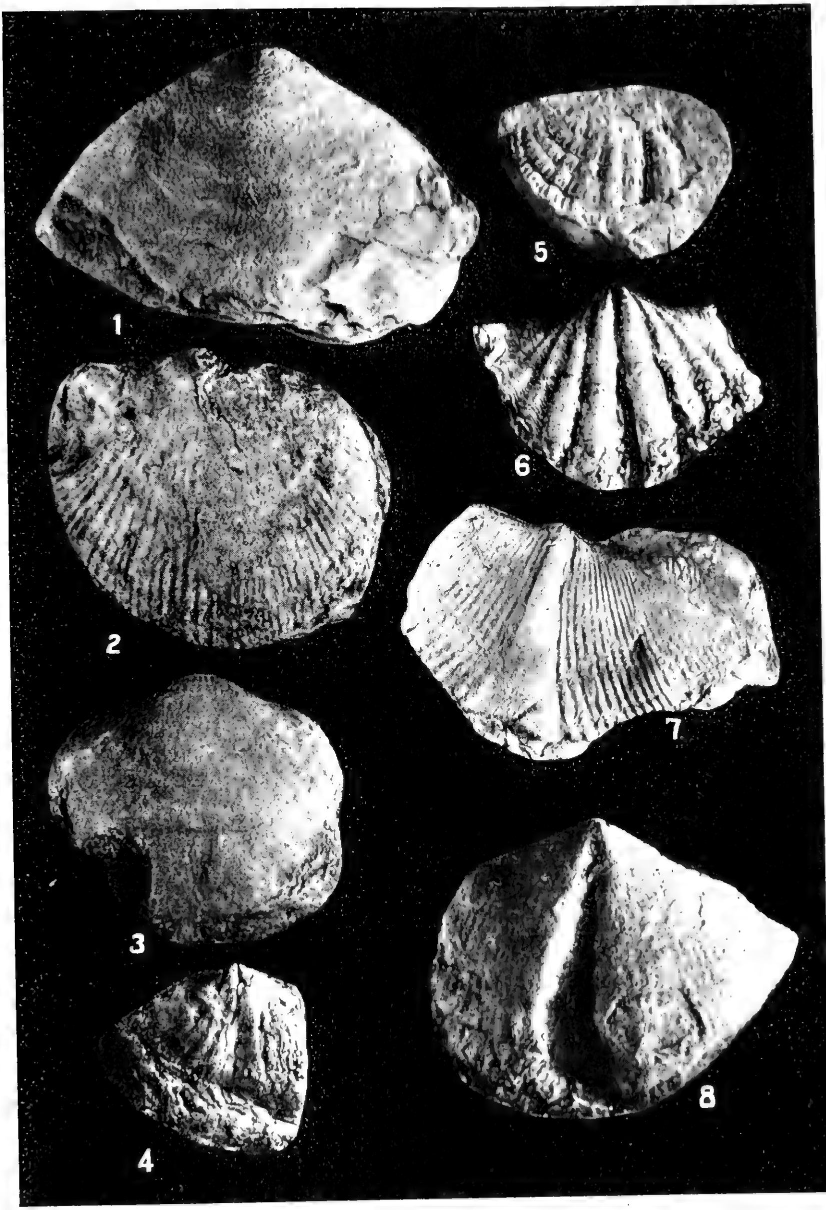
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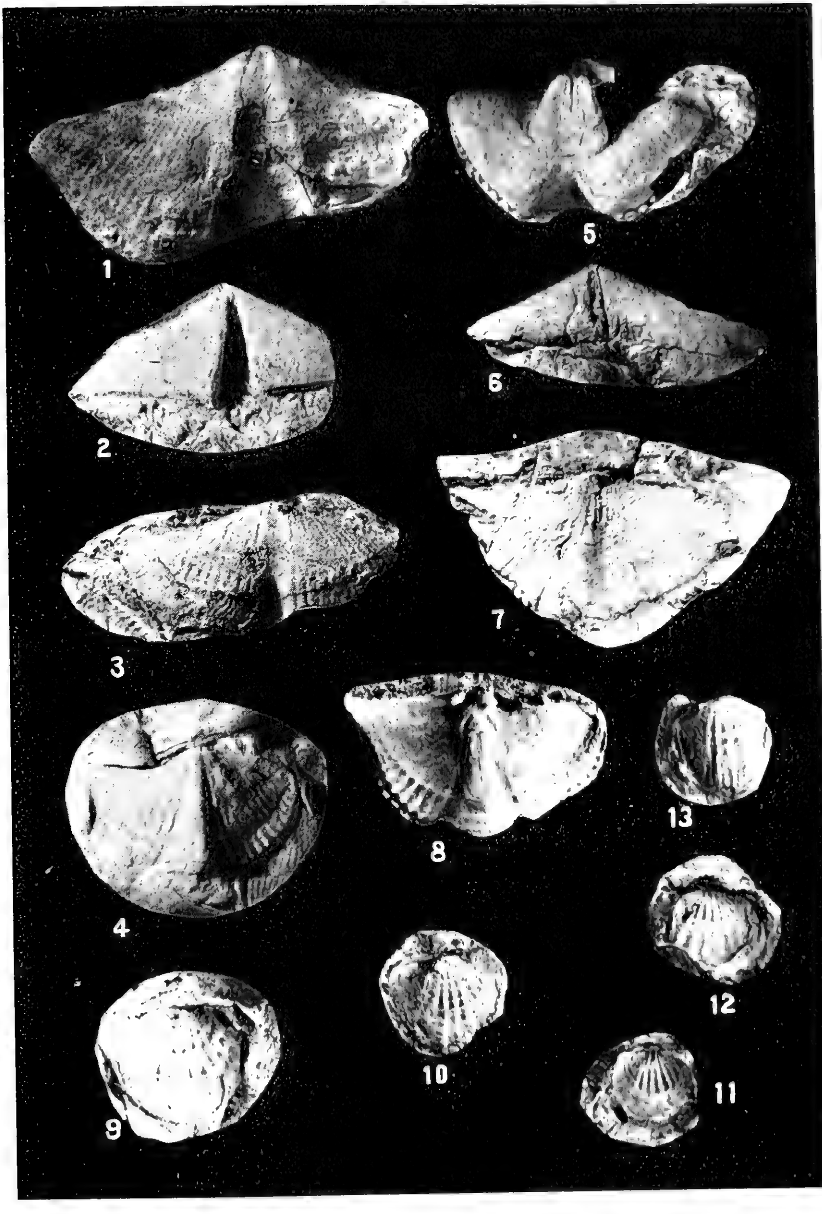

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PLATE 6

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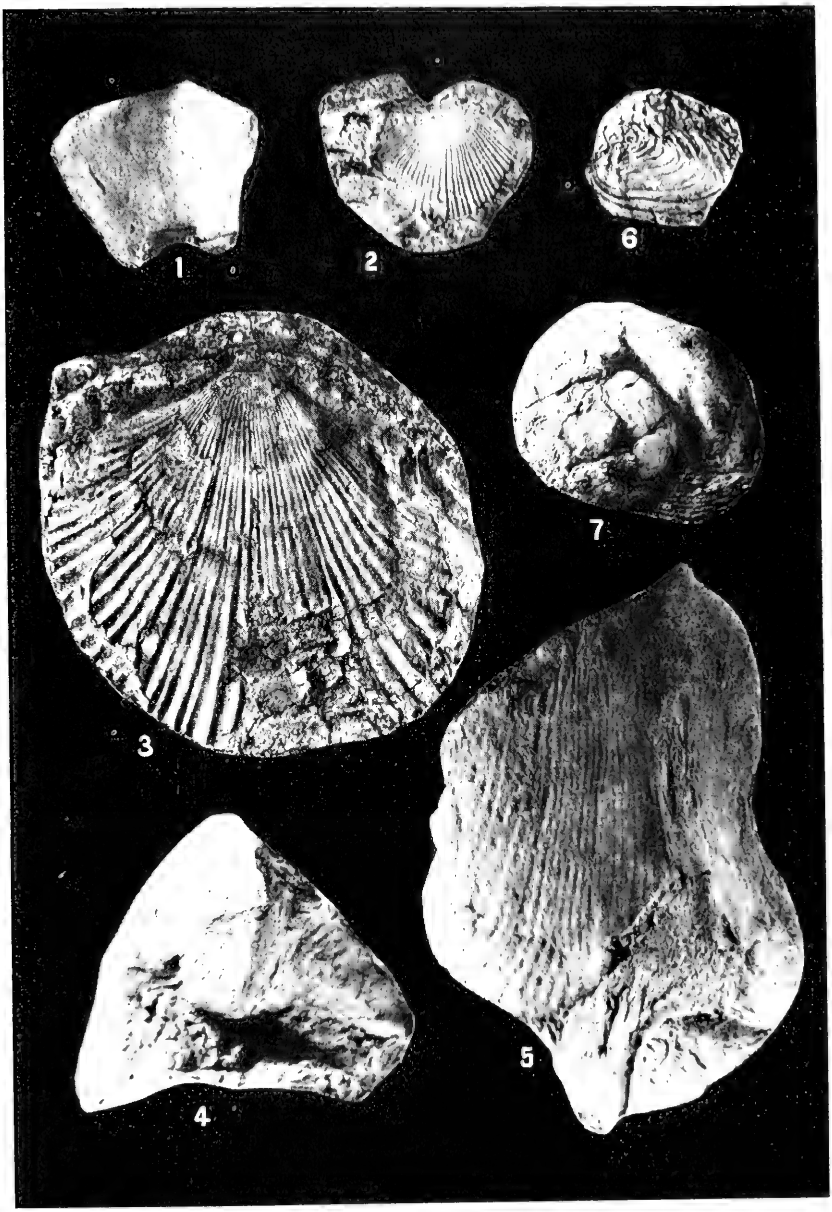
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PLATE 7

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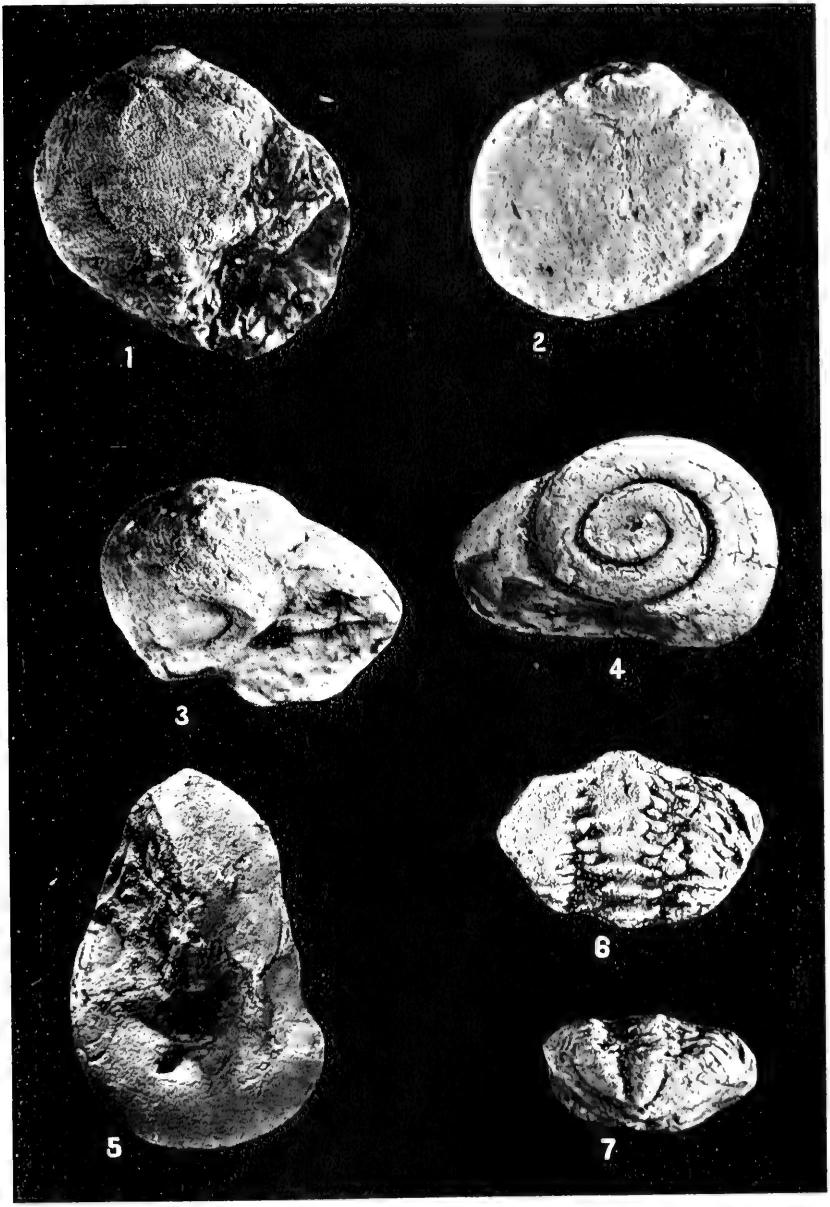

INDEX TO VOLUME XI

Figures refer to consecutive plate and page numbering of the volume, not of the separate bulletins. Bold face figures refer to plates.

END OF VOL XI