

PALEONTOLOGY OF THE LITTLETON AREA,
NEW HAMPSHIRE.*

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INTRODUCTION.

The Littleton area is located in the west-central part of New Hampshire. The district is of special geologic interest because of its fossil localities. These, although few in number, are of great importance to the geology of New England because they form a fossiliferous oasis in a large area of metamorphic and igneous rocks. They are the key to the historical geology of western New Hampshire. Despite this fact the stratigraphic and structural relationships of the rocks in the Littleton area had never been satisfactorily solved.

In an attempt to remedy this situation, the senior author spent the field seasons of 1931, 1932, and 1933 on the problem and has completed the mapping of the geology of the Moosilauke and Littleton (New Hampshire portion) quadrangles. In this work he has been very ably assisted by graduate students at Harvard University; for two seasons by Messrs. Jarvis B. Hadley and Charles B. Moke, for one season by Messrs. Randolph W. Chapman and William F. Jenks, and for part of one season by Messrs. Allen Waldo and Bartlett K. Thorogood. Without their patient help in the areal mapping the present results would be impossible. The junior author spent two weeks in the field, one in June, 1932, and the other in September of the same year. He is responsible for the paleontology, whereas the senior author is responsible for the areal mapping, stratigraphy, and structure. A brief note has already been published on the stratigraphy and paleontology of the area (1)† and a brief comment on the regional significance of our work has been presented (2). A brief description of the structure is found in another paper (3, pp. 148-150).

In addition to our own collection, which is now in the Museum of Comparative Zoölogy at Cambridge, Massa-

* Shaler Memorial Series, Publication Number 34.

† Numbers in parenthesis refer to bibliography at end of paper.

chusetts, the junior author has studied the Middle Silurian collection for Littleton in the U. S. National Museum. So far as we know this is the only other important existing collection of fossils from the locality. A few specimens at Dartmouth College and in the Boston Museum of Natural History were also examined.

We wish to take this opportunity to express our gratitude to the many friends who have aided this investigation. Professor P. E. Raymond has been very patient and helpful in discussing numerous problems concerning the identification of specimens and in criticizing the manuscript. Drs. Cooper, Ulrich, and Bassler were most courteous to the junior author during his visit to the U. S. National Museum, and Dr. G. A. Cooper, in particular, made valuable suggestions concerning the identification of several of the brachiopods. Miss M. Grace Wilmarth has very kindly discussed with us the names to be used for the various stratigraphic units and states that none of the formation names adopted have been used elsewhere.

The field work, on which this report is based, was financed in part by the Shaler Memorial Fund of Harvard University. The drafting was done by Edward A. Schmitz and the photographs were taken by F. P. Orchard.

STRATIGRAPHY.

The Littleton area contains pre-Silurian, Silurian, and Devonian strata. All the formational names are new with the exception of the "Littleton formation," for Hitchcock's (8, 9, and 10) units were lithologic rather than stratigraphic, and it has proved impossible to use them. In the present paper only a brief outline of the stratigraphy can be given, but the details will be presented by the senior author in a later paper.

The pre-Silurian rocks have been grouped into three formations: the *Albee quartzite*, *Ammonoosuc volcanics*, and *Part-ridge slate*. To date no fossils have been found in them but reconnaissance work by the senior author suggests that they may be younger than the fossiliferous Middle Ordovician of eastern Vermont (14), therefore, Upper Ordovician.

The Middle Paleozoic rocks have been divided into three formations: *Clough conglomerate*, *Fitch formation*, and *Littleton formation*. The *Clough conglomerate* is a very pure quartz conglomerate and quartzite which ranges in thickness

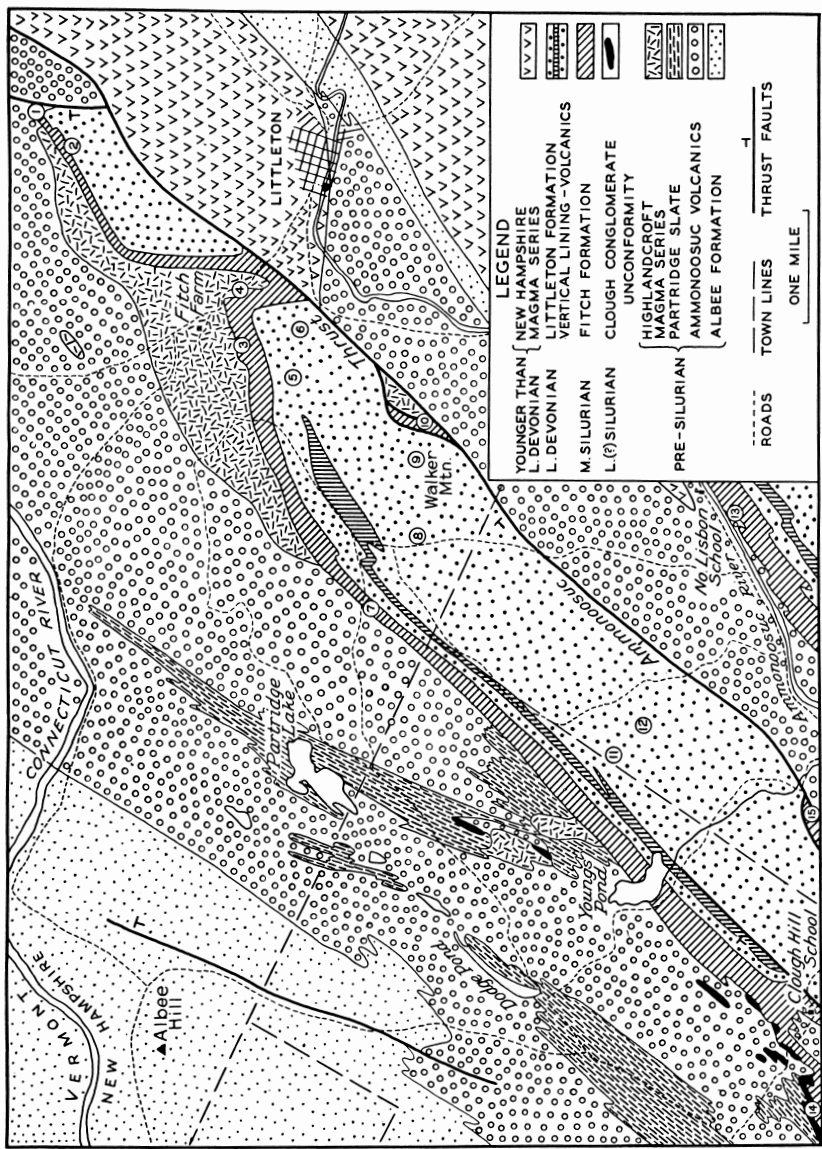


FIG. 1. Geologic map of the Littleton area, New Hampshire (part of Littleton and Moosilauke quadrangles). Areal geology by Marland Billings, assisted by Randolph W. Chapman, Jarvis B. Hadley, William F. Jenks, Charles B. Moke, Allen Waldo, and Bartlett K. Thorogood. Surveyed in 1931, 1932, and 1933. Numbers surrounded by circles indicate fossil localities discussed in text. For cross section see this Journal, vol. 25, p. 149, 1933.

from 0-200 feet. It is absent from most of the Littleton quadrangle due to overlap, but is well developed in the Moosilauke quadrangle (see Fig. 1). No fossils have been found in this formation, but since it is separated from the underlying rocks by a pronounced unconformity, and is transitional into the overlying Fitch formation, which is known to be Middle Silurian, we believe that the Clough conglomerate is Middle or Lower Silurian. The name is taken from the Clough Hill district, in the southwest corner of the area (Fig. 1).

The *Fitch formation*, northwest of the Ammonoosuc thrust (see Fig. 1) consists of limestone, calcareous slate, calcareous sandstone, arenaceous dolomite, arkose, and quartz conglomerate. In the belt which cuts across the southeast corner of the area, however, it is strongly metamorphosed, the calcite crystals being larger and such new minerals as biotite, diopside, andesine, and muscovite appearing. It ranges in thickness from 400 to 700 feet, and, as will be shown later, is of Middle Silurian age. The name is taken from the Fitch farm, two miles northwest of Littleton.

The *Littleton formation*, northwest of the Ammonoosuc thrust, consists of slate, sandstone, and volcanic rocks. In the area covered by the extreme southeastern corner of the map the rock is more severely metamorphosed, such new minerals as biotite, garnet (almandine), staurolite, and hornblende appearing. The formation is believed to be 5000 feet thick. On the basis of its fauna it is referred to the Oriskany (Lower Devonian). The name was proposed by C. P. Ross (15, p. 284).

PALEONTOLOGY OF THE FITCH FORMATION.

Fossils were first found in the Fitch formation, of Middle Silurian age, by C. H. Hitchcock in 1870 (6), apparently in some old quarries about two miles north of Littleton (locality 1 on Fig. 1). He submitted them to Elkanah Billings who identified them as Helderberg (6 and 8, vol. II, p. 339). In 1873 Hitchcock discovered the now famous locality at the Fitch farm and submitted his new collection to Billings, who this time stated that the rocks were "Upper Silurian" (our modern Silurian) or Lower Devonian (7, p. 476, and 8, vol. II, p. 340). In 1882 Hitchcock sent a collection to R. P. Whitfield who concluded that the strata were of "Middle Silurian" age, "probably Niagaran" (16).

In 1885 T. N. Dale collected material at the Fitch farm and in 1886 published a short list (5). In 1888 Pumpelly (13) published a list of species based on the material collected by Dale and identified by Walcott and Rominger. They assigned the strata to the Niagaran. In 1902 Hitchcock (9, p. 462) made a new collection from the Fitch farm and submitted the material to Schuchert, who prepared a new list, based in part on the new material and in part on the old material collected by Dale. Like most of his predecessors he concluded that the strata were Niagaran. Shortly thereafter, A. E. Lambert (9, pp. 480-482 and 10) proposed a new specific name for one of the trilobites, calling it *Dalmanites lunatus* (see pages 426-427 in this report). He concluded that the fossils "indicate a period in which the life of the Niagaran was passing over into that of a later period."

As will be shown later, we agree with most of our predecessors in assigning the Fitch formation to the Niagaran (Middle Silurian). In view of the fact that the specimens have never been described in detail or figured, we believe a careful discussion is justified.

The best faunule for the Fitch formation was found on the farm of G. E. Fitch, two miles west of Littleton. The fossil locality lies about one-third of a mile south of the house, and is designated as locality 3 on Fig. 1. The fossils are found in two beds, one a recrystallized limestone or marble, about twenty feet above the base of the formation, the other a calcareous slate—the "trilobite slate" of previous writers—about 40 feet above the base of the formation.

FAUNULE A. (Locality 3 of Fig. 1.)

Locality—The Fitch farm two miles northwest of Littleton. The classic collecting place is on top of a knoll surrounded by a growth of pine trees. The fossils occur in a recrystallized limestone and an overlying calcareous slate.

Limestone faunule—

- Cup corals gen. et sp. ind.,
- Favosites sp. ind. (two different species),
- Halysites sp. ind.,
- Stromatoporoid gen. et sp. ind.,
- Crinoid columnals,
- Conchidium nettlerothi Hall and Clarke,
- Atrypa cf. A. reticularis (Linn.),
- Spirifer sp. ind.

Calcareous slate faunule—

Bryozoa gen. et sp. ind.,
 Strophonella funiculata (McCoy),
 Leptaena rhomboidalis (Wilckens),
 Pterinea cf. P. emacerata (Conrad),
 Calymene sp. ind.,
 Dalmanites limulurus Green.

The junior writer has examined the collection in the U. S. National Museum and compared the specimens in the list identified by Schuchert with those in our own collection. The identifications by the junior writer are practically identical although our list contains fewer specimens. For the sake of comparison the two lists are placed below:

CLEAVES.	Limestone.	SCHUCHERT.
Cup corals,		
Favosites (two diff. species),		Favosites (two diff. species),
Halysites sp. ind.,		Halysites catenularia,
		Syringopora,
Stromatoporoid gen. et sp. ind.,		Stromatopora,
Crinoid columnals,		
Conchidium nettlerothi,*		Conchidium cf. knighti,
Atrypa cf. A. reticularis,		
Spirifer sp. ind.		
		Gastropod.
	<i>Calcareous slate.</i>	
		Cup coral,
		Favosites,
Bryozoa gen. et sp. ind.,		
Strophonella funiculata,		Conchidium cf. knighti,
Leptaena rhomboidalis,		Strophonella cf. funiculata,
		Leptaena rhomboidalis,
		Rhynchonella (Wilsonia?),
		Atrypa reticularis?,
		Spirifer cf. sulcatus,
		S. plicatella or S. niagarensis,
Pterinea cf. P. emacerata,		Pterinea cf. emacerata,
Calymene sp. ind.,		Calymene tail,
Dalmanites limulurus.		Dalmanites cf. caudatus and limulurus (Walcott named it limulurus).

* C. nettlerothi is the same specimen as has been called C. knighti.

Earlier workers identified several species of *Favosites* from the limestone, but after an examination of a number of these forms (in the collections at Dartmouth and the Boston Museum of Natural History) we seriously question their specific identification. Although it is believed that more than one species is represented in our collection (massive and ramose forms), no reliable specific identification can be made. The specimens which we believe to be *Dalmanites limulurus* have been variously named from this locality. The difficulty has arisen from their distorted condition. After an examination of numerous examples it is believed that only one species is represented and that is the form generally recognized from this locality as *D. limulurus*.

A study of this formation as a whole reveals that in our collection there are but four diagnostic fossils from which to judge the age. These are *Conchidium nettlerothi*, *Strophonella funiculata*, *Pterinea* cf. *P. emacerata*, and *Dalmanites limulurus*. These are outstanding Middle Silurian (Niagaran) fossils. In addition to these the presence of *Favosites*, *Halysites*, *Leptaena*, *Atrypa*, and *Calymene*, in the same beds, is strong evidence of Middle Silurian age.

In addition to the faunule found at Fitch farm poorly preserved fossils have been found at seven other localities (Fig. 1: numbers 1, 4, 7, 10, 13, 14, and 15). At those localities, which are in the same structural belt as the Fitch farm locality (1, 4, 7, and 14) the fossils are *Favosites*, *Halysites*, cup corals, and crinoid columnals. In the discontinuous belt of the Fitch formation just northwest of the Ammonoosuc thrust (localities 10 and 15) only crinoid columnals have been found. At locality 13, near North Lisbon School, only crinoid columnals have been found, but their presence is rather remarkable for the rocks have been intricately crumpled. The strata have been intruded by a dike of amphibolite, and are now recrystallized to marble (in which crinoid columnals occur), mica schists, and a lime-silicate rock consisting of diopside, actinolite, andesine, and quartz.

PALEONTOLOGY OF THE LITTLETON FORMATION.

Lahee (11 and 12) was the first to discover fossils in the Littleton formation and concluded that the strata enclosing them were probably Lower Devonian. He found fossils at a number of isolated localities, but in most cases the material

was poorly preserved. From one locality, perhaps identical with our Tip Top Hill station (Fig. 1, locality 8), he identified four specimens. John M. Clarke, who examined the collection, said in a letter to Lahee, "I should hesitate to identify any single species among them, although they are to me conclusively early Devonian" (12, p. 249).

The best collecting in this formation is at Tip Top Hill. Here several hundred specimens were gathered. They were largely confined to a lens about ten feet long and six inches thick of medium-grained, gray sandstone. Evidently this represents a pocket into which the fossils were crowded, for extensive prospecting along the strike of this zone failed to reveal additional specimens. Since the exposed part of this bed had been removed, blasting must be resorted to if a larger collection is to be made.

Identification is rendered extremely difficult by shearing which has in many cases distorted and crushed the specimens. The danger of identifying species from such material is appreciated and the junior writer has hesitated to take such a step. However, it is believed that enough distinctive features of several characteristic forms are present to make specific identifications possible. Sufficient typical species are present to establish the Oriskany age of these beds.

FAUNULE B. (Locality 8 of Fig. 1.)

Locality—Tip Top Hill, approximately 100 yards southeast of the farm buildings across the road. The fossils occur in a gray sandstone immediately above a thin bed of slate.

Crinoid columnals,
Platyorthis circularis (Sowerby),
Leptostrophia magna (Hall),
Chonetes canadensis Billings,
Chonetes hitchcocki n. sp.,
? Schizophoria sp. ind.,
? Atrypa reticularis (Linnaeus),
Spirifer murchisoni Castlenau,
Leptocoelia sp. ind.,
Pterinea radialis Clarke,
Gastropod gen. et sp. ind.

FAUNULE C. (Locality 11 of Fig. 1.)

Locality—Mormon Hill, 6½ miles southwest of Littleton near Youngs Pond (Ogontz Lake). The fossils occur in interbedded

gray sandstone and black slate all along the western face of the hill. They may also be found in isolated outcrops in the fields lying to the west of the hill. Whereas the fossils at this locality are not as abundant as at Tip Top Hill they are more widely distributed.

Crinoid columnals,
Leptostrophia magna (Hall),
Schuchertella cf. *S. becraftensis* (Clarke),
Leptaena rhomboidalis (Wilckens),
Chonetes sp. ind.,
Spirifer murchisoni Castlenau,
Tentaculites schlotheimi Koken.

Very poorly preserved specimens have also been found at localities 2, 5, 9, and 12. Lahee (11 and 12) reported finding traces of fossils at locality 6, but we were not successful.

These faunules are of great importance because they provide a new geological landmark in the perplexing assemblage of sedimentary, igneous, and metamorphic rocks in New Hampshire. Hitherto the recognition of Devonian sediments has been conjectural and uncertain. In addition they permit correlation with fossil-bearing sandstones in northern Maine which have long been established as of Oriskany age. These sandstones are in the Moose River formation and are found in the region around Moosehead Lake (4 and 17).

The bulk of the Littleton fauna consists of brachiopods, the large numbers of pelecypods and gastropods known from the Moose River formation being absent. However, most of the Littleton fossils thus far found are represented in that formation, by identical or related forms. The striking similarity to the Grand Grève formation in Quebec, and the New York Oriskany is also an important feature, as is illustrated in the table below.

The evidence shown in the table indicates a very close relationship of the Littleton fauna with those of the Grand Grève, Moose River, and New York Oriskany faunas. There is little doubt but that most of these formations are of the same age. The Dalhousie, generally recognized as of Helderberg age, contains only three of the Littleton forms and since these are all long-range types they have no significance. The Chapman sandstone of Maine, which is considered to be slightly older than the Moose River sandstone (17, p. 12), contains four typical Littleton fossils of which one is long range. If

Table Showing Age Distribution of Littleton (Devonian) Fossils in Maine, Quebec, and New York.

	D	GG	MR	C	NY
Platyorthis circularis.....		o			o
Leptostrophia magna.....		x	x	o	x
Schuchertella cf. S. becraftensis.....		x			x
Leptaena rhomboidalis.....	x	x		x	x
Chonetes canadensis.....		x	x		
C. hitchcocki n. sp.....			x		
C. sp. ind.					
?Schizophoria.....	x	x			
?Atrypa reticularis.....	x		x		
Spirifer murchisoni.....		x	x		x
Leptocoelia.....		o	o		o
Pterinea radialis.....			x	x	
Gastropod gen. et sp. ind.....					
Tentaculites schlotheimi.....			x	x	

Legend:

x Same species.

o Related form.

D—Dalhousie, GG—Grand Grève, MR—Moose River, C—Chapman, NY—New York Oriskany.

Summary of table:

	D	GG	MR	C	NY
Number of Littleton fossils in other formations.....	3	8	8	4	6
Of these there are the following long-range forms.....	3	3	2	1	2

this formation is considered to be slightly younger than the Helderberg and a little older than the Oriskany it is quite conceivable that a number of forerunners of the Oriskany fauna might be present.

A comparison of the Littleton fauna with the typical Oriskany fossils of New York reveals that the specimens in the former formation are generally smaller. Although one is impressed by the Oriskany aspect of the Littleton fauna, a critical examination of the material shows, in some instances, slight variations. This does not seem illogical if the conditions of the environment in New Hampshire were somewhat different from those which obtained during the deposition of the Oriskany strata in New York and Pennsylvania. The strata may possibly be a little older, and the fossils less highly developed than those a few hundred miles to the west and south. It appears from Dr. Clarke's descriptions, that such common fossils as *Rensselaria* and *Hipparionyx* are represented in Gaspé and Maine by smaller individuals than those in New York. It is probable that ecological factors, such as,

for instance, the amount of available food, may enter into the explanation of these differences.

Reference to the geologic map (Fig. 1) shows that the two localities, 8 and 11, at which diagnostic fossils have been found lie about 2500 to 3000 feet southeast of the line which shows the position of the base of the Littleton formation. The strata are essentially vertical and in so far as we can learn, there is no evidence of repetition by folding; for example, the sharp angles shown in the contacts of the volcanic member of the Littleton formation northwest of locality 11 and north of locality 8 are sedimentary, not structural features. The two good fossiliferous zones are, therefore, from 2500 to 3000 feet above the base of the Littleton formation. Strictly speaking, therefore, we can only say that the middle part of the Littleton formation has been demonstrated to be of the same age as the Moose River and the Oriskany. It is possible that the lower portion is older than the Oriskany and that the upper portion is younger. The few poorly preserved specimens found near the base of the formation—locality 2—and in the upper portion—locality 9—as far as we can judge do not differ greatly from the Oriskany forms of localities 8 and 11.

DESCRIPTIVE PALEONTOLOGY.

SILURIAN FOSSILS.

Coelenterata

Cup corals, gen. et sp. ind.

Simple conical corals becoming conico-cylindrical in some of the larger specimens. The septa show up well on the exteriors of the specimens, but recrystallization has destroyed all trace of the internal structure. The specimens found at Fitch Farm (locality 3) are very small whereas those found at locality 14 are of moderate size.

Locality: Fitch Farm; (locality 3), $\frac{3}{4}$ mile W Clough Hill School (loc. 14).

Museum Comp. Zoölogy, No. 9316.

Favosites sp. ind.

Two different types (massive and ramose) of *Favosites* were collected, but so much of the detail of the corallites is

obscure that no specific determinations may be safely made. Some specimens consist of hemispherical heads, others, although massive, possess no definite shape, having been crushed during the metamorphism of the rock. In no specimen is the preservation good enough to show mural pores although in one (M. C. Z., no. 9317) closely spaced tabulae are seen.

Locality: Fitch Farm (loc. 3); $\frac{1}{2}$ mile NW Parker Mountain (loc. 1); $\frac{1}{2}$ mile E Slate Ledge School (loc. 7); $\frac{3}{4}$ mile W Clough Hill School (loc. 14).

Museum Comp. Zoölogy, Nos. 9317, 9318.

Halysites sp. ind.

Although several specimens of *Halysites* were collected, in no case is the preservation sufficiently good to permit specific identifications. One specimen, however, does show closely spaced and well developed tabulae. The coralla are composed of cylindrical, compressed corallites joined in intersecting and branching laminae. The latter consist of rows of corallites united along the whole of their adjoining sides.

Locality: Fitch Farm (loc. 3); $1\frac{1}{4}$ miles NW Littleton on the St. Johnsbury Road (loc. 4).

Museum Comp. Zoölogy, No. 9319.

Stromatoporoid gen. et sp. ind.

The single specimen of a stromatoporoid obtained does not show sufficiently detailed structure to identify the genus or species. It is small and globular; a polished section shows concentric laminations. Thin sections show the laminae and indistinct, continuous radial pillars. Specimens in the National Museum show larger and better defined expansive types, with astrorhizae and radial canals.

Locality: Fitch Farm (loc. 3).

Museum Comp. Zoölogy, No. 9321.

Bryozoa gen. et sp. ind.

The one fragmentary specimen in the collection resembles a fenestellid type of bryozoan. It shows a reticulated expansion of slender, frequently bifurcating branches, which are

united by thin dissepiments. The fenestrules are elongate-oval, but their shape is accentuated by distortion. No apertures were observed.

Locality: Fitch Farm (loc. 3).
Museum Comp. Zoölogy, No. 8708.

Brachiopoda.

Strophonella funiculata (McCoy).

Plate II, Fig. 10.

McCoy, F.: Synopsis of the Silurian fossils of Ireland, p. 30, plate III, fig. 11, 1846.

Bastin, E. S., and Williams, H. S.: Eastport Folio, U. S. Geol. Survey No. 192, p. 6, 1914.

This species is represented by two specimens, both small and somewhat distorted. The hinge-line is straight and extended; outline subquadrate; surface multicostellate. Striae narrow and deep; costellae show a central groove increasing in strength toward the front. One specimen shows the anterior commissure faintly uniplicate, but this is misleading and was apparently caused by the metamorphism of the rock. The other specimen is drawn out laterally as are specimens in the U. S. National Museum. The outline of the figured specimen is doubtless due to the crushing of the rock. The cardinal angles are subauriculate, and the specimens are geniculate.

Locality: Fitch Farm (loc. 3).
Museum Comp. Zoölogy, No. 8660.

Conchidium nettlerothi Hall and Clarke.

Plate II, Figs, 8, 9.

Hall and Clarke: Paleontology of New York; Vol. 8, pt. 2, p. 234, 1893.

Two specimens of this species were collected. The shells are subtriangular in outline with a very short hinge-line. One specimen (plate II, fig. 9) is that of a small dorsal valve, and the other (plate II, fig. 8) a ventral valve. Both valves are strongly convex, but the dorsal valve has the greater convexity. Commissure not seen in the dorsal, but is rectimarginate in the ventral valve. Narrow, shallow, and straight sulcus in the dorsal valve. No fold observed in the ventral valve; shell structure partly worn away showing position of

median septum. Umbo swollen; shell multicostate. No details of the interior may be seen. This is the *Pentamerus knighti* of Nettleroth.

Locality: Fitch Farm (loc. 3).

Museum Comp. Zoölogy. Nos. 8655, 8656.

Leptacna rhomboidalis (Wilckens).

Hall and Clarke: *Paleontology of New York*; Vol. 8, pt. 1, p. 279, pl. 8, figs. 17-19, 1892.

This is a small specimen, roughly semicircular in outline. The costellae are thin and flexuous, about equal in width to the interspaces, multicostellate. The transverse wrinkles on the surface of the shell are especially strong on the lateral portions.

Locality: Fitch Farm (loc. 3).

Museum Comp. Zoölogy, No. 8665.

Atrypa cf. A. reticularis (Linnaeus).

Hall, J.: *Paleontology of New York*; Vol. 2, pp. 72-73, pl. 13, figs. 8a-e, 1852.

Two specimens of this form were collected, one from the calcareous slate and one from the limestone. Both have been severely crushed.

Shell subcircular, moderately convex, multicostellate; costellae bifurcate near anterior margin. They are left faintly nodose by the crossing of elevated lines of growth. Each is believed to be a dorsal valve.

Locality: Fitch Farm (loc. 3).

Museum Comp. Zoölogy, Nos. 8657, 8658.

Spirifer sp. ind.

Only one small, distorted *Spirifer* was collected. It is a dorsal valve on which there is a high fold and three strong costae beside it. The length of the hinge-line and the nature of the cardinal extremities is not known because of the fragmentary condition of the specimen. No detailed surface ornamentation is present. This may be the *Spirifer cf. sulcatus* identified from this locality by Schuchert.

Locality: Fitch Farm (loc. 3).

Museum Comp. Zoölogy, No. 8659.

Mollusca.
(Pelecypoda).

Pterinea cf. *P. emacerata* (Conrad).

Plate II, Fig. 15.

Hall, J.: Natural History of New York, Part IV, Geology (4th district), pp. 108 and 109, 1843.

Hall, J.: Paleontology of New York; Vol. 2, p. 83, pl. 27, 1852.

This species is represented by one fairly well preserved specimen and several badly distorted ones. The outline is semi-elliptical, valve slightly convex, longer than high. Surface ornamented by fine elevated radiating lines, which diverge toward the margin and are crossed by fine concentric lines which give the surface a faintly cancellated appearance. Anterior wing obscure, posterior wing partly broken away, but well enough preserved to show the presence of radiating and concentric lines upon it.

Locality: Fitch Farm (loc. 3).
Museum Comp. Zoölogy, No. 1855.

Arthropoda.

Trilobita.

Calymene sp. ind.

The only specimen found is a fragmentary cephalon showing a convex, globular glabella. Two pairs of glabellar furrows and three glabellar lobes are present. The latter are seen on the right side only and the first is faint. Fracturing of the specimen has destroyed other parts.

Locality: Fitch Farm (loc. 3).
Museum Comp. Zoölogy, No. 1855.

Dalmanites limulurus Green.

Plate II, Figs. 11-14.

Dalmanites limulurus. Green, J.: Monograph on the Trilobites of North America; p. 48, 1832.

Hall, J.: Paleontology of New York; Vol. 4, p. 101, figs. 1-2, 1843.

Dalmanites lunatus. Lambert, A. E.: Geol. Soc. Amer., Bull. Vol. 15, pp. 480-482, 1904.

A large number of fragments of this species has been collected. Two show most of the cephalic shield, several others portions of free-cheeks with genal spines, and twelve show entire or fragmentary pygidia. The glabella is pustulose and the frontal margin of the cephalon is lingulate.

These specimens appear to be identical with those described

as *Dalmanites lunatus* by Lambert. There is little doubt of their being the same species, but so far as the writer can see, there is no reason why they cannot be identified as *Dalmanites limulurus* Green. The cephalic shield also shows the presence of cephalic denticulations, which were said to be absent by Lambert. A comparison with specimens of *D. limulurus* in the Museum of Comp. Zoölogy shows that the nature of these denticulations varies considerably, some specimens lacking them.

Lambert established his species upon the lunate shape of the cephalic shield and its proportions. This is believed by the junior writer to be inadvisable, inasmuch as the original proportions have been destroyed during the shearing of the rocks in which the specimens are found. He also cited as characteristic the great anterior breadth of the pygidia and the shortness and acutely triangular nature of the pygidial spine. Several specimens in this collection show such features but others exhibit the normal type of pygidium and pygidial spine found in *D. limulurus*. The specimens showing abnormalities of breadth of pygidium and shortness of spine have obviously been distorted by the crushing of the rock.

The number of annulations in the axial lobe and the number of ribs of the pygidium are usually 12, and 7 or 8 respectively, as in *D. limulurus*. The ribs are furrowed in the same way. The anterior glabellar lobe extends obliquely forward.

In view of the above facts this trilobite is identified as *Dalmanites limulurus*, and *Dalmanites lunatus* is believed to be a synonym having been mistakenly established as a new species.

Locality: Fitch Farm (loc. 3)

Museum Comp. Zoölogy, Nos. 1856, 1857, 1858, 1859.

DEVONIAN FOSSILS.

Brachiopoda.

Platyorthis circularis (Sowerby).

Plate I, Figs. 2, 3, 6.

Schuchert and Cooper: *Brachiopod Genera of the Orthoides and Pentamerioidea*; Peabody Museum Natural History, Mem. Vol. IV, pt. 1, p. 135, pl. 19, figs. 27-27, 1932.

This species is represented by six specimens, all relatively small ventral valves. Four of them are fragmentary but the two complete ones measure, in length and breadth, 24 and 25

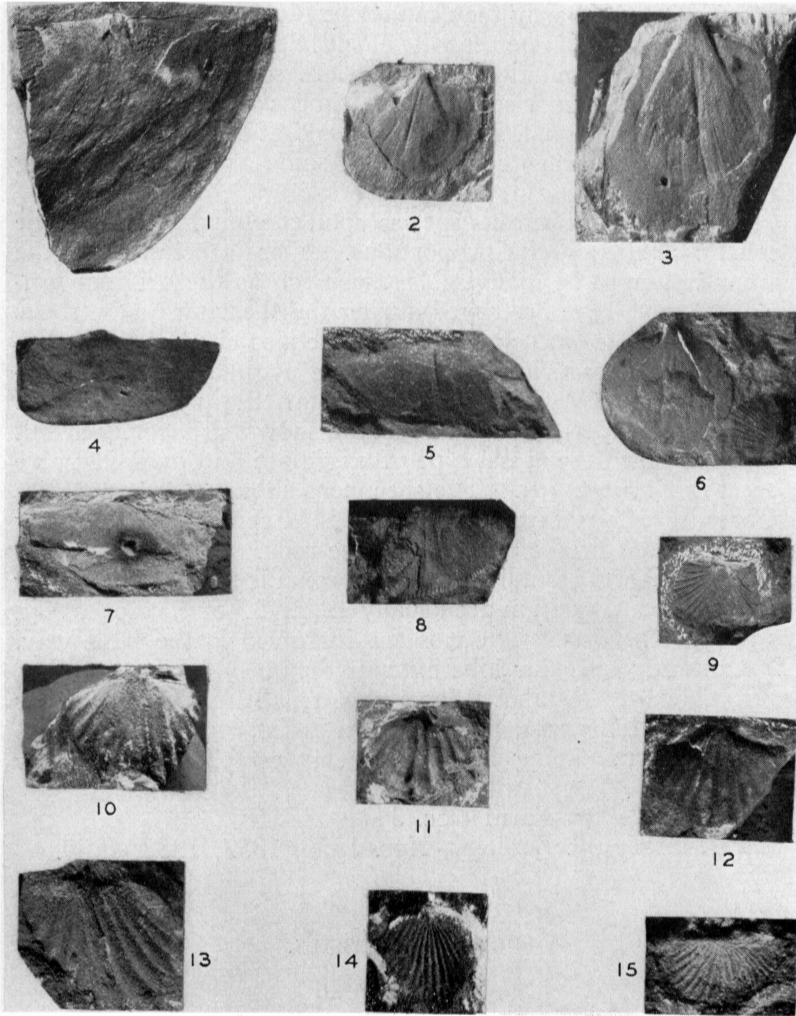


PLATE I. Lower Devonian Fossils.

millimeters, and 23 and 24 millimeters. The largest specimen is 40 millimeters long. The outline is subcircular, the greatest width being at the mid-length. The valves are moderately convex. Ventral umbo swollen, hinge-line short. The surface is multicostellate, fibrous, with neither fold nor sulcus. On the internal cast, the costellae are commonly represented by a narrow fringe around the margin. The muscle field is large, flabellate, occupying more than half of the interior; diductor scars elongate, divided by median ridge on a slight expansion of which are borne small elongate adductor scars. The muscle area is bounded by strong lamellae which diverge at an acute angle.

This shell should not be confused with *Hipparionyx unguiformis* (a nomen nudum) or *Hipparionyx minor* Clarke, both listed from the Chapman sandstone of Maine. Unlike

PLATE I.

- Figure 1. *Leptostrophia magnifica* (Hall).
Figures 2, 3, 6. *Platyorthis circularis* (Sowerby).
Figures 4, 5, 7, 8. *Chonetes canadensis* Billings.
Figure 9. *Schuchertella* cf. *S. becraftensis* (Clarke).
Figures 10-13. *Leptocoelia* sp. ind.
Figure 14. *Chonetes* sp. ind.
Figure 15. *Chonetes hitchcocki* n. sp.

1. *Leptostrophia magnifica* (Hall). $\times \frac{3}{4}$. A ventral valve showing wrinkles, the faint outline of the broad muscle-area, and the strongly pitted area between the muscle scars and the hinge-line. Littleton formation.

2, 3, 6. *Platyorthis circularis* (Sowerby). $\times \frac{3}{4}$. Three typical ventral valves showing the strong, flabellate muscle-scars, and the small abductors on the ridge along the median line. Figure 6 also shows a *Pterinea radialis* on the same block. Littleton formation.

4, 5, 7, 8. *Chonetes canadensis* Billings. $\times \frac{3}{4}$. Four specimens illustrating the large size of this species. Figures 5, 8, show the characteristic fringe on the anterior margins of the cast; they also show the presence of the mid-rib. Littleton formation.

9. *Schuchertella* cf. *S. becraftensis* (Clarke). $\times \frac{3}{4}$. Internal mold showing small size, nearly square outline, and multicostellate surface. Littleton formation.

10, 12. *Leptocoelia* sp. ind. $\times 1\frac{1}{2}$. Specimens of ventral valves showing the high, strongly elevated musculature, and the 5 or 6 rounded costae on either side of the narrow sulcus. Littleton formation.

11, 13. *Leptocoelia* sp. ind. $\times 1\frac{1}{2}$. Molds of dorsal valves showing the position of crural bases. Littleton formation.

14. *Chonetes* sp. ind. $\times 1\frac{1}{2}$. Small ventral valve showing multicostellate surface and nearly square outline. Littleton formation.

15. *Chonetes hitchcocki* n. sp. $\times 1\frac{1}{2}$. Small shell showing straight hinge-line, coarse multicostellate surface, and extended cardinal extremities. Littleton formation.

these forms, *Platyorthis circularis* has no short umbonal septum, no strongly impressed median adductor scars, or acutely diverging dental lamellae. The dental plates diverge widely and are produced forward as sharp ridges along the lateral margins of the diductor scars. It is not known definitely whether or not *Platyorthis* is punctate, although wax squeezes suggest a coarse punctosity. The shelly structure is, however, so recrystallized and the material of the cast so coarse this feature is in doubt.

Locality: Tip Top Hill (loc. 8).

Museum Comp. Zoölogy, Nos. 8666, 8667, 8668, 8669.

Schuchertella cf. S. becraftensis (Clarke).

Plate I, Fig. 9.

Clarke, J. M.: New York State Museum, Mem. Vol. III, No. 3, p. 51, 1900.

Shell small, suborbicular, nearly square in outline, with prominent sharp costellae increasing by implantation. The hinge-line is straight, shorter than the greatest width of the shell which is about half way between the hinge-line and the anterior margin. The specimen is 17 millimeters wide and 14 millimeters long. The umbo is fairly high and slopes with low convexity toward the margins. The dental lamellae diverge at an angle of 115° . The material composing the cast is coarse, and the metamorphism the rock has undergone has obscured much of the finer surface detail.

Locality: Mormon Hill (loc. 11).

Museum Comp. Zoölogy, No. 8670.

Leptostrophia magnifica (Hall).

Plate I, Fig. 1.

Hall, J.: Paleontology of New York; Vol. 3, pp. 414, 482, 1859.

About half a dozen specimens of this species were collected, all in a more or less fragmentary condition. The shell is wider than long, although a few specimens are nearly equidimensional. Front of shell arcuate, curving gently into the rounded sides. Cardinal angles rectangular to subauriculate. Maximum elevation of the shell in the pedicle valve over the muscle area, a varying distance behind the middle. Muscle-scars of the pedicle valve subtriangular, spreading from the beak, divided into at least four lobes on either side of the median line, and extending about two-thirds of the way to the

front of the shell. The margins of the muscle-scars diverge in an acute angle which varies slightly in different specimens. Strong pitting is observed in one specimen in the area between the margin of the muscle-scars and the hinge-line. The pitting becomes less conspicuous toward the hinge-line; other details of the interior are obscure.

The surface is ornamented by fine, distinct, radiating costellae approximately uniform in size and strength. They are rounded or subtriangular, and straight or slightly flexuous. They increase by implantation and in typical forms about 14 occur in a space of 5 millimeters. There are no small, oblique wrinkles in the area of the cardinal angles, as sometimes occur in typical specimens, but the triangular pit in the narrow, posterior part of the muscle area is present.

The shells vary slightly in size, but average about 60 millimeters in width along the hinge-line, and about 45 millimeters in length. These figures show the New Hampshire specimens to be generally smaller than the otherwise similar, typical New York specimens.

Locality: Tip Top Hill (loc. 8) and Mormon Hill (loc. 11).
Museum Comp. Zoölogy, Nos. 8671, 8672.

Leptaena rhomboidalis (Wilckens).

Williams, H. S., and Breger, C. L.: Fauna of the Chapman Sandstone, Maine; U. S. Geol. Survey, Prof. Paper 89, pp. 32-33, 1916.

Shell roughly semicircular, greatest width along the hinge. Costellae thin and flexuous, about equal in width to the interspaces; the wrinkles on the surface of the shell are especially strong on the anterior portion. The specimen collected is small, about 12 millimeters wide and 11.5 millimeters long; it is slightly distorted.

Locality: Mormon Hill (loc. 11).
Museum Comp. Zoölogy, No. 8673.

Chonetes canadensis Billings.

Plate I, Figs. 4, 5, 7, 8.

Billings, E.: Paleozoic Fossils of Canada; Vol. 2, pt. 1, p. 17, fig. 7, 1874.

This is a large, nearly flat *Chonetes*, transversely extended, semi-elliptical in outline, and covered with radiating costellae of which there are 12-18 in the space of 5 millimeters near the anterior margin of a typical specimen. A median rib is present on some specimens. The hinge-line is commonly equal

to the greatest width of the shell. The width and length of three typical specimens are respectively: 35 and 17 millimeters, 36 and 17 millimeters, and 34 and 14 millimeters. The lateral margins vary in their relationship to the hinge-line. In some they are roughly perpendicular to it, whereas in others they curve gently up to it. The anterior margin is a broad flat arch. The pedicle valve is depressed-convex; the brachial valve slightly concave, the shell structure pitted, multicostellate.

Locality: Tip Top Hill (loc. 8).

Museum Comp. Zoölogy, Nos. 8674, 8675, 8676, 8677.

Chonetes hitchcocki n. sp.

Plate I, Fig. 15.

This is a coarsely ornamented *Chonetes* with a small shell and a transversely rectangular outline. The one well preserved specimen is 10 millimeters wide and 5 millimeters long. The greatest convexity is in the middle; cardinal angles flattened; commissure arcuate; hinge-line equal to the greatest width.

The surface is ornamented by about twenty coarse costellae with increase by implantation and bifurcation. Interspaces as wide or wider than the costellae except in the umbonal region. The cardinal spines are not preserved.

This specimen seems to be identical with that identified by Williams and Breger as *Chonetes vicinus* var. *deflecta* Hall from the Moose River sandstone in Maine. A comparison with *C. deflecta* Hall, however, shows that the Littleton form has far fewer and coarser costellae. Furthermore the Littleton specimen measures, length to width as 1 to 2, rather than 4 to 5, or 8 to 9, as in *C. deflecta*. *Chonetes vicinus* is considered as identical with *C. deflecta* by Prosser and Kindle in their report published by the Geological Survey of Maryland. Examination of *C. vicinus* shows it to have a larger number of costellae and a more nearly square outline than the New Hampshire form.

Chonetes hitchcocki resembles *C. jerseyensis* more closely than any other *Chonetes*, yet differs from it in having fewer costellae which do not show a slight anterior curvature as they approach the margin. In addition the proportions of the former are length to width, as 1 to 2, instead of 7 to 11. In view of these differences the New Hampshire specimen is made a new species and attention is called to the fact that this

shell is doubtless the same as that called *C. vicinus var. deflecta* Hall by H. S. Williams and C. H. Breger (17, p. 49).

Locality: Tip Top Hill (loc. 8).
Museum Comp. Zoölogy, No. 8678.

Chonetes sp. ind.

Plate I, Fig. 14.

Shell small, about 12 millimeters in width, moderately convex, with distinct costellae, about 14 in number. Valve slightly longer than wide.

Locality: Tip Top Hill (loc. 8).
Museum Comp. Zoölogy, No. 8679.

? *Schizophoria* sp. ind.

Shell of small size, plano-convex; outline ovate; about twice as long as wide; 13 costellae in about 5 millimeters. Multi-costellate. The costellae curve backward strongly near the posterior margin.

Locality: Tip Top Hill (loc. 8).
Museum Comp. Zoölogy, No. 8680. (Gastropod on same specimen.)

? *Atrypa reticularis* (Linnaeus).

Hall, J.: *Paleontology of New York*; Vol. 2, pp. 72-73, pl. 23, figs. 8a-e, 1852.

Shell with coarse radiating costae; muscle-scars prominent. The one specimen collected has been crushed and severely distorted.

Locality: Tip Top Hill (loc. 8).
Museum Comp. Zoölogy, No. 8681.

Spirifer purchisoni Castlenau.

Plate II, Figs. 1-4.

Williams, H. S., and Breger, C. H.: *Fauna of the Chapman Sandstone, Maine*; U. S. Geol. Survey, Prof. Paper 89, pp. 95-103, 1916.

This *Spirifer* is the most common brachiopod in the Littleton formation and many specimens were collected. It is of medium size, with 6 to 8 strong, rounded to subangular costae on either side of the simple sulcus and fold. The outline is transversely extended, the hinge-line equal to the greatest

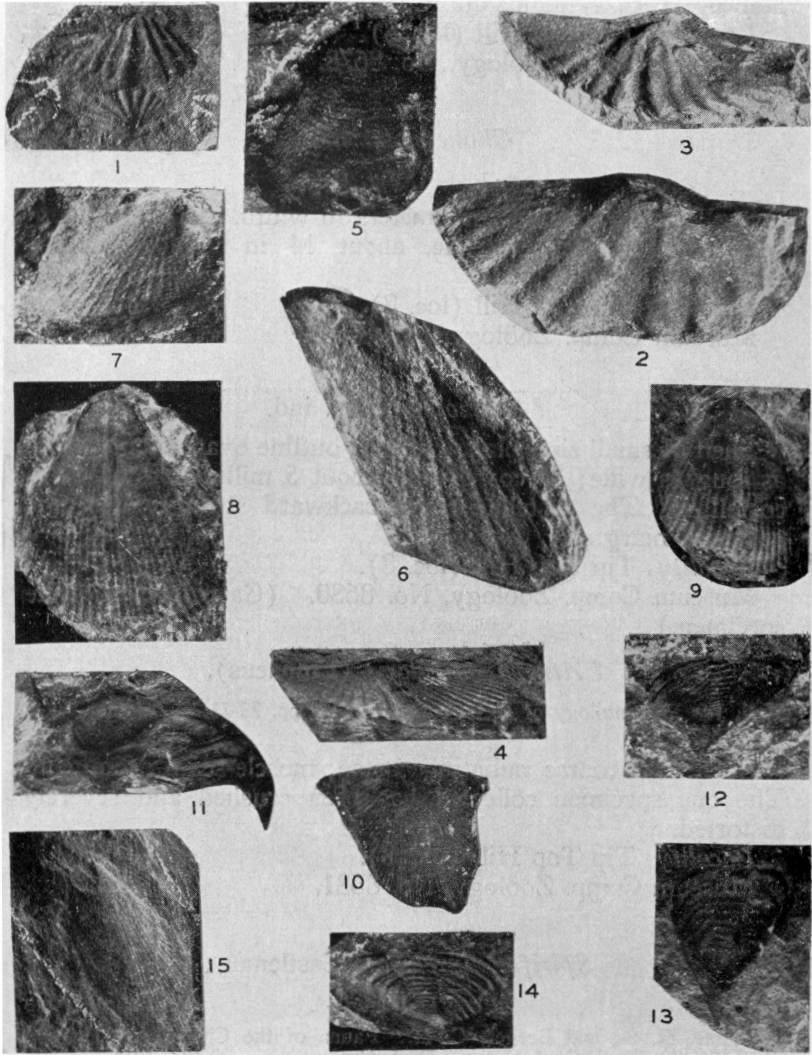


PLATE II. Lower Devonian and Middle Silurian Fossils.

width of the shell. The cardinal extremities are rectangular, and the width of the valves slightly more than twice the length. The costae are wider than the interspaces, and the outer ones are obsolescent. No finer surface ornamentation is visible.

Both ventral and dorsal valves are present. The former is more gibbous than the latter and possesses the strongly elevated muscle area so characteristic of this species. The dorsal valve is slightly convex near the middle and the mesal fold is well rounded and more than twice as wide as any of the costae.

Locality: Tip Top Hill (loc. 8) and Mormon Hill (loc. 11).
Museum Comp. Zoölogy, Nos. 8661, 8662, 8663, 8664, 8665.

PLATE II.

- Figures 1-4. *Spirifer murchisoni* Castlenau.
Figures 5-7. *Pterinea radialis* Clarke.
Figures 8, 9. *Conchidium nettlerothi* Hall and Clarke.
Figure 10. *Strophonella funiculata* (McCoy).
Figures 11-14. *Dalmanites limulurus* Green.
Figure 15. *Pterinea* cf. *P. emacerata* (Conrad).

1, 2. *Spirifer murchisoni* Castlenau. (Figure 1, $\times \frac{3}{4}$; Figure 2, $\times 1\frac{1}{2}$). Internal molds of ventral valves showing strong, simple costae and high muscle area. Littleton formation.

3, 4. *Spirifer murchisoni* Castlenau. (Figure 3, $\times 1\frac{1}{2}$; Figure 4, $\times \frac{3}{4}$). Internal molds of dorsal valves showing characteristic hinge-features. Littleton formation.

5, 6. *Pterinea radialis* Clarke. $\times 1\frac{1}{2}$. Molds of left valves showing both concentric and radial surface markings. Littleton formation.

7. *Pterinea radialis* Clarke. $\times 1\frac{1}{2}$. Mold of right valve showing radial surface markings, a poorly defined anterior wing and a portion of the posterior wing. Littleton formation.

8. *Conchidium nettlerothi* Hall and Clarke. $\times \frac{3}{4}$. A ventral valve, rectimarginate, multicostate, showing median septum. Fitch formation.

9. *Conchidium nettlerothi* Hall and Clarke. $\times \frac{3}{4}$. A dorsal valve strongly convex, with narrow, shallow sulcus. Fitch formation.

10. *Strophonella funiculata* (McCoy). $\times 1\frac{1}{2}$. Small shell with flattened, grooved costellae, slightly geniculate. Fitch formation.

11. *Dalmanites limulurus* Green. $\times \frac{3}{4}$. Cephalon, showing expanded glabella, glabella furrows and lobes, and genal spine. Fitch formation.

12-14. *Dalmanites limulurus* Green. $\times 1\frac{1}{2}$. Pygidia showing rachis with annulations, furrowed pleural ribs, and terminal spine. Fitch formation.

15. *Pterinea* cf. *P. emacerata* (Conrad). $\times \frac{3}{4}$. Mold of left valve showing concentric and radial surface markings, small posterior wing and indistinct anterior wing. Fitch formation.

Leptocoelia sp. ind.

Plate I, Figs. 10-13.

Hall, J.: Paleontology of New York; Vol. 3, p. 450, 1859.

This is a small shell in which the width is slightly greater than the length. There are from four to six strongly elevated, well-rounded costellae on either side of the simple fold and sulcus. On the dorsal valve the two central ones are slightly more prominent and stronger than the others. They are wider than the interspaces. The ventral valve is only slightly convex; the dorsal valves nearly flat in some forms are gently convex in others. The beak is elevated above the hinge-line. The outline is somewhat pentagonal. The posterior margin of the ventral valve slopes at a slight angle from the beak to the cardinal angles. Any angular measurements of the inclination of this margin outward from the beaks are unreliable because of the severe pressure to which all of the specimens have been subjected. Oblique lamellae and the position of the bases of the crural processes may be seen in figures 11 and 13. Measurements of a few valves show the following dimensions: the lengths and widths are, respectively, 11 and 12 millimeters, 12 and 15 millimeters, 17 and 17 millimeters, and 11 and 18 millimeters. These specimens bear a slight resemblance to those of the *Antispirifer* described by Williams from the Moose River sandstone in Maine, but an examination of his types in the U. S. National Museum shows them to be of a different genus.

Locality: Tip Top Hill (loc. 8) and Mormon Hill (loc. 11).
Museum Comp. Zoölogy, No. 8682a, b, c, and d.

*Mollusca.**Pelecypoda.**Pterinea radialis* Clarke.

Plate II, Figs. 5-7.

Clarke, J. M.: New York State Museum, Bull. 107, p. 207, 1907.

Williams, H. S., and Breger, C. L.: Fauna of the Chapman Sandstone, Maine; U. S. Geol. Survey, Prof. Paper 89, pp. 184, 1916.

The collection consists of a dozen specimens well enough preserved to show the outline and surface ornamentation. In only one or two of these are the wings preserved. The outline is obliquely rhomboid; height less than length and greatest just back of the middle. Hinge-line long, straight on both

sides of the beaks. The posterior end is acutely pointed; the anterior end rounded. The valves are ornamented with radial riblets, 16 to 32 in number, increasing by implantation. The radial ornamentation is not observed on the wings but the latter show, in some instances, fine concentric lines of growth. These are conspicuous on the body of the shell and in places aggregate into low, distinct varices. The oblique axis of the shell is inclined about 60° to the hinge-line. The average size of the specimens is about 17 millimeters high and 20 millimeters long.

The New Hampshire specimens are unquestionably of the same species described by Clarke and by Williams from the Chapman sandstone in Maine. Clarke, in his original description of the species, pointed out that there was some variation within the group and Williams and Breger referred the smaller specimens to the genus *Actinopterella*. The chief difference between Clarke's original *Pterinea radialis* and Williams and Breger's *Actinopterella radialis* is one of size.

Locality: Tip Top Hill (loc. 8).

Museum Comp. Zoölogy, Nos. 15056, 15057, 15058.

Gastropoda.

Gastropod gen. et sp. ind.

A single, poorly preserved specimen is a low spired shell showing only three whorls. Revolving ornamentation is present but other diagnostic features are obscure.

Locality: Tip Top Hill (loc. 8).

Museum Comp. Zoölogy, No. 27908.

Tentaculites schlotheimi Koken.

Williams, H. S., and Breger, C. L.: Fauna of the Chapman Sandstone, Maine; U. S. Geol. Survey, Prof. Paper 89, pp. 283-284, 1916.

Shell with eleven millimeters of its length showing. Eight annulations show in the space of 5 millimeters. The cone tapers from 2 millimeters in thickness to 1 millimeter near the apex. The annulations show an interspace nearly twice the width of a rib. The latter are strongly elevated and the interspaces are deeply excavated. Other finer ornamentation is obscure.

Locality: Mormon Hill (loc. 11).

Museum Comp. Zoölogy, No. 27907.

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