LOWER DEVONIC ASPECT OF THE LOWER HELDERBERG AND ORISKANY FORMATIONS

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Introduction

Why is it that nearly all leading American stratigraphers as well as the authors of the principal American geological text-books—Dana,* Le Conte,† Williams,‡ and Scott §—refer the Lower Helderberg to the Siluric system? This question gains peculiar force when another fact is pointed out, namely, that nearly all European stratigraphers who have investigated the systemic position of the Lower Helderberg, and Geikie,|| Kayser,¶ and Frech,** in their respective text-books, unhesitatingly place the same formation in the Devonic, as lowest Lower Devonic. This is not merely a question of drawing the line between two geological eras, a little higher or a little lower in the time scale, but it involves taxonomic principles and stages in faunal or evolutional progression.

* James D. Dana: Manual of Geology, 4th ed., New York, 1896, pp. 535, 569, 576.

† Joseph Le Conte: Elements of Geology, New York, 1878, p. 282. The Oriskany is here also included in the Siluric. In the edition of 1895 the Siluric terminates with the Lower Helderberg (see p. 296).

‡ Henry Shaler Williams: Geological Biology, New York, 1895, pp. 33, 52.

§ William Scott: An Introduction to Geology, New York, 1897, pp. 385, 394.

|| Sir Archibald Geikie: Text-book of Geology. London, 1893, p. 790.

¶ E. Kayser: Text-book of Comparative Geology, translated by Philip Lake, London, 1893, p. 111.

** Fritz Frech: Lethæa geognostica, 1 Theil, 2 Band, Stuttgart, 1897, p. 207.

One of the chief reasons for these varying views lies in the fact that the lower limit of the Devonic of England has never been defined, and its lowest well marked fauna is apparently not older than the Oriskany. Again, Barrande included his étages F, G, and H, together with the Lower and Upper Helderberg, in the Siluric. These are now regarded by most continental paleontologists, however, as of Lower and Middle Devonic age. Americans have not apparently paid much attention to the recent developments in the Lower Devonic of the Rhineland. Geikie writes that—

"It is rather from the sections and fossil collections of central Europe than from those of England that the stratigraphy and paleontology of the Devonian system are to be determined."

Murchison, in reviewing his work of 1842 in the Rhenish area, twelve years later, says:

"I have been convinced, through the paleontological labors of Ferdinand Roemer and the brothers Sandberger, that the types of that lower Rhenish subdivision are distinct from the Upper Silurian, and in harmony with the lowest Devonian group of other countries."

The geographically restricted condition of the Lower Helderberg and the completeness with which its fauna was described by Hall, in 1859, have left Americans little opportunity to examine its systemic position. The influence of that great nestor of American geologists has so established the position of the Lower Helderberg, that writers of text-books seem unwilling to set aside his conclusions. When Clarke published his paper on "The Hercynian question" the present writer was assistant to Professor Hall. At that time, Clarke proved the unmistakable Devonian aspect of the Lower Helderberg fauna, and Hall is not known to have objected to this presentation. Walcott,* in reviewing Clarke's paper, states in conclusion that—

"This suggestion [Lower Helderberg = Lower Devonian], comes to me with peculiar force at the present time, and, if the Silurian system was to be reclassified today, I should favor the following scheme: Lower division, Canadian, Calciferous, and Chazy; middle division, Trenton and Hudson, and upper division, Niagara and Salina. The summit of the Silurian would be drawn at the Waterlime formation, and the Lower Helderberg would be considered, with the Oriskany sandstone, as lowest Devonian. This, to my mind, is the more natural classification, and divides the Paleozoic into four subequal groups—Cambrian, Silurian, Devonian, and Carboniferous."

It may be well to state here that most system boundaries are established in regions where some physical event has made a break in the

*Amer. Jour. Sci., vol. xxxix, 1890, p. 156.

continuity of faunal evolution. In establishing such a boundary elsewhere one may assume the physical event to have been general or local in character. In the first case the system boundary is marked by an abrupt change in life; in the second there will be a gradual faunal transition, necessitating the somewhat arbitrary placing of the boundary. The writer holds that present knowledge is more in harmony with the view that physical events are local and faunas transitional. However, in carrying out this view in correlating widely separated areas, one will incur fewer difficulties by conforming as far as possible to the limitations of the systems as originally defined by their makers.

The upper limits of the Silurian have been established by Murchison, and strata younger than the "Tilestones" and "Downton Castle sandstone" can not well be added to this system unless such have a fauna whose facies is Silurian. Professor Williams* writes:

"Systems were originally groups of successive rock formations; their limitation was therefore determined, in the first place, by the extent of the rocks in the particular region where they were first defined. Hence the series of formations constituting an original system is in each case a standard of reference, and its general application is accomplished by determining its equivalent formations in other regions. . . .

"It is all-important to know what formations make up these standard systems; for only as other rocks contain the same faunas or floras can they be identified as of equivalent age and therefore as belonging to the same system. The real time indicators are, therefore, the fossils."

Has the Lower Helderberg a Siluric facies, when but 11 species, or about 2 per cent, of its fauna of 459 forms are derived from the Siluric? The generic differences are even more marked, and Clarke has well said that—

"The upper limit of the typical Silurian section was clearly defined, and time has shown that this limit was not only one of a geological series, but the dead-line of a large number of organic types."

As to the relation of the Oriskany to the Lower Helderberg, Hall,† in 1859, wrote as follows:

"The great changes in the physical conditions supervening at the close of the preceding group [Lower Helderberg] indicate an influence which would affect in an equal manner the fauna of the succeeding one, and we find accordingly few species passing from the Lower Helderberg group to the Oriskany sandstone. The changes, however, are mainly of a specific character; no new genera being introduced.

. . . .

"It is not possible, therefore, to point out any changes in the fauna of this period sufficient to indicate the commencement of a new system, and its relations with

* Geological Biology, 1895, p. 31.

† Paleontology of New York, vol. iii, 1859, pp. 401–402.

the formations below are as intimate as with those above; while in the Northern and Middle States, the Oriskany sandstone bears in its fauna a closer relation to the lower than to the overlying formations."*

It will be shown that the Lower Helderberg has its equivalent, faunally, in Barrande's étage F_2, as found at Koniepruss, in Bohemia, and that, in the Rhine section, German geologists have for this formation a fixed place in the Lower Devonic.

In his "Synopsis of American fossil Brachiopoda," published three years ago by the U. S. Geological Survey,† the writer included all Lower Helderberg and Oriskany species in "Table VI, Devonian Brachiopoda," as "Eodevonian." Apparently no one has noticed this radical departure from accepted American standards; at least, no one has pointed it out or given reasons why these forms are not of Devonic age.

SILURIAN OF MURCHISON ‡

APPLICATION OF THE TERM BY GEOLOGISTS

In 1835, the term Silurian was first applied by Murchison to a series of formations well developed in Shropshire, England, a "region once inhabited by the British tribe of Silures;" hence the name.

"From the base of the Old Red sandstone, he was able to trace his Silurian types of fossils into successively lower zones of the old 'Grauwacke.' It was eventually found that similar fossils characterized the older sedimentary rocks all over the world, and that the general order of succession worked out by Murchison could everywhere be recognized. Hence the term Silurian came to be generally employed to designate the rocks containing the first great fauna of the Geological Record."

At first the Silurian not only included what is now known as Lower Silurian, or Ordovicic, or Champlainic, and Upper Silurian, or Siluric, but also much of the Cambrian of Sedgwick. "The controversy regarding the respective limits of the Cambrian and Silurian formations survived the lifetime of the two great antagonists." §

The present work, however, has no bearing on the lower limit of Murchison's Silurian, but aims to determine what constituted the upper limit of his "Upper Silurian" and the lower limit of his "Devonian."

Regarding the Upper Silurian, Murchison, in 1854, in his "Siluria," wrote as follows:

"When, on the contrary, we follow the same deposits from North and South Wales to the exemplar tracts of Herefordshire and Shropshire, where the Upper

* For further remarks see p. 291.
† Bulletin no. 87.
‡ See Geikie's Text-book of Geology, 3d ed., 1893, p. 737.
§ Geikie, p. 737.

Silurian rocks were first classified and described, we find them diversified by interpolated courses of limestone; much calcareous matter being also disseminated, both in nodules and in flagstones.

"With additions like these to the richness and variety of the subsoil, which are so welcome to the proprietor and farmer, the geologist usually discovers a much greater abundance of fossil animal remains than in the same strata of the sterile western tracts. By observing the order of superposition, and by tracing the divisionary limestones, he reads off the order of the strata, and chronicles with precision the succession of their respective fossils.

"In this way the Upper Silurian rocks are seen to consist, as a whole, of the two formations to which I assigned the names of Wenlock and Ludlow, each of these being subdivided in the manner expressed in this woodcut."*

Murchison then describes the various horizons, and names the diagnostic fossils for the Upper Silurian. Regarding the highest beds of the Ludlow, he states that—

"The upper portion of the Ludlow formation, or capping of the bone bed is composed of light colored, thin bedded, slightly micaceous sandstones, in which quarries are opened out near Downton castle on the Teme.† The uppermost layers of the whole system, and which form a transition into the Old Red sandstone, consist of tilestones and sandstones, occasionally reddish, in which, besides other fossils found in the Ludlow rock, the Lingula cornea, with crustaceans [Leptocheles], and defenses of fishes, often occur.

"Being compelled in my researches to draw a line of demarkation between the upper part of the Ludlow formation and the bottom of the overlying Old Red sandstone, I formerly included the tilestones in the latter; particularly as in most parts of the region they decompose into a red soil, and thus they afford a clear physical line of demarkation between them and the inferior rocks, which facilitated the construction of the geological map.

"Even then, however, the fossils which were figured as characteristic of such tilestones exhibited little else, as I showed, than species common to the Ludlow rock itself. This zoological fact, and subsequent researches in other parts of England, above all those of Professor Sedgwick in Westmoreland, where the Upper Ludlow strata are much developed, have, for eleven years, led me to classify these tilestones with the Silurian rocks, of which they form the natural summit. [The fossils are listed and figured on plate xxxiv.] All of these are the most common fossils of the Upper Ludlow rock; although a few of them descend as low as the Caradoc sandstone." ‡

With the exception of the fishes, the fauna included in these tilestones, and listed by Murchison, is in harmony with the American Upper Silurian. It does not suggest anything higher than the Niagara group. On

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*Siluria (pp. 101–102). The legend to this woodcut forms the first column of the correlation table beyond.

†The Downton Castle stone, Silurian system, p. 197.

‡ Ibid., pp. 138, 139.

this point, Kayser, who has given much attention to the stratigraphy and paleontology of the Lower Devonic, writes as follows: *

"Paleontologically the Ludlow rocks, on the whole, are commonly very closely related to the Wenlock; most of the mollusks, many of the trilobites and other fossils are common to the two formations, and only a few forms, such as *Cardiola interrupta* and *Pentamerus Knighti*, are, if not entirely limited to the upper beds, at least chiefly found in them. A special peculiarity of the Ludlow is the appearance, even in the lowest beds, of numerous Eurypterids (especially *Eurypterus* and *Pterygotus*—forms which become very abundant in the Old Red sandstone)—and the peculiar Cephaspidæ (*Cephalaspis, Scaphaspis, Pteraspis*, etcetera), the oldest of British fishes."

The Upper Silurian of England, as given by Geikie in 1893, is practically that of Murchison in 1854, with the exception of the Lower and Upper Llandovery and Tarannon shales. These had been referred by the former to his Lower Silurian, but by the latter are regarded as the base of the Upper Silurian. The upper limits of the Upper Silurian are defined by Geikie as follows:

"Above the Upper Ludlow shales and mudstones lies a group of fine yellow, red, and gray micaceous sandstones from 80 to 100 feet thick, which have long been quarried at Downton castle, Herefordshire. At Ledbury these sandstones are surmounted by a group of red, purple, and gray marls, shales, and thin sandstones, having a united thickness of nearly 300 feet. Originally the whole of these flaggy upper parts of the Ludlow group were called 'tilestones' by Murchison, and, being often red in color, were included by him as the base of the Old Red Sandstone, into which they gradually and conformably ascend. They point to a gradual change of physical conditions, which took place at the close of the Silurian period in the west of England and brought in the peculiar deposits of the Old Red Sandstone. There is every reason to believe that for a long time the marine sedimentation of Upper Silurian type continued to prevail in some areas, while the probably lacustrine type of the Old Red Sandstone had already been established in others, and that by the breaking down or submergence of the barriers between these different areas, marine and lacustrine conditions alternated in the same region. The tilestones are the records of this curious transitional time. . . .

"The evidence from fossils is equally explicit. Up to the top of the Ludlow rocks, the abundant Silurian fauna continues in hardly diminished numbers. But as soon as the red strata begin the organic remains rapidly die out, until at last only the fish and the large eurypterid crustaceans continue to occur." †

DOWNTONIAN

In a very recent detailed work, "Silurian Rocks of Britain," Messrs B. N. Peach and John Horne ‡ write of the uppermost Silurian rocks of Great Britain as follows:

* Text-book of Comp. Geology, 1893, p. 65.

† Geikie, pp. 760–762.

‡ Memoirs Geol. Survey of United Kingdom, 1899, pp. 67–69, 80, 568.

"Downtonian has hitherto been regarded as of Lower Old Red Sandstone age, owing to the prevalence of red and yellow sandstones and shales which are the prominent feature of that formation. The recent discovery by the Geological Survey, in shales and mudstones intercalated in these sandstones, of a marine fauna which in some respects is identical with that of the underlying Ludlow Rocks has led to a revision of the classification hitherto adopted. These passage beds are now viewed as forming the highest subdivision of the Upper Silurian rocks."

The following is a tabulation of the Downtonian, in descending order, with an enumeration of the essential fossils. The thickness of the series is from 700–2,700 feet.

4. Chocolate-colored sandstones.
3. Conglomerate with quartzite pebbles derived from the Highlands.
2. Green and red mudstones with bands of graywacke and brown flaggy carbonaceous shales with fishes and eurypterids. Plants: *Pachytheca*, *Parka*. Animals: *Beyrichia*, *Ceratiocaris*, *Eurypterus*, *Pterygotus*, *Slimonia*, *Stylonurus*, *Glauconome*, *Spirorbis*. Fishes: *Thelodus* and four other restricted genera.
1. Red and yellow sandstones and mudstones.

The fossils mentioned above are Siluric in age and remind rather of the Tentaculite and Waterlime than of the Lower Helderberg. Messrs Peach and Horne add:

"In view of the paleontological and to some extent also of the physical evidence regarding the passage-beds that overlie the Ludlow rocks, there seems ground for maintaining that they have greater affinities with the Silurian system than with the Old Red Sandstone. They may be looked upon as stratigraphical equivalents of the Tilestones, Downton sandstones, and Ledbury shales, which in Herefordshire, overlie the Upper Ludlow rocks, and have been classified as forming the highest subdivision of the Upper Silurian rocks."*

AMERICAN EQUIVALENTS

In North America the Siluric faunas are also abundant in species, and, with a gradual change toward higher types, continue from the Anticosti formation through the Guelph, when red shales, salt and gypsum bearing, begin and bear witness to an almost total extermination of animal existence throughout the Onondaga (= Cayugan) formation. Here, as in England, eurypterid crustaceans are the prevailing fossils, but in America fishes are generally absent.

In eastern New York, above the "Waterlime" a small but normal marine fauna again makes its appearance in the Tentaculite (= Manlius) limestone. It consists of 26 species, and 4 of these, are known to occur

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*Silurian Rocks of Great Britain, p. 568.

in some higher member of the Lower Helderberg.* These figures show that the Tentaculite limestone is transitional to the Lower Helderberg, yet its fauna does not forcibly bring to mind that of the Lower Pentamerus immediately above.

Fauna of the Tentaculite Limestone of New York

† *Homocrinus scoparius* Hall.
Monotrypa (?) *spinulosa* (Hall and Simpson).
† *Stropheodonta varistriata* (Conrad).
‡ *Orthothetes hydraulicus* (Whitfield). 27859.§
Spirifer vanuxemi Hall. 4692, 9112, 26043, 10549.
Tellinomya nucleiformis Hall.
Goniophora dubia (Hall). 4693.
Illionia sinuata (Hall).
Aviculopecten (?) *obscura* (Hall).
Holopea subconica Hall.
Holopea antiqua (Vanuxem). 10625.
Holopea pervetusta (Conrad).
? † *Holopea* (?) *elongata* Hall.
Murchisonia extenuata Hall.
Murchisonia minuta Hall.
? † *Euomphalus sinuatus* Hall.
Tentaculites gyracanthus (Eaton). 5001, 10549, 17514, 9120.
† *Spirorbis laxus* Hall.
Oncoceras ovoides Hall.
Cyrtoceras subrectum Hall. 10628, 4682.
Leperditia alta (Conrad). 4699, 9115, 17515, 25853.
Leperditia parvula Hall. 10551, 10552.
Beyrichia parasitica (Hall).
Beyrichia clarkii Jones.
Beyrichia trisulcata Hall.
† *Klœdenia notata* (Hall). 10551, 10552.

American paleontologists acquainted with this fauna and that of the typical Lower Helderberg will at once see that it is not the Tentaculite fauna which gave the Lower Helderberg sea its multitudinous forms

* In Ohio a similar fauna is present in the "Hydraulic limestone of the Lower Helderberg" (Geol. Survey of Ohio, vol. vii, 1893, pp. 410–418). The following are the species:

Orthothetes hydraulicus (Whitfield).
Spirifer vanuxemi Hall.
* *Meristella lævis* (Vanuxem).
* *Meristella bella* Hall.
Nucleospira rotundata Whitfield.
* *Rhynchospira formosa* Hall.
Rhynchonella hydraulica Whitfield.
Pentamerus pesovis Whitfield.
* *Pterinea aviculoidea* Hall.
Goniophora dubia Hall.
Eurypterus eriensis Whitfield.
Leperditia alta Conrad.
Leperditia angulifera Whitfield.

† Also in higher Lower Helderberg.
‡ Also in the Onondaga (= Cayugan).
§ Register number of the specimens in the U. S. National Museum.

of life. It was rather that of the Niagara epoch, which continued to live and undergo modification in some unknown area while the Salina shales and Waterlimes were deposited. This fauna, transitional between the Niagara and the Lower Helderberg, may be that of the Guelph, Meniscus, and the higher Siluric dolomites of Ontario and the central United States. In any event, the Tentaculite fauna has a decided Siluric facies. It seems that the most natural line (faunally) for the separation of the Siluric and the Lower Helderberg lies at the top of the Tentaculite limestone, and that the fauna of the Lower Pentamerus is the earliest stage in the Devonic cycle of marine life.

Submergence and transgression begins with the Tentaculite, but in the Lower Helderberg sea are more decided than during any period of the Siluric. In eastern Pennsylvania the Lower Helderberg reposes on Clinton strata; in southern Illinois and adjoining Missouri, on Ordovicic strata, and in Gaspé on the Quebec. This evidence, therefore, shows a marked transgression over eroded land areas in widely separated localities. The Oriskany sea continues the Lower Helderberg submergence and transgression, since in New York, from east to west, it gradually comes to rest on the various members of the Lower Helderberg and finally upon the Waterlime (= Rondout limestone).

In 1882, Hall * also pointed out that "while the trend [line of greatest deposition] of the limestones of the Niagara and the two succeeding calcareous groups has a general east and west direction, the Lower Helderberg has a northeast and southwest trend."

It may also be well to state here that the Lower Helderberg is nearly everywhere followed by some member of the Oriskany. This is true for New York as well as practically throughout the length of the Appalachians, Illinois, Tennessee, and Gaspé. The Oriskany is absent in Indian Territory, and is present without the Lower Helderberg in the region of Cayuga, Ontario.

Mr Bailey Willis, of the United States Geological Survey, who has made a special study of the middle and southern Appalachian mountains, will publish the following in the third volume of the Geological Survey of Maryland:

"The student of physical changes finds no important episode of mountain growth or continental development to define the close of the Silurian period and the beginning of the Devonian. The record describes Appalachia as a monotonous lowland, now rising a little higher, now not so high, above the fluctuating coast of marsh and tideflat. . . . Before the Oriskany in the Lower Helderberg epoch it had assumed these aspects which are considered to characterize the Devonian period."

* Contribution to Geol. Hist. Amer. Cont. Presidential address, A. A. A. S., Montreal, 1857. Republished, Salem, 1882, pp. 48, 49, 68.

TABLE OF ENGLISH AND AMERICAN SILURIC EQUIVALENTS

	WALES AND SHROPSHIRE. Upper Silurian, Murchison, 1854. (Siluria, 1854, page 102.)	WALES AND SHROPSHIRE. Upper Silurian, Geikie, 1893. (Text-book of Geology, page 753.)	WALES. Upper Silurian, Kayser, 1893. (Text-book of Comparative Geology, page 64.)		NORTH AMERICA. Siluric or Ontaric equivalents, Schuchert.
Devonic.	Old Red Sandstone.	Base of Old Red Sandstone.	Old Red Sandstone.	Devonic	Coeymans or "Lower Pentamerus" limestone.
Siluric or Ontaric.	Upper Silurian. Upper Ludlow, including Tilestones. Middle Ludlow or Aymestry limestone. Lower Ludlow.	Tilestones, 300 feet. Downton Castle sandstone, 90 feet. Ledbury shales, 270 feet. Upper Ludlow rock, 140 feet. Aymestry limestone, up to 40 feet. Lower Ludlow rock, 350 to 700 feet. (Ludlow group.)	Ludlow or Clunian (Downtonian). Ledbury shales. Downton sandstone. (Passage beds or Tilestones.) Upper Ludlow beds, including the bone bed. Aymestry limestone.	Neontaric or Cayugan.	Manlius, or "Tentaculite limestone," 50 to probably 300 feet or more. Rondout, or "Waterline." Salina beds. Shales and marlites (Salina group), with Waterlime zones generally near the top ("Waterlime group"). (300 to 1,600 feet.) (A typical marine fauna is generally absent.)
	Wenlock limestone. Wenlock shale. Wenlock shale, with lower, or Woolhope limestone.	Wenlock, or Dudley limestone, 300 feet. Wenlock shale, up to 2,300 feet. Woolhope, or Barr, limestone and shale, 150 feet. (Wenlock group.)	Wenlock or Salopian. Lower Ludlow beds. Wenlock limestone. Wenlock shale and Woolhope limestone.	Mesontaric or Niagaran.	Guelph limestone, 160 feet (probably in part is the marine facies of the Salina shales). Waldron shale, 4 to 20 feet. Lockport limestone, 4 to 300 feet (includes the "Coralline limestone") Rochester shale, 80 feet. Clinton beds, 50 to 1,000 feet.
	Lower Silurian. Pentamerus limestone on the summit of the Caradoc sandstone.	Tarannon shales, 1,000 to 1,500 feet. Upper Llandovery rocks and May Hill sandstone, 800 feet. Lower Llandovery rocks, 600 to 1,500 feet. (Llandovery group.)	Llandovery or Valentian. Tarannon shales. May Hill sandstone = Upper Llandovery. Lower Llandovery beds.	Paleontaric or Oswegan.	Medina sandstone. Oneida conglomerate (includes Shawangunk). (300 to 1,800 feet.) (Anticosti divisions, 1 to 4, 1,350 feet.)
		Lower Silurian or Ordovician.		Champlainic.	A marked faunal hiatus occurs here. Cincinnatian (Richmond beds).

From Lower Helderberg time deposition is again continuous, and the chain of life in the American Appalachian and Mississippian seas is almost unbroken to the close of the Paleozoic. There is probably no land area preserving so continuous and undisturbed a sequence of Paleozoic deposits as that of eastern North America. From Lower Cambric time to the close of the Permic, the only marked hiatus exists between the Ordovicic and Siluric, and this may have been caused by the elevation of the Taconic mountains. However, beyond this area, in the gulf of Saint Lawrence, even this gap will probably be largely bridged over by the fossils preserved in the Ordovicic and Siluric strata of Anticosti island. These, as yet, have not been sufficiently studied; but it is clear from the work of Billings that the Ordovicic and Siluric fossils of Anticosti have more in common than these systems have elsewhere in America.

The table on page 251 shows the equivalents of the English Upper Silurian as understood by Murchison in 1854, and by Geikie and Kayser in 1893, with the American homotaxial equivalents.*

CONCLUSIONS

With the foregoing presentation, it is clear that the upper faunal limits of the original Upper Silurian have been and still are vague, because the normal marine fauna gradually succumbed to local conditions associated with the production of red sediments.

"As a series of rocks the upper limit of the typical Silurian section was clearly defined, and time has shown that this limit was not only one of a geological series, but the dead-line of a large number of organic types." †

Lower Devonic ‡

DEVONIAN OF SEDGWICK AND MURCHISON

The following résumé by Murchison § gives a clear history of the progress regarding the Devonian rocks in the type area:

"*Devonian rocks* (*the equivalents of the Old Red*) *in Devon and Cornwall.*—The crystalline and slaty condition of most of the stratified deposits in Devon and Cornwall, and their association with granitic and eruptive rocks and much metalliferous mat-

* The divisions and terminology here adopted are those of Clarke and Schuchert. Science, vol. x, December 15, 1899, pp. 874–878.

† Clarke: Review of "Die Fauna des Unteren Devon am Ostabhange des Ural." Am. Geol., vol. xiv, 1894, p. 121.

‡ The results of this section are arranged in tabular form beyond.

§ Siluria, London, 1854, pp. 257–258. For an encyclopedic paper on the history of the Devonian to 1867, see Quart. Jour. Geol. Soc. London, vol. xxiii, p. 568, by Robert Etheridge; also "The Geology of England and Wales," by Horace B. Woodward, London, 1887.

ter, might well induce the earlier geologists to class them as among the very oldest deposits of the British Isles. In truth, the southwestern extremity of England presented apparently no regular sedimentary succession, by which its gray, slaty schists, marble limestones, and silicious sandstones could be connected with any one of the British deposits the age of which was well ascertained. The establishment of the Silurian system, and the proofs it afforded of the entire separation of its fossils from those of the Carboniferous era, was the first step which led to a right understanding of the age of these deposits. The next was the proof obtained by Professor Sedgwick and myself, that the 'culm measures' of Devon were truly of the age of the Carboniferous limestone, and that they graduated downwards into some of the slaty rocks of this region. Hence, in the sequel it became manifest, that the rocks, now under consideration, were the immediate and natural precursors of the coal era, and stood therefore in the place of the Old Red Sandstone of other regions. The highly important deduction, however, of Mr Lonsdale, that the fossils of the South Devon limestones, as collected by Austen and others, really exhibited a character intermediate between those of the Silurian system and of the Carboniferous limestone, was the most cogent reason which induced Professor Sedgwick and myself (after identifying North and South Devon) to propose the term Devonian.* The inference that the stratified rocks of Devonshire and Cornwall, though of such varied composition, are really the equivalents of the Old Red Sandstone in the regions alluded to has since, indeed, been amply supported and extended by the researches of Sir Henry De la Beche, Professor Phillips, and many other good geologists.†

"The most instructive of the sections published by my colleague and myself to illustrate the general structure of Devonshire, is that of which the diagram in page 256 is a compiled reduction. [*a*, Lowest Devonian beds of schists and red micaceous sandstone of North Foreland; *b*, red sandstone and conglomerate of Linton; *c*, gray schists and Stringocephalus limestone of Ilfracombe, etcetera. Beds *a* and *b* are compared with the lower shelly graywacke of the Rhine (Coblenz, etcetera).] It is a section across North Devon from the Foreland on the British channel, to the granitic ridge of Dartmoor on the south, and exhibits a copious succession of the Devonian rocks between Linton and Ilfracombe on the north, and Barnstable on the south, the whole dipping under strata of the Carboniferous age, on the opposite side of a wide trough of which, or on the north flank of Dartmoor, the Upper Devonian strata again rise to the surface.

"North Devon has thus been selected as affording, on the whole, the best type of succession of the rocks to which the name Devonian was applied; because it offers a clear ascending section through several thousand feet of varied strata, until we reach other overlying rocks, which are undeniably the bottom beds of the true Carboniferous group."

Murchison and many later geologists, including Geikie, hold that the Old Red sandstone and the Devonian of North and South Devon are

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*See Reports of Brit. Assoc. for the Advancement of Science, 1836, Bristol meeting. Sedgwick and Murchison, Trans. Geol. Soc. London, vol. v, p. 633, and Phil. Mag., vol. xi, p. 311. Lonsdale, Trans. Geol. Soc. London, vol. v, p. 721.

†See Report on the Geology of Cornwall, Devon, and W. Somerset, by De la Beche, 1839, and the Palæozoic fossils of the same region, by Professor Phillips, 1841.

equivalents. As a name, therefore, Old Red sandstone has priority over that of Devonian, but since in the latter area marine fossils occur, enabling similar horizons to be identified elsewhere, this systemic name has supplanted that of the Old Red sandstone, and is now generally recognized the world over. In regard to the latter formation, Geikie* writes as follows:

"In Wales and the adjoining counties of England, where the typical development of the Silurian system was worked out by Murchison, the abundant Silurian marine fauna disappears in the red rocks that overlie the Ludlow group. From that horizon upwards in the geological series, we have to pass through some 10,000 feet or more of barren red sandstones and marls, until we again encounter a copious marine fauna in the Carboniferous limestone. It is evident that between the disappearance of the Silurian and the arrival of the Carboniferous fauna, very great geographical changes occurred over the site of Wales and the west of England. For a prolonged period, the sea must have been excluded, or at least must have been rendered unfit for the existence and development of marine life, over the area in question. The striking contrast in general facies between the organisms in the Silurian and those in the Carboniferous system, proves how long the interval between them must have been.

"At present the general belief among geologists is that, while in the west and north of Europe the Silurian sea-bed was upraised into land in such a way as to inclose large inland basins, in the center and southwest the geographical changes did not suffice to exclude the sea, which continued to cover that region more or less completely. In the isolated basins of the west and north, a peculiar type of deposits, termed the Old Red Sandstone, is believed to have accumulated, while in the shallow seas to the south and east, a series of marine sediments and limestones was formed, to which the name of Devonian has been given. It is thus supposed that the Old Red Sandstone and Devonian rocks represent different geographical areas, with different phases of sedimentation and of life, during the long lapse of time between the Silurian and Carboniferous periods. . . .

"That the Old Red Sandstone of Britain does represent the prolonged interval between Silurian and Carboniferous time can be demonstrated by innumerable sections, where the lowest strata of the system are found graduating downward into the top of the Ludlow group, and where its highest beds are seen to pass up into the base of the Carboniferous system. . . . It is quite possible, therefore, that the lower portions of what has been termed the Devonian series may, in certain regions, to some extent represent what are elsewhere recognized as undoubtedly Ludlow or even perhaps Wenlock rocks.†

"Yet even at the best the Devonian rocks of this classical region, though they served as the type formations of the same geological age elsewhere, are much less clearly and fully developed than those of the Rhine country and other parts of the continent. It is rather from the sections and fossil collections of central Europe than from those of England that the stratigraphy and paleontology of the Devonian system are to be determined."

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* Text-book of Geology, 3d ed., 1893, pp. 777-778, 783.

† See *ante*, Peach and Horne.

Frech * gives the following scheme showing the relation of the non-marine Old Red sandstone to the normal marine Devonian :

"*Non-marine development.*	*Marine development.*
Upper Old Red sandstone =	{ Lower Carboniferous, in part. Upper Devonian.
Land condition and transgression =	Middle Devonian.

[There is no middle Old Red sandstone. The interval is indicated by a great discordance.]

Lower Old Red sandstone =	{ Lower Devonian. Upper Silurian, in part."

These citations make it clear that in Wales and England a series of red marls and sandstones set in near the close of the Siluric, and continued without change through the Devonic into the Lower Carbonic period. During the deposition of 10,000 feet of Old Red sandstone strata no normal marine fauna occurs, and the best criterion for time sequence is therefore absent.

In Devon and Cornwall there is another series of Devonian rocks, and as these bear normal marine faunas they represent the type area for the Devonic system. However, it is only in recent years that the small English Lower Devonic faunas have become somewhat known. For this reason it was long ago recognized that the Devonic system could be studied to better advantage in the Rhineland.

" The Devonian system was founded upon one of the most unfavorable and incomplete developments of that series of rocks and faunas known in any part of the globe; a more precise scope was given to it by the work of its founders, Murchison and Sedgwick, in the Rhineland, but even there no determination of its lower limit was made. This admitted hiatus in the typical succession of Devonian to Silurian is the parent of the prolific discussions over 'post-Silurian' and 'Hercynian' faunas." †

Of the Devonic of Rhineland, Kayser,‡ one of the leading students of the German Devonic, writes as follows:

Murchison and Sedgwick "first broke ground on the continent in the Rhenish Schiefergebirge and their westerly extension, the Ardennes, the largest and best developed Devonian area of western Europe, which even up to the present day continues to add more to our knowledge of the Devonian than any other [European] area.

"The famous essay of the two English observers devoted to the Rhenish mountains appeared in 1842,§ and its value was enhanced by the paleontological appendix

* Lethæa geognostica, 1 Theil, 2 Band, 1897, p. 118.

† Clarke, in a review of the work cited, American Geologist, vol. xiv, 1894, p. 119.

‡ Text-book of Comparative Geology, by E. Kayser, translated by Philip Lake, London, 1893, pp. 89–91.

§ Trans. Geol Soc., 2d ser., vol. vi, p. 222.

contributed by d'Archiac and de Verneuil. In this classical work, a part of the Taunus and Hunsrück was considered as Cambrian; the chief mass of the Schiefergebirge as Silurian; a smaller part, including the Eifel Limestone formation, as Devonian; . . but the classification of the older beds has needed considerable alteration. The merit of undertaking this necessary revision is due to the 'Rheinischen Uebergangs-gebirges' of Ferd. Roemer, appearing in 1844, in which the author shows that the chief mass of the Schiefergebirge must, according to its fossils, be correlated not with the English Silurian, but with the Devonian.

"The extent of the Devonian in the Rhenish Schiefergebirge, the accuracy of the observations made upon it, the completeness and variety of the series, and its richness in fossils," make it the most important area for this system. "This mountain region, which in general has the form of a plateau, stretches from the Eder and Diemel to beyond the Meuse," and consists of "strongly compressed beds," with a "system of reversed folds. . . . All these folds consist of Devonian rocks, altogether probably at least 20,000 feet thick.

"Within the Devonian rocks themselves no unconformity has yet been found, and the whole succession seems to have been deposited without any important check, and passes up without break into the overlying Culm."

The errors made by Murchison and Sedgwick in the Rhenish area were admitted by the former after seeing Roemer's work above mentioned, and in his famous book "Siluria" (1854) he writes as follows:

"The clear general views of that Nestor of geologists, D'Omalius d'Halloy, the remarkable work and map of M Dumont, as well as the previous labors of Prussian geologists, including the maps of Leopold von Buch, Hoffman, von Dechen, and Öynhausen, unquestionably led the way in the succession of efforts, through which our present knowledge has been obtained. After the publication of the above works, Professor Sedgwick and myself endeavored to show (1839) that, like Devonshire and Cornwall, the Rhenish provinces contained a great mass of those strata, intermediate between the Silurian and Carboniferous deposits, which we had called Devonian; the equivalent, in our belief, of the Old Red Sandstone of Scotland and Herefordshire. Our contemporaries have admitted that, in our excursion of one long summer in Germany, we succeeded in proving the existence of such an intermediate series both in Prussia and Belgium, and also in showing how, on the right bank of the Rhine, the uppermost 'grauwacke' was divisible into Lower Carboniferous and Upper Devonian rocks. Misled, however, by an erroneous interpretation of some of the fossils (for at that time the Lower Devonian forms had been little developed), we adopted the belief, that the inferior 'fossiliferous grauwacke,' or that which has since been called the 'Spiriferen Sandstein' of the Rhine, was an equivalent of the Upper Silurian. I have been convinced, through the paleontological labors of Ferdinand Roemer and the brothers Sandberger, that the types of that lower Rhenish subdivision are distinct from the Upper Silurian, and in harmony with the lowest Devonian group of other countries. And for some years I have been aware that, whilst our sections representing the succession of the mineral masses were correct, the interpretation or synonymy to be attached to the lower division was erroneous. . . .

"It is, however, satisfactory to have ascertained in a recent visit to my old ground, that all the knowledge acquired in the fourteen years which have elapsed since our survey was made, has but led to a much more complete identification of the Rhenish provinces with Devonshire, than that which was proposed by my colleague and myself. In short, it now appears that not some only, as we thought, but all the paleozoic strata of Devon have their equivalents on the banks of the Rhine. So, that, starting from the North Foreland of the British channel, and ascending into the heart of the culm fields, . . . the geologist has before him the successive representatives of the Rhenish deposits.

"Those persons who may refer back to the sixth volume of the Geological Transactions of London, will, therefore, understand that all the Rhenish ground which is described or colored in the map and sections as Upper Silurian, is now embodied in the Devonian rocks; whilst to their admirable description of the fossils MM d'Archiac and de Verneuil have but to add the one plate of the few so-called Silurian fossils, to their thirteen plates of true Devonian types, and all the general features of our labors will be in harmony with subsequent observations." *

LOWER DEVONIC OF GERMANY AND THE AMERICAN EQUIVALENTS

Views of writers as to its extent, character, and divisions.—Writing of the Lower Devonic of the Rhine, Kayser says:

"This consists of at least 10,000 feet of sandy and clayey beds, almost entirely free from lime. The fossils which occur in it are almost always mere stone-casts. . . . They are generally rare, and are found only in isolated beds, which are often separated by many hundred feet of practically unfossiliferous rock. The fauna consists chiefly of Brachiopoda. The only other important forms are Lamellibranchs, Crinoids, and some Trilobites and Gasteropods, while Cephalopods and Corals are few in number. Some species . . . go through the whole, or almost the whole, series of beds, whilst others have a more restricted range. In general the constitution of the fauna points to a shallow sea, and the ripple-marks frequently met with at all horizons also speak in favor of this view." †

Frech ‡ writes that students of Rhenish geology are agreed on the following divisions of the Lower Devonic of Germany, which have for their bases four species of prevalent brachiopods:

4. Zone of *Spirifer paradoxus* . .	*c.* Zone with *S. speciosus* = Red ironstone. *b.* Upper Coblenzian. *a.* Coblenz quartzite.	
3. Zone of *Spirifer hercyniæ*	Lower Coblenz beds.	*b.* Lower Coblenzian. *a.* Porphyroid and Grauwacke of Sendorf.
2. Zone of *Spirifer primævus* . . .	Siegen. Grauwacke.	*b.* Hunsrück schiefer. *a.* Taunus quartzite.
1. Zone of *Spirifer mercuri*	Gedinnian. Taunus.	Sericitglimmer schiefer. Taunus phyllite.

* Murchison's Siluria, pp. 365, 366.

†Kayser's Text-book, 1893, p. 92.

‡ Lethæa geognostica, 1 Theil, 2 Band, 1 Lief., Stuttgart, 1897.

The following German Lower Devonic faunas and their American equivalents are based on Frech's "*Lethæa geognostica*" (1897). The lists do not indicate the entire faunas.

1. *Gedinnian, fauna of the lowest Lower Devonic, or zone of Spirifer mercuri*

Germany.	American.
Orthis verneuili (cf. *O. elegantula*).	*O.* (*Dalmanella*) *planiconvexa* or *quadrans* Hall.
Spirifer mercuri Gosselet.	*S. perlamellosus* Hall.
Rensselæria strigiceps Roemer (this is no Rensselæria, probably a pentameroid).	
Grammysia deornata.	
Tentaculites irregularis de Koninck.	
Beyrichia richteri de Koninck.	
Primitia jonesi de Koninck.	
Homalonotus richteri de Koninck.	

This meager fauna occurs near the base of the Gedinnian, and there is nothing in it that can be successfully compared with American Devonic horizons. The few American species cited are of Lower Helderberg age, and while the German Gedinnian may be the equivalent, it seems best at present to defer a positive correlation.

2. *Siegen, fauna of the Siegen grauwacke, or zone of Spirifer primævus*

Germany.	American.
Chonetes sarcinulatus.	*Chonetes melonica* Billings.
Orthis personata Krantz.	
Orthis circularis Schnur.	
Strophomena murchisoni Verneuil.	
Strophomena sedgwicki Verneuil.	
Streptorhynchus gigas McCoy.	*Stropheodonta magniventra* Hall. (Frech compares *Hipparionyx proximus* Vanuxem.)
Cyrtina heteroclita Defrance.	*C. rostrata* Hall, *C. affinis* Billings.
Spirifer primævus Steininger.	*S. murchisoni* Castelnau or *S. arrectus* Hall.
Spirifer hystericus Schlotheim (= *S. micropterus* Goldfuss).	
Spirifer bishofi Giebel.	This form of Spirifer, with the fold and sinus somewhat plicated, does not begin in America before the Oriskany.
Athyris undata Defrance.	This is an Athyris of which *A. fultonensis* of the Middle Devonic is the best known.
Rhynchonella daleidensis F. Roemer.	

Germany.	American.
Rhynchonella pengelliana Davidson.	*Camarotœchia speciosa* (Hall).
Tropidoleptus rhenanus Frech.	
Rensselæria strigiceps F. Roemer (not a Rensselæria, probably a pentameroid).	
Rensselæria crassicosta Koch.	
Megalanteris archiaci.	*M. ovalis* Hall.
Palæopinna gigantea Krantz.	*P. flabellum* Hall.
Numerous pelecypoda.	Pelecypoda rare.
Platyceroids rare.	Platyceroids common.
Homalonotus ornatus C. Koch.	
Homalonotus planus Sandberger.	*H. major* Whitfield.
Homalonotus roemeri de Koninck.	*H. vanuxemi* Hall.
Homalonotus aculeatus C. Koch.	
Phacops ferdinandi Kayser.	*P. cristata* Hall.
Dalmania (*Odontocheile*) *rhenana* Kayser.	*D.* (*O.*) *pleuroptyx* (Green).
Cryphæus limbatus Schlüter.	American species of Cryphæus begin in the Middle Devonic.
Many crinoids and starfishes.	Crinoids rare; starfishes none.
Tentaculites grandis.	*Tentaculites acula* Hall.

In this fauna there is marked evidence for purposes of correlation. Brachiopods are numerous and often of large size, a degree of development also attained in the American Oriskany. The principal American species of this horizon and their equivalents in the Siegen grauwacke are shown as follows:

American.	Siegen.
Stropheodonta magniventra Hall.	*Streptorhynchus gigas* McCoy.
Camarotœchia speciosa Hall.	*Rhynchonella pengelliana* Davidson.
Crytina rostrata Hall and *C. affinis* Billings.	*C. heteroclita* Defrance.
Spirifer murchisoni Castelnau.	*S. primævus* Steininger.
Spirifer arenosus Conrad.	A poor representative in *S. bishofi* Giebel.
Meganteris ovalis Hall.	*M. archiaci.*
Palæopinna flabellum Hall.	*P. gigantea* Krantz.
Dalmanites (*Odontocheile*) *pleuroptyx* Green.	*D.* (*O.*) *rhenana* Kayser.
Tentaculites elongatus Hall.	*T. grandis.*

From this evidence and the further fact that zone 3, or Lower Coblenzian, does not clearly indicate the Oriskany, but a rather higher horizon, it follows that the Siegen grauwacke and the American Oriskany are fairly harmonious in their faunas. Frech correlates the Oriskany with the "Spirifer sandstone" of the Lower Coblenzian. This view places the Oriskany near the top of zone 3 (see page 266), a considerably higher or younger position than that given by the present writer.

Again, if the Hercynian fauna of the Lower Wieder Schiefer, described by Kayser,* is brought into the comparison, a fauna is met which also strongly recalls the Oriskany as well as the Lower Helderberg.

The brachiopods are the predominating fossils, with the long-hinged species of Spirifer in well developed forms. The Oriskany types are *S. decheni*, *S. ilsæ* (the representatives of the American *S. murchisoni* Castelnau and *S. arrectus* Hall); *S. nerei*, var., *S. hercyniæ* (closely related to *S. cumberlandiæ* and *S. tribulis*). Another Hercyn Spirifer, *S. bishofi*, may be compared with the Oriskany species *S. arenosus*, one of the most characteristic Spirifers in the introduction of the plicated fold and sinus. Of Lower Helderberg Spirifers, *S. macropleura* may be compared with the Hercyn *S. jaschei* and *S. sp.* (figure 6 of plate xxi). On the other hand, such species as *S. togatus* and *S. sericeus* recall *S. radiatus*, clearly a remnant of the Siluric fauna, but not of that age because of the far greater size attained by these forms.

Another Oriskany reminder is Meganteris figured by Kayser. This species is far larger than *M. ovalis* and as large as *Rensselæria ovoides*, a very closely related form. However, since it is the only terebratuloid in this, the true Hercyn fauna, the paucity is most marked when compared with the Oriskany or even with the Lower Helderberg. The Hercyn pentameroids are in harmony with those of the Lower Helderberg, while the rhynchonelloids are unlike any American facies. In a number of species the latter appear to be ancestors of *Hypothyris cuboides* of the Middle Devonic.

When the Hercyn Brachiopoda of the meristelloid family is examined, there is seen to be a marked paucity of species, especially when compared with the Lower Helderberg. The same is true of the Retzias, and particularly the orthoids. On the other hand, the presence of *Atrypa aspera* in the Hercyn is that of a form first appearing in the Corniferous or Middle Devonic.

The strophomenoids are non-committal, while the presence of several species of Chonetes, some of which attained a size above the average, denotes the Middle Devonic. Craniella is also rather indicative of a horizon above the Lower Helderberg.

From this summary of the brachiopods the conclusion is reached that the Hercyn species, if of one fauna, indicate an age not as old as the Lower Helderberg and probably not much younger than the later Oriskany.

With few exceptions, the Hercyn trilobites are those of the Lower Helderberg and Lower Oriskany. The exceptions are the presence of Harpes, a remnant of Ordovicic or Champlainic times, and the occurrence of Cryphæus, a genus first appearing in America in the Middle

* Die Fauna der ältesten Devon-Ablagerungen des Harzes, Abh. z. geolog., Specialkarte von Preussen, Band ii, Heft 4, 1878.

Devonic. The great abundance of Phacops is characteristic of European faunas, and is in harmony with Lower Devonic development. The Hercyn trilobites are unmistakably of Devonic age, and seem to find their nearest relatives in the Lower Helderberg, but apparently more directly in the Lower Oriskany.

The presence of large fish spines and teeth in the Hercyn is strongly indicative of the Devonic, as well as of a development younger than anything known in the Lower Helderberg, and is more in harmony with the American Corniferous. Moreover, these Hercyn fish remains do not agree with those from the Siluric of England.

There is nothing in American Lower Devonic horizons to be compared with the Goniatite development of the Hercyn. These shells do not make an abundant appearance in American faunas until well into the Middle Devonic, and they give the Hercyn a strong and unmistakable Devonic aspect.*

The gastropods of the Hercyn point to the Lower Helderberg, but it should be borne in mind that these are nearly all capulids. Their size and the abundance of species, however, will also agree with the Oriskany age. The pelecypods are younger than the Lower Helderberg, and since but very few Oriskany species of this class are known, no direct comparisons can be instituted. The supposed occurrence of a typical Siluric graptolite zone near the top of the Hartz Hercyn gave it a very ancient aspect and a very remarkable life combination. However, from the work of Tullberg and Denckmann, it is now known that this zone is of Siluric age.†

From the foregoing review of the typical Hercyn fauna it is clear that while it contains a number of Siluric types, yet its general development, particularly the large size of many of its individuals, is not to be correlated directly with the Lower Helderberg. On the whole it appears to agree best with the Oriskany. If, in this connection, it is borne in mind that the Upper Oriskany is everywhere a shore deposit—coarse sands and shales—and has a decidedly littoral fauna, while the Hercyn is derived from limestone (the Goniatites indicating deeper water), one of the causes for the marked difference in these faunas is made apparent. On the other hand, the Lower Helderberg fauna, while not of a very deep sea, is deeper than the Oriskany, and if the former is of the same age as the Hercyn, then more harmony might be expected than exists between them. These various reasons result in the conclusion that the Hercyn fauna is to be correlated rather with the Oriskany than with the Lower Helderberg. Frech would place it a little higher, because he regards it

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* See remarks on the Goniatites of étage F_2, Konieprussian of Bohemia, p. 265.

† See Frech: Lethæa geognostica, 1 Theil, 2 Band, 1897, pp. 117, 193.

as a certain equivalent of the Lower Coblenzian, and probably also of the Siegen grauwacke. This view, joined to that of the writer's, makes the Hercyn fauna of the Lower Wieder Schiefer the probable equivalent of the American Oriskany, although it may occupy a somewhat younger position in the time scale.

Another related fauna and one derived from calcareous beds is that described by Barrois * from the hamlet of Erbray, in the lower Loire. On examining the plates illustrating this fauna, it soon becomes apparent that the Erbray fauna has the general aspect of the Hartz Hercyn, but the faunal assemblage is a different one and has a younger appearance, which is due to the scarcity of orthids, being almost restricted to *O. (Rhipidomella) palliata*, a local and distinct development. The Stropheodontas are rather those of the American Middle Devonic, and the same is true of many of the Rhynchonellas, athyroids, and centronelloids. The Spirifers, as a rule, find their analogues in the Oriskany and Middle Devonic, while the large *Megalanteris inornata* and *M. deshayesii* point to the Oriskany. Indications of the older faunas occur in the strongly plicated pentameroids, some of the Rhynchonellas, the Meristellas, and *Spirifer bisulcata.* A decided Devonic aspect is marked in the trilobites, for *Cryphæus* is here well developed and the Dalmanites (Odontocheile) section is absent. The platyceroids agree both with the Lower Helderberg and Oriskany, while the other gastropods accord with forms best developed in the Siluric. The great development of Conocardium in the Erbray fauna gives it its character, yet the forms are all small, and therefore do not have the aspect of higher Devonic species. The abundance of cup corals and Acervularia is also a decided characteristic of American Middle Devonic faunas.

It is unsafe to make definite correlations when faunas are so different as that of Erbray and those of the American Lower Devonic. It is true that the Erbray fauna and that of the Lower Helderberg are from limestones, but the Oriskany fauna is nearly everywhere found in a coarse sandstone, while practically nothing is known of the life of the Cauda-galli (= Esopus). However, the above summary of the Erbray fauna shows that the development is unlike that of the American Lower Helderberg. While the latter brings to mind some of Erbray, still the developmental progression is rather that seen in the Oriskany, and probably also of the time interval represented by the Cauda-galli.

Recently Frech † has discussed the position of this fauna and points out that there are three fossil zones the exact relation of which, one to another, is not yet fully established. He correlates the Erbray fauna

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* Faune du Calcaire d'Erbray; Cont. a l'étude du Terrain dévonien. Mém. Soc. géol. du Nord, iii, April, 1889.

† Lethæa geognostica, p. 195, and table xiii.

with all of the *Spirifer hercyniæ* zone, or the Lower Coblenzian, and the upper portion of the Siegen of the Rhine. This is exactly the view arrived at by the writer before he knew of Frech's conclusions.

In the Lower Devonic of England, at Looe, in Cornwall, a fauna occurs which Kayser* says is in harmony with that of the Siegen grauwacke. As far as the writer is able to judge, this correlation is not only correct for the Rhineland, but also is in harmony with the Oriskany. Possibly a similar fauna occurs in the Lynton slates of North Devon, England.

In this review of the Lower Devonic faunas of Europe, there are none which seem to be the direct equivalent of the American Lower Helderberg. Therefore a review will now be made of Barrande's étage F, often regarded as lowest Lower Devonic.

The greatest number of American Lower Helderberg specific equivalents exist among the brachiopods. These are in the Konieprussian of étage F_2. However, it should here be borne in mind that étage F_2 contains two distinct zones—stratigraphically, lithologically, and paleontologically—the Konieprussian and Menian. This has recently been pointed out by Kayser and Holzappel,† and they correlate the Menian limestones with the basal Middle Devonic of the Eifel, or the beds characterized by *Spirifer cultrijugatus*. This horizon appears to be about that of the Corniferous. Frech ‡ tabulates the lower Devonic of Bohemia as follows:

"G_1. Nodular limestone of Tetin with Odontocheile.

Deep sea.

F_2 in part. Red flaggy limestone of Menian (=Greifenstein) with *Agoniatites fidelis*, crinoidal limestone with trilobites, Goniatites, smooth brachiopods.
Fairly deep sea. (Oriskany (part), Cauda-galli, and Schoharie grit).

F_2 in part. White coral-reef limestone of Koniepruss, massive, with numerous corals, brachiopods, capulids, and nests of trilobites.
Shallow sea. (Lower Helderberg and Oriskany.)

F_1. Black flaggy limestone of Kosorsch with deep-sea sponges, palæoconchs, and *Hercynella bohemica*.
Very deep sea. (Lower Helderberg.)

E_2. Upper Silurian."

* Text-book of Comp. Geology, p. 105.
† Jahrb. der k. k. geolog. Reichsanstalt, Band 44, Heft 3, 1894.
‡ Lethæa geognostica, pp. 188, 256.

The succeeding list of specific equivalents for Bohemia and the Lower Helderberg of New York was not prepared to fit the case in hand, but is the outcome of an examination of Barrande's fine plates. The writer has often collected in the Lower Helderberg and Oriskany, and has studied their faunas for ten years. In going over Barrande's plates he was surprised to find that the brachiopods in the two regions were very similar. A careful perusal of the list here given will show that the most important Lower Helderberg brachiopods have direct equivalents in the Konieprussian. Each region has, of course, its own development, and the common forms of one region may be rare in the other. For instance, in America the great development of the subgenera of Orthis—Dalmanella and Rhipidomella—have but little diversity in étage F_2, while here the spire-bearing families Meristellidæ and Athyridæ have a far greater diversity. The same is also true for the Rhynchonellidæ, although these shells are varied and abundant in the Lower Helderberg. These are the local aspects of widely separated faunas, however, and when such similarities are detected as are indicated in the following list, they should be given their full value:

Bohemia, étage F_2.	Lower Helderberg.
Discina radians Barrande.	*Orbiculoidea discus* Hall.
Orthis palliata B. (Pl. 58).	*O.* (*Dalmanella*) *perelegans* Hall.
Orthis pinguissina B.	*O.* (*D.*) *quadrans* (Hall).
Orthis præcursor B.	*O.* (*Schizophoria*) *multistriata* Hall.
Strophomena rhomboidalis (Wilckens).	*Leptæna rhomboidalis.*
Strophomena bohemica B.	*Strophonella punctulifera* (Conrad).
Strophomena phillipsi B.	*Stropheodonta varistriata arata* Hall.
Strophomena sowerbyi B.	*Stropheodonta becki* Hall.
Strophomena æsopea B.	*Orthothetes deformis* Hall.
Chonetes venustus B.	*Chonostrophia helderbergiæ* H. & C.
Chonetes inconstans B. *Chonetes squamatulus* B.	*Anoplia nucleata* Hall.
Pentamerus sieberi v. Buch. *Pentamerus optatus* B.	*Gypidula galeata* (Dalman).
Pentamerus firmus B.	? *Anastrophia verneuili* (Hall).
Rhynchonella eucharis B.	*Eatonia medialis* (Vanuxem).
Atrypa assula B.	*Eatonia peculiaris* (Conrad).
Rhynchonella phœnix B.	*Rhynchonella semiplicata* Conrad.
Spirifer nerei B. F_1, F_2.	*Spirifer concinnus* Hall.
Cyrtina heteroclita Defrance.	*Cyrtina dalmani* (Hall).
Atrypa reticularis Linné.	Same species and local development.
Atrypa semiorbis B.	*Atrypina imbricata* Hall.
Merista herculea B. *Merista minuscula* B.	*Merista typus* Hall.
Atrypa compressa B.	*Meristella bella* Hall.
Atrypa inelegans B.	*Nucleospira ventricosa* Hall.

Bohemia, étage F_2.	Lower Helderberg.
Retzia haidingeri B.	*Rhynchospira formosa* Hall. *Rhynchospira globosa* Hall.
Atrypa eurydice B.	*Rensselæria mutabilis* Hall.
Retzia melonica B. (Pl. 141).	Probably another Rensselæria of Lower Helderberg development.
Dalmanites hausmanni Brongniart. G.	*D.* (*Odontocheile*) *micrurus* (Green).
Acidaspis monstrosa B. G_1.	*Acidaspis tuberculata* (Conrad).
Phacops breviceps F_2.	*Phacops logani* Hall.
Fenestella and Hemitrypa in abundant development in étage F.	An abundant development of these forms in the Lower Helderberg.
Actinostroma, Stromatopora, and Clathrodictyon in numerous examples in F.	Syringostroma and Clathrodictyon in the Lower Pentamerus limestone.

The foregoing table of equivalents leads the writer to regard the Konieprussian and the Lower Helderberg as closely related, as well as the oldest well described Lower Devonic brachiopod faunas. The great diversity of the fenestelloids in étage F is in harmony with a similar development in the Delthyris shale of the Lower Helderberg. The stromatoporoids are also in harmony with this view. The trilobites do not oppose this correlation, but two characteristic species of the Lower Helderberg—*Dalmanites micrurus* and *Acidaspis tuberculata*—find their equivalents in the next higher zone, or étage G. Barrande does not figure the gastropods and pelecypods of Bohemia, and the writer can therefore make no comparisons. The Goniatites said to be of étage F_2, described by Barrande, are now known to belong in a zone the equivalent of G (see Frech's table on page 263), and therefore do not affect the Lower Helderberg fauna. Even if they occurred in the Konieprussian fauna under review, the fact should be borne in mind that not a single Goniatite is known in America prior to the Corniferous, and that there is but a meager representation in any American Middle Devonic horizon. The weight of this argument, therefore, loses its force in point of correlation. On the other hand, of the 6 species of Goniatites said by Barrande to be from étage F_2, but 2 are restricted to that horizon—*G. solus* and *Agoniatites fidelis*—while the other 4 also occur in G_3—*G. plebius* B. = *Anarcestes latiseptatus* (Beyrich), *Agoniatites verna*, *Anarcestes crispus*, and *Agoniatites tabuloides*—and 2 of these persist into H_1—*Anarcestes latiseptatus* (Beyrich) and *Agoniatites verna*. These species thus show that they have no particular stratigraphic value beyond the fact already mentioned, which seems strong proof for a Devonic facies. The writer therefore concludes that the Konieprussian (F_2) and the Lower Helderberg are the equivalents of each other and represent the best known lowest Lower Devonic faunas.

This view differs from that of Frech, for he correlates F_1 and the F_2 Konieprussian with the Lower Helderberg and Oriskany. It seems to the writer that in Bohemia there is no equivalent for the littoral Oriskany, and that between F_2 Konieprussian and F_2 Menian a faunal hiatus exists. Étage F_2 Menian and G seem to conform to the American Schoharie grit and Corniferous. However, the writer does not insist on all these correlations, but merely wishes to point out that the Lower Helderberg fauna finds its best representative in the Konieprussian of Bohemia. The latter and étage F are now generally regarded by European stratigraphers as lowest Lower Devonic.

Barrande long ago recognized a faunal resemblance between his étage E and the Wenlock of England, although he also referred his étages F, G, and H to the Siluric system. In Barrande's time, the Cambric as a system was almost unknown, and even today Geikie* writes:

> "For myself, I repeat what I have said in previous editions of this text-book, that the most natural and logical classification is to group Barrande's three faunas [now Cambric, Ordovicic, and Siluric] as one system, which in accordance with the laws of priority should be called Silurian."

This is also the opinion of M Hebert,† F. Schmidt,‡ and De Lapparent.§ If in this connection the fact is also borne in mind that the Lower Devonic of Devonshire and of the Rhineland consists almost wholly of sandy and slaty beds whose fauna at that time was little known, thus contrasting with the well known, abundant, and almost sequential faunas from the Primordial to étage H of Bohemia, it can be partially understood why étages F, G, and H are correlated by Barrande with the Upper Silurian. Again, if the great faunal resemblances or the gradually modifying fauna of the étage E (Wenlock) into F and thence G and H are noted, another good reason appears; and, finally, if remembered that the upper limit of Murchison's Upper Silurian fauna was essentially the Wenlock, and that the known Devonic fauna of his time was practically that of the Middle Devonic, the argument is complete for Barrande's reference of étages F, G, and H to the Silurian. These facts formerly had, and still have their influence in America. At first the Oriskany and Lower Helderberg were referred to the Silurian. After De Verneuil and Sharpe's visit to America in 1847, the Oriskany was referred to the Devonic (Hall, 1858), and this then came to be the generally recognized base for this system in the United States. ||

* Text-book of Geology, 1893, p. 727.

† Bull. Soc. Géol. France, 3 ser., vol. xi, 1882, p. 34.

‡ Quar. Jour. Geol. Soc. London, vol. 38, 1882, p. 515.

§ Traité de Géologie, 3d ed., 1893.

|| Sharpe: Quar. Jour. Geol. Soc. London, vol. iv, 1847, pp. 145–181.
De Verneuil: Soc. Géol. de France, 2d ser., vol. iv, 1847, pp. 646–709.
Hall, Foster, and Whitney's Rept. on Lake Superior, pt. ii, pp. 285–318.

3. *Lower Coblenzian, zone of Spirifer hercyniæ*

Coblenzian.	American.
Orthis hysterita Grim.	*O.* (*Schizophoria*) *striatula.*
Orthis circularis Sowerby.	
Strophomena plicata Sowerby.	
Strophomena explanata Schnur.	*Stropheodonta* (*Leptostrophia*) *magnifica* Hall.
Chonetes sarcinulatus Schlotheim.	*C. melonica* Billings and *C. coronatus* Conrad.
Chonetes dilatatus de Koninck (probably Stropheodonta).	
Chonetes plebeus Schnur.	
Rhynchonella daleidensis F. Roemer.	Nothing like it.
Rhynchonella dannenbergi Kayser.	Frech compares *R. multistriata* Hall. (Of the Oriskany.)
Rhynchonella (*Wilsonia*) *pila* Schnur.	Nothing like it.
Spirifer subcuspidatus Schnur.	*S. fornacula* Hall, *S. medialis* Hall.
Spirifer carinatus Schnur.	Similar with the Hamilton *S. granulifer* Conrad.
Spirifer hercyniæ Giebel.	*S. cumberlandia* Hall.
Spirifer arduensis Schnur.	*S. duodenaria* Conrad.
Athyris undata Defrance.	The nearest is the Hamilton *A. spiriferoides* (Eaton).
Athyris ferronensis Verneuil.	Nothing like it.
Anoplotheca venusta Schnur.	
Megalanteris archiaci Verneuil.	
Rensselæria strigiceps F. Roemer.	Frech compares *R. ovoides* (Eaton).
Tropidoleptus rhenanus Frech.	
Numerous pelecypoda.	
Few gastropods.	
Homalonotus armatus Burmeister.	No spiniferous American species.
Homalonotus rhenanus C. Koch.	*H. vanuxemi* Hall.
Homalonotus ornatus Sandberger.	No ornate American species.
Homalonotus roemeri.	

This fauna does not readily correlate with any American horizon. Frech, however, says "the Lower Coblenz strata, consisting of grauwacke and slates with interbedded quartzites, form in a developmental aspect an unchanged continuance of that of the Siegen grauwacke."* This horizon is apparently not far removed from the later Oriskany and may be the equivalent of that and the Cauda-galli.

4. *Upper Coblenzian, zone of Spirifer paradoxus*

The fauna here is a very extensive one, and if the American reader will look at Frech's † plate 24*b* he will not hesitate to pronounce the age of that

* Lethæa geognostica, 1897, p. 146.
† Ibid.

Upper Coblenz slab the equivalent of the Hamilton or Middle Devonic beds. However, the present writer does not mean more than faunal resemblance, certainly not synchronous equivalence. In any event, the Upper Coblenzian has nothing to do with the Oriskany, but rather with the American Corniferous and Hamilton. These divisions are here regarded as members of the American Middle Devonic.

A very similar result is obtained by examining the plates illustrating "Die Fauna des Hauptquarzits" of the Hartz, by Kayser.* This horizon is correlated with the Upper Coblenzian of the Rhine. With very few exceptions the species there illustrated find their nearest relatives in the American Hamilton. A few of the brachiopods, however, agree best with Corniferous species.

CONCLUSIONS

If the faunas of the Hercyn (Kayser) and Siegen are the equivalents of the Oriskany, then beds the age of the Lower Helderberg are to be found in the Gedinnian and Taunus, or zone of *Spirifer mercuri*, in the Rhineland. This fauna, however, is a very small one, and the writer does not feel warranted in making a correlation of value. But the Gedinnian of Germany and France is often correlated with étage F of Bohemia. In any event, the Lower Helderberg has its equivalent in étage F_2 Konieprussian. It will be shown in the next chapter that the Lower Helderberg fauna has decided Devonic characteristics and very little of typical, or Murchisonian, Upper Silurian.

The Hercyn of the Hartz and the Siegen grauwacke of the Rhineland (possibly, also, the Linton slates of the Lower Devonic of England) appear to be equivalents of the Oriskany. Both these faunas have a brachiopod development which unmistakably points to the younger Oriskany, but there is also a facies which finds its nearest expression in America in the older Oriskany. In this connection it may be pointed out that de Verneuil,† after his visit to America, published the view, in 1847, that the Oriskany is Devonic, regarding it as the equivalent of the fossiliferous schists (Spirifer sandstone) of the Rhine. The sediments of the later Oriskany are very coarse, and the older Oriskany is as yet practically unworked paleontologically. Therefore, at present large brachiopods chiefly constitute the known Oriskany fauna. This expression is also seen in the Hercyn and Siegen faunas. On the other hand, the German sediments are less coarse, presenting conditions for a different faunal development, while the waters were also probably deeper.

* Abh. d. k. preuss. geol. Landesanstalt, n. ser., Theil 1, 1889.

† Bull. Soc. Géol. de France, 2d ser., vol. iv, 1847, pp. 646–709; see also Hall's translation, Amer. Jour. Sci., 1848, pp. 177–178.

This difference is shown in the abundance of pelecypods and the presence of Goniatites, while in the finest sediments, the slates, an abundant and varied local fauna of crinoids and starfishes is present.

The Erbray fauna described by Barrois may be the equivalent of the Oriskany or of the Upper Oriskany and Cauda-galli. In any event, it appears to be younger than the typical Hercyn and not as young as the Lower Coblenzian.

The latter does not appear to the writer to be the equivalent of the Oriskany, as stated by Frech, but brings to mind some portions of the Upper Helderberg. It may represent either the Cauda-galli fauna, which as such is there unknown, or the Schoharie grit. In any event, it seems clear that the Upper Coblenzian has a fauna which American paleontologists may safely conclude to be very much like that of the Hamilton, although it probably is not quite so recent.

American Lower Devonic*

HELDERBERGIAN SUBDIVISIONS†

This series of strata is generally known as the Lower Helderberg group, and "has been so termed from its very complete development along the base of the Helderberg mountains, constituting in this part of New York an important fossiliferous group. In some parts of the Helderberg mountains, and along the Hudson river at Rondout, and at Schoharie and elsewhere, the lowermost beds of this group [Tentaculite or Manlius limestone] rest directly on the Waterlime beds, which we regard as the uppermost member of the Onondaga salt group." ‡

The Helderbergian series in New York reposes on the Manlius (Tentaculite) limestone, and in places begins with a thin mass of limestone containing Stromatopora, which is known as the Stromatopora limestone. The next persistent horizon is the Coeymans (Lower Pentamerus) limestone, "charged with great numbers of the broken shells of *Penta-*

* A map giving the known distribution of the Helderbergian and of the Cayugan and Niagaran to 1874 was prepared by Professor James Hall, and will be found accompanying a paper entitled "The Niagara and Lower Helderberg groups; their relations, and geographical distribution in the United States and Canada." See Twenty-seventh Ann. Rept. N. Y. State Mus. Nat. Hist., 1875, pp. 117–131.

† The terminology here adopted is that of Clarke and Schuchert, Science, vol. x, December 15, 1899, pp. 874–878. It is as follows:

Eodevonic	Oriskanian.	Oriskany beds.
	Helderbergian	Kingston beds (= Upper shaly limestone).
		Becraft limestone (= Upper Pentamerus limestone).
		New Scotland beds (= Delthyris shaly limestone).
		Coeymans limestone (= Lower Pentamerus limestone).

‡ Hall: Paleontology of New York, vol. iii, 1859, p. 33.

merus [*Gypidula*] *galeatus*."* In Otsego county this limestone has a thickness of not less than 80 feet.

The Coeymans limestone "graduates above into a shaly formation, which was designated in the New York Reports as the Delthyris shaly limestone, from the abundance of this genus of fossils [Delthyris = Spirifer]."† The "Delthyris shaly limestone" or New Scotland beds is the most prolific in fossils, not less than 298 species having been found in New York alone.

The upper member of the Helderbergian is generally known in New York as the Upper Pentamerus limestone. Vanuxem named it the "Scutella limestone," because of the presence of certain large crinoidal plates, while Gebhard called it the "Sparry limestone," owing to its strong crystalline nature. Darton, with Hall's consent, has recently renamed it "Becraft limestone," a name here adopted.

All these rocks are well exposed in the Helderberg hills of New York, particularly in Albany and Schoharie counties, where they have a thickness of from 300 to 400 feet, but thin out rapidly toward the west. There is "scarcely any evidence of their existence in New York west of Oneida county."‡

Following the Helderberg hills in a southwesterly direction "through Pennsylvania, Maryland, Virginia, and Tennessee, we everywhere find the same group of strata, and bearing everywhere more or less the same species of fossils. . . . In some localities in the middle and southern [southwestern] parts of Tennessee, the collections of fossils are so like those from the Helderberg mountains, near Albany, that but for their color and here and there a difference in the development of certain forms, there would be little to distinguish the two localities."§ The same is also true of the Helderbergian of Indian Territory.

In Monroe county, in eastern Pennsylvania, the Helderbergian has a thickness of about 600 feet, but thins westward, and in Perry county is only 350 feet thick. In Pennsylvania these beds are known as division number 6, and locally as the "Stormville shales." The latter "grow buff and sandy when traced westward from the center of Monroe county, and, as seems most probable, become continually coarser, until they are consolidated with the Oriskany sandstone."‖

In western Maryland, the Helderbergian series is represented in the "Upper limestone series" of the Lewiston formation, and appears to be more extensively developed stratigraphically than in any other region

* Hall, 1859.
† Hall, 1859, p. 33.
‡ Hall, 1859, p. 37.
§ Hall, 1859, pp. 37-38.
‖ I. C. White, Geol. Survey of Pa., vol. C C, 1882, p. 132.

of the United States. The writer recently spent three days examining these deposits and the fossils gathered by Mr Robert H. Gordon. No complete section of the Helderbergian was seen in any one place, but there was sufficient to show that this series is probably not less than 500 feet thick; also that the four zones of the New York division are present in the region of Cumberland, and that the Helderbergian apparently passes without break into the Oriskany. In New York, the Helderbergian is generally followed by a few feet of Oriskany, which represent the later portion and not the whole of this formation. The following is the Helderbergian and Oriskanian section about Cumberland, as made out by the writer, while the fossils of the former series in Mr Gordon's collection are listed beyond:

Section at the "Devil's Back Bone," Kreighbaum Station, Baltimore and Ohio Railroad

Marcellus shale.	
Oriskany	Top not seen here, but elsewhere is a coarse sandstone. Dark blue, arenaceous, heavy bedded limestone, abounding above in *Spirifer arenosus*, *Stropheodonta magnifica*, and below in *S. arrectus* and *Chonostrophia complanata*. Thickness about 150 feet.
Kingston (or Oriskany)	Dark blue, arenaceous limestone with chert zones. Heavy beds above passing into thin beds. No fossils were seen. Thickness about 125 feet.
New Scotland and Becraft.	Thin bedded, shaly limestone and shale with chert, abounding in New Scotland fossils. Shales with *Anoplotheca flabellites* near the top. Thickness about 75 feet. The fossils known from this zone are *Zaphrentis*, *Leptæna rhomboidalis*, *Stropheodonta beckii*, *Orthothetes radiata?* *Orthis perelegans*, *Spirifer perlamellosus*, *S. cyclopterus*, *S. micropleura*, *Trematospira perforata*, *T.* near *multistriata*, *Eatonia medialis*, *Rhynchonella villicata?* *Phacops logani*, *Dalmanites micrurus*, and *D. pleuroptyx*.
Railroad watch-house here.	
Coeymans limestone	Heavy bedded limestone with chert. Fossils abundant, *Gypidula galeata*, etcetera. Thickness about 60 feet. Heavy and thin bedded bluish to yellowish limestone with chert zones. A well developed Stromatopora zone at the top and bottom; also *G. galeata*, corals, and crinoids. Thickness about 60 feet.

Transition	Thin bedded bluish limestone with zones of shale. Bryozoa abundant. Near the top occurs a small variety of *G. galeata* and *Favosites helderbergiæ*, and toward the bottom *Leperditia alta*, *Goniophora dubia*, and *Spirifer vanuxemi*. Thickness about 160 feet.
	Base not seen.

Section at Rose Hill, Baltimore and Ohio Railroad (*main line*)

Top not seen.

Manlius limestone	A series of heavy to thin bedded, light blue limestones resembling water limestones. The series is fossiliferous throughout in narrow zones. Has *Tentaculites gyracanthus*, *Leperditia fabulites*, *Beyrichia notata*, other Ostracods, *Rhynchospira* near *globosa*, *Meristella*, a small species very common; *Orthis* near *perelegans*, and poor Bryozoa. Thickness about 175 feet. Base not seen.
	Salina.

In southwestern Virginia the Helderbergian occurs in Lee, Wise, and Scott counties, and is described by Professor J. J. Stevenson * as follows:

"The Lower Helderberg.—The rocks of this group are exposed in the Poor valley; on the western end of Wallens ridge; in the valley between Wallens ridge and Powell mountain, in the North Fork gap; and on the southeastern slope of Powell mountain beyond the gap. The exposures are very fair, and a complete section could be obtained without much difficulty.

"The estimated thickness is not far from 250 feet. For 70 feet from the bottom the series consists of limestones in beds from three to five feet, separated by shales in somewhat thicker layers. . . . Contains abundance of *Leperditia*. [This may be the Onondaga or Waterlime horizon of the Siluric.] Overlying this is a succession of coarse grained calcareous sandstones, shales, and silicious limestones. . . .

"The lower sandstone . . . seems to be made up almost wholly of casts of *Orthis oblata*, *Rhynchonella ventricosa*, and undetermined *Meristella*.

"The silicious limestone yielded *Aspidocrinus scutelliformis*, *Atrypa reticularis*, *Strophomena rhomboidalis*, *Spirifer cyclopterus*, *Rhynchonella nucleolata*, *Orthis oblata*, etcetera."

In eastern Tennessee, the Helderbergian is not known, but in the western part of the state these beds are from 20 to 100 feet thick. The fauna here is essentially that of the New Scotland beds of New York. In Missouri, the thickness is given as 175 feet, and in Union county, Illinois, the lower 200 feet of the "Clear Creek limestone" are assigned to the Helderbergian.

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*Proc. Am. Phil. Soc., August, 1880.

Until recently no other region for these strata was known south or west of Tennessee and eastern Missouri. In 1891 Mr Hill discovered and Professor Williams identified the Helderbergian in Indian Territory. The fauna there contains 40 species, and is given in another place on the authority of Doctor George H. Girty.* Mr Taff describes the Indian Territory outcrops as follows:

"Rocks of Lower Helderberg period, as far as known in Indian Territory, are limestones and occur in the Chickasaw Nation, near its east line, in townships 1 south, range 8 east, 2 south, range 8 east, and 1 north, range 7 east. The second and third localities are known from a few fossils collected from highly tilted limestones found between black shale which is unconformably disposed above and thicker beds of Silurian or Ordovician limestone resting below. The limestone in these two localities, the one upon the south side and the other upon the north side of an extensive area of Silurian and Ordovician limestone, bears westward through an unknown distance in the Chickasaw Nation. The Lower Helderberg in township 1 south, range 8 east, is in the Atoka quadrangle and has been surveyed and mapped. It occurs at the east end of an extensive area of limestone and sandstone, part of which is known to be Lower Silurian and Ordovician. This area of Lower Helderberg limestone is 4½ miles long north and south and is from ½ to 2½ miles wide. The beds dip eastwar atd a low angle, and are overlain unconformably upon the north, east, and south sides by black fissile shale, which includes beds of flint, chert, and limestone segregations.

"The collection of Lower Helderberg fossils discussed by Doctor G. H. Girty in the Nineteenth Annual Report of the United States Geological Survey were taken from this locality. The reference of these rocks to the Lower Helderberg is based upon and due to Doctor Girty's work.

"The Lower Helderberg limestone has an estimated thickness of 140 to 200 feet, and its strata may be divided into two and possibly three stratigraphic units. While the contrast between these units is not very great, it is sufficient to induce description. (1) From the highest stratum in contact with the black shale downward through 95 feet the beds are light yellow or white limestone, which are occasionally separated by marly layers. Many of these limestone strata contain flint and cherty concretions. In almost all the beds remains of fossil shells were observed, and many especially which contain chert and flint bear shells beautifully preserved in chalcedony. (2) Next below there are 50 feet of friable layers of yellow limestone interstratified with still softer marly beds. These beds are very fossiliferous, abounding in well preserved corals, trilobites, and brachiopods. (3) Continuing downward through 55 feet thicker beds of crumbling limestone are encountered, which have yielded no well preserved fossils. Some of these beds are granular limestone and contain fragments of fossils. These, as suggested by Doctor Girty, may prove to belong to the Niagara period, as do the beds immediately below.

"The rock below these non-fossiliferous beds is a massive, whitish, silicious, oolitic limestone 15 to 30 feet thick. It has yielded but few fossils and these Doctor Girty refers to types more nearly related to the Niagara than to the Lower Helderberg period.

* Nineteenth Ann. Rep. U. S. Geol. Survey, 1899, pp. 546–550, 552–573.

"Below the oolitic limestone there are about 30 feet of shale which in turn rests upon Ordovician limestone."

Other Helderbergian areas are described by Dana as follows:

"The Saint Lawrence tidal waters of this period must have extended westward to the border of Vermont and Montreal and southward along the Connecticut valley. In Canada, in the line of the Connecticut valley, Lower Helderberg fossils occur in Dudswell and near lake Massawipi and Aylmer. They are also found in northern New Brunswick, northern Maine, near Square lake, and along the Gaspé-Worcester trough. They also occur in southern New Brunswick and near the coast in Pembroke, Maine, with many fossils, and in northern Nova Scotia, within the limits of the Acadian trough."*

A typical Helderbergian fauna is also known from Kennedy channel, latitude 80°–81° north, longitude 70° west. Doctor Hayes here collected the following species identified by Meek: †

Zaphrentis hayesii Meek.
Syringopora sp. undet.
Favosites sp. undet.
Leptæna rhomboidalis (Wilckens).
Strophonella headleyana Hall?
Stropheodonta beckii Hall?
Rhynchonella sp. undet.
Anoplotheca concava (Hall).
Spirifer perlamellosus Hall.
Loxonema (?) *kanei* Meek.
Orthoceras.
Illænus.

HELDERBERGIAN FAUNA

Relation to the Siluric.—From the appended list of the species of this fauna and their distribution, it is seen that no less than 426 are described, with 33 undescribed, in the Beecher collection. Sixteen of these, or about 3½ per cent, come from the Niagaran and Manlius formations. If the individual species are examined, it is seen that 5 have no particular stratigraphic value: *Favosites gotlandicus* Billings is probably a lax identification; *Halysites catenularia* is also known in the Trenton and Niagara; *Leptæna rhomboidalis* exists from the Trenton through nearly all the intermediate horizons into the base of the Lower Carbonic; *Orthothetes subplanus* belongs to a genus having no particular significance excepting its post-Ordovicic development, and *Atrypa reticularis* begins near the base of the Siluric, and is continuous throughout the Devonic. If the doubtful species and those not characteristic of the Siluric are eliminated, as *Favosites gotlandicus, Halysites catenularia, Atrypa reticularis*, and *Leptæna rhomboidalis*, the Helderbergian will be found to derive but 10 forms in its fauna of 459 species from the Siluric; *i. e.*, 3 from the Niagaran and 8 from the Manlius. This is a little more than 2 per cent.

* Dana: Manual of Geology, 4th ed., 1896, p. 558.

† Amer. Jour. Sci., 1865, p. 31. The specimens are in the U. S. National Museum.

Everywhere in the Cayugan, there is a scarcity of normal marine life, and this is particularly true of the Salina and Rondout stages. The Molluscoidea and Mollusca are generally absent. On the other hand, the ostracods, phyllocarids, and particularly the eurypterids, are the prevalent fossils. With the exception of the ostracods, not a single species of phyllocarid or eurypterid is known in the Helderbergian in any of the areas from Maine to the Indian Territory.

With these facts there is presented a great paleontological break between the Siluric and Devonic at the top of the Cayugan group. The succumbing of the normal marine faunas of the Niagaran group is undoubtedly associated with the red gypsiferous and saliferous sediments of the Cayugan group. If the latter had a normal marine fauna instead of one of peculiar crustacea, the continuity of life from the Niagaran to the Helderbergian would be probably complete. However, in most areas outside of New York and Ohio, there is a great hiatus between the Niagaran and the Helderbergian, which tends to make a clear and easily discoverable line for field geologists in separating the Siluric from the Lower Devonic.

*Relation to the Devonic.**—In New York, where the Helderbergian is best developed and its fauna well known, there are 364 described species, with 33 new ones in the Beecher collection. Of this fauna more than 9 per cent go into the Oriskanian (this fauna has 17 per cent of Helderbergian species). It is therefore evident that specific identity is greater between the Helderbergian and Oriskanian than between the former and the Siluric. †

Having examined the numerical specific relationships of the Helderbergian, its Siluric and Devonic aspects will now be pointed out. It is needless to go into great detail at this time, as Clarke ‡ did this work some years ago. Therefore the more prominent features only will be treated.

The trilobites are usually regarded as of first importance for stratigraphic correlation. In the Helderbergian there are the following genera

*The writer admits the unequal argument in contrasting the Helderbergian on one side with the Niagaran and on the other with the Oriskanian. The Helderbergian and Oriskanian have nearly continuous faunas, but between the former and the Niagaran intervenes the Cayugan group, of which a meager fauna is known. However, the essential question is, Has the Helderbergian a fauna more Devonic than Siluric in aspect?

† The Siluric Manlius limestone has 26 species. Of these 3 are also in the Coeymans and 3 in the New Scotland.

The Coeymans limestone has 58 species. Of these 15 (26 per cent) are also in the New Scotland beds, and 5 (or nearly 10 per cent) pass through into the Becraft limestone; 4 (or 7 per cent) also occur in the Oriskanian.

The New Scotland has 298 species. Of these 15 come from the Coeymans, while 29 (or 10 per cent) pass upward into the Becraft limestone, and 33 (or 11 per cent) also occur in the Oriskanian.

The Becraft limestone has 44 species, of which 29 come from the New Scotland, and 12 (or 27 per cent) pass into the Oriskanian above.

‡ The Hercynian Question, Forty-second Ann Rept. N. Y. State Mus., 1889.

or subgenera: *Homalonotus*, *Bronteus*, *Dalmanites*, *Probolium*, *Odontocheile*, *Phacops*, *Acidaspis*, *Lichas*, *Cordania*, *Proetus*, and *Cyphaspis*. This enumeration fails to present some of the most characteristic fossils of the American Siluric, as *Bumastus*, *Encrinurus*, *Sphærexochus*, *Cheirurus*, *Calymmene*, and particularly *Illænus* so prolific in species. Of the abundant Siluric eurypterids and of *Ceratiocaris*, none occur in the Helderbergian. On the other hand, the Helderbergian trilobites of the genera *Bronteus*, *Phacops*, *Acidaspis*, and *Cordania* have decided Devonic affinities, while *Dalmanites* (*Odontocheile*) is rather Devonic in development, although there are related species present in the Siluric. *Calymmene* again appears in the Onondaga.

The brachiopods may also be regarded as of prime importance because of their wide distribution, abundance, and specific differentiation. In the Helderbergian, there are no less than 137 species. A Devonic aspect is indicated in the large size attained by most of the species, and the abundant specific development of the subgenera *Rhipidomella* and *Dalmanella*. *Christiania* and *Leptænisca* are genera in which the shell is anchored directly to some foreign object, but this feature is unknown in earlier faunas, and becomes more and more marked in the later Devonic and Carbonic. *Chonostrophia* is introduced in the Helderbergian and is continued into the Middle Devonic. *Stropheodonta* and *Strophonella*, which are represented by few and generally small species in the Siluric, are here present in great force and large size, recalling strongly the Middle Devonic. As to size and abundance, the same is true of the Rhynchonellas, while *Lissopleura* and *Eatonia* are unknown in the Siluric. *Gypidula galeata* and *Anastrophia verneuili* are good Siluric stragglers, but also denote a younger age in their greater size. The Spirifers, while indicating the Siluric, point without exception to post-Siluric age in their larger size and abundance; a characteristic Devonic aspect not being attained before the later Oriskany. The Retzias betoken post-Siluric age in their size and greater specific differentiation, while the finely plicated form of Middle Devonic time has here its first appearance in *Parazyga*. *Meristella* is unknown in the Siluric, but in the Helderbergian there is an abundance of this genus, and some of the forms have almost specific identities in the Middle Devonic. However, the most decided Devonic brachiopod facies is in the loop-bearing genera *Rensselæria*, *Trigeria*, and *Cryptonella*. Not one of the Terebratulacea is known in the Siluric, while in the upper portion of the Lower Devonic, both in America and Europe, the genera *Rensselæria*, *Meganteris*, and *Trigeria* have a size rarely attained by any subsequent terebratuloids.

On the other hand, of the characteristic Siluric trimerelloids of the genera *Dinobolus*, *Rhinobolus*, *Monomorella*, and *Trimerella*, not one is present. Of the strophomenoids, *Plectambonites*, *Streptis*, *Mimulus*, and

Triplecia; of the orthoids, *Platystrophia*; of the pentameroids, *Capellinia*, *Pentamerus*, and *Conchidium*; of the spire-bearing families, *Meristina*, *Whitfieldella*, *Hyattella*, *Clintonella*, *Hindella*, and *Homœospira*—and *Eichwaldia* or *Dictyonella*, *Parastrophia*, and *Rhynchotreta* fail to have a single representative in the Helderbergian or any younger formation.

The gastropods of the Helderbergian undoubtedly indicate the Devonic, in the prolific development of the platyceroids of which there are about 38 species. They are very closely linked with the Oriskany forms. Even the Siluric genera *Strophostylus* and *Diaphorostoma* (= Platyostoma) show progression in their larger species.

The pelecypods are rather scarce, but the abundance of Aviculopectenidæ points rather to the Devonic because of their paucity in the Siluric. The Devonic genera *Actinopteria* and *Paracyclas* begin here. Other genera with undescribed species—*Grammysia*, *Goniophora*, *Orthonota*, *Nuculites*, and *Maminka*—are present. The specimens are in the Beecher collection in Yale University Museum.

In the abundance of fenestelloids and fistuliporoids, the Bryozoa are greater than in the Siluric, and more in harmony with the younger Devonic faunas.

The crinoids of the Helderbergian are often fragmentary and for that reason the following genera may be dropped from this review: *Aspidocrinus* may be based on roots, and probably also *Camarocrinus*, while *Brachiocrinus*, or rather *Herpetocrinus*, is only known from fragments. The other genera found here are *Homocrinus* and *Melocrinus*, ranging from the Siluric to Middle Devonic; *Mariacrinus*, *Cordylocrinus*, and *Marsupiocrinus*, found either in the Ordovicic or Siluric, and *Edriocrinus* in the Oriskany and Middle Devonic. Thus far the evidence points to a Siluric facies for the crinoids. However, the negative evidence—that is, the absence of characteristic Siluric genera—*Ichthyocrinus*, *Lecanocrinus*, *Macrostylocrinus*, *Glyptaster*, *Dimerocrinus*, *Lampterocrinus*, *Lyriocrinus*, *Eucalyptocrinus*, *Pisocrinus*, and *Stephanocrinus*—furnishes indications that the crinoid development of the Helderbergian is markedly varied, and not Siluric in character. Of these genera but two—*Lecanocrinus* and *Eucalyptocrinus*—recur in the Devonic of Germany, each with one species.

From the foregoing summary of the Helderbergian fauna it is evident that most of the characteristic Siluric genera of trilobites, brachiopods, and crinoids are there absent. This might be expected, for, as has been seen in the previous chapter, about 2 per cent of the Helderbergian fauna are derived from the Siluric. On the other hand, in some of the trilobites, Bryozoa, and pelecypods, many of the gastropods, but more particularly in the diversified brachiopods, are met organic groups, which in their culmination are characteristic of the Devonic. It can not be denied that the Helderbergian fauna has a Siluric facies, yet these types either have greater differentiation in species or the forms attain a larger size. The fact that 9 per cent of the Helderbergian fauna pass into a generally accepted Devonic horizon, the Oriskany, outweighs the evidence of a Siluric facies and specific derivatives. The writer therefore concludes that the Helderbergian has a fauna unlike the Siluric, but one in harmony with the Devonic and its position near the base of that system.

Neither of the Helderbergian zones can be regarded as the deeper water facies of the littoral Oriskany, not only because the fauna of the latter has a more decided Devonic aspect, but also for the fact that wherever the two formations are present the Oriskany always overlies the Helderbergian. As far as known, there is no interlamination, and in New York, where the stratification is simple, there is a regular sequence. Where the older Oriskany is absent there is a slight unconformity between the Helderberg and the later Oriskany. This unconformity becomes a decided one in going from eastern to central New York, because the later Oriskany gradually comes to overlie successively the various members of the Helderbergian and finally the Cayugan.

Table of the Helderbergian Fauna *

C = Coeymans limestone; S = New Scotland beds; B = Becrafts limestone.

Species with * are also in Siluric below.
Species with † are also in Oriskany above.

	New York.	Maryland and Virginia.	Illinois and Missouri.	Tennessee.	Indian Territory.	Maine and New Brunswick.	Gaspé and Nova Scotia.
Sponges, 6 species.							
Hindia fibrosa (Roemer). 10553, 17158, 26009, 27719	C S	x	....	x	x		
Lysactinella gebhardi Girty	S						
" *perelegans* Girty	S						
Receptaculites infundibuliformis (Eaton)	S						
" n. sp.	S						
Ischadites squamifer (Hall). 27720	S	....	....	x			

* Not including the Upper Arisaig, which is Siluric. Some of the Tennessee and Cumberland species are known from Hall's private collection. Numbers are of specimens in the United States National Museum.

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Cœlenterata, 30 species.							
Dictyonema crassum Girty	S						
" *splendens* Billings	...	...	...	...	...	...	x
Monograptus beecheri Girty	S						
Syringostroma centrotum Girty	C						
" *faveolatum* Girty	C						
" *microporum* Girty	C						
" *barretti* Girty	C						
" *consimile* Girty	C						
Clathrodictyon jewetti Girty	C						
Duncanella rudis Girty. 4229, 27738	S	...	...	x			
Streptelasma strictum Hall. 4129, 9168, 10555, 17160	S	x	...	x			
" *waynensis* Safford. 27735–27737	...	...	...	x	x		
†*Zaphrentis rœmeri* Edwards and Haime. 4236, 9202, 10556, 27734	S	x	...	x			
" *rugatula* Billings	...	...	...	...	...	...	x
Aulopora schoharie Hall. 26031	S						
" *tubula* Hall	S						
" *subtenuis* Hall	S						
" *elongata* Hall	S						
Favosites basalticus Billings	...	...	...	...	...	x	
*† " *gotlandicus* Billings	...	...	...	...	...	x	
" *helderbergiæ* Hall. 10554, 17159, 27726, 27727	S	x	...	x			
† " *conicus* Hall. 4040, 27722, 27723	S	x	...	x	x		
" *conradi* Girty	C						
Microplasma (?) n. sp.	...	x					
Alveolites explanatus Hall. 27733	C S						
Cladopora clarkei Girty	S						
" *halli* Girty	S						
**Halysites catenularia* Linné	...	...	...	...	...	x	
Striatopora issa Hall. 27728, 27731	S	...	...	x			
" *missouriensis* Meek and Worthen	...	...	x				
Pleurodictyum lenticulare (Hall). 27732	S	...	...	x			
Echinodermata, 23 species.							
* *Homocrinus scoparius* Hall. 9113	C						
Melocrinus nobillisimus (Hall). 4151, 4866	C						
" *pachydactylus* Hall. 4811	C						
" *paucidactylus* Hall	C						
Corymbocrinus (?) *macropetalus* (Hall)	B						
Mariacrinus plumosus Hall	C						
" *stoloniferus* Hall. (Columns)	S						
" *ramosus* Hall	C						
Cordylocrinus plumosus (Hall)	C						
" (?) *ramulosus* Hall	C						
Marsupiocrinus tentaculatus (Hall)	S						
Herpetocrinus nodosarius (Hall)	S						
Edriocrinus pocilliformis Hall. 10558	S	x	x	x			

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Aspidocrinus scutelliformis Hall. 10559..........	S B						
" *callosus* Hall........................	S						
" *digitatus* Hall.	S						
Hadrocrinus polydactylus (Hall)...................	S						
Camarocrinus saffordi Hall. 27760........	...	...	....	x			
Lepadocrinus gebhardi (Conrad). 10557, 26023....	C	x					
" n. sp. (Beecher collection)..........	C						
Sphærocystites multifasciatus Hall................	...	x					
Anomalocystites cornutus Hall. (May be crustacean).	C						
Protaster forbesi Hall..............	C						
Annelida, 5 species.							
* *Spirorbis laxus* Hall. 27847................. ..	...	...	....	x			
Cornulites chrysalis Hall........................	S						
" *cingulatus* Hall......................	S						
Arabellites 2 n. sp. (Beecher collection)...........	S						
Bryozoa, 89 species.				Tennessee Bryozoa unstudied.			
Vermipora serpuloides Hall.................	S						
" *robusta* Hall..	S						
" (?) *tortuosa* Hall....	S						
Hederella n. sp. (Beecher collection).....	S						
Chætetes sphæricus Hall...........	S						
" *proximus* Hall....................	S						
Monotrypa colliculatus Hall	S						
" *helderbergiæ* Hall.....	S						
" *monticulatus* Hall..................	S						
Monotrypella arbuscula Hall...............	S						
" *abruptus* Hall	S						
" *densa* Hall.........................	S						
Trematopora (?) *corticosa* Hall..................	S						
Rhombopora regularis (Hall)...................	S						
" *ovatipora* (Hall)...................	S						
" *canaliculata* (Hall).............	S						
" *rhombifera* (Hall)................	S						
" *parallela* (Hall)...................	S						
Diamesopora constricta Hall....................	S						
" *dispersa* Hall.....................	S						
Callopora oppleta Hall.	S						
" *cellulosa* Hall....	S						
" *perelegans* Hall....................	S	...	...	....	x		
" (*Callotrypa*) *macropora* Hall............	S						
" " var. *signata* Hall...........	S						
" " *heteropora* Hall...	S						
" " *unispina* Hall.............	S						
" " *striata* Hall.	S						
" " *oculifera* Hall...	S						
Chilotrypa venusta (Hall)......................	S						
" *mediopora* Hall...............	S						

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Fistulipora ponderosa Hall	S						
" *parasitica* Hall	S	....	..	....	x		
" *triloba* Hall	S						
Lichenalia crassa Hall	S						
" *maculosa* Hall	S	....	...	....	?		
" *torta* Hall	S						
" *serialis* Hall and Simpson	S						
" *distans* Hall	S						
Ceramopora maculata Hall	S						
" *labeculoidea* Hall	S						
" (?) *parvicella* Hall	S						
Paleschara incrustans Hall	S						
" *radiata* Hall	S						
" (?) *dissimilis* Hall	S						
" *concentrica* Hall and Simpson	S						
" (?) *bilateralis* Hall	S						
" *tenuis* Hall and Simpson	S						
Stictopora papillosa Hall	S						
" *obsoleta* Hall and Simpson	S						
" *granatula* Hall and Simpson	S						
" *granulosa* (Hall and Simpson)	S						
Ptilodictya lirata Hall	S						
" *tenuis* Hall	S						
" *nebulosa* Hall	S						
Thamniscus variolata Hall	S						
" *fruticella* Hall	S						
" (?) *cisseis* Hall	S						
" (?) *nysa* Hall	S						
Fenestella crebripora Hall	S			Tennessee Bryozoa unstudied.			
" *junceus* Hall	S						
" *cleia* Hall	S						
" *hestia* Hall	S						
" *æsyle* Hall	S						
" *noe* Hall and Simpson	S						
" *spio* Hall and Simpson	S						
" *althæa* Hall	S						
" *adraste* Hall	S						
" *sylvia* Hall	S						
" *philia* Hall	S						
" *thyene* Hall; *F. coronis* Hall; *F. indalia* Hall	S						
quadrula Hall; *F. adornata* Hall and Simpson	S						
Unitrypa præcursor Hall; *U. nervia* Hall var. *constricta* Hall	S						
Hemitrypa biserialis Hall; *H. biserialis* var. *exilis* Hall and Simpson	S						
Polypora eudora Hall, *P. stricta* Hall and Simpson, *P. idothea* Hall, *P. compressa* Hall, *P. lilæa* Hall, *P. compacta* Hall, *P. arta* Hall, *P. obliqua* Hall and Simpson, *P. paxillata* Hall	S						
Ichthyorachis nereis Hall	S						

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Brachiópoda, 137 species.							
Lingula centrilineata Hall	S	x					
" *perlata* Hall	C S						
" *rectilatera* Hall	S						
" *spathata* Hall	S						
" *artemis* Billings							x
" *lucretia* Billings							x
Orbiculoidea discus Hall. 17175	S B						
" *conradi* (Hall)	S B						
" n. sp. (Beecher collection)	S						
Schizocrania (?) *helderbergia* Hall	S	x					
" *superincreta* Barrett	B						
Pholidops ovata Hall. 27763	S			x		x	
Crania agaricina Hall and Clarke	S			x		x	
" *bella* Billings							x
" *pulchella* Hall and Clarke. 27762	S			x			
† *Orthis* (*Rhipidomella*) *oblata* Hall. 4109, 10561, 10565, 17174, 26033, 27765–27768	S B	x	x	x	x	x	
† " " *oblata discus* (Hall)	S					x	
" " *oblata emarginata* (Hall). 7487, 27764, 27769	...	x		x	x		
" " *tubulostriata* Hall	S						
" " *eminens* Hall	S					x	
" " *assimilis* Hall. 8419, 26024	S B						
" (*Dalmanella*) *subcarinata* Hall. 4114, 10566, 27773	S B		x	x	x		x
† " " *planiconvexa* (Hall)	S B	x		?			
" " *quadrans* (Hall)	S						
† " " *perelegans* Hall. 27770–27772	S B	x		x			
" " *concinna* Hall	...	x					
" (*Schizophoria*) *multistriata* Hall. 10567, 26010 (Syn. *O. peduncularis* Hall)	S B						
(*Orthostrophia*) *strophomenoides* Hall. 10568, 27774	S			x	x	x	
" (*Bilobites*) *varica* (Conrad). 4105, 8367, 9355, 10564, 27774	S			x	x	x	
Christiania subquadrata Hall and Clarke				x			
Leptænisca concava (Hall). 27780	S			x			
" *adnascens* Hall and Clarke. 27779	S			x			
" *tangens* Hall and Clarke	S						
* † *Leptæna rhomboidalis* (Wilckens). 3760, 4235, 8421, 9121, 9228, 14770, 10576, 17170, 26011, 27776–27778	C B	x	x	x	x	x	x
Strophomena (?) *elongata* Conrad	S						
† *Stropeodonta beckii* Hall. 10570, 17173, 27786, 27787.	S B	x		x			
" *perplana* (Conrad). 27788, 27789	B			?		?	
* " *varistriata* (Conrad). 10547, 26047, 27790	C			x	x	x	x

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Stropeodonta arata Hall. 9172, 10573, 27791	S	....	....	x	....	....	x
" *indenta* (Conrad)	S	....	....	....	....	x	
" *planulata* Hall. 3888, 4038, 10571, 26034, 27785	C	....	....	x			
(?) *conradi* (Hall). 10575, 27792, 27793	C	....	....	x			
Strophonella headleyana Hall. 17171, 17172	S						
" *geniculata* (Hall)	....	x					
" *punctulifera* (Conrad). 10572, 27781–27784 (Syn. *S. cavumbona* (Hall)	C B	x	x	x	x	x	x
" *leavenworthana* Hall. 10574	S B						
" (?) *radiata* (Vanuxem)	S	x					
† *Orthothetes woolworthianus* Hall. 9114, 10569, 27794, 27795	S	....	....	x			
" *deformis* Hall	S	x					
" *deformis sinuatus* Hall and Clarke	....	x					
* " *subplanus* (Conrad)	S						
Chonostrophia helderbergiæ Hall and Clarke	S						
† *Inoplia nucleata* Hall	S						
Chonetes punctata Simpson (Carbon county, Pennsylvania)	S						
" 2 n. sp. (Beecher collection)	S						
Scenidium insigne Hall	S	....	....	x			
Gypidula galeata (Dalman). 10494, 10611, 14771, 15965, 26026, 27796	C S	x	....	x	x	x	x
" *pseudogaleata* (Hall). 9181, 26019	B						
Anastrophia verneuili (Hall). 4115, 10601, 27797, 27798	S	x	....	x	x	x	
Rhynchonella semiplicata Conrad. 10597, 4232, 26012	C						
" *altiplicata* Hall	S	x					
" *aspasia* Billings	....	....	....	....	....	x	
" *acutiplicata* Hall. 27804	S	....	....	....	x	....	x
" *mainensis* Billings	....	....	....	....	....	x	
" *bialveata* Hall	S	....	....	....	....	x	
" *inutilis* Hall	S	?					
" *transversa* Hall. 27805, 27806	S	x	....	x			
" *rudis* Hall	S						
" *planiconvexa* Hall	S						
" *sulciplicata* Hall	S						
" *eminens* Hall	S						
Lissopleura æquivalvis (Hall). 4042	C	x					
Uncinulus mutabilis Hall. 4037, 10596, 15974, 26013	C	x					
" *nucleolatus* Hall. 4108, 4228, 9152, 27799, 27802	S	....	....	x	x	x	
" *abruptus* Hall. 27800	S	?	....	x			
" *pyramidatus* Hall. 4107, 10591	S	....	....	....	x		
" *vellicatus* Hall. 10593	S	?					
" *campbellanus* (Hall)	S B	x	....	x	x		
" *nobilis* Hall. 4220, 8414, 10595, 15975, 26025, 27801	B	x					

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Rhynchotrema formosum (Hall). 8415, 10594, 26017	S B	x					
Camarotœchia ventricosa Hall. 8416, 5059, 4106, 10592, 26044	B	x					
†*Eatonia medialis* (Vanuxem). 10598, 17168, 27089	S	x		x		x	
" *eminens* Hall				x			
" *singularis* (Vanuxem). 10599, 14773, 27807, 27808	S	x		x			x
† " *peculiaris* (Conrad)	S			x			
†*Spirifer cyclopterus* Hall. 4117, 10578, 27811–27815	S B	x		x	x	x	
" *concinnus* Hall. 3886, 10579, 26035, 27817, 27818	S B	x					
" (*Delthyris*) *perlamellosus* Hall. 8363, 9171, 10580, 17163, 26027, 27819–27821	C S	x	x	x	x	x	
" (*Delthyris*) *raricosta* (Conrad)						x	
" *macropleura* (Conrad). 3875, 10577, 17164, 27810	S	x	x	x		x	
" *saffordi* Hall	S			x			
" *tenuistriatus* Hall				x			
" *octocostatus* Hall. 27816		x		x			
†*Reticularia modesta* (Hall)		x				x	
" *nympha* (Billings)						x	
Cyrtina dalmani (Hall). 4140	S		x	x		x	
Trematospira perforata Hall	S	x					
" *dubia* (Billings)						x	
† " *multistriata* Hall. 10589	S	?					
" *equistriata* Hall and Clarke		x					
" *costata* Hall	S						
" *hippolyte* (Billings)					x	x	
" *simplex* Hall				x			
" *maria* (Billings)						x	
" *tennesseensis* Hall and Clarke				x			
Rhynchospira globosa Hall. 4138, 4225, 10586, 27829	S	x		x			
" *electra* (Billings)						x	
* " *formosa* Hall. 4135, 4224, 4226, 10489, 10585, 27827, 27828	S	x		x	x	x	
Parazyga deweyi Hall	S						
Nucleospira ventricosa Hall. 4147, 7488, 10584, 26029, 27831	S	x					
*† " *elegans* Hall	S						
" *concentrica* Hall				x			
*†*Atrypa reticularis* Linné. 4113, 4219, 8365, 8418, 10590, 26028, 26036, 27822–27824	C B	x		x	x		x
Anoplotheca concava (Hall). 4110, 17162, 17167, 10588, 26021, 27826, 27834	S			x			x
† " *flabellites* (Conrad)		x					x
" *subconcava* (Meek and Worthen)			x				
Atrypina imbricata Hall. 10587, 26020, 27825	S		x	x			
*†*Meristella lævis* (Vanuxem) ? 7490, 10583, 26040	C S	x	x	x		x	
" (?) *lævis* (Hall)	S						x
* " *bella* (Hall). 10582	S					x	

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Meristella (?) *blancha* (Billings)	...	...	...	...	...	x	
" *subquadrata* Hall	C S						
† " *arcuata* Hall. 17165, 27832	S	?	....	x	x	x	
" var. *atoka* Girty	...	...	...	...	x		
" *meeki* Hall. 3772	...	...	...	x			
† " *princeps* Hall. 8420, 26016, 27837	S B	x	....	x		x	
Whitfieldella (?) *bisulcata* (Vanuxem)	C						
" (?) *harpalyce* (Billings)	...	...	.	...	...	x	
Merista typus Hall	...	x					
" *typus elongata* (Hall)	...	x					
" *tennesseensis* Hall and Clarke. 27835	...	...	...	x			
Rensselæria mutabilis Hall. 26042, 27836, 27875	S	x					
" *æquiradiata* (Conrad). 26022, 27837	B	....	....	....	x	....	x
" *elliptica* Hall	S						
Trigeria (?) *portlandica* (Billings)	...	....	....	....	....	x	
Cryptonella (?) *eximia* Hall (New York ?)							
Pelecypoda, 48 species.							
Cypricardinia lamellosa Hall	S						
" (?) *dorsata* Hall	S						
† " (?) *sublamellosa* Hall	S						
" (?) *concentrica* Hall	S						
" *crassa* Hall	S						
Megambonia suborbicularis Hall	S						
" *spinneri* Hall	C						
" *rhomboidea* Hall	C						
" *mytiloidea* Hall	S						
† " *obscura* Hall	S						
" *lata* Hall	S	....	....	....	x		
" *oblonga* Hall	S						
" n. sp. (Beecher collection)	S						
**Pterinea aviculoidea* Hall. 10604	C S						
Mytilarca cordiformis Hall	S						
Plethomytilus mytilimeris (Conrad). 10605	C S						
" 2 n. sp.	S						
Avicula (?) *naviformis* Conrad. 26030	C	....	....	....	....	...	x
" (?) *tenuilamellata* Hall	S						
" (?) *subæquilatera* Hall	C						
" (?) 2 n. sp. (Beecher collection)	S						
Aviculopecten spinulifera Hall	S						
" *schohariæ* Hall	S						
" *umbonata* Hall	C						
" *manticula* (Conrad)	C						
" *obliquata* (Hall)	C S						
" *æquiradiata* (Hall)	S						
" *communis* (Hall). 10603, 27838	S	...	....	x			
" *pauciradiata* (Hall)	S						
" *bellula* (Hall). 4810	S						

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Aviculopecten securiformis (Hall). 10602	S	..	...	..	x		
†*Actinopteria textilis* (Hall)	S						
Conocardium inceptum Hall. (Also Paleontology of New York, vol. v, part i.)	S						
" n. sp. (Beecher collection)	S						
Grammysia n. sp., *Goniophora* n. sp., *Paracyclas* n. sp., *Nucula* 3 n. sp., *Orthonota* n. sp., *Nuculites* n. sp., *Maminka* n. sp., *Modiolopsis* n. sp. (Beecher collection)	S						
Gastropoda, 54 species.							
**Holopea antiqua* (Vanuxem). 10625	B						
" *danai* Hall	C						
* " (?) *elongata* Hall	C						
Loxonema emaceratum Hall. (Syn. *L. attenuatum* Hall.)	S B	...	...	...	x		
" *fitchi* Hall	S B	...	...	...	...	?	
" (?) *obtusum* Hall	C						
" (?) *compactum* Hall. 4833, 10624	C						
" *planogyratum* Hall	C						
Murchisonia bilirata Hall	S						
†*Diaphorostoma ventricosa* (Conrad). 10621	S						
" *depressa* (Hall)	S						
" (?) *subangulata* (Hall)	S						
" *arenosa* (Conrad)	S						
Strophostylus elegans Hall	S						
" *globosus* Hall	S						
" *obtusus* Hall	B						
" *depressus* Hall	S						
" *fitchi* Hall	B						
" (?) *rotundatus* Hall	B						
†*Platyceras ventricosum* Conrad	S	...	...	...	...	x	
† " *gebhardi* Conrad. 10622	S B	...	...	...	x		
" *robustum* Hall	S						
" *sinuatum* Hall	S						
" *billingsi* Hall	S						
" *trilobatum* Hall. 4123, 10616	S						
" *unisulcatum* Hall	S						
" *tenuiliratum* Hall. 10613, 27844, 27845	S	...	...	x	x	x	
" *multisinuatum* Hall. 10614, 27843. (Syn. *P. bisinuatum* and *P. pentalobus* Hall.)	S						
" *retorsum* Hall. 10609, 10617	S B	...	...	...	...	x	
" *intermedium* Hall. 10611	S						
" *unguiforme* Hall. 10610, 25989, 27846. (Syn. *P. perplicatum* and *P. plicatile* Hall.)	S	...	...	x			
dilatatum Hall. 4124, 10612. (Syn. *P. gibbosum* and *P. sulcoplicatum* Hall.)	S	...	...	...	...	x	

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Terr.	Me. and N. B.	Gaspé and N. S.
Platyceras platystoma Hall. 10615, 27991	S						
" *bisulcatum* Hall	S						
" *subundatum* Meek and Worthen	....	....	x				
" *pileiforme* Hall. 10619	S						
" *calantica* Hall. 8425, 10618	S						
" *obesum* Hall	S B						
" *lamellosum* Hall. 10607, 27842	S	....	....	x			
" *spirale* Hall. 10606. (Syn. *P. tubiforme* and *P. incile* Hall)	S	x	x				
" *newberryi* Hall	S						
" *plicatum* Conrad (Syn. *P. elongatum* Hall)	S						
" *pyramidatum* Hall	S	....	x				
" *arcuatum* Hall	S						
" *undulostriatum* Hall	S						
" *clavatum* Hall (Syn. *P. curvirostrum*, and *P. agreste* Hall)	B	....	....	....	....	x	
Hercynella perlata (Hall). 10620	S						
Pleurotomaria labrosa Hall	S B						
" n. sp.	S						
Euomphalus decollatus Hall. 25990. (Syn. *E. disjunctus* Hall)	B						
" *sinuatus* Hall	....	....	....	....	....	?	
Bucania profunda (Vanuxem). 10626, 25987	B						
" n. sp. (Beecher collection)	S						
Bellerophon n. sp.	S						
Pteropoda, 6 species.							
Conularia pyramidalis Hall	S						
" *huntana* Hall	S						
Hyolithes centennialis Barrett	B						
" *heros* Hall	S						
" n. sp. (Beecher collection)	S						
† *Tentaculites elongatus* Hall. 10627, 17176, 26046	S B						
Cephalopoda, 10 species.							
Orthoceras longicameratum Hall. 25996	C	?					
" *rigidum* Hall. 25995	C	....	....	....	....	x	
" *subtextile* Hall	C						
" *desiderata* Hall (Syn. *O. clavatum* Hall)	C						
" *tenuiannulatum* Hall	S						
" *helderbergiæ* Hall	S						
" *perstriatum* Hall	S						
" *rude* Hall. 25997	S	x	....	....	x		
" *pauciseptum* Hall	S	....	....	....	x		
" n. sp. (Beecher collection)	S						

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Crustacea, 51 species.							
Primitia mundula var. Jones (cape Bon Ami).....							
" *æqualis* Jones and Hall (cape Bon Ami)..							
Bythocypris oviformis Jones (DS. Penn.)..........							
Æchmina, 2 n. sp. (Beecher collection)..........	S						
Leperditia hudsonica Hall........................	S						
" *subquadrata* Jones (DS. Penn.)..........							
" *labrosa* Jones (cape Bon Ami)..........							
Beecherella carinata Ulrich	S						
" *subtumida* Ulrich.....................	S						
" *subtumida intermedia* Ulrich...........	S						
" *ovata* Ulrich.........................	S						
" *cristata* Ulrich	S						
" *navicula* Ulrich	S						
" *angularis* Ulrich......................	S						
Beyrichia granulata Hall........................	C						
" *oculina* Hall..........................	C						
" *arcuata* (Bean) (cape Bon Ami)........							
**Klœdenia acadica* (cape Bon Ami)..............							
* " *notata* (Hall). 10551, 10552...........	S						
" *notata ventricosa* Hall................	S						
" *pennsylvanica* Jones. (DS. Penn.)....							
Bronteus barrandei Hall.........................	C						
" *pompilius* Billings.......................						x	
" *canadensis* Logan......................							x
Prœtus protuberans Hall. 4822................	C				x		
" *junius* Billings..........................						x	
† *Homalonotus vanuxemi* Hall	S B						
Ceraurus tarquinius Billings						x	
Cordania cyclurus (Hall and Clarke)............	S						
" *macrobius* (Billings).....................						x	
Cyphaspis cœlebes Hall and Clarke	S						
" n. sp.. (Beecher collection)	S						
Phacops logani Hall. 10631, 14774, 27849	S	x		x	x		x
" *traganus* Billings.........................						x	
" *hudsonicus* Hall. 27850, 27851..........	S			x	x		
† *Dalmanites* (*Odontochile*) *pleuroptyx* (Green). 4231, 5002, 5003, 4958, 10630, 14775, 25992, 25994...........................	CB	x			x		x
" (*O.*) *micrurus* (Green). 4946, 27852, 27853...........................	CB	x		x			
" (*Odontocephalus*) n. sp................	S						
" (*Probolium*) *tridens* (Hall).............	S						
" " *tridentiferus* (Shumard)....			x				
" " *nasutus* (Conrad). 4150, 4803, 4934..............	S B						
(*Corycephalus*) *dentatus* (Barrett).......	S B						
epicratis Billings........................						x	
2 n. sp. (Beecher collection)..........	S						

Table of the Helderbergian Fauna

	N. Y.	Md. and Va.	Ill. and Mo.	Tenn.	Ind. Ter.	Me. and N. B.	Gaspé and N. S.
Lichas (*Conolichas*) *bigsbyi* Hall. 4820	C S						
" " *pustulosus* Hall. 4861, 4950	S						
" (*Arges*) *consanguineus* Clarke	S						
†*Acidaspis tuberculata* (Conrad). 4949	S						
" (*Dicranurus*) *hamata* (Conrad)	S	....	x				
Lepidocoleus polypetalus Clarke	S						
	397	64	17	74	40	56	22

ORISKANIAN SUBDIVISIONS

Stratigraphic names applied to the Oriskanian.—The Oriskany formation was noticed by Eaton, who named it "Shell Grit." During the progress of the New York Geological Survey it was studied in detail, and was known as the "White sandstone," or the "Grey Brachiopodous sandstone." In 1839 Vanuxem gave it its present name from Oriskany falls. Clarke has called its fauna the "Hipparionyx Fauna," which practically comprises all that was known as the Oriskany prior to 1892. In Pennsylvania, the Oriskany is called division "Number 7;" in Maryland and Virginia, the "Monterey formation;" in northern Alabama, the "Frog Mountain sandstone;" in western Tennessee, "Camden chert;" and in southwestern Illinois, "Clear Creek limestone." In northeastern Canada the formation is present in divisions 7 and 8 of the "Gaspé limestone," and it may also continue into the lower portion of the "Gaspé sandstone." Possibly the formation has received other names, but no particular pains has been taken to collect them, since the first geographical name is the Oriskany of Vanuxem.

General character and distribution of the Oriskanian.—In a general way, it may be said that the Oriskany formation extends with many interruptions along the eastern and northern flanks of the Helderberg mountains of New York. Along the northern side, the Upper Oriskany only is known to be present, exceedingly variable in thickness, but never more than 30 feet, diminishing in volume and resting westwardly upon the successive lower horizons of the Helderbergian and finally on the Siluric. In the region of Cayuga lake it is sparingly present, and is practically absent west of Ontario county, the Corniferous or Onondaga then resting directly on the Salina or Waterlime. Beyond the Niagara river, to the northwest of Cayuga, in Ontario, the Oriskany reappears irregularly over a very limited area, again overlying the Salina, and is from 6 to 25 feet thick. Southerly, along the western side of the Hudson river, the Upper Oriskany is very intermittent and often but 2 or 3 feet thick. On Becraft mountain there is an outlier of Oriskany. In Orange county, the Oriskany again appears to thicken, and in the Neversink valley the thickness is about 125 feet, and at this point it is intimately connected with the Helderbergian. In New Jersey, and particularly in the eastern Appalachian folds of Pennsylvania, the Oriskany in its lithologic character is ever changing from sandy shales, sandstones, and chert beds to coarse conglomerates. Its thickness also increases from north to south; in northeastern Pennsylvania it is from 50 to 125 feet thick, and on the Lehigh river, below Bowmans, it is fully 200 feet. Continuing southwesterly with the Appalachian folds, coarse grained sandstones predominate. In the region about Cumberland, Maryland, the Oriskany is said to be 300 feet thick, but probably is much thicker. It is well developed in the vicinity of Monterey, Virginia, but southwesterly, near the state line of Tennessee, the thickness has decreased to 40 feet. Throughout the Appalachian region, from New York to Virginia, it follows upon the Helderbergian, but near the Tennessee state line it begins to rest on the Clinton.

In eastern Tennessee no Oriskany is known, yet it reappears as a sandstone with chert beds of about 20 feet thickness in the adjoining counties of Floyd, Georgia, and Cherokee, Alabama. The Oriskany here unconformably overlies horizons from the Middle Cambric to the top of the Champlainic or Ordovicic.

In southwestern Illinois cherty limestones of about 200 feet thickness, followed by a sandstone from 40 to 60 feet in depth, constitute the Oriskany formation, which is here, as in southeastern New York, intimately connected with the Helderbergian. The Oriskany of Illinois is known along the Mississippi river in three counties, and again appears in western Tennessee as a white chert horizon of about 60 feet thickness. It thus thins out rapidly toward Tennessee, and only the Lower Oriskany persists there with Helderbergian shales and limestones. Elsewhere in the United States the Oriskany is unknown, although the Helderbergian is well developed in Indian Territory.

In eastern Canada there are two areas of Oriskany outcrops; typically in the region about Cayuga, Ontario, as previously mentioned, the other area being in New Brunswick, on Campbell river, about Gaspé, Quebec, and about Nictou, Nova Scotia. In Gaspé, it is a limestone formation, and, as in New York and Illinois, is intimately connected with the

Helderbergian. In thickness it is not less than 800 feet, and as a few of the typical Oriskany species continue into the sandstones above, prove that some of this depth is to be included with the Oriskany or with the Esopus grit, of which fauna in the typical area, New York, practically nothing is known.

The detailed distribution, lithologic character, thickness, and local faunæ are given in full further on (see pages 300–331).

Oriskanian fauna.—As a rule the Oriskany formation consists of littoral deposits, often of a very coarse nature. When it is remembered that, in addition to this fact, the formation has very limited, usually linear exposures, it is remarkable that its fauna should consist of 185 species. Chief among these are the brachiopods, of which 97 species are known. They are the most abundant fossils, and their generally larger growth at once marks the Oriskany as one of the easily recognized American Paleozoic faunas.

In spite of the characteristic expression of the Oriskany fauna, it is remarkable that it should be so intimately connected both with the Helderbergian and with the Onondaga. Its affinities with the former are, of course, due to the recent discovery of a lower Oriskany fauna. Of the 185 species included in the Oriskany fauna, 31, or 17 per cent, come from the Helderbergian, while 54, or 35 per cent, pass into the Onondaga. Of the Helderbergian species, 24 pass into the Lower Oriskany, 17 into the Upper Oriskany, and 5 through both into the Onondaga. The last are *Favosites conicus*, *F. gotlandicus*, *Leptæna rhomboidalis*, *Atrypa reticularis*, and *Dalmanites pleuroptyx*. The Lower and Upper Oriskany zones have 43 species in common, or a little more than 23 per cent. These figures prove that the Oriskany is intimately connected with the Helderbergian and Onondaga. This is still more forcibly brought out when it is stated that of the Becraft fauna, the one immediately beneath the Oriskany, not less than 27 per cent of its species pass into the Oriskany.* All these figures are in strong contrast with the very few species which pass from the Niagaran and Cayugan formations into the Helderbergian. Of these there are 9 persisting forms, or about 2 per cent, in a fauna of 459 described species.

The Lower Oriskany of New York, Illinois, and Tennessee, probably represents a fauna practically of one zone. The Upper Oriskany, however, seems to have three overlapping stages. The New York Hipparionyx fauna apparently holds a central position; that of Cumberland

* Doctor John M. Clarke writes that the lowest Lower Oriskany beds of Becraft mountain have "a recurrent shaly limestone fauna," after which the true Lower Oriskany fauna makes its appearance. It is therefore probable that the percentage here given will be reduced, since the list beyond includes these beds in the Lower Oriskany.

is older, in part at least; while the Cayuga, Ontario, zone is certainly the youngest. In the beds of the latter region occur most of the Middle Devonic species, and here the Oriskany is directly overlain by the Onondaga limestone. In New York the Esopus intervenes between the Oriskany and Onondaga or Schoharie, and the time interval thus indicated may be occupied in the Cayuga region by the Oriskany.

The conspicuous Devonic character of this fauna is the presence of *Cystiphyllum*, *Heliophyllum*, and *Phillipsastrea* among the corals; *Stropheodonta*, *Hipparionyx*, *Pentamerella*, *Amphigenia*, *Spirifers* with long hinges and one with plicated fold and sinus, *Ambocœlia*, *Pentagonia*, and particularly *Rensselæria*, *Megalanteris*, and *Centronella* among the Brachiopoda; *Actinopteria*, *Palæopinna*, and *Mytilarca* among the Pelecypoda; an abundance of large platyceroids among the Gastropoda; and of the trilobites *Phacops*, *Dalmanites* (*Odontocheile*), and *Dalmanites* (*Chasmops*).

Table of the Oriskanian Fauna

(Named species only. For local distribution, see pages 300–331.)

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Corals, 10 species.				
Zaphrentis incondita Billings	....	....	x	
" *cingulosa* Billings	....	....	x	
" *rœmeri* Hall	x	?		
Cystiphyllum sulcatum Billings	....	..	x	x
Heliophyllum exiguum Billings	....	....	x	x
Favosites hemisphericus Troost	....	....	x	x
" *conicus* Hall	x	x	x	x
" *gotlandicus* Lamarck	x		x	x
" *turbinatus* Billings	....	....	x	x
Phillipsastrea affinis Billings	....	....	x	
Echinodermata, 7 species.				
Anomalocystites disparilis Hall	....	....	x	
Edriocrinus sacculus Hall	....	x	x	
Homocrinus proboscidalis Hall	....	....	x	
Technocrinus andrewsi Hall	....	....	x	
" *sculptus* Hall	....	....	x	
" *spinulosus* Hall	....	....	x	
" *striatus* Hall	....	....	x	

Table of the Oriskanian Fauna

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Bryozoa, 4 species.				
Cystodictya (?) *tarda* (Billings)			x	
Fenestella celsipora Hall		x		x
Polypora hexagonalis Hall			x	x
" (?) *psyche* Billings			x	
Brachiopoda, 97 species.				
Orbiculoidea ampla Hall			x	x
" *jervensis* (Barrett)		x		
Pholidops terminalis Hall		x	x	
Orthis (*Rhipidomella*) *musculosa* Hall			x	
" " *oblata* Hall	x			
" " *cumberlandia* Hall			x	
" " *livia* (Billings)			x	x
" (*Dalmanella*) *perelegans* Hall	x	x		
" " *planiconvexa* Hall	x		x	
" ? *lucia* Billings			x	
" (?) *aurelia* Billings			x	
Leptæna rhomboidalis Wilckens	x	x	x	x
" *rhomboidalis ventricosa* Hall			x	
Stropheodonta lincklæni Hall		x	x	
" *becki* Hall	x	x		
" *magnifica* Hall		x	x	
" *perplana* Conrad		x	x	x
" *magniventer* Hall			x	
" *galatea* Billings			x	
" *vascularia* Hall			x	
" *irene* Billings			x	
" *inæquiradiata* (Conrad),			x	x
" *demissa* (Conrad) var			x	x
" *hemispherica* Hall			x	x
Strophonella headleyana Hall	x	?	x	
" *ampla* Hall			x	x
Orthothetes woolworthana Hall	x	x		
" *pandora* (Billings)			x	x
Hipparionyx proximus Vanuxem		x	x	x
Pentamerella arata (Conrad)			x	x
Amphigenia elongata (Vanuxem)			x	x
Anoplia nucleata Hall		x	x	x
Chonetes hemisphericus Hall			x	x
" *melonicus* Billings		x	x	
" *mucronatus* Hall		?	x	x
Chonostrophia complanata Hall			x	
" *reversa* (Whitfield)		x		x
Camarotœchia barrandei Hall		x	x	
" *speciosa* Hall		?	x	
" *pleiopleura* Hall		x	x	

Table of the Oriskanian Fauna

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Camarotœchia pleiopleura fitchiana Hall			x	
" *tethes* Billings		?		x
" *billingsi* Hall			x	x
Rhynchonella excellens Billings			x	
" *dryope* Billings			x	
" *ramsayi* Hall			x	
Eatonia sinuata Hall			x	
" *peculiaris* (Conrad)	x	x	x	
" *medialis* Hall	x	x		
" *pumila* Hall			x	
" *whitfieldi* Hall			x	
Atrypa reticularis Linné	x	x	x	x
Anoplotheca dichotoma (Hall)			x	
" *fimbriata* (Hall)			x	
" *flabellites* (Hall)		x	x	x
" *acutiplicata* (Hall)		x		x
Cyrtina rostrata Hall		x	x	
" *dalmani* Hall	x	?		
" *affinis* Billings		x	x	
Spirifer arenosus (Conrad)		x	x	x
" *murchisoni* Castelnau	?		x	
" *intermedius* Hall			x	
" *tribulis* Hall		x	x	?
" *cumberlandiæ* Hall			x	
" *worthenanus* Schuchert		x		
" *hemicyclus* Meek and Worthen		x		
" *cycloptera* Hall	x	x	x	
" *superba* Billings			x	
" (*Delthyris*) *raricostus* Conrad			x	x
Reticularia fimbriata (Conrad)		x	x	
" *modesta* (Hall)	x	x		
Metaplasia pyxidata Hall		x	x	x
Ambocœlia umbonata (Conrad)			x	
Meristella lævis Hall	x	x		
" *lenta* Hall		x	x	x
" *scitula* Hall			x	x
" *lata* Hall		x	x	
" *arcuata* Hall	x		x	
" *walcotti* Hall and Clarke			x	
" *princeps* Hall	x		?	
Pentagonia unisulcata (Conrad)			x	
Nucleospira elegans Hall	x		x	
Rhynchospira rectirostris Hall			x	
Trematospira multistriata Hall	x	x		
Rensselæria cumberlandiæ Hall			x	
" *intermedia* Hall			x	
" *marylandica* Hall			x	
" *cayuga* Hall and Clarke			x	
" *ovoides* (Eaton)		x	x	

Table of the Oriskanian Fauna

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Beechia suessana Hall		?	x	
Oriskania navicella Hall and Clarke		x		
Megalanteris ovalis Hall		x	x	
Centronella glansfagea Hall			x	x
" *tumida* Billings			x	x
" *alveata* Hall			x	x
Pelecypoda, 23 species.				
Megambonia obscura Hall	x	x		
Aviculopecten gebhardi (Conrad)			x	
" *recticosta* (Hall)			x	
Actinopteria textilis Hall	x	?		
" *textilis arenaria* (Hall)		?	x	
Megambonia bellistriata Hall		x	x	
" *lamellosa* Hall		?	x	
Palæopinna flabellum Hall			x	
Pterinea flabellum (Conrad)			?	x
Cypricardinia planulata (Conrad)			x	
" *indenta* (Conrad)			x	x
Cypricardinia sublamellosa Hall?	x	?		
" *distincta* Billings			x	
Sanguinolites tethys Billings			x	
Goniophora mediocris Billings			x	
Mytilarca canadensis Billings			x	
" *nitida* Billings			x	
Leptodomus canadensis Billings			x	
" *percingulatus* Billings			x	
" *mainensis* Billings			x	
" *pembrokensis* Billings			x	
Anodontopsis ventricosa Billings			x	
Conocardium trigonale (Phillips)			x	x
Gastropoda, 28 species.				
Bellerophon plenus Billings			x	
" *curvilineatus* Conrad			x	x
Platyceras nodosum (Conrad)		x	x	
" *callosum* Hall			x	
" *subnodosum* Hall			x	
" *gebhardi* Conrad	x	x	x	
" *tortuosum* Hall		x	x	
" *magnificum* Hall		?	x	
" *patulum* Hall			x	
" *reflexum* Hall			x	
" *ventricosum* Conrad			x	
" *carinatum* Hall			x	x
" *concavum* Hall			x	x
" *dentalium* Hall			x	x

Table of the Oriskanian Fauna

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Diaphorostoma affinis (Billings)	....	....	x	
" *ventricosa* (Conrad)	x	x	x	
" *turbinata* (Hall)	....	x	...	x
Strophostylus matheri Hall	....	....	x	
" *transversus* Hall	....	....	x	
" (?) *cancellatus* Meek and Worthen	....	x	....	
" *expansus* Hall	....	x	x	
" *andrewsi* Hall	....	....	x	
Cyrtolites (?) *expansus* Hall	....	x	x	
Murchisonia hebe Billings	....	....	x	
Loxonema subattenuata Hall	....	....	?	x
Pleurotomaria voltumna Billings	....	....	x	
" *delia* Billings	....	....	x	
" *lydia* Billings	....	....	x	
Pteropoda, 4 species.				
Conularia lata Hall	....	....	x	
Tentaculites elongatus Hall	x	x	x	
" *arenosus* Hall	....	....	x	
" *acula* Hall	....	x	x	
Cephalopoda, 1 species.				
Orthoceras arenosum Hall	....	....	x	
Crustacea, 11 species.				
Homalonotus major Whitfield	....	....	x	
" *vanuxemi* Hall	x	....	x	
Phacops cristata Hall	....	x	x	x
" *cristata pipa* Hall	....	....	x	x
" (*Acaste*) *anceps* Clarke	....	?	....	x
Dalmanites phacoptyx Hall	....	x	....	x
" (*Chasmops*) *anchiops* (Green)	....	....	x	x
" (*Odontocheile*) *pleuroptyx* (Green)	x	....	x	x
Prœtus crassimarginatus Hall	....	....	x	x
" *phocion* Billings	....	....	x	
Acidaspis tuberculatus Conrad	x	x		
	31	72	158	54

*Table of European and American Lower and Middle Devonic Formations**

			North America.	Bohemia.	Rhineland.	Eifel.	Harz.	France (Loire).	England.
Devonic.	Neodevonic.	Chautauquan.	Chemung beds (Catskill sandstone, local facies).	(Étages G_2 to H_2 on the authority of Kayser and Holzappel. See Jahrb. k. k. geol. Reichsanstalt, 44, 1894, p. 514.)					
		Senecan.	Portage beds (Naples beds, Ithaca beds, Oneonta beds, local facies). Genesee shale. Tully limestone.						
	Mesodevonic.	Erian.	Stringocephalus beds of British America. Hamilton beds. Marcellus shale.	Étage H_2. Étage H_1.	Stringocephalus beds.	Upper Stringocephalus beds. Lower Stringocephalus beds.			Stringocephalus beds.
		Ulsterian.	Onondaga limestone. Schoharie grit. Esopus grit.	Étage G_3. Étage G_2. Étage G_1. Étage F_2 (Menian).	Calceola beds and Upper Coblenzian. ? Lower Coblenzian.	Calceola beds. Spirifer cultrijugatus beds.	Upper Coblenzian (Kayser and Holzappel).		Upper Coblenzian of Torquay (Kayser). Lower Coblenzian of Torquay (Kayser).
	Paleodevonic.	Oriskanian.	Upper Oriskany. Lower Oriskany.	A possible hiatus here.	Siegen.		Hercyn.	Erbray.	Looe beds, Cornwall (Kayser). Foreland grits (Frech).
		Helderbergian.	Kingston beds. Becraft limestone. New Scotland beds. Coeymans limestone.	Étage F_2 (Konieprussian). Étage F_1.	? Gedinnian. ? Taunus.				
Siluric.			Manlius or Rondout limestone.	Étage E.					Tilestones.

*The terminology for North America is that of Clarke and Schuchert. Science, n. s., x, December 15, 1899, p. 876.

Summary

In pages 245–252 it was shown that the upper limit of Murchison's Upper Silurian has been and still is vague, because the normal marine fauna gradually succumbed to local conditions, associated with the production of red sediments. In England and in the United States the eurypterids are the prevailing or characterizing fossils of these landlocked waters. Since the Tilestones and Downtonian of Great Britain are approximately synchronous with the Cayugan group of America, it is convenient to use both as the terminating strata of the Siluric system. Stability in taxonomy has for its basis original definition and priority in publication. This rule will not permit of the Siluric being extended to include the Helderbergian, which contains a fauna having almost nothing in common with this system in the typical area.

The Helderbergian sea transgressed widely over the land areas. Earth oscillations appear to be gentle throughout Lower and Middle Devonic times in eastern North America, the general tendency, however, being one of transgression, culminating in a continuously sinking sea bottom in the northeastern Mississippian sea during Upper Devonic time.

The Siluric system of America has three subdivisions—the *Oswegan, Niagaran, and Cayugan.* These correspond to the English Llandovery, or Valentian; Wenlock, or Salopian; and Ludlow, or Downtonian. The English and American Siluric horizons have much in common, as may be seen by the table on page 251.

In pages 252–268 the Old Red Sandstone and the original Devonian of Murchison and Sedgwick are described. The lower limits of the Devonic system, and particularly a lowest Lower Devonic fauna, have not been indicated by Murchison. By general consent, the stratigraphy and paleontology of the Devonic system have been determined in central Europe, and especially for the Lower Devonic in the Rhineland.

Since de Verneuil's visit to America (1847), the Oriskany formation has been generally accepted as the base of the Devonic in this country. It has its equivalents in the Rhineland in the Siegen grauwacke, or zone of *Spirifer primævus.* Similar horizons appear in part in the Lower Wieder Schiefer of the Hartz, in the hamlet of Erbray in the lower Loire, France; at Looe, in Cornwall, England, and possibly in the Lynton slates of North Devon.

All the foregoing European localities are of accepted Lower Devonic age. In Rhineland beneath the Siegen grauwacke are great masses of other Lower Devonic rocks, but their faunas do not readily correlate with American horizons. While part of the fauna of the Lower Wieder

Schiefer of Erbray, and of the Rhine Gedinnian, have aspects recalling the Helderbergian, no well established equivalent for the latter is known except that of the Bohemian étage F_2, or Konieprussian.

Barrande's étages F, G, and H, together with the Lower and Upper Helderberg, were regarded by him as members of the Upper Silurian. This interpretation is explained by the fact that Barrande included his first, second, and third faunas (now Cambric, Champlainic or Ordovicic, and Siluric) in one system, which he preferred to name the Silurian system. In his day, the well known Devonic faunas of the typical areas were those now classed as Middle Devonic. After much work and discussion, particularly in Germany, the opinion has now become general that all Barrande's étages F, G, and H are of Devonic age. As the Helderbergian is the equivalent of étage F_2, or Konieprussian, it must also be regarded as of Devonic, Lower Devonic, age.

The Upper Coblenzian fauna of the Rhine correlates readily with that of the Onondaga and Hamilton. As the latter faunas are intimately related and the Hamilton is always regarded as of Middle Devonic age, it seems natural to draw the line between the Lower and Middle Devonic, at the base of the Esopus grit and Upper Coblenzian. Both these formations are usually referred to the Lower Devonic. In United States the most marked local break in the Devonic exists between the Oriskany and Onondaga, and it is not closed by the very local Esopus and Schoharie grit. In a general view this break is not so apparent, owing to the varying age of the upper limit of the Oriskany in the various localities.

Page 269 begins with a short description of the three zones of the Helderbergian, and their geographical distribution. Then follows a discussion of the faunal characteristics, with a complete list of the species. The Helderbergian has 459 forms, of which about 2 per cent come from the Siluric, while 9 per cent of the former pass into the Oriskany. It is also shown that most of the characteristic Siluric genera of trilobites, brachiopods, and crinoids, fail in the Helderbergian; also that the Siluric facies maintained in this fauna is modified and the species have a larger individual growth, indicating post-Siluric age. On the other hand, among the trilobites, Bryozoa, and pelecypods, in many of the gastropods, but more particularly in the brachiopods, are met organic groups, which in their culmination are characteristic of the Devonic. The conclusion is therefore warranted that the Helderbergian fauna is unlike that of the Siluric, being more in harmony with the Devonic, and its position near the base of that system.

A general description of the Oriskany strata and its areal distribution follows, with a complete list of the named species. There are 185 forms, of which 17 per cent come from the Helderbergian and 35 per cent pass upward into the Onondaga or Corniferous. The Lower and Upper Oriskany may have a little more than 23 per cent of species in common, but this percentage will probably be modified when Doctor Clarke has finished his work on the Becraft Mountain fauna. These figures show conclusively that the Helderbergian, Oriskanian, and Onondagan are very intimately related; also the correctness of the conclusion of Sharpe and de Verneuil (1847), and later of all American geologists, that the Oriskany is Devonic.

In conclusion, the English, Continental, and American Lower and Middle Devonic horizons are tabulated on page 297.

Local Development and Faunas of the Oriskanian

UPPER ORISKANY OF NEW YORK

The Oriskany formation was first observed in New York, and for that matter in North America, by Professor Amos Eaton, who named it the "Shell Grit." Vanuxem, the state geologist of the third geological district of New York, appears to be the next to notice this formation, for in that district the Oriskany is well shown. In 1838 * he described it as the "White Sandstone.—Characterized by large species of Orthis [Hipparionyx] and Delthyris" [Spirifer]. In the following year Conrad † writes of it as the "Grey Brachiopodous sandstone" of the "Medial Silurian strata," characterized by *Atrypa elongata* (*Rensselæria ovoides* Eaton) and *Delthyris arenosa* (*Spirifer arenosus* Conrad).

In 1839, this formation received the name by which it has since been known. In that year Vanuxem ‡ stated that "the omission or absence of these two series to the west [Delthyris shale of the Lower Helderberg and the Cauda-galli] causes the next series of layers to repose immediately upon the Waterlime group. This is the white sandstone noticed on the hill at the falls of Oriskany, and for the present may be called the Oriskany sandstone. This sandstone is well known to extend over many of the states, occupying, like all geological masses, a fixed position in the whole series, but is exceedingly variable in thickness. According to the report of the state geologist of Pennsylvania, it is there 700 feet thick [this probably includes the Esopus grit; the Oriskany appears not to exceed 300 feet]. At Oriskany falls [it is] about 20 feet, on the road from Elbridge to Skaneateles, it is over 30 feet. At the quarries near Auburn, it is from a few inches to about 2½ feet; and at Split-Rock, near Syracuse, it shows itself in some parts by a mere sprinkling of sand,

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* Second Ann. Rept. Geol. Survey, Third Dist. N. Y., 1838, p. 285.

† Second Ann. Rept. Pal. Dept., Survey N. Y., 1839, p. 62.

‡ Third Ann. Rept. Geol. Survey, Third Dist. N. Y., 1839, p. 273.

observable on the bottom of the layer which covers it, and in other parts by a thickness of about 6 inches. . . . The lower part of the sandstone abounds in fossil shells remarkable for their great size."

In 1840 Conrad * gave a section of the rocks as observed by him and John Gebhard, junior, the pioneer collector of Schoharie, New York, and places the Oriskany between the "Brown sandstone [Esopus grit] and Blue limestone" (Becraft of the Helderbergian). The fossils characterizing this zone are *Atrypa elongata* (= *Rensselæria ovoides* Eaton), *Delthyris arenosa* (= *Spirifer arenosa*), *and Strophomena unguiformis* (= *Hipparionyx proximus* Vanuxem).

In 1842 Vanuxem † gave what was known of the Oriskany formation in the third geological district of New York, and illustrated the characteristic fossils. These are *Spirifer arenosus* Conrad, *Rensselæria ovoides* (Eaton), *Eatonia peculiaris* (Conrad), and *Hipparionyx proximus* Vanuxem. He stated that—

"This sandstone . . . is readily traced from east to west through the district, by its composition and its numerous characteristic fossils, not so much as to kinds as individual species. Its position is best seen in the first district near Salem; the Helderberg division, of which it forms a part, being complete. It projects from the side of the Helderberg mountain, forming a terrace resting upon the Catskill shaly limestone [= New Scotland; the Becraft is here absent]; . . . the sandstone passing under, or covered with the Cauda-galli grit, the latter being a thick abrupt mass.

"In the third district, its immediate associates cease entirely before reaching the west end of Madison county; and the sandstone from thence rests upon the Manlius waterlime group, and is covered by the Onondaga limestone, the three rocks being coassociates to Cayuga lake. It is very variable in thickness, owing probably to the unevenness of the surface upon which it was deposited.

"With some exceptions, this sandstone consists of a medium sized quartz sand. . . . It is of a light yellow color when pure, as at Oriskany Falls. At other localities the yellow color is often shaded brown, or of some other dark color."

West of the Hudson river, in eastern New York, the Oriskany—

"Is well exposed in the hills east and west of Schoharie, various places on the Helderberg in Bern, Knox, and Bethlehem, and occasionally as it ranges southward to Esopus falls, beyond which it was not recognized. The Oriskany sandstone [in this region] is generally a hard silicious grit, which generally approaches chert and hornstone in aspect, and is replete with fossils. In some places it is white; in others brown, red, and black. . . . In the first district, it rarely exceeds 2 feet in thickness, and in many places it is not more than 8 inches, and in some places is absent; but it is extensive, strongly marked in its fossil contents, which are of large size, and generally attracts the attention of persons traveling along the roads." ‡

* Third Ann. Rept. Pal. Dept., Survey N. Y., 1840, p. 40.
† Geol. N. Y., part iii, Survey Third Dist., 1842, pp. 123-127.
‡ Geol. N. Y., part i, Survey First Dist., 1843, pp. 342, 343.

In the second district, Emmons did not observe this formation, and in the fourth district it is not well developed. Hall* writes that the Oriskany—

"Where best developed in the fourth district, is a coarse, rather loosely cemented, purely silicious sandstone, of a yellowish white color. It contains some flattened nodules of chert or flint. . . . In the upper part of the rock are numerous concretions of dark colored or nearly black compact crystalline sandstone, very hard and tough. . . . In Monroe county, its only representative is a layer of greenish conglomerate, about 4 inches thick. . . . At one or two other points it appears as a coarse sandstone of a few inches in thickness, resting on the Onondaga salt group. The last place in the district where it has been noticed is in the bed of Black creek at Morganville, in Genesee county."

The Oriskany sandstone in New York "is not more than 30 feet, and usually much less."† This, of course, does not refer to southeastern New York, where this formation is much thicker.

The Oriskany formation is best developed in southeastern New York, in Orange county.

"The western belt forms the western part of the Helderberg ridge, which extends up the Neversink valley from Pork Jervis, New York. It consists of fine-grained shaly sandstones and impure limestones, the latter often containing many fossils. . . . There are also present cherty bands containing fossils. The Oriskany forms narrow ridges, and the thickness of the formation is about 125 feet.

"The second [or eastern] Oriskany area is along the western side of Bellvale and Skunnemunk mountains, where it affords a fine grained red or gray quartzite which changes locally to a conglomerate. About 100 feet are exposed." ‡

Doctor S. T. Barrett, living for many years at Port Jervis, studied the outcrops and collected the faunas of the Niagaran, Helderbergian, and Oriskanian formations of this region. In 1876 § he published his results, and from these it is learned that the Upper Pentamerus or Becraft passes without break into the Oriskany. The Oriskany is here not less than 100 feet in thickness, while "it is probably more, the higher arenaceous layers of this division having been removed."

The fauna collected by Barrett from this horizon consists of the following:

Orbiculoidea jervensis (Barrett).
Eatonia peculiaris (Conrad).
Spirifer arenosus (Conrad).
Spirifer murchisoni Castelnau.
Rensselæria ovoides (Eaton).
Diaphorostoma ventricosa (Conrad).
Platyceras gebhardi (Hall).
Actinopteria textilis arenaria (Hall).
Tentaculites elongatus Hall.

* Geol. N. Y., part iv, Survey Fourth Dist., 1843, pp. 146–150.
† Hall: Geol. N. Y., Survey Fourth Dist., 1843, p. 147.
‡ Heinrich Ries: Fifteenth Ann. Rept. State Geol. N. Y., 1897 [1898], p. 402.
§ Ann. Lyc. Nat. Hist. N. Y., vol. xi, 1876, pp. 293, 294.

It was not until 1859 that the Oriskany fauna became well known. In that year Hall, the state geologist of New York, published his epoch-making volume, " Palæontology III of the Natural History of New York, Part VI." Below is given a complete list of the known, typical, New York Oriskany fauna, the Upper Oriskany, or, as Clarke* has named it, the " Hipparionyx fauna." Regarding this fauna Hall † wrote:

"The great changes in the physical conditions supervening at the close of the preceding group [Helderbergian] indicate an influence which would affect in an equal manner the fauna of the succeeding one, and we find accordingly few species passing from the Lower Helderberg group to the Oriskany sandstone. The changes, however, are mainly of a specific character; no new genera being introduced, so far as known, though some of them appear under modified forms."

After pointing out the characteristics of the Oriskany fauna, he concludes as follows:

" It is not possible, therefore, to point out any changes in the fauna of this period sufficient to indicate the commencement of a new system, and its relations with the formations below are as intimate as with those above, while in the northern and middle states, the Oriskany sandstone bears in its fauna a closer relation to the lower than to the overlying formations."

In the Lower Oriskany fauna discovered by Beecher and worked out by Clarke, as described beyond, there is no appreciable break between the Becraft and the Oriskany, either in deposition or in the successive faunal links. Until very recently, but 14 forms were known to be common to the Helderbergian and Oriskanian, but there are now 31 (24 in New York) species.

FAUNA OF THE UPPER ORISKANY, OR HIPPARIONYX ZONE

Favosites hemisphericus Troost. Hall collection, Albany.
Pholidops arenaria Hall.
Orbiculoidea ampla Hall. 26054.
Chonostrophia complanata Hall. 28108, 10643.
Orthis (*Rhipidomella*) *musculosa* Hall. 4882.
Anoplia nucleata Hall. 10644.
Leptæna rhomboidalis ventricosa Hall. Hall collection, Albany.
Stropheodonta lincklæni Hall. 10640, 10641, 26056.
Stropheodonta (*Leptostrophia*) *magnifica* Hall. 4885, 5082.
Stropheodonta (*Leptostrophia*) *magniventer* Hall. 4805.
Stropheodonta vascularia Hall.
Hipparionyx proximus Vanuxem. 4217, 4227, 4809, 10638, 26060, 28107.
Camarotœchia barrandei Hall. 4816.

* Amer. Jour. Sci., November, 1892, p. 411.
† Pal. N. Y., vol. iii, 1859, pp. 401- .

Camarotœchia pleiopleura Hall. 16680, 28095.
Syn. *Rhynchonella multistriata* and *R. oblata* Hall.
Camarotœchia pleiopleura fitchiana (Hall).
Camarotœchia principalis Hall (= *C. speciosa* Hall).
Camarotœchia septata Hall. Species of no value.
Eatonia peculiaris (Conrad). 10651, 26057.
Eatonia pumila Hall (= *E. whitfieldi*).
Eatonia whitfieldi Hall. 26058, 28089, 28090.
Spirifer arenosus (Conrad). 4121, 4214, 8412, 10645, 14515, 16680*b*, 26048, 28102.
Spirifer murchisoni Castelnau (= *S. arrectus* Hall). 8413, 10646, 16669, 26051, 28098.
Spirifer tribulis Hall. 10647.
Reticularia fimbriata (Conrad). Hall collection, Albany.
Metaplasia pyxidata Hall. 4215, 10648.
Cyrtina rostrata Hall.
Atrypa reticularis Linné. 28091.
Anoplotheca dichotoma (Hall). Hall collection, Albany.
Anoplotheca flabellites (Conrad). 10650.
Meristella lata Hall. 16680, 26053, 28113.
Meristella walcotti Hall and Clarke?. 16672.
Pentagonia unisulcata (Conrad). Hall collection, Albany.
Megalanteris ovalis Hall. 26059.
Rensselæria ovoides (Eaton). 4118, 4216, 8428, 8430, 10652, 16671, 28087, 26049.
Beechia suessana Hall. 16680.
Tentaculites arenosus Hall.
Conularia lata Hall.
Bellerophon curvilineatus Conrad (also in Schoharie grit).
Platyceras nodosus Hall.
Platyceras (*Orthonychia*) *tortuosus* (Hall). 10655.
Platyceras n. sp. 28083.
Diaphorostoma ventricosa (Conrad). 4802, 26050, 28080, 28082.
Strophostylus expansus Hall.
Cyrtolites (?) *expansus* Hall. 10659.
Orthoceras arenosum Hall.
Aviculopecten gebhardi (Conrad). 10654.
Aviculopecten recticosta (Hall).
Actinopteria textilis arenaria (Hall).
Megambonia bellistriata Hall.
Megambonia lamellosa Hall. 26055.
Palæopinna flabellum Hall.
Homalonotus major Whitfield
Phacops cristata Hall. 28079.

LOWER ORISKANY OF NEW YORK

Previous to the year 1892, the known Oriskany formation in the state of New York consisted of but a thin sandstone horizon, nowhere known to exceed 30 feet in thickness. The specific faunal gap between it and the Helderbergian below was considerable; but in that year Doctor

Beecher discovered in so well known a region as Becraft mountain, east of the Hudson river, and just south of Hudson, New York, a new geological horizon and a fauna intimately connected with the Becraft of the Helderbergian below and the true, or Hipparionyx, Oriskany above.

Regarding this horizon, Doctor Beecher * writes:

"In 1890 . . . in the Becraft's Mountain region of Columbia county, New York, a fauna was discovered by the writer, which in many respects is new to the State. Its affinities are with the Oriskany, but its geological position is below the true Oriskany sandstone. It appears to include a part, at least, of what has been referred to the Lower Helderberg group on account of its lithological characters and upon insufficient paleontological grounds. The fauna of the Upper Pentamerus in its original locality (Schoharie, New York) has previously been recognized to contain several species quite distinct from the Scutella, Shaly, and Lower Pentamerus limestones, which represent the typical Lower Helderberg group. Moreover, as the complete fauna has remained unknown and the series has been confused with the underlying Scutella limestone, no exact correlations have been made.

"From the fossils now known from Becraft's mountain and several other localities, it is evident that the relations of the fauna contained in the upper beds of the series above the Scutella limestone and just below the Oriskany sandstone are with the latter, and not with the Lower Helderberg group. . . .

"At Becraft's mountain the rock is a hard, cherty, arenaceous limestone, weathering into a rotten fine-grained sandstone [a few feet in thickness], preserving the molds of the fossils or their silicified replacements. . . . At Port Jervis, New York, it is in general still more calcareous, although there are some cherty layers, and many of the fossils are silicified. Here, too, the series is continuous from the Oriskany sandstone down through the trilobite beds of Mather, Horton, and Barrett. The arenaceous character of the beds gradually decreases downwards, carrying the typical Oriskany species into the *Dalmanites dentatus* layers and below, and making the whole series of this group at Port Jervis probably over two hundred feet in thickness, of which one hundred or more belong to the Lower Oriskany."

Barrett † gives the thickness of the Oriskany formation at Port Jervis, New York, as "100 feet; it is probably more, the higher arenaceous layers of the division having been removed by glacial action." Ries gives the thickness for the same region as "about 125 feet." The known Oriskany fauna from this region is meager, but for the present it is referred to the Upper Oriskany. The transition, however, from the Becraft limestone to the Oriskany in the Port Jervis region is apparently uninterrupted. Doctor Barrett writes:

"From the top of Trilobite Ridge [his uppermost Upper Pentamerus bed, or 5c, with a thickness from 5 to 10 feet] to the foot of the Cauda-galli ridge, northwest of it, Oriskany fossils predominate. There is, however, such a gradual shading off from one into the other, that no one whose knowledge of the Lower Helderberg and Oriskany strata had been acquired by the study of their exposures in this

* Amer. Jour. Sci., vol. xliv, 1892, pp. 410, 411.

† Ann. Lyc. Nat. Hist. N. Y., vol. xi, 1876, p. 294

locality would ever think of running the line separating the Silurian and Devonian ages, between the two. They seem so intimately blended that the exact line between them is an arbitrary one altogether."

If the fauna from "Trilobite ridge" or Barrett's zone "5c" or Beecher's "Dalmanites dentatus layers" is studied, it will be conceded that it is unmistakably that of the Becraft, and cannot be included in the Lower Oriskany, as is done by Beecher. The fauna as given by Barrett,* with a few additions by the present writer, is the following:

Orbiculoidea discus Hall, *O. conradi* (Hall), *Orthis* (*Dalmanella*) *perelegans* Hall, *O.* (*D.*) *planiconvexa* Hall, *O.* (*Rhipidomella*) *oblata* Hall, *O.* (*R.*) *subcarinata* Hall, *O.* (*Schizophoria*) *multistriata* Hall, *Leptæna rhomboidalis* Wilckens, *Stropheodonta becki* Hall, *S. perplana* Conrad, *Strophonella cavumbona* Hall, *S. leavenworthana* Hall, *Chonostrophia* n. sp., *Spirifer murchisoni* Castelnau, *S. concinnus* Hall, *S. cyclopterus* Hall, *Cyrtina rostrata* Hall, *Rensselæria æquiradiata* (Conrad), *Actinopteria textilis* Hall, *Platyceras retrorsum* Hall, *P. gebhardi* Hall, *Loxonema fitchi* Hall ?, *Holopea antiqua* (Vanuxem) ?, *Hyolithes centennialis* Barrett, *Dalmanites dentata* Barrett, *D. pleuroptyx* (Green), *D. nasutus* Conrad, *D. micrurus* (Green), and *Homalonotus vanuxemi* Hall.

Of this fauna with 29 species, all are Helderbergian forms with the exception of the following, which are Oriskany species: *Stropheodonta perplana*, *Spirifer murchisoni*, and *Cyrtina rostrata*. This evidence is very conclusive that the three zones of Barrett's Upper Pentamerus limestone are properly correlated.

The Becraft fauna was extensively collected by Clarke, Beecher, and the writer, but more particularly by the former, for the New York State collection. Doctor Clarke has published "A preliminary list of the species constituting the Oriskany fauna of Becraft's mountain, New York,"† which is given below, with a few alterations. Regarding this fauna, Doctor Clarke concludes that—

"This remarkable association of species furnishes the missing link in the evolution of the Lower Helderberg into the typical Lower Devonian fauna. While the presence of so many positive Oriskany types determines the faunal quantivalence, the perdurance of species and modifications of specific expressions characteristic of the shaly limestone fauna, and the inception of Lower Devonian specific forms, render this combination altogether unusual and of prime significance in the correlation of our earlier Devonian. The southwestern extension of the Oriskany (*Hipparionyx*) fauna, as in Maryland, is complicated with the Lower Helderberg, but to a less degree than here; while in the representative of the same fauna in the province of Ontario there is a great predominance of Upper Helderberg species. With the 46 species which have been identified in the Hipparionyx fauna of New York, the 106 or more species of the Becraft fauna are in striking contrast, and no

* Ann. Lyc. Nat. Hist. N. Y., vol. xi, 1876, p. 296, and Amer. Jour Sci., vol. xiii, 1877, p. 386.

† Amer. Jour. Sci., vol. xliv, 1892, pp. 411-414.

element so strongly enforces this contrast or is so unique in itself as the *Crustacean*. The association is indubitably of early Oriskany age and is eminently the Trilobite or Dalmanites facies of the Oriskany fauna."

*FAUNAL LIST OF THE NEW YORK LOWER ORISKANY**

(Numbers indicate material in United States National Museum. Those species marked with an * are also in Ulsterian.)

	Also in Held.	Lower Oriskany, Becraft Mt.	Upper Oriskany.
Hindia sp.	.....	x	
Edriocrinus sacculus Hall	.....	x	
Zaphrentis cfr. *rœmeri* Hall	.....	x	
" sp.	.....	x	
Romingeria sp.	....	x	
Trachypora sp.	.....	x	
Monticulipora sp.	.....	x	
Hederella sp.	.....	x	
Clonopora sp	.....	x	
Reptaria sp.	.....	x	
Polypora sp	.....	x	
Hemitrypa cfr. *columellata* Hall	.....	x	
* *Fenestella celsipora* Hall	.....	x	
" sp.	.....	x	
Lingula sp	.....	x	
Orbiculoidea sp	.....	x	
Crania sp. 28008	.....	x	
" n. sp.	.....	x	
Pholidops terminalis Hall. 28007	.....	x	x
" sp. n.	.....	x	
Orthis (*Dalmanella*) *perelegans* Hall	x	x	x
" (*Rhipidomella*) *oblata* Hall? 28009	x	x	x
Orthothetes cfr. *woolworthana* Hall	.....	x	
" n. sp. 28014	.....	x	
Hipparionyx proximus Vanuxem	.....	x	x
* *Leptæna rhomboidalis* Wilckens. 28013	x	x	x
Stropheodonta lincklæni Hall	.....	x	x
" cfr. *radiata*. 28016	.....	x	
" n. sp. A	.....	x	
" n. sp. B	.....	x	
" (*Leptostrophia*) *magnifica* Hall	.....	x	x
" " *becki* Hall. 28015	x	x	
* " " *perplana* Conrad. 28012	.....	x	
Strophonella headleyana Hall?	x	x	
Chonetes melonica Billings. 28018	....	x	x
Chonostrophia n. sp. 28019	.....	x	
Anoplia nucleata Hall. 28017	.....	x	x
Spirifer murchisoni Castlenau. 28020		x	x
* " *arenosus* (Conrad). 28021	.. ..	x	x

* A monograph of this fauna, by Doctor J. M. Clarke, is now in preparation.

Faunal List of the New York Lower Oriskany

	Also in Held.	Lower Oriskany, Becraft Mt.	Upper Oriskany.
Reticularia modesta (Hall)	x	x	
* " *fimbriata* (Conrad)		x	x
**Metaplasia pyxidata* (Hall). 28022		x	x
Crytina rostrata Hall. 28023		x	x
" cfr. *dalmani* Hall		x	
Meristella lata Hall. 28024		x	x
" *lævis* Hall? 28026	x	x	
* " *lenta* Hall. 28025		x	x
" n. sp.		x	
Trematospira multistriata Hall	x	x	
Anoplotheca n. sp. 28028		x	
" sp.		x	
* " *flabellites* (Hall). 28027		x	x
* " *acutiplicata* (Hall)		x	
Anastrophia n. sp.		x	
Rensselæria ovoides (Eaton). 28029		x	x
Megalanteris ovalis Hall?		x	x
Beachia suessana Hall?		x	x
Camarotœchia oblata Hall. 28011		x	x
" *barrandei* Hall		x	x
" *speciosa* (Hall)?		x	x
Rhynchonella sp		x	
Eatonia medialis Hall	x	x	
" *peculiaris* Conrad. 28010	x	x	x
Oriskania navicella Hall and Clarke		x	
Cryptonella n. sp.		x	
Actinopteria textilis Hall?	x	x	
Aviculopecten sp		x	
Megambonia bellistriata Hall. 28032		x	x
" *lamellosa* Hall?		x	x
Goniophora n. sp.		x	
Cypricardinia cfr. *sublamellosa* Hall. 28031	x	x	
Conocardium sp		x	
Platyceras (*Orthonychia*) *tortuosus* (Hall)		x	x
" *nodosum* (Conrad)		x	x
Strophostylus expansus (Conrad)		x	x
Diaphorostoma ventricosa (Conrad). 28034	x	x	x
" n. sp.		x	
Cyrtolites expansus Hall? 28033		x	x
Pleurotomaria n. sp.		x	
Bellerophon n. sp.?		x	
Conularia sp.		x	
Coleolus sp.		x	
Leperditia sp.		x	
Primitia sp		x	
Dalmanites n. sp. A. 28035		x	
" n. sp. B.		x	
" n. sp. C.		x	
" sp.		x	

Faunal List of the New York Lower Oriskany

	Also in Held.	Lower Oriskany, Becraft Mt.	Upper Oriskany.
* " *phacoptyx* Hall	......	x	
Phacops n. sp. 28036	......	x	
" (*Acaste*) cfr. *anceps* Clarke	......	x	
Homalonotus sp	......	x	
Cordania n. sp	......	x	
Cyphaspis n. sp	......	x	
Proetus n. sp. ?	......	x	
" n. sp. B	......	x	
Acidaspis tuberculatus Conrad	x	x	
Turrilepas sp	......	x	
Spirorbis sp	......	x	
Autodetus n. sp	......	x	
Fish spine	......	x	
Tentaculites elongatus Hall. 28006	x	x	x
" *acula* Hall	x	x	
	14	104	31

Of this Lower Oriskany fauna of 104 species, 45 are specifically identified with described species, and of these no less than 35 occur above, either in the Upper Oriskany or Ulsterian, while 14 are present in the Helderbergian. Doctor Clarke's statement that "this remarkable association of species furnishes the missing link in the evolution of the Lower Helderberg into the typical Lower Devonian fauna," and Beecher's "from the fossils now known from Becraft's mountain, it is evident that the relations of the fauna contained in the upper beds of the series above the Scutella limestone and just below the [Upper] Oriskany sandstone are with the latter and not with the Lower Helderberg group" are just.

It is very desirable that collectors should give attention to gathering more extensive collections from the Upper Pentamerus or Becraft about Port Jervis and Schoharie, New York, and also from the Oriskany along the Neversink valley. Such collections will probably demonstrate the intimate relationship of the Becraft and Lower Oriskany formations.

PENNSYLVANIA AND NEW JERSEY ORISKANY

At present the Oriskany formation of Pennsylvania and New Jersey is not clearly divisible into a lower and upper member as in New York.

Along the Delaware river, this formation is very variable in its lithological characters, follows directly upon the Helderbergian series, and is overlain by a great mass of Esopus grit.

Lesley * summarizes the work of the "Second Geological Survey of Pennsylvania" on the Oriskany formation as follows:

"In Pennsylvania the outcrops of Oriskany extend in straight and curved lines and many zigzags through nineteen counties, a total distance of 1,100 miles; the formation, however, appearing and disappearing, thickening and thinning; varying in character from sandy shales to massive flint rock; in some places crowded with shells, at others almost destitute of them; in some places calcareous, in others with scarcely a trace of lime, in some places highly ferruginous, even containing iron enough to furnish furnace ore."

The maximum thickness in Pennsylvania is probably not over 200 feet. It has been given as 700 feet, but this depth apparently includes either the Helderbergian or the Esopus grit.

The Oriskany and Helderbergian series, as exposed in the Neversink valley, enter New Jersey and Pennsylvania southwestward from Port Jervis, New York. The Oriskany of this region is described by I. C. White,† as follows:

"The rocks which make up the Oriskany series change so radically in character in passing southwest from the eastern line of the district that there is scarcely anything in common to the sections of the group at the eastern line of Pike and the western line of Monroe.

"The sandstone member of the series is entirely absent at the eastern extremity of Pike county, the only representative of the Oriskany there present being a bed of limy, cherty shales, weathering down into muddy looking beds holding Oriskany fossils. They are in fact a mere continuation of the Lower Helderberg beds up to the very base of the Cauda-galli grit."

At Carpenters Point village, the Oriskany was estimated as 50 feet thick. On crossing the Delaware river into Monroe county, the Oriskany appears to thicken and at Broadhead creek is 45 feet thick, at the western line of Monroe about 175 feet, and is fully 200 feet thick on the Lehigh river below Bowman's.

George H. Cook,‡ the state geologist of New Jersey, describes the Oriskany of that state as follows:

"Under this division [Oriskany sandstone] we have included the large mass of rock lying between the Lower Helderberg and Cauda-galli. There is a thin bed of tender sandstone, or almost sand, full of indistinct marks of fossils, which may be considered as the base of the formation. It is hardly eight feet thick, and may

* Second Geol. Survey Pa., Summary Final Report, vol. ii, 1892, pp. 1036, 1037.

† Second Geol. Survey Pa., vol. G6, 1882, pp. 122–126.

‡ Geol. of New Jersey, 1868, pp. 160, 161.

be seen above W. Nearpass' quarries; near Peters valley; at Walpeck Center, and west of Flatbrookville. Lying on this is a thick body of shale, which constitutes the principal part of the formation.

"The shale is light-colored, soft, and disintegrates easily. Some of the beds are very calcareous, while others are gritty. Fossils are quite abundant, especially in the upper layers, near the Cauda-galli grit.

"This formation may be seen almost everywhere, from the Stateline to Walpeck bend. . . . A fine locality for examining rocks and included fossils is along Chamber's Mill brook, northwest of Isaac Bonnell's residence.

"As estimated, west of Flatbrookville the shaly rock is about 120 feet thick. From the breadth of the outcrop west of Walpeck Center, and with a uniform dip of 40 degrees to the northwest, its thickness would be made to be over 300 feet. The difficulty of always fixing the angle of the dip renders this examination a matter of uncertainty."

The Oriskany of New Jersey is intimately connected with that of New York and Pennsylvania, and the reader is referred to these sections of this paper for other details.

FAUNAL LISTS OF NEW JERSEY AND PENNSYLVANIA

At Carpenters Point, 4 miles southeast of Port Jervis, New York, in a lime shale with chert, I. C. White* found—

Tentaculites elongatus Hall.
Eatonia peculiaris (Conrad).
Spirifer murchisoni Castelnau.
Spirifer arenosus (Conrad).
Rensselæria ovoides (Eaton).
Actinopteria textilis arenaria (Hall).
Platyceras gebhardi Hall.
Platyceras ventricosum Conrad.

On Broadhead creek, near Stroudsburg, Pennsylvania, I. C. White† found—

Spirifer arenosus (Conrad).
Hipparionyx proximus Vanuxem.
Rensselæria ovoides (Eaton).
Platyceras ventricosum Conrad.

Claypole‡ has given the following species as occurring in cherty beds at Grove tunnel, Northumberland county, Pennsylvania:

Orbiculoidea ampla Hall.
Orthis (*Rhipidomella*) *musculosa* Hall.
Spirifer murchisoni Castelnau.
Spirifer arenosus (Conrad).
Spirifer cumberlandiæ Hall.
Anoplotheca flabellites (Conrad).
Megalanteris ovalis Hall.
Platyceras magnificum Hall.
Platyceras (*Orthonychia*) *tortuosum* (Hall).

Potts Grove, Northumberland county, Pennsylvania:

Spirifer murchisoni Castelnau. 28096.
Diaphorostoma ventricosa (Conrad). 28081.

* Second Geol. Survey of Pa., vol. G6, p. 123.
† Ibid., p. 124.
‡ Second Geol. Survey of Pa., Sum. Final Rept., vol. ii, p. 1075.

At Three Springs, in Huntingdon county, Pennsylvania, in a coarse, friable sandstone, in the lower 30 feet, were found the following:*

Hipparionyx proximus Vanuxem.
Eatonia peculiaris (Conrad).
Spirifer murchisoni Castelnau.
Spirifer arenosus (Conrad).
Rensselæria ovoides (Eaton).
Rensselæria marylandica Hall.
Megalanteris ovalis Hall.
Actinopteria textilis (Hall).
Megambonia lamellosa Hall.
Platyceras ventricosum Conrad.

At Mapleton, Huntingdon county, Pennsylvania, on the Upper Juniata, the Oriskany is about 150 feet thick. *Spirifer arenosus* (Conrad) occurs near the top, and from the lower half was secured—

Eatonia peculiaris (Conrad).
Spirifer murchisoni Castelnau.
Rensselæria ovoides (Eaton).
Platyceras tortuosum Hall.
Platyceras platyostoma Hall.
Diaphorostoma ventricosa (Conrad).

Bedford, Bedford county, Pennsylvania:

Diaphorostoma ventricosa (Conrad). 2063.

Newry, Blair county, Pennsylvania:

Spirifer murchisoni Castelnau. 25362. *Atrypa reticularis* Linné. 25363.

Near Chambersburg, Franklin county, Pennsylvania:

Diaphorostoma ventricosa (Conrad). 3920.

MARYLAND AND WEST VIRGINIA ORISKANY AND ITS FAUNA

In western Maryland, the Oriskany occupies "the central division of the Appalachian region" and enters into the formation of the Alleghany plateau. It follows upon the Helderbergian series, and in turn is overlain by the "Romney formation," the equivalent of the New York Hamilton. In Maryland, the Oriskany is known as the "Monterey formation," and is described by Professor Clark † as follows:

"The Monterey formation, so called for its typical occurrence at Monterey, Virginia, is confined, like the Upper Silurian formation, to the central division of the Appalachian region in western Washington and Alleghany counties, Maryland. The deposits of the Monterey formation are typically rather coarse-grained, somewhat friable sandstones, white or yellow in color. At times the materials become very coarse grained, resulting in a clearly defined conglomerate, while at other times, especially in the western portion of the area, the materials are fine-grained, with here and there interstratified layers of coarse materials. The sandstone is very fossiliferous and carries the typical Oriskany fauna of the north. The formation has a thickness of about 300 feet."

* Ibid., p. 1101.
† W. B. Clark: Md. Geol. Survey, vol. i, 1897, pp. 182, 183.

When the writer was at Cumberland recently, Mr Robert H. Gordon pointed out to him the localities which furnished most of the Oriskany fossils. At the "Devils Backbone," the Oriskany follows the Helderbergian, but before the fossils of the former formation appear there is interpolated above what may be the Kingston, beds about 120 feet thick. (See section on page 271.) In the short time devoted to collecting, no fossils were seen, excepting at the base of the formation, where *Anoplotheca flabellites*, a true Oriskany fossil, was found.

Cumberland, Maryland, has long been famous for its splendid Oriskany fossils, which are preserved as silicious pseudomorphs. These were collected by Mr William Andrews, of Cumberland, and were submitted for description to Professor Hall. This enabled him to enlarge considerably the Oriskany fauna described in 1859, in Paleontology of New York, volume iii. Many of the Brachiopoda show not only the interior structure of the valves, but also the processes for the support of the brachia. The Gastropoda are also very well preserved, and are found with other fossils in pockets of loose sand where the shells are free, but usually with the finer surface structure destroyed. Hall writes that "all of the specimens of the Crinoidea of the Oriskany sandstone have been derived from the collection of Mr Andrews," of Cumberland.

The following list contains the names of the species known to occur in the Monterey formation about Cumberland, Maryland:

	Helderbergian.	Lower Oriskany.	Upper Oriskany.
Zaphrentis sp. undet. 28110			
Favosites conicus Hall	x		
" two additional species in the Gordon collection			
Homocrinus proboscidalis Hall			
Technocrinus andrewsi Hall			
" n. sp. (Gordon collection)			
" *sculptus* Hall. Founded on separated calyx plates			
" *spinulosus* Hall			
" *striatus* Hall. Founded on separated calyx plates			
Edriocrinus sacculus Hall. 10661. (In the Gordon collection there are fragments of at least 8 other species of crinoids)			
Anomalocystites disparilis Hall			
Pholidops arenaria Hall (= *P. terminalis*)		x	x
Chonostrophia complanata Hall. 28108			x
Orbiculoidea n. sp. (Gordon collection)			
" *grandis* Hall			x
Orthis (*Rhipidomella*) *cumberlandiæ* Hall			
" " *musculosa* Hall. 8436, 10663			x

	Helderbergian.	Lower Oriskany.	Upper Oriskany.
Orthis (*Dalmanella*) *planiconvexa* Hall	x		
Leptæna rhomboidalis ventricosa Hall	....	....	x
Stropheodonta magnifica Hall. 28111	....	x	x
" *magniventer* Hall	....	....	x
Strophonella headleyana Hall	x	x	
Hipparionyx proximus Vanuxem	....	x	x
Camarotœchia barrandei Hall	....	x	x
" *speciosa* Hall. 10671		x	
Rhynchonella ramsayi Hall			
Eatonia peculiaris (Conrad). 8434, 10672	x	x	x
" *sinuata* Hall			
" *whitfieldi* Hall	....	....	x
Spirifer arenosus (Conrad). 10664, 28103	....	x	x
" *murchisoni* Castelnau. 28097	....	x	x
" *cumberlandiæ* Hall (Syn. *S. submucronata* Hall). 10666, 10667			
" *intermedius* Hall			
" *tribulis* Hall. 10668	....	...	x
Metaplasia pyxidata Hall	....	x	x
Cyrtina rostrata Hall	...	x	x
Rhynchospira rectirostris Hall			
Atrypa reticularis Linné. 8432	x	...	x
Anoplotheca dichotoma (Hall)	....	...	x
" *fimbriata* (Hall)			
" *flabellites* (Conrad). 10673	...	x	x
Meristella lata Hall. 28094	....	x	x
" cfr. *princeps* Hall	x		
" n. sp. (Gordon collection)			
Rensselæria cumberlandiæ Hall			
" *intermedia* Hall			
" *marylandica* Hall. 10670, 28088			
" *ovoides* Hall	....	x	x
Megalanteris ovalis Hall	...	x	x
Beachia suessana Hall. 8435, 10669	x		
Centronella ? (probably n. gen. et sp., Gordon collection)			
Platyceras callosum Hall			
" *gebhardi* Conrad. 4201, 28085	x		
" *magnificum* Hall. 28086, 10676			
" *patulum* Hall			
" *reflexum* Hall. 28084			
" *ventricosum* Conrad. 8431, 10674	x		
Diaphorostoma ventricosa (Conrad)	x	x	x
Strophostylus andrewsi Hall			
" *matheri* Hall			
" *transversus* Hall			
Cyrtolites expansus Hall	..	x	x
Tentaculites (near *scalariformis*, Gordon collection)			
Actinopteria textilis arenaria (Hall)	....	....	x
Aviculopecten, 2 or 3 n. sp. (Gordon collection)			
Megambonia lamellosa Hall	...	x	x
Homalonotus vanuxemi Hall	x		
Dalmanites, 2 undet. sp. (Gordon collection)			

On analyzing this Cumberland fauna, it is seen that of the 58 species found there, 25 are restricted and do not occur to the north in New York. Of the remaining 33 species, 10 are also found in the Helderbergian, a far greater number than in the Upper Oriskany of New York, where but 2 species are common to it and the Helderbergian ; 19 are also found elsewhere in the Lower Oriskany and 25 in the Upper Oriskany. The degree of evolution therefore indicates that the Cumberland fauna is older than that of the typical Upper Oriskany of New York, but not quite as old as that of the Lower Oriskany of Becraft mountain.

If this fauna were derived from a limited zone, its developmental progression would indicate that the Cumberland Oriskany is older than the Hipparionyx fauna of New York and not quite as old as that of Becraft mountain. However, it is certain that the Helderbergian here passes without break into the Oriskany, as can be seen at " Devils Backbone," near Cumberland, and it may be that both the Lower and Upper Oriskany are there present. It is probable that Mr Andrews' collection was derived from the entire series, and that there is some mixing. This causes the Cumberland Oriskany to appear older than the Hipparionyx fauna, when it probably contains both the latter and the Becraft fauna.

The following species are from Keyser, Mineral county, West Virginia, and were obtained on the north branch of the Potomac river :

Spirifer arenosus (Conrad). 16674, 16676.
Spirifer murchisoni Castelnau. 16675.
Eatonia peculiaris (Conrad). 16678.
Beachia suessana Hall. 16679.
Stropheodonta magnifica Hall. 16673.
Diaphorostoma ventricosa (Conrad). 16673.

Moorefield, Hardy county, West Virginia :

Spirifer arenosus (Conrad). 28104.

The following forms are from Pendleton county, West Virginia, and were collected on the north fork of south branch of Potomac river :

Orthis (*Rhipidomella*) *musculosa* Hall. 18156, 18157.
Stropheodonta magnifica Hall. 18154.
Stropheodonta lincklæni Hall. 28112.
Hipparionyx proximus Vanuxem. 18155.
Chonostrophia complanata Hall. 18153.
Spirifer arenosus (Conrad). 18158.
Spirifer like *arenosus* in form, but without a plicated fold and sinus. 28106.
Spirifer murchisoni Castelnau. 28100.
Spirifer cumberlandiæ Hall? 28101.
Camarotœchia barrandei Hall. 18159.
Meristella lata Hall. 28092, 28093.
Anoplotheca flabellites (Conrad). 18160.
Rensselæria sp. undet. 18162.
Rensselæria marylandica Hall. 18161.
Diaphorostoma ventricosa (Conrad). 18164.
Platyceras nodosum Conrad. 18165.

VIRGINIA ORISKANY AND ITS FAUNA

In the northwestern part of Virginia, adjoining West Virginia and Maryland, the Oriskany is probably not less than 300 feet thick. It is very difficult to find reliable data concerning this formation to the southwest, and the extract given below is all that the writer has found.

W. B. Rogers,* in his description of the several members of the geological series belonging to the region west of the Blue Ridge, thus describes the Oriskany:

"(No. 7.)—The sandstones composing this member of the series are, in general, characterized by an open and rather coarse texture, and an extraordinary abundance of organic impressions. In color they vary from a yellowish white to a dark greenish gray. They are usually presented, especially the lighter colored variety, in massive beds of several feet in thickness, and from their frequent occurrence along the flanks and declivities of the ridges, dipping at a steep angle, and bare of vegetation, they form a curious feature in many of the wild scenes among our mountains. . . .

" Nearly all of the mountains of Hampshire, Hardy, Pendleton, Pocahontas, and Alleghany counties, exhibit extensive and instructive exposures of this rock, which from its whiteness, frequently bare surface, profusion of organic impressions, and disposition to disintegrate into a coarse white sand, is one of the most strongly and uniformly characterized of the members of our series.

"An iron ore has been found in various places in connection with these strata" (p. 179).

From Rock Enon Springs, on Great North mountain, in Frederick county, 15 miles northwest of Winchester, in Shenandoah valley, the United States National Museum has received the following fossils collected by Mr Geiger, of the United States Geological Survey:

Spirifer arenosus (Conrad). 15954.
Platyceras magnificum Hall. 15957.
Modiomorpha sp. undet. 15958.

From the northwest pike, six miles from Winchester, *Spirifer murchisoni* and *S. arenosus* (15955) were collected by Mr Geiger.

From the drift about Washington, D. C., and Alexandria, Virginia, have been gathered many characteristic Upper Oriskany species, of which those given below are in the United States National Museum. The origin of this drift is unknown, but it must be either from the west or northwest:

Favosites, ramose form. 18137.
Tentaculites acula Hall. 18166.
Camarotœchia speciosa Hall. 17494.
Anoplotheca flabellites (Conrad).
Spirifer arenosus (Conrad). 28105.
Mytilarca sp. undet. 18149.

In southwestern Virginia, near the Tennessee state line, Professor J. J. Stevenson has observed the Oriskany sandstone in a number of places. It is there never more than 40 feet thick, and may repose either on the New Scotland member of the Helderbergian or on the Clinton. It is

* Rept. Geol. Survey Va. for 1837–'38. From "A Reprint of Ann. Rept. on the Geology of the Virginias," Appleton, 1884, pp. 179, 199.

always covered by the "Black shale" of Safford or its equivalent in this region—the Hamilton formation of Stevenson. The latter describes the Oriskany as follows:

"This is a sandstone, probably not more than 35 or 40 feet thick, which is shown in the Poor valley of Powell river [Lee and Scott counties, near the Tennessee state line] and along the valleys of Wildcat creek and the North fork of Clinch; also along the latter stream at the foot of Powell mountain, and in the Hunter valley at Stony creek. . . .

"The Oriskany sandstone is coarse, reddish on exposed surface, but white on the fresh surface. It is friable, and at some localities, notably along the North fork of Clinch river, it readily disintegrates on exposure. . . . This rock contains *Hipparionyx proximus* in Stony creek; in the Poor valley of Powell river, it contains *Meristella lata*, but with that there occur some forms [*Spirifer perlamellosus*]* belonging to the Helderbergian.

"The Oriskany was seen only in Bland county, where it is exposed at the foot of Round mountain and the Garden mountains, as well as along the foot of Wolf Creek mountain in the 'Wilderness.' The rock is a thin sandstone, which resists the weather so well as to make a small ridge. . . . As shown in the 'Wilderness,' the rock is a moderately coarse gray sandstone, evidently not more than ten feet thick."†

A Lower Oriskany horizon appears to be present on Flat Top mountain, near Saltville, Smythe county, Virginia. Here in chert were collected the following species, which the writer identified for a correspondent of the United States National Museum:

Leptocœlia, fragment.
Meristella.
Spirifer hemicyclus Meek and Worthen.
Chonetes melonica Billings.
Rhynchospira, near *globosa*, but with three central plications, on each side of which are two large ones.
Zaphrentis, like *Z. rœmeri*.
Platyceras gebhardi Conrad.

CLEAR CREEK LIMESTONE AND UPPER ORISKANY OF ILLINOIS

In the spring of 1858 Professor A. H. Worthen identified the Oriskany formation in Alexander and Union counties, Illinois, but did not describe it until 1866. He then restricted the Oriskany to a "quartzose sandstone" horizon from 40 to 60 feet in thickness overlying his "Clear Creek limestone."‡ The former horizon was then regarded as the base of the American Devonian, but in southern Illinois, he writes—

"It is underlaid by a group of silicious limestones [Clear Creek limestone], that in their upper beds contain well marked Devonian fossils, and below, those that seem to be characteristic Upper Silurian forms; thus forming beds of passage from the

* Proc. Amer. Phil. Soc., January, 1881, p. 234.
† Ibid., March, 1887, p. 84.
‡ Geol. Survey of Ill., vol. i, 1866, pp. 124-129.

Upper Silurian to the Devonian systems. . . . We have, therefore, drawn the dividing line between the Devonian and Upper Silurian, in our general section, through this limestone group underlying the Oriskany sandstone" (pp. 125, 126).

In the second volume, Meek and Worthen * state that "the name 'Clear Creek limestone' was provisionally used for a series of strata holding a position, in Union and some of the adjoining southern counties, between the so-called Hudson River group of the Lower Silurian, and a Devonian sandstone that had been identified with the Oriskany sandstone of New York." Mr Engelmann secured more fossils "at different horizons above the middle of the doubtful series," and these were "found to indicate that at least a considerable portion of these beds are more nearly allied to the Oriskany sandstone than to the Upper Silurian." Meek and Worthen sought to avoid this uncertainty and delayed the printing of volume ii until the region could be revisited by them. This trip resulted in their finding fossils of Helderbergian age in the lower 200 feet of the Clear Creek limestone, a result in harmony with that attained by Doctor Shumard in 1855.† In the upper part of the Clear Creek limestone, or "cherty limestone, or chert formation, as it might properly be called," was found a fauna confirming the conclusion—

"That a considerable portion of the cherty limestone forming the upper part of the Clear Creek series, as first understood, belongs to the Oriskany period, and that this line between the Upper Silurian and the Devonian, of this region should be drawn between these cherty beds and the strata below, equivalent to those from which we collected the Lower Helderberg. Exactly how far down in the series this line should be carried we are unable to say, as we found no abrupt lithological change, and we saw no fossils near the horizon of the probable junction. From all the facts, however, we are led to believe that possibly as much as 200 feet, and probably more, of these beds should be included in the Oriskany." ‡

The "Clear Creek group" is from this time restricted to the cherty limestones, above a thin band of brown shale of the "Clear Creek limestone," as formerly defined, while the lower half, 200 feet in thickness, is referred to the New Scotland horizon of the Helderbergian. It should also be borne in mind that the passage from the latter into the Clear Creek limestone, as restricted, is not marked, agreeing in this with the passage from the Becraft limestone into the Lower Oriskany at Becraft mountain, near Hudson and Port Jervis, New York.

According to Meek and Worthen,§ the "quartzose sandstone" overlying the Clear Creek limestone contains a small *Zaphrentis*, *Pleurodic-*

* Geol. Survey of Ill., vol. ii, 1866, p. x.
† Geol. of Mo., 1855, p. 109.
‡ Loc. cit., p. xii.
§ Geol. Survey, of Ill., 1866, pp. xiii, xiv.

tyum problimaticum, *Orthis* (*Rhipidomella*) *musculosa*, *Stropheodonta magnifica*, *Amphigenia elongata* var. *curta*, and *Dalmanites* (*Odontocephalus*) sp. undet. "We have concluded to place it provisionally as an upper stratum of the Oriskany." Since the Clear Creek limestone fauna is to be correlated with that of Becraft mountain, or the Lower Oriskany, it follows that the quartzose sandstone holds the horizon of the typical, or Upper, Oriskany, as developed in Albany and Schoharie counties, New York.

The following Lower Oriskany fauna of the "Clear Creek limestone" of Alexander, Jackson, and Union counties, Illinois, is on the authority of Meek and Worthen:

Anoplia nucleata Hall.
Camarotœchia speciosa Hall.
Eatonia peculiaris (Conrad).
Amphigenia curta Meek and Worthen.
Anoplotheca flabellites (Conrad).
Spirifer engelmanni Meek and Worthen (= *S. worthenanus* Schuchert).
Spirifer hemicyclus Meek and Worthen.
Megalanteris condoni (McChesney).
Strophostylus (?) *cancellatus* Meek and Worthen.
Platyceras gebhardi Conrad.
Platyceras (*Orthonychia*) *tortuosum* Hall.

CAMDEN CHERT OF TENNESSEE

There appears to be no Oriskany present in eastern Tennessee, but in the western part of the state this formation is developed and is apparently a continuation of that of southern Illinois. It is described by Professor Safford * as follows:

"In March, 1855, the writer discovered in Benton county, Tennessee, at several points, excellent outcrops of Lower Helderberg shales and limestones very rich in fossils. The discovery was important, since it settled the question as to the presence of the Lower Helderberg, as a distinct formation, in Tennessee west of the meridian of Nashville. In subsequent years, this discovery also led to a recognition of the chert now referred to as Oriskany, which I have designated the Camden chert for the reason that at Camden, the county-seat of Benton, is seen one of its best exposures.

"One of the localities discovered in Benton county was a bluff on Big Sandy river, about 5 miles from its mouth, at a point then in Henry county, and known as the old Williams mill site. This locality is referred to in 'Geology of Tennessee,' 1869. As stated on page 325 of that book, there are here exposed about 50 feet of bluish limestone, mostly shaly. Above this and running back on a slope from the precipitous portion of the exposure 'are loose, angular, flinty masses, containing the fossils of the rocks below, and derived from cherty layers not seen.' The fossils in the chert were not numerous nor in good condition, but what was seen of them led, at the time, to the foregoing conclusion.

"In 1884 I recognized the chert at Camden as a distinct formation. I had, in passing through the country, seen this horizon and had referred it without special examination to the 'Silicious group' (lowest of Subcarboniferous), outcrops of

* Amer. Jour. Sci., June, 1899.

which, very like the chert of Camden, are seen at many points in Benton and counties north and south of it. In my excursion of 1884, however, I stopped for some time at Camden to study the formations. The fossils in the chert arrested my attention, and reminded me of those in the flints seen at Williams' mill in 1855. But at Camden the chert was in comparatively great force, at least 60 feet of it being exposed. At first I was inclined to consider the chert a division of the Lower Helderberg, but subsequent studies of the fossils at home forced me to the conviction that as a group they must be Oriskany. The fact that the formation was one of chert also pointed to this.

"Afterwards, in 1885, 1886, and 1887, I visited localities where I thought the Camden might outcrop. One of these is Big Sandy station, in Benton, on the Memphis branch of the Louisville and Nashville railroad, and near the point where the road crosses Big Sandy river. Here I found the chert well developed and abounding in fossils. The outcrops are as extensive and as good as at Camden. For several miles south of Big Sandy, the chert appears on the hillsides as loose angular gravel.

"Five miles south, on the Lower Camden road, Lower Helderberg limestones are seen cropping out from beneath Camden chert, with Tertiary beds also overlapping all in unconformable contact.

"In Henry county the Camden chert outcrops in considerable areas, west and south of the Williams Mill locality. It is seen in limited thickness above the Lower Helderberg in Decatur county, and in the same relation, east of the Tennessee river, in Stewart county. In the latter locality, it outcrops in the bluff on the Cumberland river below Cumberland city. The greatest development of it, however, is on the west side of the Tennessee river, in a strip of country lying in Henry, Benton, and Decatur counties.

"In 1897 I called the attention of Mr Schuchert to the Camden chert, at the same time trusting he might be able to visit the Camden locality. This he did, collecting a series of fossils, which he studied, kindly giving me the results. I am under special obligation to him for this visit."

CAMDEN LOWER ORISKANY FAUNA

In the spring of 1897 the writer collected Lower Helderberg fossils in western Tennessee, and while in Nashville, Professor Safford also directed his attention to a lot of Camden chert organisms. Since no strata of Oriskany age had been recorded in Tennessee, the importance of determining the equivalency of the Camden chert with other regions made it desirable to know more of its fauna, and with that object in view, a collection was made at Camden.

The fossils of this formation are, as a rule, natural casts both of the interior and exterior of the organism, and preserve in detail the finest markings. This fauna is closely related to that described by Meek and Worthen* from the "Clear Creek limestone" of southern Illinois, in Alexander, Jackson, and Union counties. From this region are known but 11 species, and 8 of these are also found in Tennessee. They are

*Geol. Survey of Ill., vols. i, ii, and iii.

Anoplia nucleata, *Anoplotheca flabellites*, *Eatonia peculiaris*, *Spirifer worthenanus*, *S. hemicyclus*, *Megalanteris condoni*, *Amphigenia curta*, and *Strophostylus cancellatus*.

The "Clear Creek limestone" of Illinois is intimately connected with the Helderbergian below, and is not less than 200 feet thick, being followed by a "quartzose sandstone" from 40 to 60 feet in depth. The latter is probably equivalent to the Upper, or typical, Oriskany of New York, and does not appear to be present in western Tennessee. From Professor Safford's description of the Camden chert, it is evident that the Lower Oriskany thins rapidly southward. In Tennessee it is about 60 feet in thickness, while it is not less than 200 feet thick in Illinois, exclusive of the Upper Oriskany which is entirely absent in the former state.

The Camden chert fauna contains 32 species, and 6 of these are restricted to southern Illinois and western Tennessee. Of the entire fauna, 24 species are found either in the Helderbergian or in the Lower Oriskany of other regions, and 20 occur in the Upper Oriskany, or Onondaga. After removing the 13 species common to both the Lower and Upper Oriskany and the 2 restricted forms, 17 remain. Of these 10 occur either in Helderbergian or Lower Oriskany rocks of other regions, while 6 are found in higher beds. This evidence therefore indicates clearly a Lower Oriskany age for the Camden chert of Tennessee and the "Clear Creek limestone" of Illinois, which indication is the more marked because of the absence of such characteristic Upper Oriskany species as *Hipparionyx proximus*, *Chonostrophia complanata*, *Spirifer arenosus*, *Rensselæria ovoides*, *Meristella lata*, *Camarotœchia pleiopleura*, *C. barrandei*, or *C. speciosa*.

The following is the Lower Oriskany fauna of the Camden chert of Camden, Benton county, Tennessee:

	In Lower Oriskany elsewhere.	In Upper Oriskany elsewhere.
Zaphrentis roemeri Hall? 26938	H *	
Pholidops terminalis Hall. 26939	x	x
Hipparionyx proximus Vanuxem? A very small specimen of this species. 26940	x	x
Chonetes mucronatus Hall? 26941	......	x
" *melonica* Billings. 26942, 26943	x	x
Chonostrophia reversa (Whitfield). 26944	......	O

* H = Helderbergian; O = Onondaga.

	In Lower Oriskany elsewhere.	In Upper Oriskany elsewhere.
Stropheodonta (*Leptostrophia*) *perplana* (Conrad). 26945	x	O
Orthothetes woolworthanus Hall. 26947	x	
Anoplia nucleata Hall. 26946	x	x
Cyrtina affinis Billings. 26948	x	x
Metaplasia pyxidata Hall. 26951	x	x
Spirifer hemicyclus Meek and Worthen. 26949	x	
" *tribulis* Hall. 26953	x	x
" *worthenanus* Schuchert. 26950	x	
Anoplotheca flabellites (Conrad). 26954	x	x
Meristella lævis (Vanuxem). 26958	x	
" sp. undet. 26857	......	O
Atrypa reticularis Linné. 26959	x	x
Eatonia peculiaris (Conrad). 26961	x	x
Amphigenia curta Meek and Worthen? 26962	x	
Rensselæria ovoides (Eaton)? 26964	x	x
Megalanteris condoni (McChesney). 26963	x	
Tentaculites acula Hall. 26965	x	x
Avicula cfr. *obscura* Hall. 26966	H	
Actinopteria cfr. *textilis* Hall. 26967	x	
Platyceras magnificum Hall? 26969	......	x
" (*Orthonychia*) *tortuosum* (Hall)? 26968	x	x
Diaphorostoma turbinata (Hall). 26970	......	O
Strophostylus (?) *cancellatus* Meek and Worthen. 26971	x	
Phacops cristata Hall. 26973	......	x
Ostracoda. 26972		
Total, 32 species	24	20

GEORGIA AND ALABAMA ORISKANY

It has been stated that the Oriskany thins out rapidly in Virginia toward the Tennessee state line, and the thickness is given as about 40 feet. Nothing is known of this formation in eastern Tennessee, but it is present in the western part of the state as a chert horizon not less than 60 feet thick. In Floyd county, Georgia, and in Cherokee county, Alabama, the Oriskany is again present, having a thickness of not more than 20 feet. It here bears the name of "Frog Mountain sandstone," and is described by Mr C. W. Hayes * as follows:

"A few miles southwest of the region mapped [Coosa valley of Georgia and Alabama] the Rockmart slate is overlain by a thin bed of white quartzose sandstone, and this by fossiliferous chert. . . . There are between Indian and Weisner mountains several small areas occupied by a formation which comes in

* Bull. Geol. Soc. Amer., vol. 5, 1894, p. 470.

contact with all the older rocks thus far described [Middle Cambric to top of Champlainic]. It consists of coarse ferruginous sandstone, in some places white, resembling quartzite, and in others yellow or gray and weathering to incoherent beds of sand. Beneath this sandstone and usually deeply covered by its debris are shales, also variable in composition and appearance. . . .

"A number of fossils have been found [by Mr Cooper Curtice] in these sandstones of Frog mountain [Cherokee county, Alabama]." They include *Zaphrentis* (28109), *Spirifer arenosus*, *S. murchisoni* (28099), and *Orthis* (*Rhipidomella*) *musculosa ?* "Concerning these fossils Mr Walcott says that all the specific determinations are uncertain, but the horizon of the Oriskany sandstone is strongly suggested by the general facies of the fauna." *

"A few miles south of Cedartown, Georgia, the stratigraphic relations are shown better than in the disturbed region about Frog mountain, though no fossils have been collected. Resting on the Rockmart slate [Champlainic] is a bed of sandstone not more than 20 feet thick, and upon this is a fossiliferous chert." †

On Armuchee creek, at the northeast end of Lavender mountain, in Floyd county, adjoining the Alabama state line, Mr A. H. Brooks, of the United States Geological Survey, gathered unmistakable Oriskany fossils from chert beds, which contain the following species, as identified by the writer:

Orthis (*Rhipidomella*) *musculosa* Hall. 28078.
Stropheodonta magnifica Hall. 28077.
Anoplotheca fimbriata (Hall). 28075.
Spirifer tribulis Hall. 28076.
Meristella cfr. *walcotti* Hall and Clarke. 28074.
Ambocœlia umbonata (Conrad). 28073.

ORISKANY OF CANADA

Cayuga, Ontario.—In the region of Cayuga lake, New York, the Upper Oriskany is sparingly present and is fossiliferous, but west of Ontario county it is only present "in small lenticular patches," or in "nodules of dark colored non-fossiliferous sandstone which hold the position and preserve the characters of the Oriskany sandstone in other localities."‡

The Oriskany sandstone is not again seen until some distance beyond the Niagara river, in the province of Ontario, Canada, near Cayuga. This formation is described by Logan § as follows:

"In the township of Oneida and North Cayuga . . . there are large exposures of the [Oriskany] rock. It is composed of fine grains of white quartz, in some parts so closely cemented as to assume the characters of a white, compact quartzite. . . . The beds are massive, and from 6 inches to 6 feet thick. . . . The greatest thickness of the mass may be about 25 feet, but, though now and then attaining 10 feet, it seldom exceeds about 6, and it is frequently wanting between the Waterlime series and the overlying Corniferous formation."

* Bull. Geol. Soc. Amer., vol. 5, 1894, p. 470.
† Hayes: Amer. Jour. Sci., vol. 47, 1894, p. 237.
‡ Hall: Pal. N. Y., vol. iii, 1859, pp. 401–.
§ Geol. of Canada, 1863, p. 360.

In 1895 the present writer spent two days in collecting Oriskany fossils for the United States National Museum, at localities about 6 miles northwest of Cayuga. It is from these outcrops that all the Ontario Oriskany fossils are derived which were collected through many years by Mr John De Cew, furnishing Professor Hall his collections. These the writer worked out when assistant to the New York State geologist, and a list of them was published on pages 51–55 of the "Eighth Annual Report of the State Geologist of New York, for the year 1888," issued in 1889. When this work was in hand, it was apparent that there had been some mixing of Corniferous corals with those of the Oriskany fauna, and a number of species were then eliminated. It now appears that more of these corals must be removed from Professor Hall's Oriskany collection, and a number are not included in the list given below.

The unconformity between the Oriskany and the Waterlime groups is not a marked one. A short distance east of Mr David Fleming's farm, the Oriskany is 16 feet thick and rests on the evenly bedded or domed Waterlime group. The contact is well shown, with the bottom of the Oriskany somewhat uneven and filling the fissures in the Waterlime group. On the farms of Mr Fleming and Mr Anderson, the sandstone is not more than 6 feet thick and is abundantly fossiliferous. In other closely adjacent places, the upper layers of the Oriskany are thin bedded, containing rarely a Coral of Corniferous age. Above these layers is the Onondaga chert.

North of the quarry east of Mr Anderson's, the Oriskany is seen in low domes, and in some of the depressions between them thin bedded cherty limestones occur, preserving Bryozoa, trilobites, or an occasional coral of Onondaga age.

Upper Oriskany Fauna of Ontario.—The following forms were obtained in Oneida and North Cayuga townships, Ontario, Canada :

	Also in Helderbergian.	Also in Lower Oriskany.	Also in Onondaga.
Favosites conicus Hall. Hall collection	x	......	x
" *gothlandicus* Lamarck. Geological Survey of Canada	x	......	x
" *hemisphericus* Troost. Geological Survey of Canada	......	......	x
" *turbinatus* Billings. Geological Survey of Canada	......	......	x
" sp. undet. 28054			
" sp. undet. 28055			
Heliophyllum exiguum Billings. Geological Survey of Canada	......	......	x
Cystiphyllum sulcatum Billings. Geological Survey of Canada	......	......	x

	Also in Helderbergian.	Also in Lower Oriskany.	Also in Onondaga.
Zaphrentis prolifica Billings. Geological Survey of Canada			x
Polypora hexagonalis Hall. Hall collection			x
Hemitrypa sp. undet. 28056			
Orbiculoidea ampla Hall			x
Pholidops terminalis Hall. 28057		x	
Chonostrophia complanata Hall			
Chonetes hemisphericus Hall			x
" *mucronatus* Hall?			x
Orthis (*Rhipidomella*) *livia* (Billings)			x
" " *musculosa* Hall. 28058			
Leptæna rhomboidalis Wilckens	x	x	x
Stropheodonta demissa (Conrad) var. 28062			x
" *hemispherica* Hall			x
" *inæquiradiata* Hall. 28059			x
" *magnifica* Hall. 14781, 28063		x	
" *magniventer* Hall. 28061			
" *perplana* (Conrad). 28060		x	x
" *vascularia* Hall			
Strophonella ampla Hall			x
Hipparionyx proximus Vanuxem. 14719, 28069		x	x
Orthothetes pandora (Billings)			x
Camarotœchia billingsi Hall			x
Eatonia peculiaris (Conrad)	x	x	
Pentamerella arata (Conrad)			x
Amphigenia elongata (Vanuxem). Geological Survey of Canada			x
Spirifer arenosus (Conrad). 28068		x	x
" *murchisoni* Castelnau. 28066		x	
" *tribulis* Hall (=? *S. duodenarius* Hall). 28067			
Metaplasia pyxidata Hall		x	x
Cyrtina rostrata Hall? (or *C. hamiltonensis?*). 28065		x	
Nucleospira elegans Hall. Hall collection	x		
Anoplotheca dichotoma (Hall)			
" *flabellites* (Conrad)		x	
Atrypa reticularis Linné. 28064	x		x
Meristella scitula Hall			x
" *lata* Hall. 28071		x	
" *lenta* Hall. 28038		x	x
" *walcotti* Hall and Clarke. 28070			
Rensselæria cayuga Hall and Clarke, 14778, 28039, 28040			
Centronella glansfagea Hall. Hall collection			x
" *tumida* Billings. Hall collection			x
" *alveata* Hall. Hall collection			x
Tentaculites arenosus Hall. 28041			
Platyceras carinatum Hall. Hall collection			x
" *cancavum* Hall. Hall collection			x
" *dentalium* Hall. Hall collection			x
" *nodosum* Conrad. 28048		x	
Diaphorostoma ventricosa (Conrad). 28049, 14783	x	x	
Callonema sp. undet. 28050			
Cyrtolites expansus Hall		x	
Loxonema subattenuatum Hall? 28051			x
Actinopteria textilis arenaria (Hall). 28045			

	Also in Helderbergian.	Also in Lower Oriskany.	Also in Onondaga.
Aviculopecten sp undet. 28042			
Pterinea cfr. *flabellum* (Conrad). 28043			
Mytilarca sp. undet. 28046			
Cypricardinia planulata Conrad			
" *indenta* Conrad	......	......	x
Conocardium trigonale (Phillips)	......	......	x
Conularia near *C. undulata* Conrad	......	......	x
Dalmanites (*Chasmops*) *anchiops* (Green)	......	......	x
" (*Odontocheile*) *pleuroptyx* (Green). 28052	x	......	x
Phacops cristata pipa Hall. 28053	......	......	x
Proetus crassimarginatus Hall	......	......	x
Fish spine			

From the Oriskany sandstone of Ontario, 71 species are now known, and of these not less than 42 are also found in the Onondaga limestone above. The close affinity of this Oriskany fauna with that of the Onondaga is made more apparent when it is noted that 36 species of the 71 constituting the Ontario Oriskany do not occur elsewhere, and that 31 of these are typical Onondaga limestone species. About half the species restricted to the Oriskany of Ontario (36) are therefore early introductions of species characterizing the Onondaga limestone. Further, a person collecting fossils in this region will find difficulty in distinguishing the Oriskany fossils, mainly corals, of the thin upper layers from those of the Onondaga.

That the Ontario Oriskany fauna is probably considerably younger than the Upper Oriskany of New York or of the Appalachian region, is also indicated by the absence of the Esopus grit in Ontario and the many species common to it and the Onondaga cherty limestone. Moreover, of the 71 species found in Ontario, but 16 occur in the Lower Oriskany of New York, and but 8 Helderbergian species are present. These figures, as thus stated, do not so forcibly bring out the fact of its younger age as when it is remembered that 42 of the 71 species are also found in the Onondaga limestone of the same region, while of the 56 species constituting the New York Upper Oriskany fauna, but 11 are in the Onondaga and 30 are present in the Lower Oriskany. In other words, more than half the New York Upper Oriskany species also occur in the Lower Oriskany of the same state, while in Ontario about 60 per cent occur in the Onondaga and but 20 per cent in the Lower Oriskany fauna.

Gaspé, Quebec.—In the counties of Gaspé and Rimouski, unconformably overlying the Quebec group, "is a series of limestones about 2,000 feet in thickness." In regard to these limestones, Billings * writes that—

"The entire volume of these limestones is about 2,000 feet. The two lower divisions (1 and 2) [160 feet] are most probably Silurian, about the age of the [Lower] Helderberg of the New York geologists. The upper two members (7 and 8) [800 feet] are nearly of the age of the Oriskany sandstone, and are, therefore, about the base of the Devonian. Divisions 4, 5, 6 [880 feet] may be regarded as constituting passage beds between the Upper Silurian and Devonian."

There can be no doubt that "division 8" of the "Gaspé limestone" is equivalent to the Oriskany of New York, and while there are nearly as many Lower as Upper Oriskany species present, the writer inclines to regard this division as of Upper Oriskany age. In the sandstones 1,100 feet above "division 8" occur three Oriskany species—*Stropheodonta blainvillei* (Billings), *Rensselæria ovoides* (Eaton), and *Anoplotheca flabellites* (Conrad). From the same horizon, Billings has described *Zaphrentis corticata, Chonetes canadensis, C. dawsoni, C. antiope, Stropheodonta blainvillei, S. tullia, Spirifer gaspensis, Grammysia canadensis, Murchisonia egregia*, and *Modiomorphia inornata.* On the basis of the known fossils, there is no positive evidence that the lower 1,100 feet of these sandstones should not be regarded as of Oriskany, or at least of Esopus, age. However, the entire Gaspé limestones and sandstones of more than 9,000 feet thickness appear to represent uninterrupted deposition from early Helderbergian time to the close of the Devonian. Regarding this, Professor Hall † states that—

"From the Reports of the Canadian Geological Survey we learn that the physical conditions in the northeastern part of that territory, from the beginning of the Oriskany period, continued with little change through a long interval, and so uniform as to have prevented, up to the present time, the establishment of any lines of subdivision among the strata, which in their lower part, bear fossils characteristic of the Oriskany sandstone, and in their higher members those which mark the period of the Hamilton and Chemung groups of New York."

Of the Gaspé limestones and sandstones, Logan ‡ writes as follows:

"The limestones of cape Gaspé appear, for the most part, to belong to the Lower Helderberg group. The fossils of the summit, however, bear a striking resemblance to those of the Oriskany formation, with which several of them are identical. It appears probable, therefore, that we have here a passage from the Lower Helderberg to the Oriskany, and the latter formation may be more especially represented by the lower part of the Gaspé sandstones. . . . We have already mentioned that a species of *Rensselæria*, identical with or closely resembling *R. ovoides*, which

* Pal. Fossils, vol. ii, pt. i, 1874, p. 2.
† Pal. N. Y., vol. iii, 1859, p. 404.
‡ Geol. Canada, 1863, p. 403.

occurs in the upper part of the limestones, is met with at 1,100 feet above the base of the sandstone series. This fact, together with the constancy in the lithological characters of the latter, make it not improbable that at least this lower portion of the sandstones, will ultimately be classed with the Oriskany formation" (p. 403).

Ells* also regards "divisions 7 and 8" as Oriskany, since he says that—

"We have therefore drawn the dividing line between the two systems to reach the coast at Cape Gaspé, by which the passage beds [divisions 4, 5, 6 of Logan] will be placed as the upper portion of the Lower Helderberg, while numbers 7 and 8 of the scale (vol. ii, Pal. Foss.), will be assigned to the lower part of Lower Devonian."

New Brunswick, Canada.—In New Brunswick, there is another area of Upper Oriskany on Campbell river, which is described by Bailey † as follows:

"A small area of soft, dark blue, calcareous slates, and soft, dark gray, rusty buff weathering sandstones referable to this age [Oriskany] occurs on Campbell river."

From this locality Doctor H. M. Ami has identified the following forms:

Stropheodonta magnifica Hall.
Stropheodonta varistriata Conrad ?
Leptæna rhomboidalis Wilckens.
Hipparionyx proximus Vanuxem.
Orthis cfr. *oblata* Hall.
Anoplotheca flabellites (Conrad).
Eatonia.
Spirifer murchisoni Castelnau.
Spirifer sp. undet.
Actinopteria textilis Hall.
Megambonia ?

Oriskany fauna of Gaspé, Canada.—This is "bed 8" of Billings. The specific names in parentheses are Appalachian equivalents. Species with an * also occur in the "Gaspé sandstone" above "division 8."

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Zaphrentis incondita Billings				
" *cingulosa* Billings				
Favosites gotlandicus Goldfuss. (Authority of Ells.)	x	....	x	x
Phillipsastrea affinis Billings				
Polypora (?) *psyche* Billings.				

* Geol. and Nat. Hist. Survey of Canada, Rept. Prog., 1882–'84, 1885, p. 25E.

† Geol. Survey of Canada, Ann. Rept., n. s., ii, 1887, pp. 8, 9N.

	Helderbergian.	Lower Oriskany.	Upper Oriskany.	Onondaga.
Cystodictya (?) *tarda* (Billings)				
Chonetes melonica Billings	....	x	x	
" *mucronatus* Hall	....	x	x	x
Stropheodonta galatea (Billings)				
" *blainvillei* (Billings). (Authority of Ells.)				
" *magniventer* Hall	....	....	x	
" *inæquiradiata* Hall	....	....	x	x
" *irene* Billings (*S. magnifica* Hall)				
Leptæna rhomboidalis (Wilckens)	x	x	x	x
Strophonella punctulifera (Conrad)	x			
Orthis (*Rhipidomella*) *livia* Billings (*O.* (*R.*) *musculosa* Hall)	....	....	....	x
" (*Dalmanella ?*) *lucia* Billings (*O.* (*D.*) *planiconvexa* Hall)				
" (?) *aurelia* Billings				
Rhynchonella excellens Billings				
" *dryope* Billings				
Camarotœchia pleiopleura Conrad	....	x	x	
Eatonia peculiaris (Conrad)	x	x	x	
**Rensselæria ovoides* (Eaton). 14772	....	x	x	
**Anoplotheca flabellites* (Conrad)	....	x	x	x
Atrypa reticularis Linné. (Authority of Ells.)	x	x	x	x
Spirifer superba Billings (*S. arenosus* Conrad)				
" *arenosus* (Conrad). (Authority of Ells.)	....	x	x	x
" *cyclopterus* Hall (probably = *S. arrectus* = *S. murchisoni*)	x	x	x	
" (*Delthyris*) *raricostus* Conrad	...	....	....	x
Cyrtina affinis Billings	....	x		
Meristella arcuata Hall. (Authority of Ells.)	x			
Sanguinolites tethys Billings				
Goniophora mediocris Billings				
Mytilarca canadensis Billings (*M.* sp. undet. Cayuga, Ontario)				
" *nitida* Billings	....	....	x	
Actinopteria textilis arenaria Hall. (Authority of Ells.)				
Leptodomus canadensis Billings				
" *percingulatus* Billings				
" *mainensis* Billings				
" *pembrokensis* Billings				
Anodontopsis ventricosa Billings				
Cypricardinia distincta Billings (*C.* sp. undet., Becraft)				
Murchisonia hebe Billings. 14788				
Diaporostoma affinis (Billings) (*D. ventricosa* Conrad)				
Pleurotomaria voltumna Billings				
" *delia* Billings				
" *lydia* Billings				
Bellerophon planus Billings				
Proetus phocion Billings				

From the foregoing list it is seen that the Oriskany fauna of "division 8" of the Gaspé limestones has 47 species, of which 27 are not known to occur elsewhere. The 20 species having wide distribution are, with one exception, brachiopods, and 16 of these are Oriskany species, while 2 are Helderbergian and 2 are Onondaga forms. It is the brachiopods that indicate the age of these Gaspé limestones. Of the 19 widely distributed forms, 12 occur in the Lower Oriskany and 14 in the Upper Oriskany. The evidence, therefore, as far as numbers are concerned, is non-committal as to which of the two Oriskany horizons "division 8" should be referred. If the components of this fauna are analyzed, the evidence is somewhat in favor of placing it in the Upper Oriskany. This proof lies either in the degree of development or size of the species when compared with the same forms in Upper Oriskany faunas. The Campbell River locality indicates more definitely the Upper Oriskany horizon.

The reason that so many species are restricted to Gaspé is probably to be found in the difference in the sediments, indicating deeper water. In the Appalachian region the deposits are almost always sandstones—at least those from which the writer has seen fossils—while in Gaspé limestones predominate. Corals and mollusks are rare in the Appalachian faunas, while in the Gaspé fauna they give it a distinct facies.

The great numbers of brachiopods common to Gaspé and the Appalachian Oriskany show that the two areas had free communication, since in their faunal aspect they are almost identical. In fact there is greater diversity in the brachiopods of the Lower Oriskany of Tennessee and New York, than in those of the Upper Oriskany of Gaspé, New York, and Ontario.

Nova Scotia, Canada.—In Nova Scotia, in the region of Nictau, the Oriskany is present and is described by Sir William Dawson* as follows:

"We reach a band of highly fossiliferous peroxide of iron, with dark colored, coarse slates. . . . The fossils of the ironstone and the accompanying beds, as far as they can be identified, are *Spirifer arenosus*, *Stropheodonta magnifica*, *Atrypa unguiformis* [= *Hipparionyx proximus*], *Strophomena depressa* [= *Leptæna rhomboidalis*], and species of *Avicula*, *Bellerophon*, *Favosites*, *Zaphrentis*, etc. These Professor Hall compares with the fauna of the Oriskany sandstone. The most abundant fossil is *Spirifer nictauvensis* Dawson.

"To the southward of the ore, the country exhibits a succession of ridges of slate holding similar fossils, and probably representing a thick series of Devonian beds, though it is quite possible that some of them may be repeated by faults or folds."

* Acadian Geology, 3d ed., 1878, p. 499.

In the following year Dawson * gave a detailed list of fossils from the Nictau ore and the neighboring beds as follows:

Zaphrentis.
Favosites, like *cervicornis* Edwards and Haime.
Michelinia problematica (Goldfuss).
Stenopora.
Stropheodonta magnifica Hall.
Leptæna rhomboidalis (Wilckens).
Spirifer arenosus Hall.
Spirifer murchisoni Castelnau.
Spirifer nictauvensis Dawson.
Hipparionyx proximus Vanuxem.
Anoplotheca flabellites (Hall).
Rensselæria ovoides (Eaton).
Megambonia lamellosa Hall?
Actinopteria, like *textilis.*
Tentaculites elongatus Hall.
Platyceras.
Bellerophon.
Orthoceras.

Regarding the age of these fossils, he remarks: "The above I hold to be amply sufficient to prove that the beds in which they occur are approximately of the age of the Oriskany sandstone," a conclusion undoubtedly correct.

Doctor H. M. Ami † has more recently studied this Nictau Oriskany fauna, and states that—

"The paleontological evidence at hand from the Nictau district shows the existence there of strata which are for the most part referable to the Devonian system. The following forms are present in several of the collections: *Spirifera arenosa, S. arrecta, Leptocœlia flabellites, Leptostrophia magnifica.* These are of Lower Devonian age and are selected from a considerable number of species as characteristic of that age. . . .

"*Nictau.*—With the exception of the New Canaan limestone fossils, the collections from this region are referable to the Lower or Eo-Devonian epoch. The most complete collection is to be found in the Peter Redpath Museum, and contains 22 species of fossils. The fauna consists, for the most part, of brachiopods, trilobites being very rarely seen. . . .

"*Bear river.*—A very interesting collection made by Doctor Bailey in 1892 has revealed the presence of some 21 distinct species of fossils, whose facies is that of a transitional series. Brachiopoda are predominant, whilst not a single trilobite has been recorded." This fauna is "either at the summit of the Silurian or at the base of the Devonian epoch, the weight of evidence being perhaps in favor of the Eo-Devonian."

Saint Helens Island near Montreal, Canada.—In 1879, J. T. Donald ‡ gave a list of fossils derived from a "dolomitic conglomerate" of Saint Helens island, opposite Montreal. This formation is thus described by Chapman: §

* Canadian Nat., vol. ix, 1879, pp. 6, 7.
† Geol. Survey of Canada, Ann. Rept., vol. vi, 1895, p. 15 Q.
‡ Canadian Nat., vol. ix, 1879, pp. 302–304.
§ Exposition of the Minerals and Geology of Canada, Toronto, 1864, p. 191.

"At Saint Helens island and Round island, opposite Montreal, on isle Bizard, and one or two neighboring localities, some outlying or small isolated patches of conglomeratic rock, referred to the Lower Helderberg division, have been recognized of late years. Their existence was first pointed out by Doctor Dawson. They are made up of fragments of various rocks, gneiss, Trenton limestone, Utica shale, syenite, etc., cemented together by a paste of grayish dolomite. These conglomerates are regarded as patches of strata once continuous with the Lower Helderberg series of New York."

The Saint Helens Island fauna based on Donald's list contains:

Favosites gotlandicus.
Orthis (Rhipidomella) discus (Hall).
Orthis (Rhipidomella) oblata Hall.
Orthis (Rhipidomella) tubulistriata Hall.
Orthis (Rhipidomella) eminens Hall.
Hipparionyx proximus Vanuxem.
Orthothetes deformis Hall?
Strophonella punctulifera (Conrad).
Strophonella (?) *radiata* (Vanuxem).
Stropheodonta varistriata (Conrad).
Leptæna rhomboidalis (Wilckens).
Spirifer concinnus Hall. Very abundant.
Spirifer cyclopterus Hall.
Spirifer, allied to *S. arenosus* (Conrad).
Rhynchotrema formosum (Hall).
Lissopleura æquivavis (Hall).
Uncinulus mutabilis Hall.
Uncinulus nucleolatus Hall.
Camarotœchia ventricosa Hall.
Atrypa reticularis Linné. Very abundant.
Stricklandinia gaspiensis Billings.
Anastrophia verneuili (Hall).
Gypidula galeata (Dalman).
Gypidula pseudogaleata (Hall). Very abundant.
Diaphorostoma depressa (Hall).
Tentaculites helena Donald (has vertical striæ between the annulations).

This assemblage of Silurian, Helderbergian, and Oriskany fossils is remarkable, and the present writer hesitated to accept the identifications of Mr Donald without further proof. He therefore wrote to Professor J. F. Whiteaves, paleontologist of the Geological Survey of Canada, who borrowed the specimens of *Hipparionyx proximus* and *Spirifer* allied to *S. arenosus*, of McGill University and sent them to the writer. These show that the Saint Helens Island fauna includes neither *Hipparionyx proximus* nor "*Spirifer* allied to *S. arenosus*." Both these identifications relate to a *Spirifer* apparently near *S. granulosus* Conrad of the Middle Devonian. *S. arenosus* has a plicated fold and sinus, characters not seen in Donald's specimens. His *Spirifer concinnus* Hall is more like *S. cumberlandiæ*, but the bilobed fold of the dorsal shell is a character which associates his species with *S. mucronatus* Conrad, of the Hamilton.

Under these circumstances, judgment is deferred as to the age of the conglomerates on Saint Helens island.