University of the State of New York

# BULLETIN

OF THE

# New York State Museum

FREDERICK J. H. MERRILL *Director*

No. 42 Vol. 8

April 1901

## HUDSON RIVER BEDS NEAR ALBANY

AND THEIR

## TAXONOMIC EQUIVALENTS

BY

RUDOLF RUEDEMANN Ph.D.

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1901

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# HUDSON RIVER BEDS NEAR ALBANY

AND THEIR

# TAXONOMIC EQUIVALENTS

## INTRODUCTION[1]

The study of a rich graptolite fauna from the vicinity of the city of Hudson, Columbia co., identical with the Normans kill fauna of Kenwood, Albany co., made known by the late Prof. Hall, impressed the writer with the great uncertainty still prevailing among geologists as to the age of these shales and with the wide differences in their stratigraphic assignments by various writers. To illustrate this condition the most important of these differing views may be cited. While Hall finally placed the graptolite-bearing shales of Normans kill above the Utica shale and in the Hudson river beds, asserting their homotaxy with the Lorraine beds, Whitfield and Walcott have considered them a part of the Utica shale formation. Lapworth and Gurley assign them to the Trenton stage, and Ami is inclined to regard them as lying below the Trenton and above Chazy limestone. Frech recently cites graptolites of this zone as from the "Utica shale of Normans kill."

Such an apparent inability to correlate properly a terrane with such a rich fauna would seem inconceivable, specially so in a state which, by the labors of Prof. Hall and of his many followers, has furnished the standard scale of formations for all America, were it not for the indescribably folded, tilted and crushed condition of the beds, the one-sided character of the fauna, and the distribution of the graptolites in thin bands in the otherwise utterly barren, huge mass of shales and sandstones, which, practi-

[1]This paper was submitted Ap. 1, 1900, to the Boston society of natural history in competition for the Walker prize, and a synopsis of the same read before the American association for the advancement of science June 26, 1900.

cally, have discouraged investigators and collectors from studying this unfruitful terrane. Thus, for example, the Hudson river beds were left out of consideration by N. H. Darton in his investigation of the stratigraphy of the formations of Albany county (48)[1].

The writer has tried to approach the problem by systematically visiting and collecting at all outcrops in a rather limited territory, embracing the banks of the Hudson river and its tributaries between Waterford, 8 miles north of Albany, and Coeymans, 13 miles south of Albany. This region contains many of the localities where fossils were found before, and among them also the classic collecting grounds of the Normans kill (Kenwood) and the Abbey (Glenmont). A number of new localities have been found, which, by their arrangement in zones and by their fossil contents, allow a step forward toward the solution of the problem and justify the present publication.

## HISTORY OF THE HUDSON RIVER BEDS

The history of the problem of the Hudson river beds has been treated, though only in regard to the validity of the term, by James Hall (17) and C. D. Walcott (36a), to whose papers the reader may be referred here.

### W. W. Mather

The term "Hudson river slate group" was proposed in 1839 by Mather, in his annual report on the geology of the first district (1), where he says (p. 212): "(1) The lowest in the series [of fossiliferous rocks] is the *Hudson river slate group*, consisting of slates, shales and grits, with interstratified limestones, all of which occur under various modifications. This group is overlaid unconformably in many places by the various rock formations of more recent origin." The following fossils (graptolites) are mentioned besides a few shells: "Fucoides serra, F. dentatus, and two other species which are probably F. lineatus and F. ramulosus".

[1] *See* References, p. 581.

In the final report of the first district (1843) Lieut. Mather (4) changed the name Hudson river slate group to Hudson river group. Of its fossil contents he reports (p. 369): "These rocks contain *few fossils* except fucoids, and these are extremely abundant in some of the strata. A few specimens of testacea only have been found in this group, although it is well exposed to view over a great extent of country in the first geological district." The strata of the Hudson river group in the northern counties (including Albany county) are described under two heads (p. 375):

1 Those east of the anticlinal axis, which are upturned.

2 Those west of the anticlinal axis which are but little disturbed.

The anticlinal axis above referred to ranges from near New Baltimore by Saratoga lake to Bakers falls.

Of the upturned strata it is said that they all dip eastsoutheast, and in regard to the less disturbed beds Dr Mather remarks (p. 377); "*The horizontal and slightly inclined strata of slates and grits* of the Hudson river group, lying on the west of the anticlinal axis, as traced from New Jersey to Saratoga lake, were *formerly* considered as *more recent strata than the upturned rocks of the Hudson valley, and as resting unconformably on them.* It was not until the labors of the geologic survey were more than half completed, that sufficient evidence was obtained to establish the fact with *certainty* that they are of the *same* geologic age." It is farther stated that the strata could be traced across the line of disturbance only in the Mohawk valley, that however, the Trenton and the Utica formations were recognized in the tilted strata by their fossils, the Utica shale by the graptolites.

It follows from these quotations that Dr Mather distinctly correlated the Hudson river beds with the Lorraine beds, or rather with the Frankfort slates of the Mohawk valley, that he farther believed that the Trenton and Utica beds could be recognized in the Hudson valley. As to the latter, it is evident from his description of the Utica slate that he did not yet discern between the Normans kill graptolites and the Utica shale graptolites and considered all graptolite-bearing shales as being of Utica age;

for he mentions among the localities of the Utica shale such typical collecting grounds of the Normans kill fauna as the banks of the Normans kill itself, the Kinderhook creek and the city of Hudson. Misled by the supposed identity of the two graptolite faunas which later were separated by Hall, he considered the Normans kill shales as homotaxial with the Utica shale. This wrong conception has apparently mislead still later writers.

## Lardner Vanuxem

Lardner Vanuxem (5), like all the members of the survey, accepted Mather's term and called all the beds between the Utica shale and the gray sandstone of Oswego, the Hudson river group, but pointed out, that there are two divisions which are not coëxtensive, embraced by this term, namely, a lower one (the Frankfort slates) which passes from the Hudson valley through the Mohawk valley and extends north by Rome through Lewis county into Jefferson county; and an upper division (the Pulaski shale), which first appears in Oneida county and extends from thence north and west. Fossils are rare in the Frankfort slate, but are numerous where it joins the next series, the Pulaski beds. They have been reported from near Rome, Westmoreland and Utica, and also from Cohoes near Waterford, though the species are not enumerated.

It is obvious that Vanuxem correlates only the lower or Frankfort slates with the beds of the Hudson valley.

## Ebenezer Emmons

In the same year Dr Emmons (3) described shales of the Hudson valley as the *Hudson river series* or *group* and stated their extension northward through New York and Vermont to Quebec and through Pennsylvania into the southern states. He proposed the name "Lorraine shales" in place of the names "Pulaski shale" and "Hudson river shale," used before, on the ground that at Lorraine alone a complete section with the top and bottom of the group exposed, could be found (3:119). This term has since been struggling for ascendancy with the term, Hudson river beds.

## James Hall

Hall, in his report on the fourth geological district (6), also accepted the term Hudson river group, but remarked that along the Hudson river, where disturbance has prevailed, the Utica shale and Hudson river group are not easily separable (6:30). He, hence, assumed the presence of Utica shale in the Hudson valley.

In 1847 the same author furnished the means of separating the two formations by describing the fossils of the Hudson river group (7). The fossils described under the caption "Hudson river group" are components of two entirely different faunas, the mollusk fauna of the Lorraine beds of northwestern New York and the graptolite fauna of Normans kill. That Hall retained Mather's and Vanuxem's views of the homotaxy of the Hudson river beds with the Frankfort beds seems to the writer to have been caused principally by the finding of Frankfort slate fossils (Modiolopsis nuculiformis, Cleidophorus planulatus, Lyrodesma pulchella, Murchisonia gracilis, Carinaropsis patelliformis, C. orbiculatus, Bellerophon cancellatus), and of Ambonychia radiata, which is characteristic of Vanuxem's upper division, in the Hudson river shales of Waterford (*see* localities of these fossils in v. 1, *Pal. N. Y.*) These fossils seem, indeed, to connect the western fauna with that of the Normans kill beds, but it may be remarked here that the writer has obtained evidence showing that these mollusks nowhere occur in the same beds with the Normans kill graptolites, but in actual Lorraine beds which are stratigraphically widely separated from the graptolite beds. That Hall himself did not feel sure of his correlation becomes evident from an interesting footnote on page 329 of the above cited fundamental work.

This uncertainty may also explain why in the third volume of the *Paleontology of New York* (8: 14), Hall extended the term Hudson river group to "all the beds from the Trenton limestone to the Shawangunk conglomerate," an extension of the term which has been taken up by the textbooks and has come into general use.

In the same volume Hall described some new graptolites from the Point Lévis shales of Canada as coming from near the summit of the Hudson river group (p. 503), a correlation to which exception was taken by Billings (9), who not only claimed a greater age for the Point Lévis and Quebec, but also for the Normans kill graptolites. Billings derives his conclusion from a comparison with the vertical range of the graptolites in England, a proceeding which, 25 years later, was repeated by Lapworth and, interestingly enough, with similar results. This paper of Billings's is indicative of the complete change in the correlation of the Hudson river shales which, about this time, was wrought by the influence of the Canadian survey. The latter, influenced by the presence of primordial fossils in the Hudson valley region, assumed that the older rocks of Canada and of the Champlain valley extended into the Hudson valley. The influence of Emmons, who had extended the term, Taconic, to the shales of the Hudson valley and asserted the continuation of the Hudson river shales to the primordial region of Quebec, was also powerful in shaping Hall's view of the older Lower Siluric age of the Hudson river shales. When Hall received the graptolites of the Canadian survey for description, and believed that he recognized in species from Point Lévis and other localities on the St Lawrence below Quebec, Normans kill species, he came out openly (10) for the "primordial (Quebec) age" of the bulk of the Hudson river beds, assuming with Logan, that the two or three occurrences of a few fossils of the "second fauna" were "outliers of insignificant extent embraced within the folds of the older rocks or resting upon these primordial beds which formed the fundamental rocks of the valley, and that the deranged and altered Hudson river beds were separated from the unaltered beds in the west by a fault". He, therefore, dropped the term Hudson river group, stating expressly (10:444) that the graptolites of the Hudson valley do not belong to the second fauna, but "hold a lower position and belong to the great mass of the shales below".

But Hall soon discovered his error in regard to this correlation with the Point Lévis graptolites and protested against the inclusion of the Hudson river graptolites with those of the slates of Point Lévis; as a consequence of which they were omitted from the report of the Canadian survey (decade 2) after having been figured.

Soon still more facts began to accumulate which threw doubt on that correlation, and finally, in 1877, Hall read a paper (17) before the American association for the advancement of science, in which the famous investigator fully relates how in joint excursions with his friend, Sir William Logan, along the Hudson river and the adjacent counties, the evidence on which the original conclusions were based, was reviewed. He said:

> A farther careful study of the materials collected showed conclusively that, within the limits indicated, all the fossils were of the second fauna. Many of the species of graptolites, so abundant in certain localities of the disturbed and partly altered shales, were also found in the shales and sandstones which gradually assumed an undisturbed and unaltered condition within a few miles west of the river, extending thence through the Mohawk valley, where they rest conformably upon the limestones of the Trenton group.

With this declaration Hall returned to his former view of the continuity of the graptolite-bearing beds of the Hudson river shales with the Frankfort slates of the Mohawk valley and the Lorraine beds of the northwestern region. It is a misfortune that he does not specify the many species of graptolites which he says are common to the altered shales of the Hudson valley and to the more western undisturbed beds, as this observation forms the principal base of his correlation and has not been verified by other observers, while it disagrees with the writer's results on the distribution of the Normans kill fauna to the west of the Hudson valley.

The cause of the misinterpretation of the rocks of the Hudson valley is, in the same address (17:261), very appropriately attributed to the "fact, that not only the rocks in the immediate valley of the Hudson, but also those between the river and the eastern limit of the state, were treated as a single group or system of rocks, and belonging to one geologic age, thus creating confusion in whatever aspect they were regarded". The occurrence of lithologically homogeneous, but faunistically heterogeneous terranes, forming apparently a stratigraphic unit, has been the cause of endless discussion and confusion, as the Taconic, Quebec and this, the Hudson river group controversy fully demonstrate. It appears, now, that, while Hall freed the Hudson river group, by insisting on its upper Champlainic (Siluric) age, from being farther involved in the Taconic controversy, he, to a certain extent, committed a similar error by uniting the Lorraine and Normans kill faunas in one group, for this correlation is, as will be shown still farther on, the principal cause of the controversy in regard to the age of the Hudson river group.

## R. P. Whitfield

The composite character of the Hudson river beds was first positively asserted by R. P. Whitfield in a letter written in 1875 to Dr C. A. White (16). Prof. Whitfield's most important statements in regard to our investigation are:

> From the evidence furnished by these fossils (graptolites), I have reached the conclusion that the graptolite-bearing layers there are of the age of the *Utica slate*, the following being a summary of the facts I have observed.
>
> I have found the following species common to both the graptolite layers at Normans kill and those of the Utica slate formation at the mouth of Oxtungo creek near Fort Plain N. Y.: Graptolithus (Monograptus) serratulus, Hall, G. (Diplograptus) pristis, Hall (not Hisinger), G. (Climacograptus) bicornis, Hall and G. (Dicranograptus) ramosus, Hall.
>
> Just south of Troy, in the shaly partings between layers of metamorphic limestone, I have found a species of graptolite in great abundance indistinguishable from G. amplexicaulis Hall from the Trenton limestone of Herkimer county, N. Y. The same species was also found abundantly in the yard of the arsenal at Watervliet by Capt. C. E. Dutton, U. S. A.
>
> From the foregoing facts I infer that the slates below Troy and in the arsenal yard, together with the associated metamorphic limestones, are the equivalents of the Trenton limestone.

The most interesting discovery of Whitfield's is that of the presence of shales of Trenton age among the shales of the Hudson valley. The writer has carefully compared specimens of the graptolite in question found at the arsenal yard and preserved in the state museum with the D. amplexicaulis found in the Trenton limestone at Middleville and is convinced of their identity. Besides this graptolite other fossils have been found in the shales and calcareous sandstones (not limestone) of south Troy and the neighborhood of the arsenal which more firmly establish Prof. Whitfield's discovery.

The supposed homotaxy of the Normans kill fauna with that of the Utica shale is based on the occurrence of four graptolites in both faunas. Of these the presence of Didymograptus serratulus in the Utica beds has not been verified by other collectors and is doubted by Lapworth and Gurley; Hall's Diplograptus pristis, however, is partly identical with Hall's D. quadrimucronatus, which is very common at Fort Plain as everywhere in the Utica shale, and which at that time was considered also by Hall as occurring only at the locality from which it was first made known (Lake St John, Canada), and partly identical with Diplograptus foliaceus, Murchison.[1]

The two forms, D. foliaceus and D. quadrimucronatus, are not always easy of separation, when completely flattened in the shales; and the writer also has, following Hall's example and identification, described colonies of D. quadrimucronatus as belonging to D. pristis Hall. Fritz Frech (54:626) supposes this large mucronate form of the Utica shale to be D. whitfieldi, Hall. A detailed account of all these forms will be given by the writer in another paper.

Climacograptus bicornis and Dicranograptus ramosus are, indeed, common to the Normans kill and

[1]Diplograptus quadrimucronatus is restricted to the Utica shale, and for this reason, can not be adduced as connecting the Utica and Normans kill shales; Diplograptus foliaceus, which is more common in the Normans kill shale, ranges from the Chazy to the Lorraine beds and hence is of no taxonomic value.

Utica shales, as declared by Whitfield. These two, however, appear insignificant when compared with the great number of differing graptolites in the two zones, specially when the entirely different aspect of the two faunas is taken into consideration; for, while the Normans kill fauna as to prevailing species and individuals is characterized by branching forms, notably of the genera Coenograptus, Didymograptus and Dicellograptus, the Utica shale fauna is almost entirely composed of Diplograptidae and Climacograptidae and bears in its genera and species a decidedly younger character than the Normans kill fauna, as becomes apparent by a comparison with the vertical range of the same forms in Sweden and Great Britain. In fact, to the time of his death Hall insisted on the different age of the two faunas, as the writer can assert by personal information from the genial paleontologist.

The concurrence of the two graptolites will indicate hardly more than the Middle Champlainic (Siluric) or Mohawkian age of the Normans kill beds.

The Cohoes beds which Whitfield believes to be of equal age with the Normans kill beds are homotaxial with the Lorraine beds, as already suggested by the Trinucleus concentricus collected in them by Whitfield. They are evidently the same beds from which Hall reports such typical Lorraine fossils as Ambonychia radiata and in which also the writer has found an undoubted Lorraine fauna. In regard to the Lorraine beds, however, which Whitfield supposes to occur close to the Normans kill graptolite beds along the Normans kill, the writer has not been able to obtain any data, but he believes the small Diplograptus on which Whitfield principally bases his correlation to be the Diplograptus putillus of the Utica shale, which has been found by the writer in several localities farther up the Normans kill.

### C. D. Walcott

Four years later, in a paper read before the Albany institute by C. D. Walcott (36a), the Normans kill beds were included in the Utica slate (as "Utica slate 2"—*see* the catalogue of fossils,

p. 34, *op. cit.*), obviously on the ground (p. 2) "that the Utica slate formation was traced by the New York geologists down the Mohawk valley from Oneida county through Herkimer, Montgomery, Schenectady and Saratoga counties to the shores of the Hudson", and that "Prof. W. W. Mather gives the following localities in the Hudson river valley below Bakers falls, where the Utica slate is to be observed with its characteristic graptolities, at Waterford, Cohoes, Normans kill below Albany, at Hudson," etc. The evidence which the graptolites at Normans kill afforded to Whitfield of the equivalency of the graptolitic slates and the Utica slate, is also cited.

As these citations prove, Walcott based his correlation on the continuity of the shales of the Mohawk valley with those of the Hudson valley and on the Utica slate localities in the Hudson valley as mentioned by Mather, and finally on Whitfield's assertion of the partial identity of the Normans kill and Utica faunas. The first argument has been meanwhile weakened by the establishment of the presence of a fault between the disturbed and undisturbed regions, which was already assumed by Emmons, and will be spoken of farther on (p. 504). Mather's assertion of the presence of a zone of Utica shale localities in the Hudson valley was caused, as shown above, by his failure to distinguish between the Normans kill and Utica shale graptolites; and Whitfield's correlation has just been discussed on the preceding pages.

### T. N. Dale

In the same year T. Nelson Dale (20) discovered in an outcrop of argillaceous schist about a mile west of the Hudson opposite Poughkeepsie, crinoid stems, Orthis testudinaria, O. pectinella, Leptaena sericea, Strophomena alternata, Bythotrephis subnodosa and a cast of a gastropod which resembles Bellerophon bilobatus (all being Hall's identification), some of these fossils being also found near Vassar college and south of Poughkeepsie.

The author concludes from his determinations that "the clay slates and shales in the vicinity of Poughkeepsie, on both sides of the river, are fossiliferous and that they very probably belong to the Hudson river group, as indicated by Mather in 1843, and certainly to some member of the Trenton period ".[1]

But it seems to the writer that the evidence afforded by these fossils has been here somewhat strained to bring the facts into accordance with Hall's views; for, while Orthis testudinaria, Leptaena sericea, Strophomena alternata, Bellerophon bilobatus are noncommittal, occurring from the Trenton to the Lorraine beds, and Bythotrephis subnodosa, being a rather indistinct plant fragment, is of little or no taxonomic value, Orthis pectinella is declared by Hall himself (7:123) to occur in nearly every part of the Trenton limestone, though unknown to him in the Hudson river group. Theodore G. White, in his very useful paper (51:83, 94), reports the form only from a six foot bed overlying the Black river limestone of the Poland limekiln section. In the Cincinnati region and in Canada the fossil is found in the Black river and Trenton beds, and Winchell and Ulrich announce it in their carefully prepared lists only from the upper Black river beds of Minnesota (49).

The evidence afforded by the fossils of Poughkeepsie would then rather indicate for these Hudson river schists the age of the Trenton limestone.

### J. D. Dana and W. B. Dwight

At the same time the problem of the Hudson river shales was approached from the east by James D. Dana (21), who found that the five limestone belts traversing the schists east of the Hudson river are anticlines of limestones, underlying the schists. He also succeeded in finding fossils in the limestones which were described by W. B. Dwight (23), as denoting a Trenton fauna. Dana, therefore, concluded that the "Taconic schists" overlying the limestone are of Hudson river age.

Dwight cites the following fossils: Orthis tricenaria, O. pectinella, O. testudinaria, Leptaena seri-

[1] Dana had meanwhile (Manual of geology. 1874) proposed to unite the Trenton, Utica and Cincinnati (= Lorraine) epochs under the term Trenton period.

cea, Strophomena alternata, Escharopora recta, Ptilodictya acuta, caudal shield of a small trilobite probably Asaphus vetustus, Endoceras (probably proteiforme), Orthoceras, not well defined, spiral univalves, Chaetetes named Ch. tenuissima, encrinal columns, Receptaculites.

In another paper (24) the same investigator states that the Chaetetes with fine columns has been identified, in part at least, as Stromatopora compacta, Billings, and adds as new from Rochdale a number of Cyathophylloid corals, among them, with little doubt, Petraia corniculum, a caudal shield of a trilobite which has been identified by Ford as Illaenus crassicauda, and a head of Echino-encrinites anatiformis.

He also found in the continuation of the limestone belt across the Hudson, $2\frac{3}{4}$ miles north of Newburgh ferry: Orthis lynx, O. pectinella, Rhynchonella capax, Leptaena sericea, Strophomena alternata, a new Discina (later described as D. conica), Chaetetes compacta, very abundant, Ch. lycoperdon var. ramosus, Schizocrinus nodosus, Echino-encrinites anatiformis, probably O. tricenaria, and Petraia corniculum.

The author adds: "These developments establish this beyond doubt as a stratum of the Trenton limestone". A farther conclusion which could be drawn, is that these faunas contain no forms characteristic of or restricted to the upper Trenton, while they distinctly point to a lower and perhaps in some degree middle Trenton age for the beds; for Orthis tricenaria and Petraia corniculum are restricted to the lower Trenton, Illaenus crassicauda occurs in the upper Lowville and Trenton limestone, Schizocrinus nodosus is most abundant in the lower Trenton, Ptilodictya acuta and Escharopora recta occur only in the lower and central part of the Trenton, Echino-encrinites anatiformis is a middle Trenton form, and the abundant Chaetetes compacta is restricted to the Black river.

The middle and upper Trenton must, hence, be either absent or represented by shales of the appearance of the Hudson river shales. The latter conclusion seems the most acceptable to the writer as it agrees with his own results obtained around Albany.

### C. E. Beecher

The next important discovery of fossils in the Hudson river series of shales was made by C. E. Beecher in the shales near the old Dudley observatory, a short distance northwest of Albany (26). The following fossils were identified: Climacograptus bicornis, Dicranograptus ramosus, Diplograptus mucronatus, crinoid stems, Trematis terminalis, Leptaena sericea, L. subtenta, Orthis testudinaria, Zygospira modesta, Avicula trentonensis, Cleidophorus planulatus, Ambonychia undulata, Tellinomya dubia, T. levata, Lyrodesma poststriatum, 10 undetermined species of lamellibranchiata, Hyolithes americanus, H. sp.?, Bellerophon bilobatus, B. cancellatus, Murchisonia gracilis, Endoceras proteiforme, Orthoceras bilineatum?, Cornulites flexuosus, Plumulites sp.?, Triarthrus becki, Trinucleus concentricus.

Beecher referred this fauna to the Utica epoch, and Walcott (36a : 345) later declared it to be "as a whole, characteristic of the upper portion of the Utica shale in the Mohawk valley and of the passage beds between the Utica shale zone and the lower portion of the Lorraine shales in the section at Lorraine, Jefferson co. N. Y."

The import of this discovery is that it establishes the hitherto only suspected presence of the Utica shale among the shales of the Hudson valley, but it does not warrant the conclusion of the Utica age of the Normans kill graptolite fauna, for of the three graptolites found by Beecher, two, Climacograptus bicornis and Dicranograptus ramosus, are common to both the Normans kill and Utica faunas, and the third, identified as Diplograptus mucronatus, but unquestionably a new species, is one of the small mucronate forms of the Utica shale not occurring in the Normans kill fauna.

### S. W. Ford

In the next year, the untiring collector, S. W. Ford, reported the discovery of another interesting locality at Schodack Landing, to the southeast of Albany, on the east bank of the Hudson river (29).

He found the slates excellently exposed, though bent and contorted almost beyond description, in two promontories, where a band of black slates yielded the characteristic Normans kill fauna, and "at once resolved to institute a careful search for other fossils in the rocks of the neighborhood"; in which endeavor he was very successful, for a bed of limestone about 2 feet thick, and in part somewhat brecciated in appearance, inclosed in the slates, was found. This yielded the following species: Asaphus platycephalus, Calymene senaria, Orthis testudinaria, O. lynx, Leptaena sericea, Strophomena alternata and the hemispheric form of Chaetetes lycoperdon. He concluded: "None of the species of this locality are distinctive of the Utica slate, and both the limestone and its associated graptolitic slates represent in my estimation the Hudson river group." These fossils are, however, not restricted to the Hudson river group and would prove only that the Normans kill graptolite shales may belong anywhere from the base of the Trenton to the Lorraine beds.

In another paper (30), Ford discussed the age of the slaty and arenaceous rocks in the vicinity of Schenectady, which by Mather, Emmons and Whitfield have been considered to be of Lorraine age. Ford found at Schenectady Graptolithus pristis, Gr. mucronatus (that is, a mucronate Diplograptus), Triarthrus becki and a Lingula, which he considers to be Lingula curta. On the strength of this evidence he regards the Schenectady beds as of Utica age. This result, if farther verified, would be interesting in so far as it would show that the Utica beds change toward the Hudson valley in lithologic character and approach more closely the aspect of the Lorraine beds; and hence the former could not be recognized in this region by their lithologic character, as former geologists have attempted to do.

It is farther stated by Ford that "the rocks at Schenectady continue to the eastward to Rexford Flats where a break occurs, and from that point all the way to the Hudson the rocks are greatly tilted. The break here alluded to, Dr Emmons considered identical with the fault occurring at Saratoga Springs and Bakers falls, and believed it to pass somewhere between Albany and Schenectady, and to be traceable in its effects as far south as Kingston." The demonstration of this break between the tilted strata of the Hudson river region and the undisturbed beds of the Mohawk valley is of great importance for our investigation, as it refutes the argument presented by Mather, Hall and Walcott, that the Hudson river beds of the Hudson river region are continuous with and can be traced along the Mohawk valley to the Utica and Lorraine beds of that valley. As the lamellibranchs, cited by Hall from Cohoes, and other fossils found by the writer at the same locality (*see* farther on) prove, the Lorraine formation is well represented at the lower Mohawk, while on the western side of the fault, the Utica shale, as claimed by Ford, may be found. Hence there is no continuity along the lower Mohawk. Similarity of lithologic characters can, in the great mass of similar argillaceous shales, arenaceous shales, sandstones, grits and argillites, representing the Hudson river series of beds in the Hudson valley, only, if ever, be relied on in distinguishing the formations after the most minute study of these lithologic characters. The description of the localities in another part of this paper will bear out this statement.

### N. H. Darton

The same fruitful year brought out another discovery of fossils in the Hudson river shales, that by Nelson H. Darton (32) near Sugar Loaf, 21 miles southwest of Newburgh and at

Walden, on the banks of the Wallkill, 11 miles northwest of Newburgh on the Hudson, two localities in Orange county which were mentioned by Mather. The following fossils (according to Whitfield's identification) were collected: Orthis pectinella, O. testudinaria, O. plicatella, Leptaena sericea, Camarella hemiplicata, Strophomena alternata, Streptorhynchus planumbona or Str. filitexta? and a Trinucleus concentricus. Besides fragments of Chaetetes or Favosites, a crinoidal column and a fragment of Conularia (probably trentonensis).

The greatest interest attaches to Orthispectinella, and Streptorhynchus planumbona or filitexta, as these forms indicate the Trenton age of that shale.

### I. P. Bishop

While thus the fortunate discoveries of fossils other than graptolites in the "Hudson river shales" began to furnish evidence of the Trenton age of part of the shales, other investigations, notably those of I. P. Bishop (33) tended to demonstrate the close stratigraphic relationship of the Trenton limestone and the graptolite-bearing Hudson river shales; for, in Columbia county, it was established by Bishop that "the limestone containing Trenton fossils immediately underlies the graptolite shales of the Hudson river group".

### Charles Lapworth

An entirely new course to the solution of the problem of the age of the Normans kill fauna was entered on by Charles Lapworth (34), who studied the graptolite faunas from numerous localities in Canada, and sought to determine their age by comparing them with the faunas of the detailed graptolite zones which he had so well succeeded in establishing in Great Britain. A farther innovation in the mode of viewing the problem is implied in Lapworth's suggestion that the Normans kill graptolite beds do not necessarily represent a separate stage in the series of formations but are probably equivalent with certain calcareous strata of Canada and New York. Lapworth found the Normans kill fauna typically represented at numerous localities and termed it the Marsouin river or Coenograptus zone. This is followed by another zone with a similar graptolite fauna.

As to the taxonomic relations of these two zones, Prof. Lapworth arrived at the following views (p. 170 *loc. cit.*):

There can be no question of the general identity of this Griffin's Cove rock and the Marsouin Coenograptus zone with that of the Normans kill of the Hudson river valley. The New York geologists have always adhered to the opinion that the Normans kill beds are of the age of the Hudson river group (Lorraine) or of that of the Utica slate.

But here we have to recollect that, with the exception of Whitfield's distinct assertion that G. serratulus, Hall occurs in the Utica slate of Oxtungo creek—which may be easily accounted for on the supposition that what Whitfield calls a Didymograptus may possibly be a Leptograptus—not a shadow of paleontologic evidence has yet been adduced to show that these Normans kill or Marsouin rocks are newer than the Trenton.

I will not discuss the evidence further in this place, but will merely say that in Great Britain the fossils of the Coenograptus (Normans kill) zones occur in the beds immediately succeeding the typical Llandeilo limestone of Wales, with Ogygia buchii and Asaphus tyrannus, and in association with the Craighead (Stinchar) limestone of Scotland, with Maclurea logani and Ophileta compacta, i. e. in beds apparently homotaxeous with the Chazy or lowest Trenton (Birdseye and Black river).

If, therefore, we provisionally regard this Normans kill (Marsouin and Griffin's Cove) zone as coming between the Chazy (Maclurea) and the Trenton limestone in America, it will answer roughly to its equivalent, the Coenograptus gracilis zone in Great Britain, in age as well as in fossils.

We must remember that they appertain, possibly, almost to the very lowest beds of that second fauna, i. e. their place is practically Trenton-Utica, and not Utica-Hudson.

## E. O. Ulrich

E. O. Ulrich cited some Normans kill graptolites from the Utica shale of Cincinnati (35:183). As these have not been mentioned in later lists of fossils (49), it is probable that they have meanwhile been differently determined, and that the Normans kill zone is not represented in the regions studied by him.

### C. D. Walcott

The most careful investigation in the field, bearing directly on the problem of the Hudson river group, has been made by C. D. Walcott (36a). Mr Walcott's working plan was to trace the formations from the undisturbed regions in the northwest and west into the regions of disturbance. These researches gave the following results bearing on our investigation.

The Utica shales can be traced from their contact with the Trenton limestone at the falls of the Hudson near Sandyhill, "with little interruption, to the neighborhood of Albany, where they are very much disturbed and stand at a high angle. In this vicinity the noted graptolite beds of Normans kill occur; also the locality where Mr Beecher discovered the upper fauna of the Utica shale zone". Following up the Normans kill, alternating shales and sandstones are passed over, which "with the same lithologic character" continue across the line of disturbance till the superjacent Lower Helderberg limestone is met with. These shales and sandstones which, at the Indian Ladder, were found to contain *Orthis testudinaria* and *Trinucleus concentricus*, are correlated with the Frankfort shales of the Mohawk valley. Mr Walcott's conclusions of the presence of a zone of Utica shales in the Hudson river valley and of the extension of the Frankfort shales along the Normans kill are mainly based on lithologic evidence. Fossils found at numerous localities by the writer have served to verify the former conclusion; while Utica shale fossils found on both sides of the line of disturbance at the Normans kill indicate the presence of faunistic differences in the shales and sandstones, in spite of their apparent lithologic continuity.

The relation of the Normans kill, or Coenograptus, zone to the Utica shale is not expressly stated by the author, but it is clear that he places it near the top of the Utica shale. This follows from the following statement (p. 349): "Comparing the fauna, we find that the forms of the upper part alone of the Utica zone occur within the valley of the Hudson, and that the great graptolitic fauna of the Hudson valley is largely unknown in the interior of the state. It is probable that the graptolitic fauna was prevented from spreading over the interior of the state by some such barrier as subsequently excluded the interior continental fauna of this period [Hudson river period] from the valley of the Hudson". This combined with the statement that the upper or true Lorraine fauna has not been found to the east of Utica (p. 347), leaves only the faunas of the upper Utica and of the Frankfort shales to the Hudson river region. Thus according to Walcott the upper Utica is represented by the fauna discovered by Beecher near the old Dudley observatory, that of the Frankfort shales or of the lower division of the Lorraine formation is known from the shales of Waterford, and in the upper part of the former or the lower part of the latter the Normans kill fauna is to be placed.

In accordance with this conception of the divisions of the Hudson river shales and sandstones in the Hudson river valley, the term "Hudson" was proposed "for the series of shales between the Trenton limestone and the superjacent Upper Silurian rocks".

In the discussion following the reading of this paper Prof. Hall expressed his full concurrence with the results obtained by Mr Walcott.

### H. M. Ami

It is an interesting fact that, as seen again from this paper, whenever the New York geologists had occasion to assign the Normans kill zone in the series of the New York rocks, they gave it a position within or above the Utica terrane, while the geologists who were studying the fauna of the same zone in Canada, Billings, Logan and Lapworth, invariably placed it below the Utica shale. This attitude of the two schools is still more emphasized by the next student of the graptolite faunas of Canada, Henry M. Ami (38).

Ami makes the following interesting remarks:

Before assigning a definite position to the rocks of Quebec city in the scale of terranes in America, it is necessary for the writer to state that so far he has been unable to find any evidence in the field, either stratigraphic or paleontologic, whereby the Hudson river rocks and Lorraine shales, as originally understood by Emmons, could be correlated and referred to the same or an immediately following geologic terrane.

The fossils collected at Côte d' Abraham have a decided lower Trenton facies, as the presence of S o l e n o p o r a c o m p a c t a, or a variety of this species, seems clearly to indicate. From the long list of species obtained in the Montcalm market rocks [Normans kill fauna] it can readily be seen that we have there represented a fauna which has never yet been found either in the Lorraine, Utica or Trenton terranes—a fauna distinct from the faunas included in these three terranes whose characters are so well known throughout the continent in their undisturbed and complete development. It is the same fauna which has received in numerous places the name "Hudson river" e.g. at Normans kill and many other localities in New York and Vermont, and in Canada. Similar strata have also been observed in northern Maine, in Newfoundland and New Brunswick.

The apparently lower Trenton aspect of a portion of the Quebec *massif* as seen at Côte d' Abraham and Côte de la Négresse gives us an indication of the age of the strata at these points. Cut off on all sides by faults and separated from the Lévis rocks by the St Lawrence river, the Quebec terrane (which name I beg to propose for this series of strata such as we meet at the Montcalm market, Parliament square, and drill shed exposures) stands by itself in an anomalous position very similar to rocks of similar age which Prof. Lapworth designated as "unplaced in the series".

The presence of such forms as A g n o s t u s, A e g l i n a, A m p y x, D i o n i d e, B a t h y u r u s, etc., points to a rather low[er] horizon than the Trenton, while I believe that it is perhaps premature to give the precise geologic position of the strata at Quebec, in the present light of our knowledge.

In the discussion which followed the reading of this important contribution to our knowledge of the Champlainic [Lower Siluric] terranes, Mr Walcott expressed the opinion, that, "if Mr Ami's determination of the fauna is correct, the horizon of the Quebec city rocks is that of the Trenton, probably the lower Trenton, and perhaps the upper portion of the Chazy of the New York section".

The writer concurs with Lapworth and Ami in considering the Normans kill or Marsouin zone as "a distinct development of the Ordovician", which view is supported by evidence obtained around Albany, and also with Walcott in so far as he considers the horizon of the Quebec city rocks as that of the lower Trenton.

In support of this view the writer desires to point out the following facts which can be derived from Ami's observations. The joint occurrence of a lower Trenton fauna with the Normans kill fauna in the Quebec massive suggests that the Normans kill fauna is either of lower Trenton age or directly preceded or succeeded that age. It is true that the presence of such genera as Agnostus, Aeglina, Bathyurus, Ampyx and Dionide, when considered in the light of their now known vertical range in America, is indicative of an older than Trenton age; but the writer has found east of Albany, at Rysedorph hill and Moordener kill, partly below the Normans kill shales, partly embedded in them, a conglomerate full of lower Trenton fossils, in matrix and pebbles, and mixed with numerous specimens of Ampyx and Remopleurides. And in Europe, notably in Sweden, the above mentioned genera ascend into and above horizons considered as homotaxial with the Normans kill and Utica shales. Agnostus and Ampyx occur in the Trinucleus shales of Sweden, Ampyx tetragonus even in the upper part of the middle graptolite shales; and Dionide is an important genus of the Trinucleus shales, where also Aeglina still occurs. Bathyurus is still well represented in the Trenton of America by forms like Bathyurus extans, spiniger and schucherti. The occurrence of these genera in the Quebec beds is, in the writer's opinion, an interesting proof of the European and Atlantic connections of the Normans kill fauna already indicated by the distribution of these graptolites which occur only in Europe and to the east of the Appalachian region, west of the Mississippi valley and in the far northwest, etc.; while the Trenton fauna has all the characters of an epicontinental fauna, restricted to the American continent and progressively developed by a sudden transgression of the sea. The retention of these ancient trilobite genera in the graptolite facies of the Trenton is then only an interesting instance of the retarded development of the oceanic fauna in contrast to the progressive development of the epicontinental faunas; relations which lately have been so well elucidated by Chamberlin (59) and Weller (60). These facial and geographic relations of the Hudson river shales and Trenton limestone will be discussed more fully at a more opportune occasion.

### R. R. Gurley

Dr R. R. Gurley has, after an exhaustive study of the North American graptolites, prepared a list of their vertical range (50) and, as a result of his investigations, concluded (p. 291) that " the vertical range of the American species represents a complete parallel to the range in other countries. This parallel is not a general one only, but is exceedingly detailed, extending beyond the genera down to the species, which in each horizon correspond to those of the equivalent European horizon almost without exception, although of course not every European species occurs in America, or vice versa ". This inference stands in accord with Lapworth's conclusion of the parallelism of the graptolite faunas and supports his correlation of the Normans kill zone with the lower Trenton on the base of such parallelism. Dr Gurley also asserts the lower Trenton age of this zone, which he terms the Lower Dicellograptus zone.[1]

### T. N. Dale

Shortly after the completion of the present paper a most elaborate account of the slate formation in the region to the northeast of the investigated territory, by T. Nelson Dale (63) came to hand. Mr Dale's views in regard to the age of the Hudson river beds agree in a gratifying manner with the results to which the writer was led by his own observations. In the slate belt, which extends northward from the Hoosac river in eastern New York and in Vermont for about 55 miles, the Cambrian slates are in some localities followed by Calciferous shales, with Calciferous graptolites and thin limestone beds, but in more localities they are overlaid by various other Champlainic [Lower Siluric] rocks which are described as Hudson grits, Hudson

[1]The upper Dicellograptus zone is Lapworth's zone without Coenograptus gracilis, in which, however, subsequently a Coenograptus has been found by Ami, and which has not yet been clearly differentiated in the Hudson river valley.

white beds, Hudson shales, Hudson red and green slates and Hudson thin quartzite. The Hudson grit (graywacke) is interbedded in many places with black shales or slates, which in a great number of localities furnished the typical Normans kill graptolite fauna (identified by R. R. Gurley). Many of these localities had been found by C. D. Walcott. These graptolite shales are not only closely connected with the Hudson grits, as the writer found them also to be at south Troy (Poesten kill, *see* p. 539) and near East Greenbush, but also with the green and red slates; for "at several points the Hudson grits appear to be replaced along the strike by the red and green Ordovician slate" (p. 189).

The Trenton limestone (p. 190) occurs only sporadically within the lower Siluric areas. "In some places it was probably deposited contemporaneously with the Hudson grits and shales, or it may underlie portions of them. In others it may represent the entire Lower Silurian series and should then be regarded as Trenton, Chazy and Calciferous."

This correlation of the Trenton limestone and the Hudson river beds is also expressed in the table of formations (p. 178), where it is said: "Trenton limestone: Limestone, occurring mostly west of the slate belt, replacing probably I (Hudson grits, red and green slate and graptolite shales), H (Hudson white beds and Hudson thin quartzite) and G (Hudson shales), and possibly F (Calciferous) and then representing the Trenton, Chazy and Calciferous."

## RESULT OF FORMER INVESTIGATIONS

A brief retrospect of the opinions expressed by the various authors on the Normans kill fauna will show that there has been a decided trend in these opinions toward a correlation of the Normans kill zone with deeper and deeper terranes till now it oscillates, so to say, about the lower Trenton. This correlation is based entirely on paleontologic evidence and, as Dr Gurley's concise statement clearly shows, is hardly more than tentative. This, however, can not be surprising, when it is borne in mind, that all the graptolite beds in New York, notably those at Normans kill, the Abbey (Glenmont), Schodack Landing, Kinderhook and

Hudson, have, besides the graptolites, yielded only few other fossils, and none of decisive taxonomic value (*see* p. 569); that these graptolites are restricted to these beds; that, farther, these beds are hidden away in a huge mass of mostly barren shales and sandstones, and that, finally, this whole mass of rocks, which contains Trenton, Utica and Lorraine beds in similar lithologic development, is in New York as well as in Canada cut off from the neighboring terranes by extensive faults, thus apparently also frustrating all attempts at a stratigraphic solution of the problem.

## DISCOVERY OF OUTCROPS (STATIONS) WITH FOSSILS

It is only in view of these extreme difficulties which besiege the Hudson river problem that the writer presents his observations on this problem in an area which appears insignificant in comparison with the great geographic extension of the beds in question. But only by restriction to a definite small territory has it been possible to visit every outcrop and, what is still more important, to collect in every outcrop most exhaustively and minutely. As a gratifying result of this method, there were found in the region described in the introduction, 29 localities which furnished fossils. These, with 7 localities known before, give 36 stations with fossils. These can be arranged according to their fossil contents in four zones, which, following the general strike of about n 20° e of the rocks in this part of the Hudson river valley, extend from n n e to s s w. The stations will be described according to these zones (*see* map).

## DESCRIPTION OF STATIONS

### A LORRAINE BEDS

#### Station 1. Cohoes falls of the Mohawk river

All along the lower Mohawk and specially from the high falls of the river at Cohoes to the islands in the Hudson river opposite the mouth of the Mohawk, is exposed an enormous mass of greatly contorted rocks (a sketch of these contortions is given by Mather, 4, pl. 2, fig. 1) of mostly shaly character; that is argillaceous and arenaceous shales with beds of argillaceous sandstone and gritty bands. These rocks have, in many places, become semi-metamorphic ("glazed shales" of the older New York geologists) by the influence of the orogenic forces. Fossils from them were known to Vanuxem, and the species reported by Hall (7) have been enumerated above (p. 493). Walcott remarks that this fauna connects the shales of the Hudson valley region with the Frankfort shale fauna of the central part of the state.

The writer had the good fortune to find an excellent opportunity for collecting in the usually very refractory shales by the opening of ditches for the purpose of laying water pipes in the southern part of Waterford. Here, at the end of Grace street, near the Mohawk, beds of dark argillaceous shales, changing through dark sandy shales into ferruginous sandstones, were cut into. They furnished:

Glyptocrinus decadactylus, *Hall*, numerous joints

Diplograptus putillus, *Hall*, several specimens[1]

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[1] This small form was originally described by Hall (11:44) from the "Hudson river group of Iowa", and is also cited by Schuchert from the "Hudson river group" near Granger and near Springvalley Minn., and from Graf Ia. One of Hall's types is reported in Whitfield & Hovey's catalogue (61) to have come from Dubuque Ia. According to Gurley's lists the form is restricted to the Utica horizon (lower Maquoketa shales). Sardeson (57) distinguishes the lower Maquoketa formation as "Diplograptus-bed". Though he does not give any identification of the Diplograptus, it becomes apparent from the localities of this horizon, mentioned by him (Graf Ia. and Granger Minn.) that Hall's and Schuchert's specimens were also obtained from this horizon. The writer's observations on the vertical range of this form in the east agree well with these data; for D. putillus has been found to be common in the Utica shale of certain parts of the Mohawk valley, specially north of Utica and near the village of Mohawk; and I have recently found it in great abundance, together with Orthograptus quadrimucronatus, Corynoides curtus and a minute, undescribed spinous Diplograptus, in the Utica shales directly above the Trenton limestone in the beautiful section along the shore of Lake Champlain near Panton Vt., to which interesting locality the writer's attention was kindly directed by Dr Theodore White of Columbia university.

The form may, however, as its occurrence at Waterford proves, pass into the Lorraine beds.

Diplograptus *sp.*, fragment of a larger mucronate (?) or macerated form, not well preserved

Corynoides *cf.* curtus, *Lapworth*[1]

Dalmanella testudinaria, *Dalman* sp.

*cf.* Orthis (?) centrilineata, *Hall*

Platystrophia biforata, *Schlotheim* sp.

Plectambonites sericea, *Sowerby* sp.

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[1]This little known graptolite has, hitherto, not been observed in America. Corynoides calicularis Nicholson, which occurs in the Scottish Hartfell and Glenkiln shales was recognized by Lapworth in the Canadian Dicellograptus zones and is the only species of Corynoides mentioned by him and Dr Gurley from America. It is also very common in the Normans kill shale, and was figured by Hall among the "germs", evidently on account of its similarity with the sicula (Decade 2, pl. B, fig. 19; 20th mus. rep't, pl. 1, fig. 19; Pal. N. Y., 3:508, fig. 7). While Corynoides calicularis is apparently restricted to the Dicellograptus zones, and did not continue to live into Utica time, another form, only half as long, much stouter and agreeing with the figure of Corynoides curtus, given by Lapworth (Armstrong, Young, and Robertson, Catalogue of West Scottish fossils. 1876. pl. 2, fig. 92) has been found to replace the longer form in the Utica beds of Panton Vt., the Rural cemetery of Albany and other localities in the Hudson valley, while specimens in the collection of the New York state museum prove its presence also in the Utica shale of Amsterdam. One slab from this locality is so densely covered with these graptolites that hardly any interspaces are left; on another slab from the same locality they lie associated with Diplograptus putillus, Lingula curta and Leptobolus insignis. One slab of typical black Utica shale from Sprakers Basin shows the same fossil. It is a remarkable circumstance that the writer has never seen a single specimen in the Utica shale of the middle or upper Mohawk valley, nor are there any specimens in the rich Rust collection of the state museum from Holland Patent. This may indicate a regional difference in the fauna of the Utica shale. The common occurrence of this fossil in the sandy shales of Waterford, whence the writer has it in the same slabs with Trinucleus concentricus and the lamellibranchs of that locality, proves that it even ascends into the Lorraine beds. One specimen has been found at Callanan's quarry near South Bethlehem in the shale of that formation 18 feet below the waterlime bed of the Upper Siluric.

The writer has obtained such a good representation of this still very imperfectly understood form (Frech cites it among the doubtful forms, 54: 580), that its more important morphologic characters can be made out, and will be published in another place.

Rafinesquina alternata, *Emmons* sp.
Modiolopsis anodontoides, *Conrad* sp.
M. nuculiformis, *Hall*
Cleidophorus planulatus, *Hall*
Lyrodesma poststriatum, *Emmons*
Archinacella patelliformis, *Hall* sp.
Conularia (Sphenothallus, *Hall*) sp.
Cameroceras proteiforme, *Hall* sp.
Lepidocoleus jamesi, *Hall and Whitfield* sp.
Triarthrus becki, *Green*
Trinucleus concentricus, *Eaton*

This fauna is undoubtedly, as determined by Hall, an eastern representative of the Lorraine fauna, or more exactly, as pointed out by Walcott, of the lower division of the Lorraine beds, viz, the Frankfort slates.

## Station 2. Block island, Cohoes

Another typical Lorraine fauna was found a little farther northeast on Block island, a picturesque steep cliff rising from the rocky bed of the northern branch of the Mohawk below Cohoes. Along the eastern wall, besides graptolite shales with Diplograptus foliaceus and a few specimens of D. putillus, a stratum of fossiliferous mudstone is exposed over a considerable area. This furnished:

Heterocrinus heterodactylus, *Hall*. Stems and points, cc[1]
Sagenella *sp.* on Endoceras. r
Crania *sp.* r
Platystrophia biforata, *Schlotheim* sp. r
Cyrtolites ornatus, *Conrad*. c
Archinacella patelliformis, *Hall* sp. Smooth variety, c
Modiolopsis faba, *Hall*. c
Modiolopsis ? nuculiformis, *Hall*. c
Cleidophorus planulatus, *Hall*. cc
Lyrodesma poststriatum, *Emmons* sp. Lorraine form, c
L. pulchellum, *Hall*. c

[1] r=rare, rr=very rare, c=common, cc=very common.

Cameroceras proteiforme, *Hall* sp. r
Trinucleus concentricus, *Hall.* cc

### Station 3. Dry creek, Watervliet

The writer has been unable to find another locality with as complete a fauna as this going southward in the strike of the beds of Cohoes. This is partly due to the lack of outcrops of these beds, caused by the general n ne-s sw strike of the Hudson river shales, which carries these Lorraine beds under the drift-covered plateau to the west of the Hudson river. Following the edge of the plateau about 3 miles to the southwest, a large outcrop is met with (station 3) along Dry creek, west of Green Island. This creek has formed a deep gorge through a homogeneous mass of soft gray argillaceous shales. In these beds only a single layer with fossils was found. There were a few specimens of Corynoides curtus and more abundant stipes of Diplograptus foliaceus. The writer colors station 3 (Dry creek) as a Lorraine station, as the two graptolites are of themselves noncommittal, while the beds by their extreme barrenness suggest their Lorraine age and also lie in the strike of the Cohoes rocks.

### Station 4. South Cohoes

The reconstruction of a sidewalk in south Cohoes brought out a considerable mass of rock, which like that of Dry creek (station 3) consisted mostly of compact dark gray to black, argillaceous shales with very few specimens of Diplograptus foliaceus and Corynoides curtus.

### Other outcrops of Lorraine beds

No outcrops of rocks which by their fossil contents could be attributed to the Lorraine age were found to the northwest and west of Albany, as the brooks have nowhere cut through the heavy drift covering to the bed rocks. This is specially observable along the northern affluents of the Normans kill. The next outcrops occur along the Vly, a southern tributary of the Normans kill, at the sawmill below Voorheesville, 7 miles west of

Albany, where alternating fine grained sandstone, conglomerate beds and gray fissile argillaceous and arenaceous shales occur. These rocks did not yield any fossils; but, as they are lithologically similar to the Lorraine beds of the Mohawk valley, dip regularly at 18° to n 80° w and are consequently outside of the region of disturbance of the Hudson river valley and probably continuous with the Lorraine beds of the Mohawk valley, they can with a sufficient degree of certainty be correlated with these beds. Furthermore, Utica shale fossils (*see below* station 21) were found in underlying rocks farther down the creek. Similar shining gray fissile shales were found on the south bank of the Normans kill about a mile above (west) the mouth of the Vly; and an excellent exposure of Lorraine beds was met at French mills, 11 miles west of Albany, where gray sandstone banks, 10 feet and more in thickness with intercalated shales, cross the river.

South of this neighborhood, at the Indian Ladder, the Lorraine beds underlie the Manlius limestone, and yielded Dalmanella testudinaria and Trinucleus concentricus, as reported by Walcott. Other outcrops of Lorraine beds can be observed at several places along the foot of the Helderberg mountains. One of the best of these is that along Sprayt kill at South Bethlehem, where, below the railroad bridge, some 20 feet of sandstone causes a waterfall and farther up, at Callanan's road metal quarry, the contact with the Upper Siluric Waterlime is exposed. Numerous sandstone banks alternate here with light colored, soft, argillaceous shale and some bands of more sandy shale. In the shale, 18 feet below the Waterlime, a Corynoides was found. These beds dip slightly southwest. A very coarse sandstone with bluish green mud pebbles is exposed 4½ miles farther south close below the Waterlime and Manlius limestone along the road leading from Ravena to Aquetuck. It strikes n 60° e and dips 40°, n 150° e, is hence, again involved in the tilting to the east, characteristic of the Hudson valley region. It is doubtful whether this sandstone still belongs to the Lorraine rocks or is already the sandy development of a deeper terrane. Its strike would carry it far to the east of the Lorraine zone, and it is possible that it is continuous with similar beds of lower Trenton age exposed along the lower Vlaumans kill. Unfortunately no outcrops could be found along the middle and upper courses of the Coeymans and Vlaumans kills.

No other exposures of Lorraine beds have been found in the investigated area. Their distribution to the northwest, west and southwest of Albany is evidence of the restriction of the Lorraine beds to the western part of the area.

Prof. Prosser has lately separated the Utica and Lorraine shales of the lower Mohawk valley by testing them with HCl, with which reagent the calcareous Utica shale will strongly effervesce, while the Lorraine shale does not react. This test had not suggested itself to the writer when in the field; but, on later application to the shales of the various terranes of the Hudson valley region near Albany, it was found to fail in the clastic rocks of this region, where even the Trenton is represented by argillaceous shales, and among the Utica shales only those from the penitentiary at Albany were found to effervesce, while all specimens of Utica shale from various localities of the Mohawk valley subjected to this test by the writer have strongly reacted. This indicates the great change in the marine conditions from west to east in this region throughout a long period.

### B - UTICA BEDS

East of this area of Lorraine rocks, the presence of a zone of Utica shale extending in the direction of the general strike of the shales of the Hudson river valley, has been established by the finding of 15 outcrops which contain Utica shale fossils (Compare the accompanying map).

#### Station 5. Mechanicsville

The excavation of a large spillway for the establishment of the Hudson light and power company of Mechanicsville, on the Hudson, about 2 miles below Mechanicsville, offered a rare opportunity for collecting in the shale. Though this locality lies several miles north of the boundary of the area investigated thus far, it was thought expedient to include its description in this paper, as the fauna was found to contain some valuable additions to the list of Trenton and Lorraine fossils observed in the Utica beds of this region, and besides, indicates the presence of the upper Dicellograptus zone, which hitherto has not been observed south of the St Lawrence region, in eastern New York. The fossils collected are:

Sponge. r
Corynoides curtus, *Lapworth*. cc
Diplograptus quadrimucronatus, *Hall*. cc
D. foliaceus, *Murchison* sp. c
Climacograptus caudatus, *Lapworth*. c
Dawsonia campanulata, *Nicholson*. c
Pontobdellopsis cometa *sp. n.*[1]
Lingula curta, *Conrad*. c
Leptobolus insignis, *Hall*. c
Schizocrania filosa, *Hall*. r
Pholidops subtruncata, *Hall*. c
Plectambonites plicatella, *Ulrich*. cc
P. sericea, *Sowerby* sp. c
Cyclospira bisulcata, *Emmons* sp. c
Archinacella patelliformis, *Hall* sp. cc
Protowarthia cancellata, *Hall* sp. (=Bellerophon bilobatus, *Hall*) r
Cyrtoceras annulatum, *Hall*. rr
Modiolopsis modiolaris, *Conrad*. r
M. ? nuculiformis, *Hall*. r
Goniophora carinata, *Hall* sp. c
Cuneamya, *sp.* fragment. r
Ctenodonta levata, *Hall*. r
Conularia trentonensis, *Hall*. c[2]

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[1] *See* p. 574.

[2] A comparison of this form with the type species of Conularia trentonensis, Hall, preserved in the New York state museum, and with typical material of Conularia hudsonia, Emmons, from the Lorraine beds, proved that the Utica form, instead of approaching the Lorraine species by greater coarseness of its sculpture, has, if any different sculpture, a rather closer and finer arrangement of the transversal and longitudinal lines than even the Trenton form.

Aparchites minutissimus, *Hall.* c
Ctenobolbina ciliata, *Emmons* sp. c
Lepidocoleus jamesi, *Hall & Whitfield* sp. cc[1]
Turrilepas (?) filosus *sp. n.* r[2]
Pollicipes siluricus *sp. n.* r
Calymmene *sp.* small pygidia. r
Trinucleus concentricus, *Hall.* cc
Triarthrus becki, *Green* sp. cc

While this fauna by its most common fossils, Corynoides curtus, Diplograptus quadrimucronatus, and Triarthrus becki, which cover whole surfaces, and by the presence of Leptobolus insignis and Lingula curta is characterized as being of Utica age, it contains a considerable number of Trenton as well as of Lorraine forms. The Trenton forms are:

Climacograptus caudatus, Cyclospira bisulcata, Cyrtoceras annulatum, Goniophora carinata, Ctenodonta levata, and Conularia trentonensis.

The Lorraine forms are: Pholidops subtruncata, Plectambonites plicatella, Modiolopsis modiolaris, Aparchites minutissimus, Ctenobolbina ciliata.

[1]The vertical range of this minute but pretty fossil cirriped is worthy of special notice. It was originally described by Hall and Whitfield (Paleontology of Ohio. 1875. 2:106) from the Hudson river group, Cincinnati O., the authors stating however, at the same time, that they had received from C. D. Walcott "specimens apparently identical on surfaces of Trenton limestone from near Trenton Falls N. Y." This statement can be verified by the writer, who collected in the Rafinesquina deltoidea beds of Trenton Falls a well preserved specimen. The collections from the shales of the Hudson valley prove now that it also occurs and is even most abundant in different horizons of the Utica terrane; for it has been found besides in the Lorraine beds of Waterford (station 1), in the upper Utica beds of Green Island (station 10) and of the Dudley observatory (Dr Beecher), in the lower Utica beds of Mechanicsville (station 5) in great profusion, and in the middle Trenton shales of Port Schuyler (station 23). It therefore persisted, at least in this region, from the middle Trenton into the Lorraine.

[2]*See* descriptions of this and the next species p. 577.

Of these however, Pholidops subtruncata, Modiolopsis modiolaris and Aparchites minutissimus present varietal differences. Pholidops subtruncata does not possess the faint median angulation of the Lorraine form, and has besides, been found in the Canadian Trenton by Ami; Modiolopsis modiolaris has the back and base nearly parallel and thus approaches Ulrich's M. subrecta, or is identical with one of the Utica varieties, mentioned by this author; and also the Aparchites minutissimus approaches the Trenton variety by the absence of the subcentral projecting point.

The Lorraine element is, hence, by no means, so strongly represented in this Utica fauna of Mechanicsville as appears at first glance or as it is in the Utica shales of Green Island. This is still more emphasized by the absence of Cleidophorus planulatus, Cyrtolites ornatus and Lyrodesma pulchellum, while, on the other hand, the Trenton element is so strong that the beds almost assume the character of transitional beds between the Trenton and Utica terranes.

An important and novel factor in this fauna is the peculiar Climacograptus caudatus which occurs frequently and in large specimens. This striking type of graptolite structure was first described by Lapworth from the Hartfell shales of Scotland which are considered homotaxial with the upper Dicellograptus zone of Canada, from which the same graptolite has been reported. As it is restricted to the upper Dicellograptus zone, and, therefore, is a valuable index fossil, its occurrence in the lowest Utica shale of Mechanicsville is of significance, indicating the presence of this zone in the Hudson river region and its proximity to the lowest Utica. If we add, that also Dawsonia campanulata, found at Mechanicsville, and Cryptograptus tricornis, found in similar lower Utica beds on Van Schaick island (*see* station 8) are fossils of the Dicellograptus zones, and not of the Utica horizon, it can be concluded with some degree of certainty that the upper Dicellograptus zone, when present in the Hudson river valley, directly underlies the Utica terrane, that is, is homotaxial with the whole or part of the upper Trenton. Unfortunately, no fossils have been found yet in this neighborhood between the middle Trenton Diplograptus amplexicaulis beds (*see* stations 22-27) or the lower Dicellograptus beds of Lansingburg and the Utica belt farther west.

### Station 6. Laveny's point, Waterford

This locality is a small bluff on the west bank of the Hudson, a little north of the bridge connecting Waterford and Lansingburg. Here are exposed steeply east dipping (50°, n 110° e) intensely black, hard, indurated, argillaceous slates, overlain a little farther north by gray arenaceous and micaceous shales, which in turn underlie alternating sandstones and shales. The black slate was found to contain:

Climacograptus typicalis, *Hall*[1]
Diplograptus putillus, *Hall*
D. spinulosus *sp. n.* (a colony and numerous hydrorhabds)
Endoceras proteiforme, *Hall*

Climacograptus typicalis and Diplograptus spinulosus are restricted to the Utica shale, while Diplograptus putillus finds its principal development in that terrane.

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[1]Climacograptus typicalis is, according to the consensus of all writers on the Utica and Normans kill faunas, restricted to the Utica shale and does not occur in the latter fauna. The only exception is found in Frech's statement (54:612) that he has seen specimens of this form from Normans kill in the Breslau museum. Frech, however, also considers Cl. parvus a dwarf form of Cl. typicalis, basing this opinion on a specimen from Cincinnati in the same museum. As Cl. parvus does not occur at Cincinnati, but is restricted to the Normans kill beds, where it is one of the most common forms, and as a comparison of these two graptolites, which nowhere occur together, shows that they can not be identical, it is probable that he did not recognize the two forms, and his Cl. typicalis from Normans kill is only a somewhat larger specimen of Cl. parvus.

Frech also proposes to change Hall's adjective, "typicalis" to "typicus" on the ground that the former is an anglicism. While it is true that typicalis is not a word of classic Latin origin, it was of common usage in later Latin, and, as many very expressive words have been taken from the post-classic Latin, it would not be practical to deprive the paleontologic nomenclature of this source of words by too strict philology.

### Station 7. Peoble's island, Waterford

In a similar black slate on Peoble's island (station 7), in the Hudson river opposite Waterford and about 2 miles southwest of Laveny's point, were found:

Climacograptus typicalis, *Hall*

Leptobolus insignis, *Hall*

### Station 8. Van Schaick island

This large island lies directly south of Peoble's island and forms a part of the city of Cohoes. The construction of a sewer system provided here a good opportunity of collecting in the compact, black, carbonaceous shales of the northern part of the island. The shale contains:

Diplograptus foliaceus, *Murchison* sp. cc

D. putillus, *Hall*. r

Cryptograptus tricornis, *Carruthers* (=Diplograptus marcidus, *Hall*) r

Cameroceras proteiforme, *Hall* sp. r

Leptobolus insignis, *Hall*. r

Schizocrania filosa, *Hall*. r

While the general character of the rock and fauna is distinctly that of Utica beds, the occurrence of Cryptograptus tricornis is wholly unexpected and difficult of explanation, as this graptolite thus far has been, in America, observed only as a member of the upper and lower Dicellograptus faunas, and in Scotland is restricted to the Glenkiln shales, which are homotaxial with the Normans kill or lower Dicellograptus shales. The presence of this graptolite points evidently to a position of these beds at the base of the Utica horizon.

### Station 9. North shore of Green Island

In the bluff along the northern shore of Green Island, directly west of the railroad bridge, several fossil-bearing bands were found in the shales. Two of these were calcareous, and consisted almost entirely of valves of brachiopods, a third was a black compact mudstone, which in one place was highly charged with fossils. The fossils collected were:

Pholidops subtruncata, *Hall.* r

Dalmanella testudinaria, *Dalman* sp. cc

Plectorthis plicatella *Hall.* c

Plectambonites sericea, *Sowerby* sp. var. aspera, *James*[1]

Rafinesquina alternata, *Emmons* sp. cc

Parastrophia hemiplicata, *Hall.* c

Pleurotomaria *cf.* lenticularis, *Hall.* r

Murchisonia (Lophospira) uniangulata *var.* abbreviata, *Hall.* c

Cyclonema bilix, *Conrad*, sp. r

Archinacella patelliformis, *Hall* sp. cc

Protowarthia cancellata, *Hall*, sp. (=Bellerophon bilobatus, *Hall*) c

Cyrtolites ornatus, *Conrad.* r

Clionychia undata, *Emmons* sp. c

Technophorus cancellatus *sp. n.* c

Cleidophorous planulatus, *Hall.* cc

Lyrodesma poststriatum, *Emmons* sp. r

L. pulchellum, *Hall.* c

Orthoceras tenuitextum, *Hall* sp. r

O. lineolatum, *Hall* sp. r

Spyroceras bilineatum, *Hall* sp. c

Isotelus gigas, *De Kay.* c

Calymmene senaria, *Conrad.* r

Pterygometopus callicephalus, *Hall.* cc

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[1]This variety is marked by acute, oblique wrinkles along the cardinal line, such as occur in Strophomena rugosa var. subtenta, and Strophomena incurvata (= S. filitexta). This feature is constant in the vast numbers of valves which compose some of the pebbles in the conglomerate of Rysedorph hill (*see* p. 546) and Moordener kill, and it continues upward into the Utica shale of Green Island, and Menands, though in these localities forms with and without wrinkles occur together. The same variety was observed by Dr Beecher in the material from the Dudley observatory, and listed as Leptaena subtenta ?. The wrinkling is apparently rare among specimens collected west of the Hudson river region, for it is not mentioned in the very detailed accounts of the characters of this species in the west by Sardeson, Winchell and Schuchert, but it was listed among the Cincinnati fossils by James as Leptaena aspera and has been figured by Hall and Whitfield. (Geol. sur. Ohio. Paleontology. v.1. pl. 5. fig. 3 f.)

Trinucleus concentricus, *Hall.* cc
Ceratocephala (Acidaspis) trentonensis, *Hall.* rr
Lepidocoleus jamesi, *Hall & Whitfield* sp. r
Pollicipes siluricus *sp. n.* c

### Station 10. East shore of Green Island

Nearly the same fauna was found in dark gray, fissile argillaceous shales, outcropping at the water edge along the east shore of Green Island a quarter of a mile below the state dam. The fauna of these shales consists of:

Diplograptus foliaceus, *Murchison.* r
Climacograptus typicalis, *Hall.* r
Corynoides curtus, *Nicholson.* r
Pholidops subtruncata, *Hall.* r
Dalmanella testudinaria, *Dalman* sp. cc
Plectorthis plicatella, *Hall.* c
Plectambonites sericea, *Sowerby* sp. cc
Rafinesquina alternata, *Emmons* sp. c
Murchisonia (Lophospira) uniangulata *var.* abbreviata, *Hall.* r
Lophospira bicincta, *Hall* sp. r
Archinacella patelliformis, *Hall* sp. c
Clionychia *sp. n.* rr.
Cleidophorus planulatus, *Hall.* cc
Modiolopsis faba, *Hall.* c
Cameroceras proteiforme, *Hall.* r
Triarthus becki, *Green* sp. r
Calymmene senaria, *Conrad.* r
Cyphaspis *sp.* rr
Trinucleus concentricus, *Hall.* cc
Ctenobolbina ciliata, *Emmons* sp. c
C. ciliata *var.* conuta *var. n.* c
Lepidocoleus jamesi, *Hall & Whitfield* sp. r

A comparison of these two faunas from Green Island with that discovered by Dr Beecher near the Dudley observatory at Albany proves their identity. Dr Beecher considered this fauna as being of Utica age, and Walcott declared it to represent in the whole the upper Utica age of the Mohawk valley region. It is remarkable for the considerable number of Lorraine forms on one hand and the nearly as great number of Trenton forms on the other. Some of these Lorraine forms were also observed in the very old Utica beds of Mechanicsville, and their varietal differences from the typical Lorraine forms remarked on. None of these Trenton forms occur in the pure Lorraine faunas of Block island and Waterford.[1]

### Station 11. Railroad station, Menands

A few fossils were discovered by Dr Clarke in fissile argillaceous shales exposed in a small gravel pit about a hundred yards north of Menands station. The fossils are:

Dalmanella testudinaria, *Dalman* sp. cc
Plectorthis plicatella, *Hall*. c
Plectambonites sericea, *Sowerby* sp. cc
P. sericea *var.* aspera, *James* var. c
Rafinesquina deltoidea, *Conrad* sp. rr
Archinacella patelliformis, *Hall*. c
Bellerophon bilobatus, *Hall*. r
Spyroceras bilineatum, *Hall*. r
Ctenobolbina ciliata, *Emmons* sp. r

The presence of Plectorthis plicatella and Spyroceras bilineatum connects this faunule with the faunas of Green Island.

### Station 12. Devil's Den, Watervliet

In a deep gorge, called Devil's Den (station 12), behind Gen. Schuyler's historic home and half a mile west of Watervliet, blackish and gray, fissile, soft argillaceous shales, somewhat sandy toward the upper end of the gorge, are exposed for about half a mile. These yielded a number of well preserved specimens of Orthograptus quadrimucronatus, Hall sp.

[1]The association of Trenton and Lorraine forms in the same beds, and the peculiar position of these beds in the Utica zone will be discussed later (p. 564).

### Station 13. Buttermilk fall, Watervliet

At the so-called Buttermilk fall (station 13) just south of the Devil's Den, Diplograptus putillus, Hall was found in black shales.

### Station 14. Rural cemetery, Albany

One mile directly south of the last two localities lies the Rural cemetery of Albany (station 14). Here a rich fauna was discovered by Dr Clarke in a road metal quarry close to Prof. James Hall's grave. The rock is a deep black, strongly carbonaceous, argillaceous shale. It contains:

Orthograptus quadrimucronatus, *Hall* sp. in great profusion and exquisite preservation, in fact in the best state of preservation of rhabdosomes of graptolites ever seen by the writer in shale.

Diplograptus putillus, *Hall*

D. spinulosus *sp. n.*

Corynoides curtus, *Lapworth*

Dendrograptus *sp.*[1]

[1]There occur in the shale of the Rural cemetery extremely fine and slender, chitinous, irregular branching threads of undoubted graptolitic nature. These are rolled up, the larger and smaller branches separately, into an intricate, irregularly convolute mass. Such a form has been described and figured by Emmons American geology. 1875. pt 2. p. 109. pl. 1. fig. 7) as Nemagrapsus capillaris. Hall did not recognize the genus, as one of Emmons's species, N. elegans, is only a fragment of Coenograptus gracilis, and the relations of the other form, N. capillaris, on which neither thecae nor thecal apertures were observed, "can scarcely be determined from the figures given" (11:43; 13:211). The genus was later accepted by Lapworth, but Roemer (54:587) remarks that Hall, having access to the material, was certainly better prepared to judge its value. Ami (Bul. geol. soc. Amer. 1891. II. table p. 495) reports it doubtfully from the Canadian Calciferous; and Gurley, after having described a form as belonging to Nemagraptus which he later recognized to be a Thamnograptus, declares that he has found typical specimens of Nemagraptus capillaris at Stockport, Columbia co., but does not describe them (50:296). The writer's material shows all the features indicated by Emmons's figure. Both the figure mentioned and the material suggest that the fossils consist of the broken terminal filiform branches of some delicate ramose graptolite which, drifting about, were rolled up. A comparison with specimens of Dendrograptus tenuiramosus, Walcott (10:21. pl. 1. fig. 4) from the Utica shale shows that our form on the

Eopolychaetus albaniensis *sp. n.*
Pontobdellopsis cometa *sp. n.*[1]
Leptobolus insignis, *Hall*
Schizambon (?) fissus *var.* canadensis *Ami*
Hormotoma *cf.* gracilis, *Hall* sp.

With the exception of Dendrograptus, which at this locality is of rare occurrence, all graptolites of this fauna were found in the lowest Utica shale at Panton Vt. As the same combination of graptolites has also been observed on slabs from the neighborhood of Amsterdam N. Y., it seems to constitute a faunule characteristic of a certain horizon of the Utica shale in New York, evidently of the lower part of the formation. In all three localities the graptolites are rarely found mixed but occur on different surfaces of closely adjoining layers; only the rarer D. spinulosus mingling with the others, as if they were assorted according to their weight while drifting about. The other graptolites of the Utica shale occur for the most part separately in the shales of the Mohawk valley; this is specially notable of Climacograptus typicalis, Cl. bicornis and Diplograptus ruedemanni.

### Station 15. Old Dudley observatory, Albany

3 miles S SW of the Rural cemetery exposure and just north of Albany, on Patroon's creek near the old Dudley observatory (station 15) is the exposure from where Dr Beecher, in 1889, obtained the first unmistakable Utica fauna from the Hudson river shales (*see* p. 502).

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whole is more slender and flexible (only .1 mm wide), but its thickest basal parts correspond in thickness to the terminal parts of that extremely delicate graptolite whose thin filiform ends also show at times an inclination to become convolute. Furthermore most of the branches possess the same smooth, unindented character and apparently, though not distinct enough to permit positive assertion, small pits along the median line. In the absence of more complete material, it seems therefore justifiable to consider this fossil as consisting of the broken, thin filiform ends of Dendrograptus tenuiramosus or a similar species.

[1] *See* description of these fossils p. 574.

### Station 16. Penitentiary, Albany

At the opposite outskirts of Albany, 2 miles to the southwest of the locality just mentioned, a graptolite fauna was discovered by Dr Clarke near the penitentiary (station 16) in a soft, black shale of the appearance of typical Utica shale and which also effervesces with HCl. The fauna consists of:

Corynoides curtus, *Lapworth*

Orthograptus quadrimucronatus, *Hall* sp.

Diplograptus putillus, *Hall*

D. spinulosus *sp. n.*

Climacograptus typicalis, *Hall*

Leptobolus insignis, *Hall*

Undetermined brachiopod

The first is the most common graptolite; it entirely covers some slabs.

### Station 17. Beaver park

J. Van Deloo collected, some years ago, at the time of the laying out of Beaver park, a few graptolites in a ravine in the northern part of the park. These on investigation proved to be specimens of Diplograptus putillus, Hall, indicating the Utica age of the beds of this locality, which is only a short distance east of the preceding locality.

### Station 18. Normansville

2 miles farther southwest, along the general strike of the rocks, is Normansville on the Normans kill. While at Normansville itself, in the sandstones and shales exposed above and below the bridge, no fossils were found, and the age of these rocks remains in doubt, a small outcrop of shale about a mile farther up, 100 yards below the landing of the picnic ground on the right bank of the river, furnishes graptolites (station 18). The rock is a deep bluish black, thick bedded argillite with conchoidal fracture and iron-stained cleavage planes. It is filled with specimens of

Climacograptus bicornis, *Hall*

Besides this occur:

Diplograptus quadrimucronatus, *Hall*

Diplograptus *cf.* foliaceus, *Murchison*, fragments

Corynoides curtus, *Lapworth*

Leptobolus insignis, *Hall*

**Station 19. Ravine by Normans kill**

About half a mile farther up the river in a ravine in the south bank a gray, arenaceous and micaceous, thin bedded shale was found which yielded quite a number of specimens of Diplograptus putillus, Hall (station 19). The beds of this, as those of all preceding stations, dip steeply to the east and have been involved in the tilting of the Hudson river beds.

**Station 20. Black creek, Voorheesville**

Following the Normans kill no outcrops are found in its widening valley or along any of the tributaries till reaching Black creek, a small southerly affluent, 4 miles farther up (station 20). The banks and the bed of this creek are formed of dark, often black, soft, non-metamorphic, mostly argillaceous shales, from which the creek derives its name. While near its mouth the shale is slightly disturbed by a fault which, according to its southwest strike, still belongs, as an accessory fault, to the Hudson river system of faults, the shales farther up the creek show a regular n 70° w dip and n 160° w strike, and lie hence outside the easterly tilted block of the Hudson river region. The large fault reported by Emmons and Ford as extending from Saratoga Springs across the Mohawk river and separating the tilted and folded Hudson river region from the undisturbed region to the west, probably passes the Normans kill between the last two stations and may also account for the lack of outcrops and the broadening of the valley between them. These black shales contain:

Orthograptus quadrimucronatus, *Hall* sp.

Diplograptus putillus, *Hall*

Climacograptus typicalis, *Hall*

Sagenella ambigua, *Walcott*
Cameroceras proteiforme, *Hall* sp.
Triarthrus becki, *Green*
They are hence undoubtedly of Utica age.

## Station 21. The Vly, Voorheesville

The next southerly tributary of the Normans kill is the Vly. This creek forms, as above noted, a fall below Voorheesville, caused by a heavy bank of sandstone which suggests the Lorraine age of these beds. Following the course of the creek downward, argillaceous shales, sandy shales and sandstone beds are passed in manifold alternations. They show a general western dip (20°), and in two places are thrown into a series of small parallel folds, a few feet wide, striking n 15° e. These as well as a fault, which runs in the same direction, are evidently the faint westerly outrunners of the powerful Appalachian disturbances of the Taconic mountains and of the Hudson river valley region with which they run parallel.

Farther down, about halfway between the sawmill and the mouth of the creek, black shales begin to replace the sandstones and lighter colored shales. In one of the lower drab beds of sandstone numerous large specimens of Climacograptus typicalis were found, indicating the Utica age of these lower sand beds (station 21). This sandstone effervesces with HCl and is, hence, calcareous, like the Utica shale of the Mohawk valley. In the dark gray sandy shales below this sandstone, which, however, do not effervesce, were found:

Climacograptus typicalis, *Hall*
Sagenella ambigua, *Walcott*
Cameroceras proteiforme, *Hall* sp.

It thus appears that along the Vly a section is exposed from the Utica shale into the overlying Lorraine beds. This outcrop of Utica shale is the most southern and western which could be found in the region studied, as this shale toward the Helderberg mountains dips under the Lorraine beds, which in their turn are overlain by the Upper Siluric and Devonic strata of these mountains.

### Extension of zone of Utica shale

The stations 5 to 21 comprise all the localities with Utica fossils known to the writer in this region. They are arranged, as a glance at the map will show, in a zone which, beginning at the banks of the Hudson river at Laveny's point, passing over the islands at the mouth of the Mohawk and following thence the edge of the plateau to the west of the Hudson valley, crosses the upper part of the city of Albany and extends to the Normans kill, where it passes under the drift. As this series of outcrops lies in the general direction of the strike of the rocks, and the latter form a mass with uniform easterly dip, it may be safely concluded that this zone represents a continuous terrane of Utica beds overlying the Lorraine beds of equal dip in the tilted region, and underlying the latter in the undisturbed region to the west of the separating fault. Toward the north the zone probably connects with the Utica shale known from the neighborhood of Mechancisville, Saratoga Springs, Sandyhill, etc.

## C MIDDLE TRENTON BEDS

### Station 22. Watervliet arsenal

The next group of stations (stations 22-26) comprises five localities which may be arranged in two rows extending from n ne to s sw on both sides of the Hudson river south of Watervliet and Troy. These localities furnish Trenton fossils. The occurrence of the latter was first made known by Whitfield (see p. 496), who reported the finding of D i p l o g r a p t u s a m p l e x i c a u l i s at the Watervliet arsenal (station 22), and south of Troy in shaly partings between layers of metamorphic limestone. The locality at the arsenal is no more accessible, but part of the material collected at that time is preserved in the state museum. It consists of very soft bluish black, argillaceous shale, which does not effervesce with HCl and is thickly packed with a long, narrow graptolite which in dimensions, arrangement and form of thecae corresponds with the Middleville specimens of Diplograptus amplexicaulis[1] with which it was compared.

### Station 23. Fitzgerald's quarry, Port Schuyler

In James Fitzgerald's quarry (station 23) ¾ of a mile south of the arsenal, at the western terminus of Fourth street in Port Schuyler, thick bedded gray and black argillaceous shales and arenaceous, mica-bearing argillite are broken for road metal. The sandy beds contained:

Schizocrinus nodosus, *Hall*
Dalmanella testudinaria, *Emmons* sp.
Plectorthis plicatella, *Hall*
Platystrophia biforata, *Schlotheim* sp.
Plectambonites sericea, *Sowerby* sp.
Rafinesquina alternata, *Conrad* sp.

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[1] Diplogaptus amplexicaulis was first described by Hall from the middle Trenton of Trenton Falls and Middleville. There, as well as at Trenton, it occurs in great profusion in certain beds of the middle Trenton, while in the Rathbone brook section, south of Trenton Falls, it was also observed in beds considered as lower Trenton by Dr Th. A. White (51:86). Whitfield, as observed (p. 496) found it at the Watervliet arsenal and at south Troy, and based on it his correlation of these shales with the Trenton. Gurley, who considers it as only a mutation of D. foliaceus, assigns it to the Chazy (Mystic, Can.) and Trenton. Joseph F. James records its collection in the typical Maquoketa locality (Amer. geol. 4:237); Walcott mentions its being found in the upper part of the Lorraine section (36a:339); and Whitfield enumerates in his catalogue (61:20–21) as D. amplexicaulis a number of Hall's types of Gr. pristis of *Pal. N. Y.*, v. 1, from Turin, Lorraine, Collinsville and the Oxtungo creek. It becomes apparent from these citations that this graptolite is of rather uncertain value as an index fossil of the Trenton; it has been reported from beds ranging from the Chazy to the Lorraine, and probably the form is not yet well understood or D. foliaceus, to which it is closely related, has been mistaken for it. The amplexicaulity of the thecae is not restricted to this species, the concavo-convex section of the rhabdosome is not observable in flattened specimens, so that in the determination of specimens from the shale one is restricted to the observation of the dimensions, outline of thecae and rhabdosome, and of the general habit. These characters, however, being subject to alteration by variations in pressure, are often difficult of exact observation. The relations of this form to D. foliaceus and its vertical range apparently need farther study. The writer has not seen typical specimens of this form from beds of younger than middle Trenton age.

Ctenobolbina subrotunda *sp. n.*

Lepidocoleus jamesi, *Hall & Whitfield* sp.

In the more argillaceous rock were found:

Diplograptus (Glyptograptus) amplexicaulis *Hall*

D. foliaceus, *Murchison*

Proëtus *cf.* parviusculus, *Hall*

The combination of Diplograptus amplexicaulis with Schizocrinus nodosus and Proëtus cf. parviusculus is fairly sufficient evidence of the Trenton age of the shales and sandstones in Fitzgerald's quarry; for D. amplexicaulis occurs typically in the lower and middle Trenton and Schizocrinus nodosus and Proëtus parviusculus (*see* next station) are known from the Trenton only. Ctenobolbina subrotunda is nearest related to the Trenton species (Ct. fulcrata and Ct. crassa, Ulrich) of that genus (*see* description, p. 576).

### Station 24. Brothers's quarry, south Troy

The outcrop south of Troy where Whitfield 26 years ago collected the Trenton graptolite, could not be precisely located; at least no information of the former occurrence of limestone in that neighborhood could be obtained. There were, however, several localities found which furnished ample evidence of the presence of Trenton fossils and which, as they contain calcareous sandstone banks with intercalated impure limestone banks and shales, may be identical with Mr Whitfield's collecting ground.

The most important locality is the Brothers's or Lavery's quarry station 24), at the brow of the hills east of south Troy. Diplograptus amplexicaulis is found here in great numbers in black, argillaceous shale at the east side of the quarry and more sparingly in association with Corynoides calicularis in similar beds at the opposite side of the quarry.

In calcareous sandstone beds which contain dark impure limestone banks consisting of brachiopod shells, in the middle part of the quarry, occur brachiopods, a number of which were first collected by Gilbert Van Ingen of Columbia university and kindly left with the writer; and one bed is filled with bryozoans. The beds yielded:

Schizocrinus nodosus, *Hall*

Pachydictya acuta, *Hall* sp.

*cf.* Escharopora angularis, *Ulrich*

Prasopora *sp.*

Dalmanella testudinaria, *Dalman* sp.

Plectorthis plicatella, *Hall*

Platystrophia biforata, *Schlotheim* sp.

Plectambonites sericea, *Sowerby* sp.

Rafinesquina alternata, *Emmons* sp.

Rhynchotrema increbescens, *Hall* sp. (= inaequivalvis, *Castelnau* sp.)

Proëtus parviusculus, *Hall*

Of these species Schizocrinus nodosus indicates the Trenton age in general, while Pachydictya acuta is reported by Hall (7: 75) as "of frequent occurrence in both the lower and central portions of the Trenton limestone", a statement with which Winchell and Ulrich concur in reporting the fossil from the Clitambonites, Fusispira and Nematopora beds of Minnesota (49: 111). Escharopora is, according to the same authors, restricted to the Stones river, Black river, lower and central Trenton beds. Rhynchotrema increbescens, in the restricted meaning (i. e. with the exclusion of the distinct Lorraine form, R. capax, originally included by Hall in this species) is a Trenton form. In the west it occurs in the upper Black river group, lower and middle Trenton (49: cxv) and in Canada it is found in Black river and lower Trenton. It is, hence, indicative of the lower or middle Trenton age of the Troy beds. Proëtus parviusculus was originally described by Hall (14: 223) as occurring "in shales of the Hudson river group, Cincinnati, Ohio". The correlation of these shales has, however, changed since that time; for Winchell and Ulrich cite the form from the Trenton of the Cincinnati region. Dr Clarke (49: 754) reports it from the base of the Galena shales at St Paul (Clitambonites bed, Winchell and Ulrich, which is lower Trenton). In Canada it has also been found in the Trenton.

The occurrence of Pachydictya acuta, Rhynchotrema increbescens and Proëtus parviusculus would, hence, indicate a lower or middle Trenton age for these beds, which correlation can, on account of the abundance and association of Diplograptus amplexicaulis, with these fossils, be limited with a fair degree of exactness to the middle Trenton age.

A remarkable and easily misleading feature of some beds in this as well as in the Fitzgerald quarry is their great similarity to some Lorraine beds at Waterford; for in all three localities there occur gray, sandy argillaceous rocks with iron-stained fossils, which it would be difficult to separate by their lithologic aspect, but the fossil contents and a strong admixture of calcareous matter in the rocks of the Brothers's quarry show that this similarity is only accidental.

### Station 25. Ruscher's quarry, south Troy

Directly south of the Brothers's quarry and in the strike of its rocks lies another large quarry, Ruscher's (station 25). The same black shales, heavy sandstone banks and arenaceous limestone beds, as well as greenish shales toward the eastern part, are here exposed. Diplograptus amplexicaulis is also quite common.

### Station 26. Corner of Adams and 10th streets, Troy

In the railroad cut at the corner of Adams and 10th streets in North Troy, (station 26) in a compact, black argillaceous shale Diplograptus amplexicaulis, Hall, and Corynoides curtus, Nicholson, were found. These fossils and the appearance of the rock leave no doubt of the identity of these beds with those exposed in their direct strike in the Brothers's and Ruscher's quarries in south Troy. No other exposures of these beds have been met with farther north, in the investigated area, though they undoubtedly continue in the direction indicated by the outcrops in Troy.

### Extension of zone of middle Trenton beds

The five stations, 22-26, establish the presence of a zone of rocks of the general appearance of the Hudson river shales and sandstones (but containing some limestone), between Troy and Watervliet, which is about 1 mile wide and equivalent to the middle Trenton. This zone could not be traced farther south, which fact, however, finds its explanation in the topographic conditions prevailing to the south; for the strike of the middle Trenton beds brings them, as an examination of the map will show, into the alluvial plain of the Hudson river where outcrops are absent. The zone would then probably pass through the lower part of the city of Albany and could be expected along the Normans kill above Kenwood and below the Utica shale outcrops described above. But along that part of the river only one exposure is found, that at Normansville, and this, unfortunately, is not known to have ever yielded any fossils. From here to the Lorraine sandstones and shales at the base of the Helderberg escarpment no farther outcrops could be found. Both the Vlaumans and the Coeymans kills, which have been followed by the writer along their entire courses, show outcrops only near their mouths, and these belong to the next following zone. The outcrops at the upper Coeymans kill and its tributary, the Sprayt kill, have been mentioned above. On account of the general n ne-s sw strike of all the beds in this region, it can, however, be safely surmised that this zone passes under the Helderbergs.

### D NORMANSKILL BEDS (LOWER DICELLOGRAPTUS ZONE)

After the presence of these zones of Lorraine, Utica and Trenton shales in the Hudson river valley had become evident to the writer, a thorough search for the graptolites of the Normans kill or lower Dicellograptus zone was instituted, this zone being, in accordance with the views of previous writers, sought for between the Lorraine and Utica, and between the Utica and Trenton zones. There has, however, no trace of these graptolites been found between or within the Utica and Lorraine zones, while an investigation of the rocks to the east of the Trenton zone has furnished ample evidence of the presence of the Dicellograptus zone.

The following stations with these fossils were found:

### Station 27. Cahill's hill, south Troy

Behind the Brothers's quarry outcrops of mostly dark shales may be followed up almost to the top of Cahill's hill, whence a small gully runs north into the Poesten kill in upper Spring avenue, south Troy (station 27). This gully furnishes a good section. In its upper part greenish gray argillaceous shales, farther down gray, somewhat sandy shales, and at the bottom softer, black argillaceous shales are exposed. The last contain graptolites in a fine state of preservation; besides Corynoides calicularis and a narrow Diplograptus which closely approaches D. amplexicaulis; well developed specimens of Diplograptus foliaceus occur in fair number. The combined presence of these indicates the transition of the middle Trenton shale of station 24 into another zone.

### Station 28. Poesten kill, South Troy

The Trenton shales of the Brothers's quarry appear again across the Poesten kill in Spring avenue in a small road metal pit behind the northern row of houses. Going from here 200 yards east, along the north bank of the Poesten kill, just above Ruff's canal mills, a four foot sandstone bed is met with to the left of the road, which is overlain by black, strongly carbonaceous, argillaceous, rather thick bedded shales. These were found to contain graptolites in considerable number and in a fair state of preservation (station 19). There were observed:

Leptograptus subtenuis, *Hall* sp.
Dicellograptus intortus, *Gurley*
D. sextans, *Hall* sp.
Climacograptus bicornis, *Hall*
C. parvus, *Hall*
Diplograptus foliaceus, *Murchison* sp.

Cryptograptus tricornis, *Carruthers* sp.(=D. marcidus, *Hall*)

Corynoides calicularis, *Nicholson*

Dawsonia *sp.*

Rhombodictyon *sp.*

Of these Leptograptus subtenuis, Dicellograptus intortus, Climacograptus parvus, Dawsonia and Rhombodictyon are restricted to the Dicellograptus zones, while Cryptograptus tricornis passes from the Calciferous into the lower Dicellograptus zone, but not into the Utica or Lorraine beds. This shale is, hence, an unmistakable representative of the Normans kill or lower Dicellograptus beds, and this interesting discovery demonstrates the presence of the Normans kill fauna only a few hundred yards to the east of the middle Trenton fauna.

Following the section farther up along the Poesten kill, alternations of sandstones and black argillaceous shales are first met with, then a four foot conglomerate with black shale as matrix, at the water tower of the wire mill; above this alternations of fissile, black and greenish gray shales and finally, by gradual disappearance of the black shales, only green shales. On the other side of the Poesten kill, just below the picturesque waterfalls, specimens of Rhombodictyon were found in a black shale, intercalated in a green shale, the latter containing great quantities of fragments of algae. These shales extend eastward as far as the great fault which brought up the Cambrian beds against the "Hudson river shales".

### Station 29. Mount Olympus, Troy

Another outcrop of graptolite shale was found 2 miles farther north at Mt Olympus, a landmark of North Troy, consisting of a cliff rising some 60 feet above the alluvial plain.

The deep black, fissile argillaceous shales contain:

Didymograptus tenuis, *Hall* sp. rr

Dicranograptus ramosus, *Hall.* r

Climacograptus bicornis, *Hall.* cc

C. parvus, *Hall.* cc

C. *sp. n.*[1]

Dawsoni campanulata, *Nicholson.* c

Leptobolus walcotti *sp. n.* r

### Station 30. North end of Lansingburg

An exceptionally good opportunity for collecting was offered for a time by a large excavation made around the new long distance telephone power-house at the north end of Lansingburg, north of Troy. The rock consists of black, fissile argillaceous shales, black, hard, compact argillite and intercalated, green argillaceous shales. The black shale furnished:

Corynoides calicularis, *Nicholson.* In immense number

Didymograptus serratulus, *Hall.* rr

Dicranograptus ramosus, *Hall.* r

Diplograptus angustifolius, *Hall.* Completely covering some surfaces

D. *aff.* putillus, *Hall.* rr

D. foliaceus, *Murchison.* sp. c

D. whitfieldi, *Hall.* c

Climacograptus bicornis, *Hall.* c

C. scharenbergi, *Lapworth.* c

C. *sp. n.* cc

C. *sp. n.* c

The faunas of Lansingburg and Mt Olympus, which lie in the same strike and evidently belong together, differ in general aspect from that of the lower Dicellograptus fauna by the scarcity of branching forms and the strong prevalence, in species and individuals, of the biserrate graptolites, notably of the genera Diplograptus and Climacograptus. They approach in this regard the fauna of the upper Dicellograptus beds, to which they could be referred, were it not for the occurrence of a few stipes of Didymograptus tenuis,

[1]The new species of graptolites will be described in a separate, later paper.

Didymograptus serratulus and the countless numbers of Diplograptus angustifolius, these three graptolites belonging to the lower Dicellograptus zone. The general aspect of this fauna, the appearance of several new species of Climacograptus in it and the fact that the graptolite shales of Mt Olympus on one hand lie to the northwest, that is apparently above the Diplograptus amplexicaulis beds of station 27, and on the other hand closely approach the Utica beds at Lansingburg and at station 31, half a mile farther north, may be taken to suggest that we have here a separate horizon. If these beds do not represent another zone, but only a part of the upper Dicellograptus zone, the Diplograptus amplexicaulis zone would seem partly to overlie with its beds at Watervliet, and partly to be intercalated into, the lower Dicellograptus zone, at station 27, east of Mt Olympus, an irregularity which may be also caused by the complicated folding of the region, which partakes of the nature of an anticlinorium (*see* p. 557). The entire problem, however, of the relation of these beds of Lansingburg to the lower Dicellograptus and Diplograptus amplexicaulis zones awaits its solution in the tracing of the entire system farther north at some future time.

### Station 31. Bluff above Lansingburg

Directly opposite Laveny's point, station 6, in a high bluff, half a mile above the Lansingburg-Waterford bridge, a fossiliferous bed was found. The soft, fissile, black shale contained:

Corynoides calicularis, *Nicholson.* r
Diplograptus *sp.* Small fragment
Climacograptus bicornis, *Hall.* c
Climacograptus *sp. n.* c

These beds probably belong to the horizon represented by the Lansingburg fauna.

Following these sandstones, black gray and greenish shales of the Poesten kill southward, a good section is met along a creek entering the river opposite Lagoon island. Here similar rocks are exposed, which, however, did not yield any fossils.

### Station 32. Rensselaer

The next fossils were found in a small road metal pit at the corner of High street and Third avenue in Rensselaer (Greenbush) (station 32), where dark glazed shales and some thin gritty bands are exposed. In the shales were found some specimens of Leptograptus subtenuis and the young of a Didymograptus. The Leptograptus subtenuis is sufficient to characterize these shales as belonging to the lower Dicellograptus zone.

### Station 33. Kenwood (Normans kill)

In the latitude of this station the lower Dicellograptus zone has crossed the Hudson river; for 3 miles southwest of it Hall's classical graptolite locality at the lower Normans kill (Kenwood) is situated (station 33). The rocks, exposed in a railroad cut and at the falls of the Normans kill consist of thick, partly coarse sandstone banks with intercalated, glazed, grayish argillaceous shales and some black shale from which the graptolites were obtained (described in *Pal. N. Y.*, v. 1 and 3).

### Station 34. Glenmont (the Abbey)

Another locality which furnished fine material and still contains graptolites is the cut on the West Shore railroad, half a mile below the station of Glenmont (the Abbey, station 34), where similar beds with a thin black band, full of characteristic and finely preserved Normans kill graptolites, have been exposed. Southward from here, localities with this fauna have been found on both sides of the Hudson river; on the west side as far as 70 miles south of Albany (27).

### Station 35. Moordener kill, Castleton

There is first the fine exposure of "Hudson river shales" and of the overthrust Cambrian beds along the Moordener kill or Murder creek extending from Castleton on the Hudson, 7 miles south of Rensselaer, to East Schodack (station 35). The section begins opposite the mill of the Fort Orange paper co. with much contorted black, partly glazed, argillaceous shale, which proved to be rich in specimens of Climacograptus parvus, but also furnished:

Diplograptus foliaceus, *Murchison* sp.

D. angustifolius, *Hall*

Climacograptus bicornis, *Hall*

Lasiograptus mucronatus, *Hall* sp.

Corynoides calicularis, *Nicholson*

The presence of Climacograptus parvus, Diplograptus angustifolius and Lasiograptus mucronatus places this fauna in the lower Dicellograptus zone.

## CONGLOMERATE BED OF LOWER TRENTON ASPECT IN SHALE

About 150 yards farther up in the nucleus of a small anticline, a conglomerate bed with black shales above and below is exposed. The exact thickness of the latter could not, on account of the intricate contortions and the resulting swelling up and thinning out of the bed within a short space, be made out in this place, but the same conglomerate bed, or a very similar one, farther up the creek proved to be about 13 feet thick and was also inclosed on both sides by black shales. The matrix consists of a dark arenaceous limestone which weathers into a drab sandstone, while the boulders, which are all well worn, consist of small pebbles of reddish or yellowish sandstone, probably of Potsdam and Beekmantown (Calciferous) age, of large boulders (up to 1 foot in diameter) of light blue, hard Lowville (Birdseye) limestone with birdseyes and Tetradium cellulosum, Hall sp. (a typical Lowville limestone fossil), and of still larger boulders (one 2½ feet in diameter) of dark gray Trenton limestone. The latter contained:

Streptelasma corniculum, *Hall*

Callopora *cf.* ampla, *Ulrich.* c

Plectambonites sericea, *Sowerby* sp. var. aspera, *James.* cc

Strophomena incurvata, *Shepard* sp. (=Str. filitexta, *Hall*) c

Rhynchotrema increbescens, *Hall.* r

Conradella compressa, *Hall* sp. r

Pterygometopus callicephalus, *Hall.* sp. r

Isotelus *cf.* gigas, *De Kay.* c

Macronotella ulrich *sp. n.* r

Bollia *sp. n.* r

In pebbles of a very fine grained, dull black limestone were found:

Callopora ampla, *Ulrich.* c

C. multitabulata, *Ulrich.* c

Dalmanella testudinaria, *Dalman* sp. c

Platystrophia biforata, *Schlotheim* sp. c

Plectambonites *sp. n. aff.* gibbosa, *Winchell & Schuchert.* cc

Christiania trentonensis *sp. n.* r

Eccyliopterus *sp. n.* r

Pterygometopus callicephalus, *Hall* sp. c

Ceraurus pleurexanthemus, *Hall.* r

Conularia trentonensis, *Hall.* Young specimen. r

The matrix contained:

Pachydictya *sp.* c

Stromatocerium *sp.* cc

Rafinesquina alternata, *Emmons* sp. c

Plectambonites sericea, *Sowerby* sp. var. aspera, *James.* r

Strophomena incurvata, *Shepard* sp. r

Plectambonites, *sp. n. aff.* gibbosa, *Winchell & Schuchert.* r

Of these forms Streptelasma corniculum occurs, according to Hall, principally in the lower Trenton; Winchell and Schuchert report it from the lower and middle Trenton; Callopora ampla and multitabulata are both Black river and lower Trenton forms in the west; Pachydictya is principally developed in the lower and middle Trenton; Strophomena incurvata occurs according to Hall in the lower Trenton at Middleville, is reported by White from the same bed with Diplograptus amplexicaulis, and may therefore, rise into the middle Trenton; and in the west it is princi-

[1]The new fossils of this and the next station will be described in a separate paper.

pally distributed through the Stones river and Black river groups. The single species of Macronotella, made known by Ulrich (49:648), comes from the Stones river group (Lowville limestone). All the other fossils found belong either to species which lived throughout the Trenton age or to new species too different from those known to allow taxonomic conclusions.

It is obvious that the faunas of both the pebbles and of the matrix point to a low horizon in the Trenton stage which may even descend into the Black river stage. A threefold interest attaches, therefore, to this fauna, firstly that of its location in the eastern region, secondly that of the remarkable character of its components and finally, its intercalation in the Normans kill shales.

## CONGLOMERATE BED ON RYSEDORPH HILL

This interest is hightened by the occurrence of another conglomerate bed on the top of Rysedorph hill or the Pinnacle, east of Rensselaer (station 36 on map), which contains the same groups of Trenton pebbles bearing the same faunas, augmented, however, by numerous other species, in part new.[1] The peculiar antique character of this Trenton fauna of Rysedorph hill finds its most pregnant expression in the numerous specimens of Ampyx hastatus sp. n. (*see* pl. 1, fig. 1) and Remopleurides linguatus sp. n. found in the same pebbles with Ceraurus and Pterygometopus. As before observed, Ami found similar antique forms in the Dicellograptus zone of the Quebec massive. The different composition of this eastern Trenton fauna when compared with the other Trenton faunas of the state, is a fitting corollary to the restriction of the Normans kill fauna, with which it is homotaxial, to the eastern margin of the state. Both faunas, together with Ami's interesting discoveries, point to conditions and connections of this eastern border sea altogether different from those of the regions to the west.

[1] This is the locality termed by Emmons (Am. geol. pt 2, p. 72) and Walcott "Cantonment hill."

One fossil of the Rysedorph hill fauna deserves special notice in this place. It is a small graptolite, several specimens of which were found in an exquisite, uncompressed state of preservation in a small, dark gray limestone pebble which within a cubic inch contained, besides the graptolites, a cranidium of Ampyx hastatus, a cephalon of Pterygometopus callicephalus, Plectambonites aff. gibbosa and a Callopora (*see* pl. 1, fig. 1). The graptolite is a Climacograptus. A careful comparison of it with all the species of Climacograptus obtained so far from the Normans kill and Utica shales of New York shows its absolute identity with a form which is quite common in the Normans kill shale of Mt Moreno near Hudson. It differs from all other species of Climacograptus by its strong sculpture and specially by the characteristic deep, strongly zigzag groove along the median line of the rhabdosome. This is a characteristic feature of Climacograptus scharenbergi Lapworth, with which it also agrees in the rectangular outline of the thecae and apparent absence of appendages. Cl. scharenbergi has been reported before by Lapworth and Gurley from the lower and upper Dicellograptus zones (the former=Normans kill zone) of Canada. It does not rise into the Utica and Lorraine beds. Its association at Rysedorph hill with a peculiar lower Trenton fauna, is, hence, a strong argument in favor of the lower Trenton age of the Normans kill shale.

In Europe this graptolite occurs at even deeper horizons; for Roemer (54:612) collected it in the Phyllograptus shales near Christiania, and Tullberg reports it from the horizons with Didymograptus geminus and Diplograptus putillus, which, in Scania, lie below the Coenograptus gracilis zone (=lower Dicellograptus zone). In Scotland it occurs in the corresponding Glenkiln shales, which also lie deeper than the zone with Coenograptus gracilis which forms the base of the Moffat beds.

The beds on Rysedorph hill which outcrop at the fault between the Normans kill shales and the Cambrian slates represent probably, as remarked by Walcott (36:319) a block caught on the line of the fault. A similar case has been made known by Vanuxem from the East Canada creek, where along a fault a Trenton limestone bed has been caught between the Utica shale and the Beekmantown (Calciferous) limestone (5:210). This would indicate that the conglomerate bed was the first resistent stratum within or below the Normans kill shales. Its similarity with the Moordener kill bed permits the conclusion that it is, like the latter, inclosed in the shales, and perhaps continuous with it. A few miles south of Castleton another brecciated limestone bed, intercalated in graptolite-bearing Normans kill shales, was discovered by Ford (*see* p. 503). This lies directly in the strike of the Moordener kill bed and is probably also continuous with it.

The conclusion to be derived from the observations on these conglomerate beds, which is of the greatest import for the present investigation, is that there is intercalated in undoubted Normans kill or lower Dicellograptus shales a conglomerate bed which, in pebbles as well as matrix, contains as its youngest fossils those of lower Trenton aspect. The occurrence of pebbles of two different kinds of limestone (even three at Rysedorph hill) means that the formation of several Trenton limestone beds must have preceded the deposition of these shales, and that an unconformity exists between the limestone and the shale. The more common fossils of the pebbles have however been found also in the matrix. This could be explained either by the assumption that some fossils became separated from the pebbles and embedded in the matrix, a view which seems to be supported by the scarcity of fossils in the matrix and opposed by the occurrence of whole specimens of such fragile shells as Strophomena incurvata and Plectambonites sericea var. aspera, James; or by the assumption that the forms entombed in the pebbles were still flourishing at the time of the formation of the conglomerate. As the conditions of living in a region where the deposition of large boulders proceeds are evidently not favorable to a benthonic fauna, the scarcity of fossils in the matrix appears natural; and the view of the continued existence of the fauna of the pebbles, in some adjacent region, and its occasional incursion into the graptolite province seems to be the better supported. This would mean that the Normans kill graptolite fauna and the mollusk and trilobite fauna of the conglomerate with lower Trenton aspect were synchronous. The presence of Trenton fossils in so-called Hudson river shales has been proved before (*see* p. 536). So has the resting of these shales immediately on lower Trenton limestone beds in the regions to the east (33) and to the south, near Poughkeepsie (21).

Following up the Moordener kill to the base of the second falls, black shales with intercalations of hard, black chert beds and some thinner sandstone and limestone bands are passed, and at this point a conglomerate bed, 13 feet thick and flanked by thinner conglomerate beds, crosses the creek. On account of the disturbed character of the region, this bed may be identical with that first mentioned. The shales continue to the third falls, where a third conglomerate bed, 20 feet thick, is met with. Then follow coarse sandstones in layers from 2 to 4 feet thick, and sandy shales, and above them black, fissile, argillaceous shales with many thin intercalations of dark limestone and sandstone. After a break of some 300 feet, dark gray, fissile shales again appear, and these continue to the bridge over the Moordener kill on the road between Castleton and Schodack depot (Brookview). Just below this bridge, in steel gray, somewhat sandy, argillaceous shales, numerous excellently preserved specimens of Corynoides calicularis were found. This occurrence suggests that all these beds may belong to the Dicellograptus zone.

A mile and a half farther up, the creek passes again over glazed gray and black shales and bluish quartzite beds, followed, below Dickerman's mill, 2 miles below Schodack Center, by the green and purple slates and grits of the Cambric formation.

## EXTENSION OF ZONE OF NORMANS KILL BEDS

(*Lower Dicellograptus beds*)

That the Dicellograptus beds extend farther south along the Hudson river is fully demonstrated by the collection made by Ford at Schodack Landing and by the rich collecting grounds of graptolites near Stockport on the Kinderhook creek and at Mt Moreno, near Hudson. An occurrence worthy of record is the alternation of indurated green slate containing fucoids, with black, graptolite-bearing shales, in a quarry at the north side of Mt Moreno where the alternating bands often do not exceed an inch in thickness.

The presence of the Normans kill fauna at the Poesten kill near Troy, at Rensselaer, the Moordener kill, Schodack Landing, the Kinderhook creek and Hudson, all east of the Hudson river, and at the Normans kill (Kenwood) and the Abbey (Glenmont), west of the river, demonstrates the presence of a zone of Normans kill or Dicellograptus beds to the east of the other zones, as a glance at the map will show. This zone may extend northward through Vermont into Canada. It has also been found in Maine (39).

## TAXONOMIC POSITION OF THE NORMANS KILL GRAPTOLITE BEDS

In the region northeast, east and southeast of Albany the Normans kill zone is cut off by the overthrust fault which brought it in contact with the Cambric beds. Farther south it has been found to rest on lower Trenton limestone (33). These Trenton limestone beds, which are in the north only indicated by the conglomerate beds of Rysedorph hill, the Moordener kill and Schodack Landing, would, hence, constitute a fifth zone. Between this zone and the zone of middle Trenton shales and limestones, outcropping at Watervliet and south Troy, is now interposed the Dicellograptus zone. There can, hence, in the mass of "Hudson river shales" be discerned four zones from west to east, namely:

1 Lorraine beds
2 Utica beds
3 Upper and middle Trenton beds
4 Dicellograptus beds; these resting on
5 Lower Trenton limestone

The legitimate conclusion to be drawn from this succession of beds is that *the Dicellograptus zone is homotaxial with a part of the middle or lower Trenton limestone.* This conclusion stands in full accord with the evidence furnished by the conglomerate beds.

None of these zones, however, is entirely uniform in its fossil contents, as a comparison of the fossils from the various stations easily demonstrates. Not taking into account the difference between graptolite and mollusk beds which may be synchronous, run into each other and alternate irregularly, it is evident that the associations of fossils in some beds differ greatly from the typical faunas of their epoch.

There is first the difference between the typical lower Dicellograptus beds and the Dicellograptus beds of Mt Olympus and Lansingburg; farther the remarkable admixture of Trenton fossils and the presence of the *Climacograptus caudatus*, which is a typical upper Dicellograptus form, in the Utica beds of Mechanicsville, and the appearance of *Cryptograptus tricornis* among the Utica fossils of Van Schaick island. These latter faunas differ markedly from the typical Utica graptolite fauna of the Rural cemetery, the penitentiary and the lower Normans kill. There is finally the peculiar combination of Trenton and Lorraine forms with the Utica fauna of the old observatory and Green Island.

The full list of the various faunas observed is the following:

Lower Trenton fauna of conglomerate beds of Rysedorph hill, consisting at least of three different faunules

<table>
<tr><td rowspan="3">Trenton</td><td>Typical lower Dicellograptus fauna</td><td></td></tr>
<tr><td>Lower Dicell. fauna of Mt Olympus and Lansingburg</td><td rowspan="2">Relative position of these two faunas not yet clearly determined</td></tr>
<tr><td>Dipl. amplexicaulis fauna</td></tr>
</table>

| | |
|---|---|
| Utica | Utica fauna of Mechanicsville with Con. trentonensis and Climacogr. caudatus |
| | Utica fauna of Van Schaick island with Cryptogr. tricornis |
| | Typical Utica graptolite fauna of Rural cemetery, etc. with Diplogr. quadrimucronatus and Diplogr. putillus |
| | Upper Utica beds of old Dudley observatory and Green Island |
| | Typical Lorraine beds of Waterford and Block island |

Which of these minor faunas constitute constant sub-horizons of the larger divisions has not been established thus far; but it is expected that a continuation of this investigation in the areas adjoining north and south will furnish the desired information.

## EXPLANATION OF THE OVERTURN OF THE STRATA

All these beds now dip east and the Lorraine beds are, hence, the lowest in the series (*see* fig. 5, p. 556). It is, therefore, necessary to assume either a series of parallel overthrusts which brought up deeper beds successively or a complete overturn of the whole series of strata. The former assumption would seem to find some support in the abundance of slickensides and small faults in some localities, as specially in the Brothers's quarry at south Troy and along Dry creek, west of Watervliet. But it could hardly be supposed that a system of larger faults could produce such a regular succession of zones following the general strike of the beds as that found in the investigated area, without repetition of zones or other irregularities. The slickensides, which are often not a foot apart, might be assumed to indicate an upward movement of the entire mass along an infinite number of small faults, such that the more easterly beds were regularly pushed a little farther up, in a manner illustrated by Van Hise (58) to show the possible great surficial elongation of the crust by small displacements along shearing joints. Under such assumption the whole orogenic movement would evidently have been uniform and would have, regularly and gradually, brought up the deeper beds in the east, and, therefore, not interfere with our conclusion as to the stratigraphic position of the Dicellograptus zone. But slickensides and small faults abound in all folded regions, while the presence of numerous small folds as far west as the Vly and throughout the whole territory, as well as the bounding of the area by powerfully folded parts of the crust in the east (Taconic mountains), in the south by the limestone belts which traverse the shales and in the southwest by the folded parts of the Helderberg region, makes the explanation of the inversion of the beds by a system of shearing joints appear rather forced and suggests that the inversion is the result of overfolding. The writer much prefers the latter view, as it considers the inverted system of beds as a whole and as not necessarily involving a great disturbance of the original succession. It does away with those elements of uncertainty as to the unbroken succession of the four zones which would be involved in the assumption of inversion by an overthrust system. Arguments in support of this view are therefore here presented.

It is an established fact that the numerous folds of the Appalachian mountain system have their steepest slopes facing the northwest or the interior of the continent and are more or less overturned in that direction. The presence of the Appalachian system of folds in the middle Hudson valley region was first suggested by Mather (4) and asserted by Hall (15), who proved the existence in the Catskills of four lines of very low anticlinals, nearly parallel to each other and running from southwest to northeast in conformity with the ordinary trend of the Appalachian ranges; the synclinals occupying the summits, the anticlinals the bottom of the valleys. This discovery has been verified by Arnold Guyot (25).

Two years later the existence of folds of true Appalachian type in the region between the Catskill mountains and the Hudson river was reported by N. S. Shaler (18). On the other side of the river it was found by James D. Dana that the schists of Hudson river age dip under the limestone of Trenton-Calciferous age in the limestone belts of Dutchess county and western Connecticut.

I. P. Bishop (33) found the facts gathered by him in regard to the limestone belts in Columbia county "suggestive of a synclinal having the Trenton limestone outcropping on both sides, and with the edge pushed over westward." As a synclinal is only the complement of an anticlinal, these observations prove the overfolded character of the eastern Hudson valley region directly south of the investigated area. That the Taconic mountain range to the east of our territory is built after the Appalachian type has been demonstrated by I. E. Wolff (45) in an elaborate paper in which it is shown that the Hoosac mountain is an anticline. "This anticline preserves the rocks in their normal position on the east side, but on the west they are folded under in inverse position with eastern dip."[1]

Fig. 1 Geologic profile of Hoosac mountain. After I. E. Wolff. (45 pl. 6, 5a)

With the presence of folds of Appalachian type to the south and east of our region, the assumption of an anticlinal with underturned west sides to explain the inversion of the zones, does not seem to be hazardous.

It was long ago proved by the Professors Rogers (2) that the great faults in southwestern Virginia lie in the direction of axes of plications instead of in monoclinal strata and "coincide in the great majority of instances with the steep or inverted sides of the flexures." It has been farther demonstrated that overfolds often change into overthrusts, and theoretically should do so, as soon as the differential stress of the layers reaches their ultimate strength (*see* the lucid exposition of these relations by C. R. Van Hise, 52). The wonderful regularity with which these overthrust faults appear in the steep western sides of the numerous folds of the Appalachian mountain system has been fully demonstrated by Bailey Willis (43).

[1]One of the profiles has been copied to illustrate this type of mountain structure. (*See* fig. 1)

The whole system of shales from the Lorraine at Waterford through the Utica, upper (?) and middle Trenton shales and Dicellograptus shales to the Cambric slates and again to the metamorphic slates east of the Cambric zone, which have been found to be of "Hudson river age", proves by its conformability (its uniform eastern dip) that it was one in system of dislocation and one in system of mountain-making. Hence the writer feels safe in assuming that the great overthrust fault between the Dicellograptus beds and Cambric beds is a fault cutting parallel to the axial plane of an overfold, the western underturned wing of which is exposed in the four zones described in this paper.

The orogenic and physiographic stages through which this region then passed would have been:

1 A folding of Appalachian type, involving all terranes inclusive of the Lorraine beds (fig. 2).

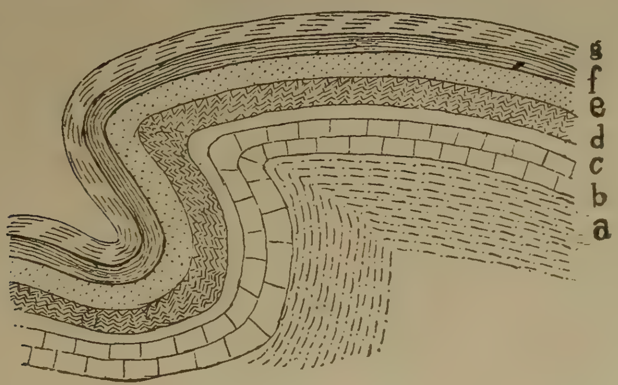


Fig. 2 Overfolding of Appalachian type (*see* fig. 1) in Hudson valley of Albany. a=Cambric; b=Beekmantown limestone (Calciferous); c=lower Trenton limestone; d=Normans kill shale; e=middle and upper Trenton shale; f=Utica shale; g=Lorraine beds.

2 The formation of a fault in the underturned wing parallel to the axial plane (fig. 3).

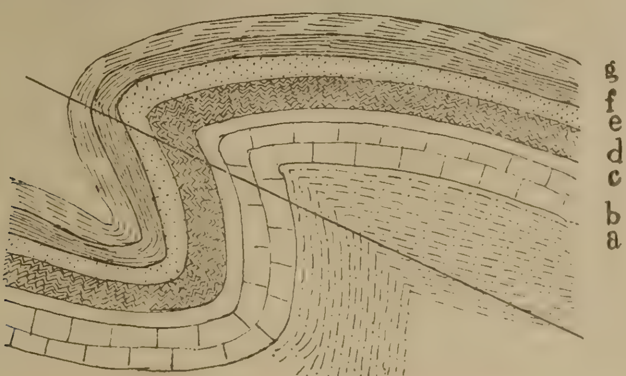


Fig. 3 Fault in underturned wing of fold.

3 An overthrust of the eastern wing over the western, bringing the Cambric beds in contact with the Dicellograptus beds in the core of the fold (fig. 4).

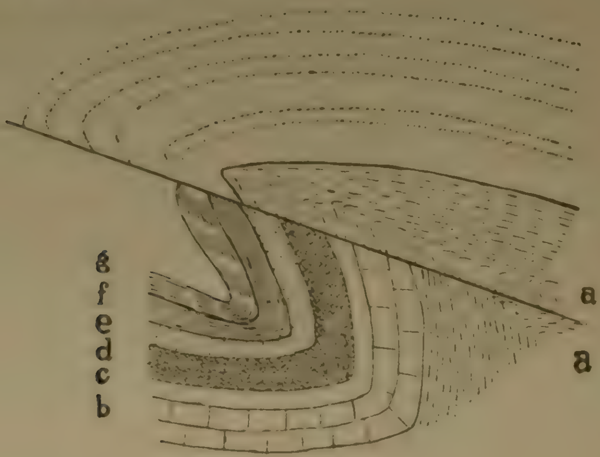


Fig. 4 Overthrust fault.

4 Reduction to a plain. The erosion, working proportionally to the elevation of the beds and, later, on the abrasion by the seas of upper Siluric and Devonic time, as evinced by the unconformable deposition of the limestones at Becraft mountain (Columbia county), on the "Hudson river" shales, reduced the surface of the disturbed area to nearly or entirely the condition of a plain, leaving the steeply dipping conformable and inverted series of beds and the overthrust fault as witnesses of the former powerful activity of orogenic forces (fig. 5).

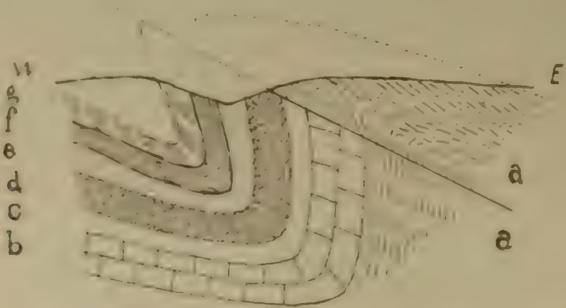


Fig. 5 Profile through Hudson valley at Watervliet.

The small anticlines crossing the Vly are the weak western manifestations of the fold-producing forces; for they run parallel to the greater deformations of the crust in the east, while the larger anticlines, pretty examples of which are visible along the lower Vlaumans kill and in the Brothers's quarry at South Troy, probably are not merely contortions restricted to weaker strata, for the heavy sandstone banks are also involved in the folding, but, probably, partake of the nature of smaller folds riding on the larger ones, a phenomenon observable in many folded regions and which, when regularly and strongly developed, has been termed an anticlinorium by Dana. Viewed in this light these narrow, but steep folds serve as additional evidence of the presence of a larger fold of a higher order.[1] In fact it is necessary to assume the presence of such riding folds of various sizes to explain certain irregularities in the succession of the beds within the zones in this region. Thus it will be difficult to account in any other way for the presence of the upper Utica beds on northern and eastern Green Island, where we should expect the lowest Utica beds. Also the apparent intercalation of shales with Diplograptus amplexicaulis in lower Dicellograptus shales, east of Mt Olympus, may, on farther investigation, find its explanation in such minor folds.

The end which the writer has in view in discussing the tectonic relations of the investigated area is to demonstrate that the inverted position of the beds can be brought into harmony with the general structure of the whole region, and that this inversion, therefore, can not in any way be construed as weakening the conclusion drawn from the succession of the zones and the paleontologic evidence, viz that the Normans kill or Dicellograptus zone

[1]The possibility that the whole region investigated is built up of nothing but closely packed, overturned small folds, such as were found by Shaler farther south (18) and are described by Dale (63) from the slate belt, has not been discussed by the writer, though the presence of such small folds can be observed in several localities; for, on account of their small size and evident surficial character, they would not be able to produce such long and wide belts of rocks, as for instance that of the Utica shale. Dale (63:199) also reports that in his territory, the northern extension of our region, "series of such various folds form compound anticlines, and these minor Cambrian anticlinoria alternate with Ordovician synclinoria conformably overlying Cambrian ones. As the Ordovician area consists of shales, slates, grits and small quartzite beds, the beds being more heterogeneous, slaty cleavage is less prevalent, but the folds are also overturned toward the west".

is an eastern representative of part of the lower Trenton. It is hoped that this end has been attained, at least in so far that the necessity of assuming an inversion of the beds will not be considered as necessarily fatal to the above mentioned conclusion, which appears fully warranted by stratigraphic and paleontologic evidence. This evidence, which we may be allowed to sum up here to emphasize the multiformity of its character, consists in the observation of four zones, the lowest of which is the Normans kill shale; the observed intercalation of a conglomerate bed containing lower Trenton fossils; and the discovery that this shale rests on lower Trenton limestone.

## CLASTIC DEVELOPMENT OF TRENTON IN HUDSON RIVER VALLEY

It seems appropriate to state here certain inferences which can be drawn from the principal conclusion of this paper, and which seem either to militate against other well known facts of the geology of New York or apparently are difficult of explanation.

There is *first* the shaly development of the mass of the Trenton in contrast to its typical calcareous character a short distance to the west; for the correlation of the Normans kill shales with part of the lower Trenton, of the Watervliet beds with the middle Trenton and the absence of limestone beds between this zone and the Utica shale zone necessitate the assumption of the replacing of the Trenton limestone principally by shales and sandstones. This view harmonizes with the well-known fact of the clastic development of the majority of the formations in the Appalachian region, to which the investigated territory, by the character of the disturbances and of those of the neighboring regions belongs. This clastic character and the great thickness of the mass of shales are both characteristic features of the Appalachian region, and of themselves constitute evidence in support of the structure indicated.

The eastward clastic development of the Trenton is farther indicated by the facts which have been gathered by others in regard to the thickness and fossil contents of this Trenton in the Hudson and Mohawk valley regions. As noted in the introduction, the fauna of the Trenton limestone has in the limestone belts to the south only a lower Trenton aspect. This limestone is directly followed by shales; hence the middle and upper Trenton beds must either be absent entirely or be represented by another facies. The possibility that the middle and upper Trenton limestone had been present and subsequently abraded (as the Trenton limestone conglomerate bed in the shales might suggest), can be disregarded on account of the presence of middle Trenton fossils in the shales. It has farther been observed by Walcott (36) that at Mt Anthony (Rensselaer county), where 400 feet of limestone occur, Maclurea and Murchisonia are found "nearly 200 feet below the shales". The Trenton limestone could, therefore, at that locality reach 200 feet at the utmost, from which figure, however, are certainly to be subtracted the measurements of the Black river, Lowville (Birdseye) and upper Chazy limestones, which reduce this figure probably by one half. In contrast to this stands the thickness of the Trenton limestone in the typical section at Trenton Falls, where though the top and bottom of the formation are covered, 270 feet were obtained by Prosser and Cumings's careful measurements (56). It is a highly interesting fact that, according to the figures obtained by the same investigators, the Trenton limestone gradually thins out in approaching the Hudson valley region. At Littlefalls only 104 feet of limestone was found between the Lowville limestone and the Utica shale; at Canajoharie and the Flat creek near Sprakers only 17 feet of Trenton limestone; at Tribeshill, 40 feet; along Morphy creek between Cranesville and Amsterdam, 37 feet; and opposite Cranesville, 21 feet; while Walcott reports only 40 feet of Trenton limestone from Saratoga, north of the region under consideration.

Hand in hand with this eastward decrease in the thickness of the limestone is a rapid increase in the thickness of the Utica and Lorraine shales. While the combined thickness of Utica and Lorraine shales in a well at Rochester, Monroe co., amounted to only 598 feet, the two formations were found to measure at Chittenango, 32 miles west of Utica, 233 and 640 feet respectively (46). Walcott reports a thickness of 710 feet for the Utica shale at Utica; and in the section along Morphy creek to the top of Adebahr hill between Cranesville and Amsterdam, Prosser (56: 649) found 1160 feet (the Trenton limestone measures there only 21 feet). In the well-boring at Altamont (37) 3475 feet of shale between the Upper Siluric and Trenton limestone was found; and in Washington county the thickness of the "Hudson river shales" has been estimated by Walcott at 5000 feet (36a).[1]

This decrease of the Trenton limestone eastward of Trenton Falls and the increase of the superjacent shales are, however, not to be understood as implying that the shaly facies of the Trenton limestone, specially the Normans kill shale, gradually replaces the calcareous facies, for the Utica shale has been found everywhere in the Mohawk valley to rest on the Trenton limestone, and the Normans kill fauna is as yet unknown west of the Hudson river valley; but it certainly shows that either the conditions for the formation of calcareous deposits throughout Trenton time became less favorable toward the east, and hence the calcareous forma-

[1] The last estimates seem not to be verified by later observers. Dale (44) observed the dwindling in the thickness of the Hudson river shales in the region east of the Hudson to "400 feet and possibly even 200 feet". This phenomenon is attributed to a replacement of the shales by grits or an erosion of the former before the deposition of the latter. The same cause is admitted as probably explaining his low estimates (1000 to 1200 feet) for the Ordovician of the slate belt in his last paper (63:179). Kimball (42) also found in Columbia county only 1285 feet of Hudson river shales, but there also the series may have been reduced by subsequent erosion.

It is to be remembered that only the Normans kill graptolites have been found thus far in the above mentioned Hudson river shales and slates; and that, if this 1200 feet represents only the thickness of the Normans kill zone, which is still to be followed by the overlying formations, middle and upper Trenton, Utica and Lorraine shales, this would bring the thickness of the entire series nearer to the figure given by Ashburner.

tion as a whole dwindled to an insignificant thickness, or that only a short span of the Trenton period is represented in the lower Mohawk valley by limestone, presumably the earliest portion, as in the Hudson valley. The facts at hand do not permit a choice between the two alternatives, but the thinning out of the limestone, together with the entire absence of the Dicellograptus fauna in the Mohawk valley, suggests the presence of a barrier, perhaps by a shallowing of the sea as indicated by the thin formation of limestone in the region of the lower Mohawk, in early Trenton time. The very peculiar Trenton fauna of the limestone conglomerate of Rysedorph hill and Moordener kill, characterized by the occurrence of Plectambonites sericea var. aspera, Plectambonites aff. gibbosa, Christiania, Eccyliopterus, Ampyx and Remopleurides, indicates a great faunistic difference between the Hudson valley and Mohawk valley regions even before the deposition of the Dicellograptus zone, and at the time of the deposition of the basal Trenton limestone beds.

## DISCONTINUITY OF FAUNISTIC SUCCESSION IN TRENTON AND UTICA BEDS

A fact apparently incongruous with the separation of the Normans kill and the Utica shales by the middle and upper Trenton beds is the discontinuity of the faunistic succession in these Trenton beds; for, while the lower Dicellograptus fauna disappears in the middle Trenton shales, a small part of the graptolite fauna of the Dicellograptus zone reappears in the Utica shale. It is this observation which induced Whitfield and Walcott to connect the Normans kill with the Utica shale. On the other hand, the graptolite, Diplograptus amplexicaulis, common in the middle Trenton, disappears in the Utica shale and is said to reappear in the Lorraine beds. The latter fact is in accordance with the known return of other Trenton forms in Lorraine times. The explanation of this alternating recession and return of graptolite faunas in the Hudson valley region seems to lie in the distribution of the faunas and the character of the associate forms.

While the Dicellograptus fauna occurs only in the Appalachian region, Canadian basin and the far west and Pacific region, but not east of the Mississippi, Diplograptus amplexicaulis is also found in the Trenton of central New York (Middleville, Trenton Falls) and in the Lorraine beds of northwestern New York (Turin), and in Iowa (J. F. James, *loc. cit.*). The fauna found by Ami associated with the Dicellograptus fauna in the Quebec region and the fauna of the conglomerate beds of Moordener kill and Rysedorph hill, are different in strong features from the Trenton of the rest of New York and the states directly southwest of it. Here is the genus Christiania, which has not been found in the Lower Siluric of North America, but lived at that era in European waters, the Bohemians genus Paterula, which is well represented in the Normans kill shales and which besides has been found only in Canada and is therefore restricted to the continental margin; the trilobite genera Agnostus, Aeglina (rediviva Barr. ?), Ampyx, Dionide (?), observed by Ami with the Normans kill graptolites, and the genera Ampyx and Remopleurides in the conglomerate bed of Rysedorph hill, all forms which had apparently become extinct in the typical Trenton of New York, but continued to live in Europe. Furthermore, as the Normans kill graptolite fauna has been found by Lapworth to be an exact correlate of a European graptolite zone, the conclusion seems to be unavoidable that the Normans kill or Dicellograptus fauna was foreign to the American continental platform east of the Mississippi but was at home in the oceanic basins of lower Trenton time and entered North America along the eastern continental shelf.

The middle Trenton shales of south Troy and Watervliet are, by the occurrence of Diplograptus amplexicaulis, and Proëtus parviusculus, connected with the Trenton of Trenton Falls and the eastern Mississippi basin.

The Utica graptolite fauna is again fully represented in Europe, and quite certainly entered the North American continent from the northeast, as asserted by Matthew (47) and the writer (55). Perhaps, as suggested by Frech (54. 2:100) the highroad to Europe was already opened in the younger Trenton period; for Isotelus gigas and Trinucleus concentricus (=ornatus Stbg.) appear already in the Caradoc and its equivalents. Triarthrus becki, the most characteristic form of the Utica shale, seems to occur already in the Chasmops limestone of Sweden. In the later Utica age the Lorraine fauna from the western part of the state seemed to gain the ascendancy, as indicated by the fauna discovered by Beecher near the old Dudley observatory at Albany and by the writer on Green Island.

The Lorraine fauna, with its close relationship to the Trenton fauna in identical or vicarious forms (a relationship which becomes still more emphasized toward the interior of the continent in the overlying Richmond beds) is again evidently an epicontinental fauna derived from the Trenton fauna.

To state it more concisely, the writer believes that the Trenton fauna and its derivative, the Lorraine fauna, are of epicontinental origin, and entered the Hudson valley region from the west, while the Dicellograptus fauna and its derivative, the Utica fauna, are foreign to the continent, and entered it from the Atlantic ocean by way of the Canadian basin. This follows from the necessary assumption of the presence of a Paleo-Appalachian continent (*see* Frech, 54) to the east of North America. The former assumption seems to be supported by the indications of the presence of a ne—sw current in the Mohawk region during the Utica epoch, found by the writer in the prevailing arrangement of the graptolites, cephalopod shells, sponge spicules, etc. in the shales (55). Lapworth, followed by Walther, maintains (53) that the graptolites were planktonic or rather pseudo-planktonic animals which, drifting along the coasts, left their remains in the quieter waters at a certain distance from the coast. This view would also suggest that the Trenton and Utica shales were formed along the continental shelf under the influence of currents entering from northeast. The alternations of coarse, mostly barren sandstones with fine grained, muddy graptolite-bearing deposits indicate the changing conditions along this coast shelf, which, on the whole, were very unfavorable to the Trenton fauna, then flourishing in the clear waters on the continental platform. During the Utica epoch the mud-bearing currents encroached on the eastern part of the continent and drove out a part of the Trenton fauna.[1]

## DISCUSSION OF THE VALIDITY OF THE TERM, "HUDSON RIVER GROUP"

The demonstration of the presence of Trenton, Utica and Lorraine faunas in the shales of the Hudson river valley, necessitates a renewed investigation of the validity of the old term, "Hudson river group", or its modification, "Hudson group", as proposed by Walcott for all the beds between the Trenton limestone and the Upper Siluric. As the term has been so ably and forcibly defended by such authorities as Hall (17) and Walcott (36a), its validity can be questioned only after obtaining new facts. These,

[1]A parallel case to the continued appearance of genera in the Quebec Dicellograptus shales and the conglomerate of Rysedorph hill, which have disappeared in homotaxial beds of other regions of eastern North America, is the continuation of Trenton forms which nowhere else have been observed to go above the Trenton, as Parastrophia hemiplicata, Cyclospira bisulcata, Clionychia undata Spyroceras bilineatum, Cyrtoceras annulatum, Cryptograptus tricornis, and Climacograptus caudatus, into beds which by the general character of their fossil contents are characterized as being of Utica age. This phenomenon has been observed in several localities, at the Dudley observatory by Dr Beecher, in two outcrops on Green Island, one on Van Schaick island, and one south of Mechanicsville by the writer. The beds near Mechanicsville may be here excluded as being evidently transitional between the Trenton and Utica epochs, or of oldest Utica age, but the other beds lie at or near the top of the Utica terrane and yet contain Trenton forms still. This peculiarity in the composition of the Utica faunas is, to the writer's knowledge, restricted to the Hudson valley region, and therefore, marks a regional difference in the character of the Utica faunas. This conclusion is supported by the distribution of Corynoides curtus mentioned before. This graptolite disappears in the Utica beds of the middle Mohawk valley, while it fills the beds of the lower Mohawk and the Hudson valley, and is also common in the Utica shale just above the Trenton at the Panton shore of Lake Champlain. Also the variety of Plectambonites sericea with wrinkled cardinal margin, mentioned before, is a fossil which extends in this region from the lowest Trenton into the upper Utica beds, and is rarely observed outside of it.

the writer trusts, have been secured in sufficient quantity to justify a reopening of the discussion.

Both investigators based their defense of the term on the supposition that the entire series of the Hudson river shales, though in diminished thickness, continued into the Mohawk valley, and that these, like the Mohawk valley shales, represented only the lapse of time between the Trenton and Medina formations. This supposition, though at that time warranted by the facts at hand, has now proved to be only partly correct; for only the Utica and Lorraine shales of the Hudson valley continue westward, while the apparently enormous mass of Trenton shales does not leave its confines. The term could then be applied only to the shales in the Hudson valley north of Cohoes and in the hills on the west side of the valley as far south as Albany, while the shales all

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These two differential features of the Utica faunas of the Hudson valley, viz, the ascension of the Trenton forms and the restriction of the different faunal composition to the marginal region, are evidently to be traced to the same cause. The assumption that these Trenton forms continued to live in Utica time in the adjoining Atlantic basin, while they had become extinct on the American continental platform, and thus were enabled to leave their shells in the deposits of the eastern continental shelf, seems to offer a reasonable explanation.

At the same time it is evident that in this region the change in physical conditions from the Trenton to the Utica epoch was by no means so profound as in the Mohawk valley and west of it; for there Utica mud shales follow more or less pure Trenton limestones, and here the deposition of clastic sediments was uninterrupted from the lower Trenton to the top of the Lorraine. Such forms as in Trenton time were accustomed to live under conditions that led to the deposition of mud and sand had of course a much greater chance to continue living when the Utica time was ushered in, in such easy stages as are apparent at Mechanicsville and on Green Island, than the faunas farther west. But it is, then, pertinent to ask why these forms did not wander with their new Utican companions, which came across these marginal areas on the continental platform, into the interior. This latter fact and the restriction of the graptolite, Corynoides curtus, to the east suggest again that this regional difference is of a character similar to that between the Hudson river Trenton and the continental Trenton, viz, a difference between the oceanic fauna, encroaching on the continental margin, and the fauna of a shallow continental and partially inclosed sea.

along the river from Watervliet and Troy southward would have to be excluded as being of Trenton age. The term would, hence, become misleading. But, even if it should be desired to retain it for the Lorraine and Utica zones, the objection would have to be raised that these are nowhere exposed in typical sections with their upper and lower boundaries and with their typical faunas in the Hudson valley, while these conditions which would appear absolutely necessary for the proper definition of a stratigraphic term are satisfactorily fulfilled in the neighborhoods of Utica and Lorraine, as shown by Walcott and Emmons. The writer holds, therefore, that the term "Hudson river group" for the terranes between the Trenton and Medina (Oneida) formations should be dropped. Clarke and Schuchert (62) have proposed the term, "Cincinnatian", for this interval in the geologic time scale of North America. This term has the advantage of derivation from a region where not only the Utica and Lorraine beds are fully developed, but where also a stage which intervenes between the Lorraine and Upper Siluric age, and which is missing in New York, viz the Richmond stage, is present.

It would hardly be appropriate or practical to transfer the term, "Hudson river shales", to the shales of the Normans kill or Dicellograptus zone, which indeed is fully developed in the Hudson river valley and is seen there to rest on lower Trenton limestone and to be overlaid by middle Trenton shales. As a facies which faunistically and lithologically differs strongly from the synchronous lower Trenton limestone, it certainly deserves to be designated by a separate name. Ami used the term, "Quebec or upper division of the Quebec group", for the same facies, while Walcott, in the discussion following the reading of Ami's paper, suggested that the term, "Quebec", be restricted to this upper division alone in distinction from "Lévis" etc. In the Quebec massive the beds are cut off from the neighboring terranes by faults, and their taxonomic position can not be fixed conclusively by the stratigraphy of the region, but the equivalent shales of the Hudson river valley are well defined in their stratigraphic position.

Lapworth, in correlating the Canadian with the British graptolite shales, transferred his term, Coenograptus gracilis zone, to the corresponding Canadian and Normans kill beds. He discerned a closely related zone directly above this, which, in his opinion, differed by the absence of *Coenograptus gracilis*. Ami, however, subsequently also found that graptolite in this second zone. The two zones were then termed lower and upper Dicellograptus zones (50). But these terms are not fully appropriate, because there have been already distinguished two Dicellograptus zones in England (those of *D. complanatus* and *D. anceps*), which lie above the zone with *Coenograptus gracilis*, and one in Sweden by Tullberg, which lies above the beds with *Diplograptus pristis* and *D. quadrimucronatus*. It would seem more correct to designate these American graptolite shales also by their most characteristic species, a task which must be postponed till after a closer investigation of the vertical distribution of the graptolites and the possible more detailed division into graptolite zones of the graptolite beds of the entire middle and upper Lower Siluric. Meanwhile, and perhaps even then, the term, *Normans kill shales*, may be of good service in designating this graptolite bearing, clastic facies of the middle Lower Siluric.

## SUMMARY

This paper purports to demonstrate the presence of four zones of shales in the "Hudson river shales" of the Hudson valley region about Albany. These zones, which extend from n ne to s sw consist, going from west to east, of shales containing the Lorraine, Utica, middle Trenton and Normans kill graptolite faunas. The shales last named include lower Trenton conglomerate and rest on lower Trenton limestone. This succession of zones places the Normans kill graptolite beds, which form the mass of the "Hudson river shales" in the Hudson river valley, between the middle and lower Trenton and determines, together with other facts, the lower Trenton age of these shales.

The beds lie conformably inverted, on account of their being the remnant of the underturned wing of an overturned fold of Appalachian type. This fold has turned into an overthrust fault, which brought the Cambric beds as the next succeeding terrane above the Normans kill shales.

On account of the fact that the mass of beds hitherto called Hudson river shales and correlated with the Lorraine beds of central New York, is composed of terranes ranging from the Lorraine to the lower Trenton, and on account of the lack of a fully representative fauna and of a complete section of the Lorraine portion of these terranes, it is proposed to drop the term, "Hudson river shales", for the uppermost part of the Lower Siluric, and the term, "Hudson river group", for the Utica and Lorraine beds, and to employ the term Normans kill shales for the clastic facies of a part of the lower Trenton which is characterized by the graptolite fauna at the Normans kill.

## DESCRIPTIONS OF NEW FOSSILS FOUND IN THE DESCRIBED SHALES

### § 1 BRACHIOPODA

With the exception of a few brachiopods no fossils which could assist in establishing the age of the Normans kill shales have been found associated with the graptolites. These are small chitinous shells which, being invariably strongly exfoliated and macerated, have so far not admitted of identification, and are, in the literature, usually mentioned as "oboloid shells". Bishop (33) speaks of several species of Lingulops.

The shales of Mt Moreno near Hudson have furnished small accumulations of such shells, which, similar to the accumulations of specimens of Leptobolus insignis in the Utica shale, appear to have been caused by drifting. Some of these valves have proved to be so well preserved that they deserve notice. Three different forms have been made out.

1 Paterula amii, *Schuchert*. Synopsis Amer. foss. Brach., bul. U. S. geol. sur. 87: 301

Paterula (?) sp., *Hall* and *Clarke*. Pal. N. Y. 1892. v. 8, pt 1, pl. 4, fig. 1 (*see* pl. 1, fig. 2)

This is one of the more common forms in the shale. It is characterized by its oval outline, broad marginal border, narrow, marginal pedicle fissure, radiating muscular impressions, and its rather strong, lustrous and well preserved shells.

The dimensions of the figured specimen were 3 mm (length) and 2.5 mm (width).

As the specimens which were sent to Professors Hall and Clarke by Mr Ami came from the beds of the city of Quebec, which contain the same graptolite fauna as the shales of Mt Moreno, it is very probable that the forms from the two localities are identical.

2 Leptobolus walcotti sp. n. (*see* pl. 1, fig. 6-12)

The most common brachiopod is a larger shell of subcircular outline, as usually preserved, very slightly convex and provided with strong concentric and apparently regular, radiating corrugations. The latter become obsolete toward the lateral margins. The extreme thinness of these corrugated shells suggests that they are much macerated, and only one shell layer preserved. As similar corrugations occur in exfoliated and compressed specimens of Leptobolus insignis, where the characteristic, fine radiating striae of the inner layer develop under like conditions into a system of wrinkles, the supposition seems legitimate that these corrugations are only the result of maceration and compression of an originally more convex shell. This supposition is strengthened by the occurrence of less corrugated shells, furnishing various transitions to thicker, smooth, unexfoliated valves. The latter, instead of becoming corrugated, yielded to the pressure by breaking radially in two or more segments (*see* fig. 12).

The presence of a strong median septum, a pedicle-groove, traces of curving laterals and a posteriorly situated median muscular scar in the brachial valve, as well as of a narrow pedicle-groove below the beak of the pedicle-valve, indicate its position in the genus Leptobolus.

It differs from all other species of Leptobolus by its larger size. Young valves closely resemble specimens of Leptobolus insignis, but differ in being less convex, having a less prominent beak, a thinner shell and specially a more regular and finer concentric striation.

Dimensions. The largest specimen observed attains a width of 10.2 mm and a length (not fully preserved) of 8 mm.

Lower Trenton. Normans kill shales. Kenwood and Glenmont, near Albany, Mt Moreno, near Hudson.

3 Schizotreta papilliformis sp. n. (*see* pl. 1, fig. 3–5)

A third very rare form among the brachiopods of the Normans kill shales has been recognized as a new species of Schizotreta.

Diagnosis. Pedicle-valve subcircular, depressed conical, sloping equally in all directions, beak abruptly projecting just behind the center, not procumbent in any direction; pedicle-groove begins on top of beak, is deepest directly behind the beak and becomes shallower toward the margin, to which it extends. Surface covered by very fine, regular, concentric growth lines which are not interrupted by the pedicle-groove. Shell apparently quite thick; not so much flattened as those of other forms.

A low convex shell with two posteriorly diverging oval muscular scars may represent the corresponding brachial valve.

Dimensions. Length of type specimen, 3 mm, width 3.2 mm.

This form differs from Sch. ovalis, Hall and Clarke, of the Trenton, by its subcircular outline and more central position of the beak; from Sch. conica, Dwight, also from the Trenton, by its smaller convexity and equal slope. It has the circular outline and regular concentric striation in common with Sch. pelopea, Billings sp., from the Canadian Trenton and Galena shales and Salmon river (Hudson river) formation of Minnesota (49: 365), and with the interesting Sch. minutula, Schuchert and Winchell (p. 366). The latter occurs in abundance associated with stems of Diplograptus in the "lower portion of the Hudson river group near Granger Minnesota" (=Utica shale). Sch. papilliformis differs from both these species in size, the more central position and more abrupt elevation of the beak or apex, and in the presence of a distinct pedicle-groove instead of the apical circular pedicle opening of the others.

It will be seen that these minute brachiopods do not directly determine the position of the Normans kill graptolite shales, as all three species are peculiar to this horizon, but their relationship to Trenton and Utica forms of the genera Leptobolus and Schizotreta, would certainly suggest the Trenton-Utica age of the shales in question.

It is certainly peculiar that only these minute, thin-shelled, non-calcareous brachiopod valves and no other fossils occur associated with the graptolites. Their size, thinness and the composition of their shells indicate strongly that they led a pseudoplanktonic life. Winchell and Schuchert suggest that Sch.

minutula was attached to stems of Diplograptus; the writer has noticed several cases of apparent attachment of valves of Paterula to rhabdosomes of graptolites in the shales of Mt Moreno. Farther, the accumulation of these shells in small heaps must be considered as indicative of a preceding drifting of this slowly settling organic detritus.

## § 2 PELECYPODA

Technophorus cancellatus sp. n. (*see* pl. 1, fig. 19-25)

Shell small, moderately convex, elongate, length twice the hight, greatest length in about the middle, subalate posteriorly; cardinal margin short and straight, anteriorly longer, slightly concave posteriorly; anterior end rounded, ventral margin first convex, then gently concave, the postero-basal part produced, the posterior margin slightly concave, vertical; postero-cardinal angle slightly truncate; beak sub-anterior, of moderate size and convexity, little elevated above the hinge line.

Surface uniformly convex in the middle and anterior parts, with a broad, shallow depression extending from the beak to the postero-ventral margin; post-cardinal slope with two straight, diverging, strongly projecting angular ridges or folds, which extend to the postero-ventral angle, and are separated by a rounded, ventrally deepening sulcus; posterior wing traversed by another oblique and shallower depression and posterior extremity slightly raised. Surface marked by equal filiform, concentric lines, which on the anterior and middle parts pass parallel to the ventral margin, between the post-cardinal ridges turn upward, and on the posterior wing swing obliquely forward; these are crossed on the anterior and middle parts by another system of vertical, more closely arranged thread-like lines, which in smaller specimens appear only between the concentric lines, in larger specimens become continuous and more prominent than the latter.

Casts with a deep, backward curving impression in front of the beak and a corresponding shallower, forward curving impression behind the beak; both connected ventrally from the beak by a slight impression, causing the beak to project more strongly in casts.

Muscle impressions and the character of the hinge have not been observed.

Dimensions. Largest specimen: length 12.3 mm, hight 6.6 mm, thickness 1.8 mm; another specimen measured respectively 8x5x1.5 m; another 9x5.3x1 mm; a fourth 8.6x5.5x2 mm.

This form, which belongs to the peculiar and not yet fully understood Siluric group of lamellibranchs, for which S. A. Miller (*North American geology and paleontology*, 1889. p. 514) introduced the generic name Technophorus, and of which E. O. Ulrich described several species, has its nearest relative in Technophorus subacutus, Ulrich from the upper part of the Trenton limestone of Minnesota, which, however, is known only in casts; the casts of the two species differ materially in the charater of the beaks, in the cardinal and general outline. Our species differs from all other congeneric forms whose surface sculpture is known, by its cancellate surface.

Upper Utica shales of northern Green Island, Albany co. N. Y.

## § 3 ANNELIDA

Certain layers of the Utica graptolite shales of the Rural cemetery near Albany are profusely covered with worm-shaped carbonaceous films. The actual presence of organic matter, the uniform dimensions of certain types and the distinct terminations of the fossils leave no doubt that they represent not mere tracks but actual bodies of animals. Two types could be made out of sufficient perfection to warrant their being named and described.

Eopolychaetus albaniensis gen. nov. et spec. nov. (*see* pl. 1, fig. 13)

Head distinctly separate from the body, semicircular, with a median oval depression which extends a little on the first body segment.

Body long, slender, of approximately equal width, distinctly segmented, segments about half as long as wide, apparently convex, each provided with five to eight annulations and long setae on one side (dorsal side?) which apparently were not tufted.

Posterior end not well observed, apparently rounded.

Dimensions. Type specimen: length 13 mm, or more, (specimens of much greater length observed), width 1.2 mm; length of segment .7 mm, length of setae 1.4 mm.

While, with the material at hand, the exact systematic position of this worm could not be established with certainty, it seems clear that this type belongs to the class Polychaeti. To express this taxonomic date the generic term, Eopolychaetus, is proposed for worms with similar, slender, cylindric, regularly annulated bodies and long non-tufted setae on one side. The presence of another worm with setae was made known by E. O. Ulrich, who found tufts of long setae in the Cincinnati group (*Jour. Cin. soc. nat. hist.* 1878. 1:91).

Pontobdellopsis cometa, gen. et spec. nov. (*see* pl. 1, fig. 14-18)

Body cylindric or rather long conical, regularly tapering and abruptly terminating (with ring-like section) at wider end. Other (anterior?) end provided with chitinous disk, the latter sometimes with central depression.

Segmentation coarse; 6 segments in 2.9 mm; segments smooth, apparently not annulated; no appendages observed; test thick (strong carbonaceous film).

Dimensions. Length of largest specimen observed, 11.7 mm and width at broadest end, 1 mm.

This small but common and characteristic form has been termed Pontobdellopsis in allusion to its similarity to the recent genus Pontobdella, from which, however, no close systematic relationship of the fossil with that highly specialized genus of recent worms is claimed.

The form is most common in the Utica shale of the Rural cemetery near Albany, but it has also been observed in the lower Utica shale of Mechanicsville.

## § 3 CRUSTACEA

C t e n o b o l b i n a.

Several different forms belonging to this genus, which has, hitherto, not been reported from this state, were found at various horizons. They are:

1 C t e n o b o l b i n a c i l a t a, Emmons sp. var. c o r n u t a, var. nov. (*see* pl. 2, fig. 5-7)

This form differs from the typical C t e n o b o l b i n a c i l i a t a in having the posterior lobe not so round and bulbous, and the middle lobe produced into a long, stout, blunt spine. The latter it has in common with a variety described by Ulrich (*Jour. Cin. soc. nat. hist.* 1890-91. 13:109) as C t e n o b o l b i n a c i l i a t a var. c u r t a, from the lower (Utica) shales of the Cincinnati group. It differs from this western relative in being relatively longer, having the principal and posterior furrow fully as wide as the type of the species and possessing a well developed frill. Both forms, which occur in homotaxial beds, represent an early divergence from the typical direction of development of the genus by the production of an elevated process, thus forming a separate section of the species; in a very similar manner as the species of C e r a t o p s i s, Ulrich (as B e y r i c h i a o c u l i f e r a, Hall) differ from those of T e t r a d e l l a by possessing an elevated process. The remark of Mr Ulrich that these processes in C e r a t o p s i s (*loc. cit.* p. 113) are not a "mere ornament" but of a certain classificatory value, would be also pertinent in regard to the two horned varieties of C t e n o b o l b i n a c i l i a t a; and it may at some time become necessary to unite them under another generic name.

Dimensions. Length 1.45 mm, hight .80 mm.

Lower Utica shale of Mechanicsville, Saratoga co. N. Y. Upper Utica shale of Green Island, Albany co. N. Y.

2 C t e n o b o l b i n a c i l i a t a, Emmons sp. (*see* pl. 2, fig. 8, 9).

Typical specimens of C t e n o b o l b i n a c i l i a t a have been collected at Green Island and at Menands (stations 10 and 11);

at the latter place with a remarkably strong development of the sulci, which extend nearly to the ventral margin, leaving the middle lobe projecting as a prominent sharp ridge.

Upper Utica shale of Green Island and Menands, Albany co. N. Y.

3 Ctenobolbina subrotunda sp. n. (*see* pl. 2, fig. 1, 2, 3, 4).

E. O. Ulrich, who made an exhaustive study of these forms and described the species of Ctenobolbina occurring in the Cincinnati beds, reports also two new species from the Trenton beds of Minnesota (49:674, 675). To these can be added a new species found in the middle Trenton shales of Port Schuyler (station 23).

Valves shortly subovate, strongly convex, dorsal margin nearly straight; ventral part approaching a semicircle in outline; sulcus wide and deep, beginning near the middle of the dorsal margin, oblique, curving backward below, dividing the carapace into two subequal lobes, which are broadly connected in the ventral region, the posterior lobe distinctly rounded and inclined to be a little larger than the anterior; both lobes equally convex, with a thick (?) edge anteriorly and posteriorly; surface minutely granulose.

Dimensions. Length .56 mm, hight .37 mm, thickness .17 mm; length of a smaller carapace, .48 mm, hight .34 mm, thickness .20 mm.

These minute valves are undoubtedly closely related to the two Trenton species of Ctenobolbina described by Ulrich. They fully agree with them in the presence of only one sulcus which is strongly curved and of two bordered lobes; but they differ from the one (Ct. fulcrata) in having the posterior bulb already farther advanced, and from the other (Ct. crassa) by the lesser development of the border and the shorter, more rotund outline. Ctenobolbina subrotunda differs from Ct. duryi, S. A. Miller sp. (*Cin. quart. jour. sci.* 1874. 1:232), a similar form from the "Hudson river group" of Cincinnati in being relatively much higher and having the sulcus more medially located.

Turrilepas (?) filosus, sp. n. (*see* pl. 2, fig. 13, 14, 15).

In the lower Utica shale of Mechanicsville, two plates were found, which in size, outline and surface ornamentation greatly differ from the minute plates of Lepidocoleus jamesi, associated with them in great number. Both plates, though of different size, are so clearly alike in outline and sculpture that they undoubtedly belong to the same species.

Plates obliquely subtriangular, comparable in outline to an isosceles triangle with the apex pushed to one side; the nucleus falling into the apex, and the two legs standing nearly vertical on the slightly convex base; the lengthened side strongly convex, the shortened nearly straight; surface marked by strongly elevated, very regular concentric lines, which have multiplied more rapidly on the posterior side.

Dimensions. The smaller specimen measures 4 mm along the base, and 4.5 mm along the vertical side; the larger 7 mm and 9 mm in the same directions.

Both valves figured differ markedly from the typical plates of Turrilepas by their outline, the absence of the sigmoidal curvature in the base, their relatively larger size, and the character of the concentric striae, which appear not as the edges of imbricating layers, but as strongly elevated lines with deep, even interspaces and by the conical shape which they probably possessed originally; for they present the appearance of convex bodies which became flattened in fossilization. This is specially distinct in the smaller specimen (pl. 2, fig. 13), where a median furrow or break separates two differently convex halves. In all these features they agree with another group of valves which have been doubtfully referred to Turrilepas by Whitfield (*Annals New York acad. sci.* 1882. v. 2. no. 8. p. 217) and by Hall and Clarke (*Pal. N. Y.* 1888. 7:219). The latter authors remark "that it is difficult to see how the combination of these subconical bodies in vertical ranges could produce such a scaly peduncle or capitulum as existed in Turrilepas" and point out their resemblance with Spathiocaris. This form (Turrilepas (?) newberryi), from which ours differs only by the stronger elevation of the concentric lines, is restricted to the upper Devonic (Cleveland shales), while Turrilepas (?) filosus occurs in the middle Lower Siluric. The occurrence of these valves of equal structure at such widely separate epochs can serve only to strengthen the belief in their representing a different and persistent type of crustacean structure.

Pollicipes siluricus sp. n. (pl. 2, fig. 16-24).

In the Utica shales of Green Island and Mechanicsville occur variously shaped valves in considerable number, which by their peculiar shapes, the arrangement of their growth lines and their shell structure, differ from the valves of all mollusks associated with them in the same rock. A suggestion of Dr Clarke as to their possible crustacean nature led to the astonishing discovery that they all find their homologues in parts of the capitula of the pedunculate cirriped genera Scalpellum and Pollicipes, notably of the latter. On this account the various valves have been united under the caption, Pollicipes siluricus, in full consciousness of the enormous gap existing between the appearance of this Lower Siluric type and the next Upper Triassic (Rhaetic) representatives of these genera. But the analogous case of the related Balanidae might be cited in support. Charles Darwin, in his classic memoir on the fossil Cirripedia,[1] stated that in the sessile Cirripedia, or Balanidae, the negative evidence of their not being found in primary or secondary formations is of considerable value, considering their great number where they appear, their strong shells, etc.; and yet, meanwhile, undoubted Paleozoic genera of Balanidae (Protobalanus, Palaeocreusia) have been found, leaving the long interval from the Devonic to the Cretaceous without any representatives of this family. It is an interesting query, what were the conditions of marine life that suppressed the Lepadidae and Balanidae, which today fill the oceans with such vast

[1] A monograph of the fossil Lepadidae, or pedunculated cirripedes of Great Britain. Palaeont. soc. 1851.

numbers of individuals that, Darwin writes, one could call the present age that of the cirripeds, in all the time from the Devonic to the Upper Jurassic. The long suppression of the mammals in Mesozoic time and their sudden rise at the beginning of the Cenozoic time seems to be an analogous case from the terrestrial fauna.

The valves have been tentatively described by terms of such valves of Pollicipes and Scalpellum as they most resemble, with which it is not so much intended to assert their actual homology as to designate them by names, and to emphasize their great similarity to the parts of the capitula referred to.

1 Tergum. Convex, elongate subrhomboidal to subtriangular, as the upper and lower carinal margins blend into each other. Carinal margin the longest, rounded; scutal margin gently rounded, about twice as long as the occludent margin. Occludent margin and upper part of carinal margin meet at an angle of over 45°, occludent and scutal margins at about 135°. From the apex to the sharp basal angle, a strongly projecting, angular, strongly curved conspicuous ridge runs at about one fourth of the entire width of the valve from the carinal margin; the surface slopes,apparently on account of lateral compression, much steeper away on the carinal side. A wide depression with a central, broad but low, slightly curved ridge extends from the apex to the middle of the scutal margin.

The surface is covered with unequal, somewhat lamellose growth lines, running parallel to the base of the valve. Where the shell has become exfoliated, regular rows of pustules running parallel to the keel become visible. These probably represent a system of pores within the corium.

It is specially this valve that, in its outline, diagonal keel, direction of growth lines and curved fold on the larger face, fully agrees with the terga of some species of Pollicipes.

2 Carina. Lanceolate fragments are thought to have been part of the carina. The fragment figured apparently had two equal wings and a median, highly prominent, angular keel (an-

gulation probably exaggerated by lateral compression). Growth lines obliquely pennately arranged, turning subparallel to the margin in the flat marginal border. A faint depression and ridge running parallel to the keel are observable on either wing. The longitudinal rows of pustules are very prominent, wherever the shell is exfoliated.

While this valve, in its long, lanceolate form and long, oblique basal margins, reminds one of the carina of Scalpellum, it lacks the angles, separating the tectum from the parietes and intra-parietes, which are characteristic features of that genus. The possibility that this valve could be a laterally compressed and extenuated tergum is excluded by its symmetric form.

3 Rostrum. Small, thick-shelled, symmetric, forming two sides of a tetrahedron; apex incurved (flattened in the figured specimen by compression, as indicated by a break); keel strongly elevated, angular, broad; surface with strong unequal growth lines running parallel to the basal margin.

This valve bears a strong resemblance to the rostrum of Pollicipes carinatus, which, however, has a flat-topped keel.

4 Upper latus. Small, little convex, six-faced, eight-sided, thick-shelled; two middle faces forming a high, basally widening keel; other faces nearly flat; surface with fine, concentric growth lines; broad, concentric undulations, crossed by fine radial striae, on the two extreme faces and along the basal margin.

This valve has been termed an upper latus on account of its similarity to the upper latera of Scalpellum quadratum and Sc. fossula. The general form of this valve is very much like that of some of the problematic Pterothecas described by Hall from the Trenton, and by Barrande from the Bohemian Siluric. As our specimen however, agrees in the nature of its shell with the valves of Pollicipes with which it is associated and can be referred to a part of the capitulum of this crustacean, it seems at present more profitable to unite it with the latter than to compare it with the still entirely problematic Pterotheca.

Dimensions: Tergum: length along keel, 9.5 mm, width 6.7 mm; length of another specimen (not complete) 13 mm, width 7 mm. Scutum: length along keel, 12.5 mm, width 7.5 mm. Carina: length of specimen (upper third missing) 12.3 mm, width 10.2 mm; length of other large fragment, 16 mm, width 10 mm; width of another fragment, 7 mm. Rostrum: length along keel, 8.3 mm, width 4.7 mm. Upper latus: length 6.7 mm, width 8 mm.

Lower Utica shale of Mechanicsville, Saratoga co. N. Y. Upper Utica shale of Green Island, Albany co. N. Y.

## DESCRIPTION OF MAP

The roman figures indicate the localities which furnished fossils and correspond with the numbers of the stations described. The boundary lines of the zones or belts have nowhere been observed directly; they are only approximations obtained from the location of the stations. The location of the fault, separating the Cambric and Normans kill beds, is taken from Walcott's map of the Taconic region (36).

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## EXPLANATIONS OF FIGURES

### Plate 1

Fig.

1 A pebble of Trenton limestone with Pterygometopus callicephalus, Ampyx hastatus sp. n. and Climacograptus scharenbergi. x2

Lower Trenton conglomerate, Rysedorph hill, Rensselaer co. N. Y.

**Paterula amii Schuchert**

2 A partial cast of a pedicle-valve. x6

Normans kill shale of Mt Moreno near Hudson N. Y.

**Schizotreta papilliformis** sp. n.

3 A pedicle-valve. x4

4 Profile of the same. x4

5 A supposed brachial valve. x6

Normans kill shale of Mt Moreno near Hudson N. Y.

**Leptobolus walcotti** sp. n.

6 A small perfect specimen; showing fine concentric striation. Somewhat compressed. x6

7 An internal cast of a brachial valve; showing pedicle-groove, median septum and lateral scars. x4

8 The interior of a brachial valve, showing median septum and lateral scars. x6

9 A very young specimen, partially exfoliated; showing radiating striation of internal surface and pedicle-groove. x10

10 A strongly concentrically and radially corrugated specimen; the usual mode of preservation. x4

11 The interior of a similar specimen, showing pedicle-groove. x4

12 A shell, which instead of becoming corrugated, burst on compression. x4

Normans kill shale of Mt Moreno near Hudson N. Y.

**Eopolychaetus albaniensis** gen. et spec. nov.

Fig.

13 A specimen from the Rural cemetery, Albany N. Y. x4

**Pontobdellopsis cometa** gen. et spec. nov.

14–18 Specimens from the Rural cemetery, Albany N. Y. x3

**Technophorus cancellatus** sp. n.

All specimens from the upper Utica shale of Green Island, Albany co. N. Y. All enlarged. x3.

19 Small short specimen, showing basal margin

20 Surface sculpture of the same. x6

21 Specimen with perfect posterior part

22 Partial cast, showing the impressions on both sides of the beak

23 Valve with nearly equally strong concentric and vertical lines

24 Largest specimen observed with somewhat different outline and stronger vertical lines

25 Surface sculpture of the same. x6

## Plate 2

**Ctenobolbina subrotunda** sp. n.

1 Right valve. x17

2 Ventral view of the same. x17

3 Another valve. x17

4 Ventral view of the same. x17

Originals of figures 1-4 are from middle Trenton shale of Port Schuyler, Albany co. N. Y.

Ctenobolbina ciliata Emmons sp., var. cornuta var. nov.

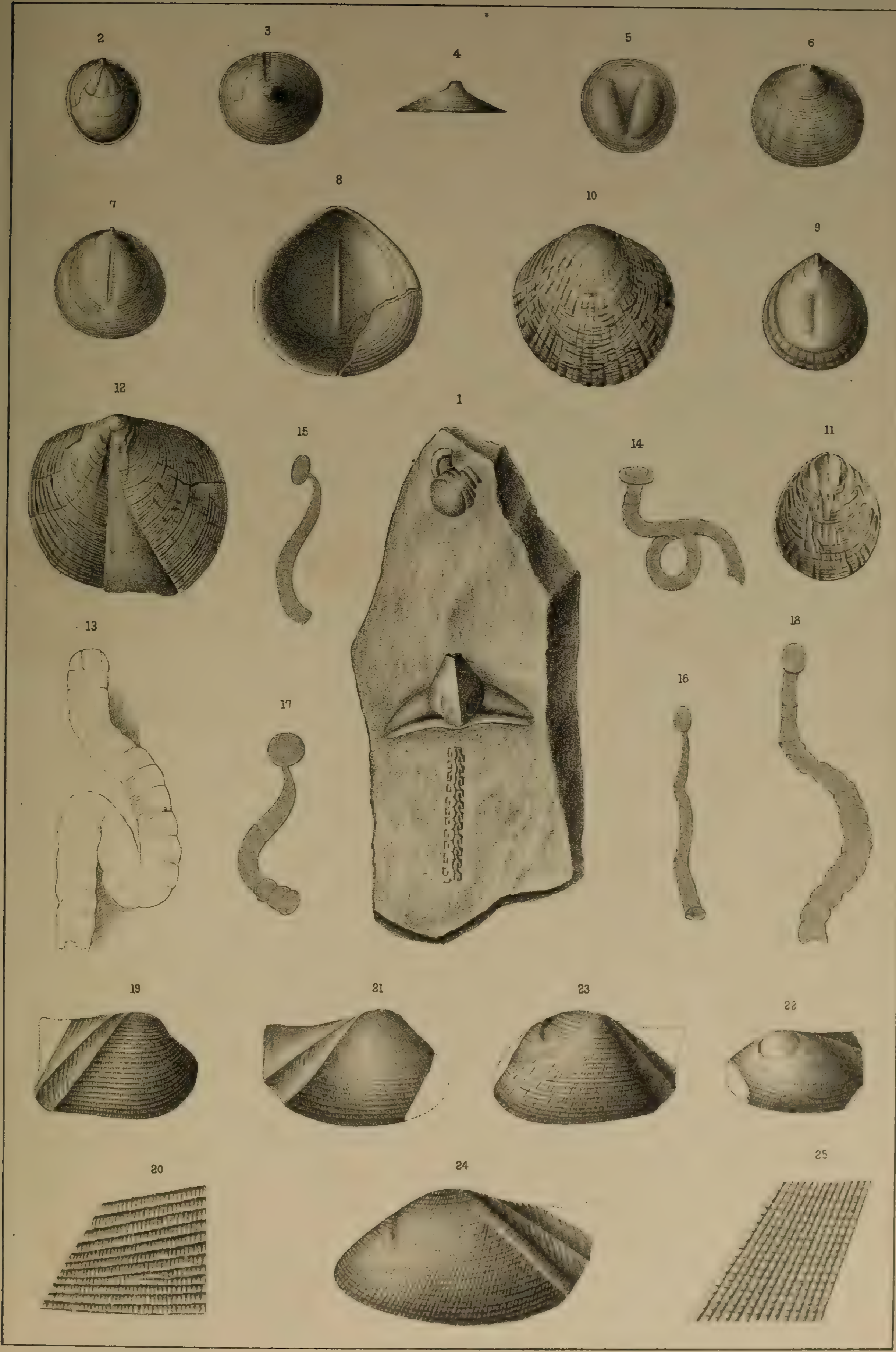
5 Small left carapace. x17

6 C t e n o b o l b i n a c i l i a t a. Larger right valve. x17

From lower Utica shale at Mechanicsville, Saratoga co. N. Y.

7 C t e n o b o l b i n a c i l i a t a. Right valve

From the upper Utica shale of Green Island, Albany co. N. Y. x17

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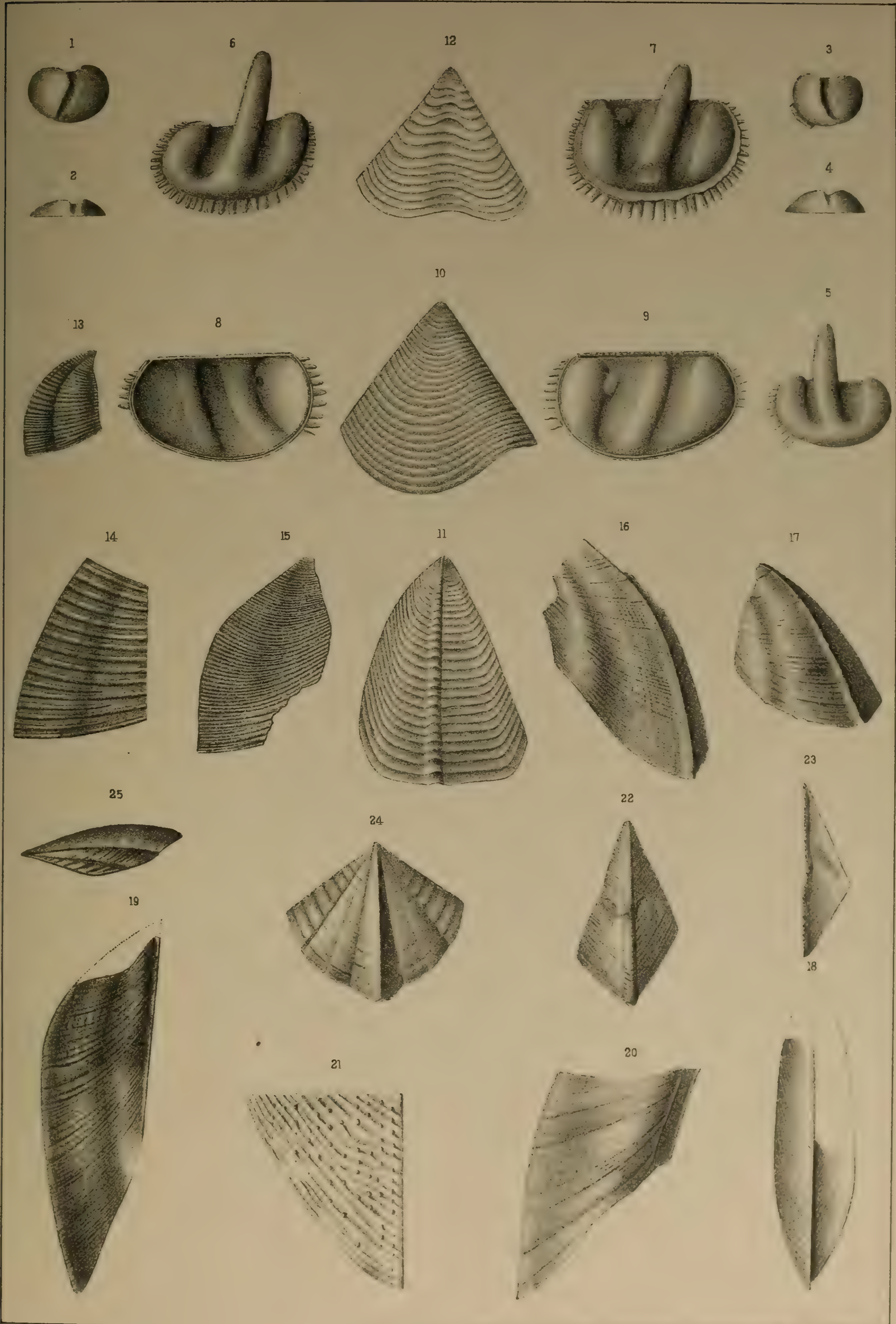


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**Ctenobolbina ciliata** Emmons sp.

8 Internal cast. x17
Upper Utica shale, Menands, Albany co. N. Y.
9 Gutta percha impression of the same

**Lepidocoleus jamesi** Hall and Whitfield sp. x10

10 Trenton beds of Trenton Falls N. Y.
11 Middle Trenton beds at Port Schuyler, Albany co. N. Y.
12 Lower Utica beds, Mechanicsville, Saratoga co. N. Y.

**Turrilepas (?) filosus** sp. n.

13 Smaller plate. x3
14 Enlargement of part of the same. x9
15 Larger plate. x3
Lower Utica shale of Mechanicsville, Saratoga co. N. Y.

**Pollicipes siluricus** sp. n.

All figures enlarged three times.

16 Left tergum
Upper Utica shale of Green Island, Albany co. N. Y.
17 A smaller and shorter tergum from the lower Utica shale of Mechanicsville, Saratoga co. N. Y.
18 Carina
19 Lateral view of larger carina. This valve has a prominent lateral ridge and narrow marginal border
20 Fragment of a carina with broad and low lateral ridge and broad marginal border
21 Farther enlargement of surface of original of fig. 18. x8
22 Rostrum
23 Lateral view of the same.
Originals of figures 18-23 are from the upper Utica shale of Green Island, Albany co. N. Y.
24 Upper latus, from a gutta percha impression. Lower Utica shale of Mechanicsville, Saratoga co. N. Y.

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The superior figures tell the exact place on the page in ninths; e. g. $520^{3}$ means page 520, beginning in the third ninth of the page, i. e. about one third of the way down.

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