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TWO BELTS OF FOSSILIFEROUS BLACK SHALE IN THE TRIASSIC FORMATION OF CONNECTICUT.*

BY W. M. DAVIS AND S. WARD LOPER.

(*Read before the Society December* 31, 1890.)

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I. INTRODUCTORY STATEMENT: BY W. M. DAVIS.

PREVIOUS STUDIES.

For a number of years past I have given some of my spare time in the summer, generally with the assistance of Mr. C. L. Whittle, of the United States Geological Survey, to the study of the Triassic formation of Connecticut, especially in the neighborhood of Meriden. The peculiar structure of the formation is well shown there, and it makes an excellent problem for field teaching; for that reason Meriden has been chosen for several seasons

* Communicated by permission of the Director of the U. S. Geological Survey.

as one of the districts to be visited by the Harvard Summer School of Geology. The following papers have been published during the progress of my study:

"Brief Notice of Observations on the Triassic Trap Rocks of Massachusetts, Connecticut and New Jersey:" Amer. Journ. Sci., 3d ser., vol. XXIV, 1882, pp. 345–349.

"The Structural Value of the Trap Ridges of the Connecticut Valley:" Proc. Bost. Soc. Nat. Hist., vol. XXII, 1882, pp. 116–124.

"The Relations of the Triassic Traps and Sandstones of the Eastern United States:" Bull. Mus. Comp. Zoöl. at Harv. Coll., geol. series i, 1883, pp. 249–309, with three folded plates.

"Mechanical Origin of the Triassic Monoclinal in the Connecticut Valley:" Proc. Amer. Assoc., vol. XXXV, 1886, pp. 224–227.

"The Structure of the Triassic Formation of the Connecticut Valley:" Amer. Journ. Sci., 3d ser., vol. XXII, 1886, pp. 342–352.

"The Structure of the Triassic Formation of the Connecticut Valley:" 7th Annual Rep. U. S. Geol. Surv., 1888, pp. 461–490, with one plate.

"The Ash Bed at Meriden and its Structural Relations:" Proc. Meriden Scient. Assoc., III, 1889, pp. 23–30.

"Topographic Development of the Triassic Formation of the Connecticut Valley:" Amer. Journ. Sci., 3d ser., vol. XXXVII, 1889, pp. 423–434.

"The Faults in the Triassic Formation near Meriden, Connecticut; a week's work in the Harvard Summer School of Geology:" Bull. Mus. Comp. Zoöl., geol. series ii, 1889, pp. 61–87, with five plates.

"The Intrusive and Extrusive Triassic Trap Sheets of the Connecticut Valley;" By W. M. Davis and C. L. Whittle: *Ibid.*, pp. 99–138, with five plates.

Structure of the Triassic Formation about Meriden.

Origin of the Deposits.—As at present understood, the structure of the formation may be described as follows: The Triassic strata were deposited in a body of water formed by the submergence of a peneplain of crystalline schists and gneisses; detritus was washed down from the unsubmerged portions of the region on either side, east and west. The pre-Triassic surface is spoken of as a peneplain because it is, in the first place, manifestly a surface of deep erosion on strongly deformed schists; and second, because the line of contact of this deeply eroded surface with the Triassic beds along the under or western margin of the formation is at present so nearly straight. If the pre-Triassic surface had been very uneven, as it must have been for much of the time during its deep erosion, the unevenness should now make itself manifest in a very irregular boundary along the base of the formation; but, as stated above, this is not the case: the base of the formation appears to rest on a relatively even foundation, an ancient peneplain. In a small way, this is best shown in a ravine west of Southington, where a sandy basal conglomerate is seen lying directly on the evenly eroded surface of the tilted crystallines.

The original extent of the complete formation beyond its present boundaries is not known. It may have been many miles broader than it now is, but there is no good evidence now in hand on this question.

Formation of the Trap Sheets.—During the period of deposition there were outflows of lava at several dates. The sheets formed by outbursts at three of these dates are now well correlated; the first of them is relatively thin and vesicular or amygdaloidal; the second is much thicker and more massive, and at some places it appears as a double flow, one sheet of lava lying on another without a noticeable accumulation of sediments between them; the third is again thin like the first. The outcropping edge of the massive middle sheet now forms a series of strong ridges; hence it was called the "main" trap sheet by Percival, while the lower and upper were called the

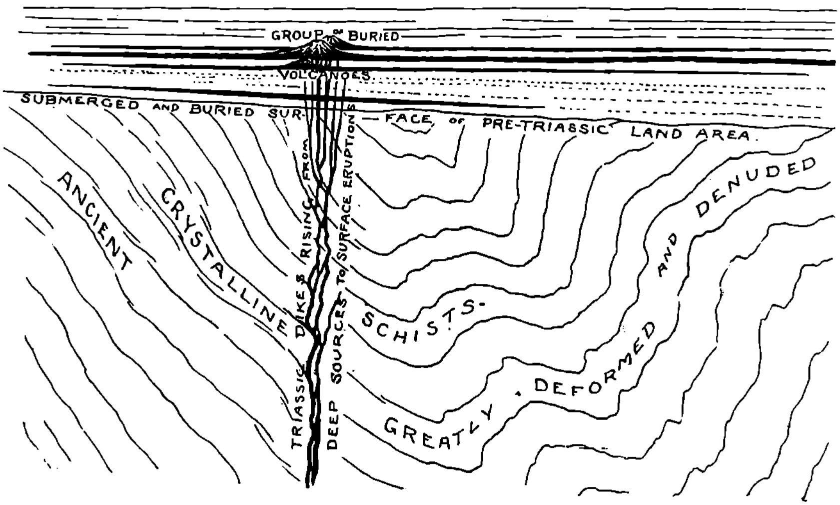

FIGURE 1—*A Portion of the completed Triassic Formation lying on the denuded Crystallines.*

The lower lava bed, spreading out from the dikes near the bottom of the Triassic strata, is the intrusive sheet. The three upper sheets, spreading out from the volcanic cones, are the overflows, called respectively the anterior, main and posterior.

"anterior" and "posterior" sheets respectively, although he did not recognize that these names, which he used to indicate relative topographic positions, would indicate relative time of outflow as well.

In addition to these great overflows, there is at least one great intrusive sheet* and, apparently, several smaller ones. The large one occurs close to the base of the formation, and hence is now seen near its western margin, because the present structure is, as a whole, an eastward-dipping monocline. The date of this intrusion is not definitely fixed, although it appears that

* Professor Newberry has misquoted me (Monograph XIV, U. S. Geol. Survey, 1888, p. 7) as saying that all the trap sheets were overflows. The intrusive nature of the West rock and palisade sheets was recognized in my first essay, and I have never found reason to regard it as of other origin.

good reasons can be shown for provisionally regarding it as of earlier date than the tilting and faulting of the formation, and hence of roughly synchronous date with the overflows. Besides various minor sheets and dikes of undetermined relations, there is a great mass of dikes in Mount Carmel which may be plausibly regarded as marking the vent through which the lava of the sheets rose to the surface. All of this inferred original structure is illustrated in figure 1.

Deformation.—The time of deposition appears to have been terminated by an upheaval, accompanied by tilting and faulting. The tilting is generally to the eastward, or somewhat south of eastward. The faulting has not been well made out except in the neighborhood of Meriden, where the lines of fracture run northeastward or east-northeastward with much regularity. As this direction corresponds with the strike of the underlying schists, where they are seen beyond the limits of the Triassic beds toward the southwest and toward the northeast, it may be supposed that the trend of the faults was determined by the strike of the schists; *i. e.*, that the forces by which the formation was disturbed reached deep below the foundation of the Triassic beds and moved the schists as well, and the latter slipping and faulting along or nearly along their planes of foliation, the overlying Triassic beds broke in the same direction, the dislocations of the smaller superficial mass being guided by those of the greater underlying mass, as has been suggested for the origin of the Great Basin ranges by Gilbert.*

Be this as it may, it is clearly determined that the whole sequence of aqueous and igneous beds has been tilted and strongly faulted, the entire mass being thus divided into a number of long narrow blocks from an eighth of a mile to a mile or more in width, and separated from one another by dislocations, varying from a few tens of feet up well toward two thousand feet. In nearly all cases the heave or upthrow is on the southeastern side of the fracture, and the amount of heave is in a rough way proportionate to the width of the next block toward the southeast; and this seems to be strongly confirmatory of the theory above stated concerning the cause of the faulting.

In the southeastern corner of the present Triassic area the strata were gently folded, or dished, as well as faulted; and here the ridges formed on the harder trap sheets are consequently curved.

If the deformation thus described went on with ordinary geological rapidity, the constructional form of the country produced by it must have been peculiar, to say the least. The nearest existing likeness to it that I have found is in southern Oregon, in the region of the tilted and faulted blocks of lava so well described by Russell;† but there the breaking of the originally even mass into blocks is not so orderly as it was in Connecticut, or at least about Meriden.

* Wheeler's Surveys West of the 100th Meridian, vol. III, 1875, p. 62.
† Fourth Annual Report, U.S. Geol. Survey, 1884, p. 443 *et seq.*

Subsequent Degradation.—At present, the Triassic formation presents no trace of its ancient constructional topography; that was completely obliterated in the long period of erosion that followed the post-Triassic tilting. From evidence found in New Jersey,* it may be said with a good degree of probability that the period of erosion ran through Jurassic and into Cretaceous time, and that it endured long enough to reduce the broken constructional surface of the Triassic area and of the adjacent crystallines, which shared in the post-Triassic disturbance to a greater or less degree, to a surface of moderate relief and low altitude; that is, to a peneplain: a peneplain of much later date than that on which the Triassic beds lie. The same peneplain may be traced far and wide along our Atlantic border, and for an unknown distance inland.† In New Jersey and further south, the denudation of the peneplain was succeeded by a time of moderate depression, when the ocean advanced over the lowland; the waste then received from the interior, not at that time submerged, constitutes the Cretaceous strata of the Atlantic slope. Whether these strata ever reached over southern New England has not been determined, but their appearance in Long island makes such an extension eminently possible; and when the map of Connecticut is completed and the relation of topography to structure is well studied, it may be possible to say something more on this point by means of the location of the rivers, inferring an inland extension of the Cretaceous if the preglacial valleys are generally discordant with the structure.

The Cretaceous peneplain or lowland of denudation is no longer a lowland; it was elevated about the beginning of Tertiary time to a greater altitude inland than near the coast, thus forming a gently sloping plateau; and since then the streams and the processes of subaërial decay have been at work dissecting it. On the crystalline areas they have made but little advance, and here the valleys are still narrow; but on the softer Triassic rocks a broad lowland has again been opened out at a lower level. The preservation of distinct traces of the old Cretaceous lowland, now a highland, on the hard crystalline rocks, while the weaker Triassic beds have already been reduced to a second peneplain close to the newer and lower base-level, is an interesting example of the strong difference in the rates of topographic development of masses of different resistance.

Topographic Expression of Structure.—The trap sheets of the Triassic formation, being much harder than the adjacent sandstones and shales, have resisted erosion more successfully; and the main trap sheet still retains a good measure of the height to which the old Cretaceous peneplain was lifted.

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*The Geographic Development of Northern New Jersey; by W. M. Davis and J. W. Wood, Jr.: Proc. Bost. Soc. Nat. Hist., vol. XXIV, 1889, p. 385.

† W J McGee. Three Formations of the Middle Atlantic Slope: Amer. Journ. Sci., 3d series, vol. XXXV, 1889, p. 35.

B. Willis. Round about Asheville: Nat. Geogr. Mag., vol. I, 1889, pp. 299–300.

W. M. Davis. Rivers and Valleys of Pennsylvania. Ibid., p. 15.

Standing on one of its summits, such as Chauncey peak or Higby mountain, three miles northeast of Meriden, one may see the crest-lines of the main ridge in the various blocks toward the northwest and southeast, all reaching about the same height, and this common height closely like that of the remarkably even sky-line of the crystalline plateau by which the Triassic lowland valley is enclosed on the east and west. The gradual descent of the highland to the south is also apparent from this point of view. Another notable feature seen at the same time is Mount Carmel, apparently in the same block with Higby, but some ten miles toward the southwest, rising somewhat above the sky-line of the crystalline highland, and, therefore, to be regarded as having been a low hill on the old peneplain in Cretaceous time.

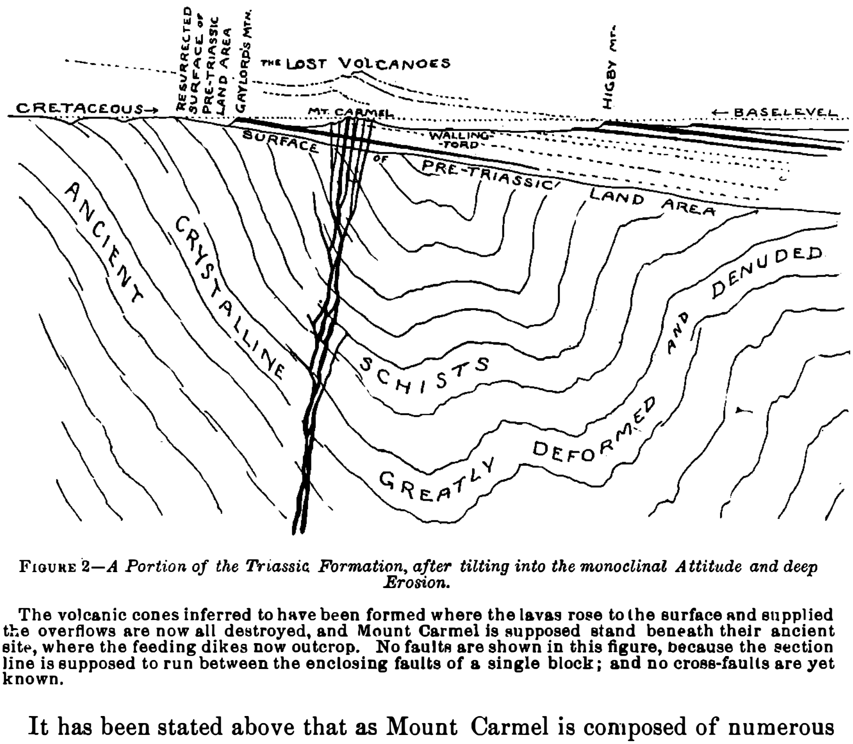

FIGURE 2—*A Portion of the Triassic Formation, after tilting into the monoclinal Attitude and deep Erosion.*

The volcanic cones inferred to have been formed where the lavas rose to the surface and supplied the overflows are now all destroyed, and Mount Carmel is supposed stand beneath their ancient site, where the feeding dikes now outcrop. No faults are shown in this figure, because the section line is supposed to run between the enclosing faults of a single block; and no cross-faults are yet known.

It has been stated above that as Mount Carmel is composed of numerous dikes, many of large size, it may be regarded as the locus of the volcanic pipes up through which rose the lavas now seen in the extrusive and intrusive sheets. No direct evidence of this correlation can be obtained at present; for the intrusive sheet near the base of the formation would intersect the Mount Carmel dikes below the actual surface of the country, and the extrusive sheets would rise far above Mount Carmel, if prolonged in its direction towards their hypothetical volcanic centers of eruption; but the interpretation here suggested is very satisfying when on the ground with the whole district spread out before the observer, as is illustrated in figure 2.

Let the observer climb to the crest of Higby mountain or to any of the other summits near Meriden. It is manifest from these fine points of observation that the lava sheet of which the ridge is formed once continued upward on the plane of its dip into the air, as it still continues downward under ground. The main sheet may be traced forty or fifty miles along its outcrop; it may reasonably be supposed to have had a breadth of a quarter or half of this measure. Its great volume suggests a vent of good size from which the lavas were poured out. The association of ashes and lava blocks with the anterior sheet indicates violent explosive action and the building of volcanic cones at the center of eruption. Not a trace of these cones can now be found. They may still be buried in the lower part of the eastern half of the monocline; but we have no means of testing this supposition. They may have been eroded from the uplifted part of the western half of the monocline; and this supposition is strongly supported by the occurrence of the great irregular "neck" or network of dikes in Mount Carmel. There is no demonstration of connection between these volcanic roots and the outflowering surface sheets; but the two parts correspond so well that the supposition of their genetic connection is eminently satisfactory, even though it involves the wholesale destruction of the uplifted volcanoes in Jurassic time.

Objection may of course be made on the ground of the great erosion that this supposition involves. Certainly a great amount of material has been denuded if the section is here drawn correctly; but, in spite of that, this is still the best interpretation that I can offer.

Verification of Inferences as to Structure.

It is manifest that the correctness of the interpretation here briefly sketched depends in large measure on the certainty with which the faults in the formation are demonstrated. I have therefore given particular attention to the evidence on which their recognition depends, and have made it the main theme of the exercises in the seven-day halt of the Harvard summer school in the Meriden district, as mentioned above. It seems to me to reach an absolute demonstration.

The character of the evidence is as follows: In the first place, an examination of the lava sheets of the district shows them to be extrusive, because they are vesicular and slaggy at the upper surfaces; because they are associated with beds of ashes; because their fragments, large and small and more or less water-worn, occur in the overlying sandstone; and because the bedding of the overlying sandstones conforms to the inequalities of the lava sheet, even filling the small crevices and open vesicles at the surface. Under the microscope, minute fragments of trap are seen to be mixed with the sand grains in the filling of the vesicles. Being extrusive, the lava sheets may be regarded as conformable members of the bedded series; being resistant, they form ridges and are easily traced; hence much of the stratigraphic study of the region is based upon them. In the second place, when the region is examined on several northeasterly lines parallel to one another, the sequence of beds on each line is found to be essentially constant, namely, lower sandstones and conglomerates, a vesicular lava sheet (the anterior), shales, a heavy lava sheet (the main), shales, a thin lava sheet (the posterior), and finally an upper series of shales and sandstones. This repetition of so complicated a sequence of beds is not thought to be possible as an accidental occurrence; hence the hypothesis of faulting is introduced, and the fault lines are searched out. These, in the third place, are found by tracing the ridge-making members of the series until they end, and drawing lines to connect their terminations. The lines thus drawn are found to run systematically northeast-and-southwest; bands of breccia are found at several points along them; local disturbances of the generally uniform dip of the beds occur along the lines, and always acoordant with the drag of the supposed faults; the heave of the faults is, with one exception, systematically on the eastern slide of the line of fracture. In the fourth place, the peculiarly intricate relations of the ridges, by which they are offset from one another and their ends overlapped—the "advancing" and "receding order" of Percival,—find a simple geometrical explanation, susceptible of trigonometrical formulation, by means of the theory of faulting; and the prevalence of abrupt bluffs at the southern ends of the ridges, while the northern ends fall away gradually (a very marked feature of the Meriden district) follows necessarily from the degradation of monoclinal lava sheets cut by oblique faults, the bluffs being formed where the strike of the sheets and the trend of the faults make an acute angle.

When evidence so varied and so complete is repeated over and over again in the most systematic order, the conclusion to which it leads cannot be gainsaid.

But even though the faults are seemingly demonstrated fully by general structural evidence, additional evidence is always in order; and for that reason I have endeavored during the past summer to discover whether the fossils of the formation would bear on the question.

If a fossil-bearing horizon is found in one of the blocks into which the formation is divided, it evidently might be expected to occur in the same position relative to the trap sheets in the adjoining blocks, and so on for a considerable distance from the place of its original discovery, as indicated in figure 3. A correct knowledge of the location and throw of the various faults should thus enable one to define with considerable accuracy the localities where outcrops of any fossiliferous bed might be looked for in the several blocks.

With this thesis in mind, I secured the assistance of Mr. S. Ward Loper, of Middletown, formerly of Durham, Connecticut, where he had made explorations of certain fossil-bearing beds of black shale, and from which he had obtained a large collection of Triassic fishes and plants. Many of the fishes described in Professor Newberry's monograph were of his collecting. It was clear that two of his localities were simply different outcrops of a single bed of black shale in the Totoket block, about a quarter way from the anterior trap sheet up through the anterior shales to the main trap sheet. This will be called the anterior black shale. Search for the same shale bed was then

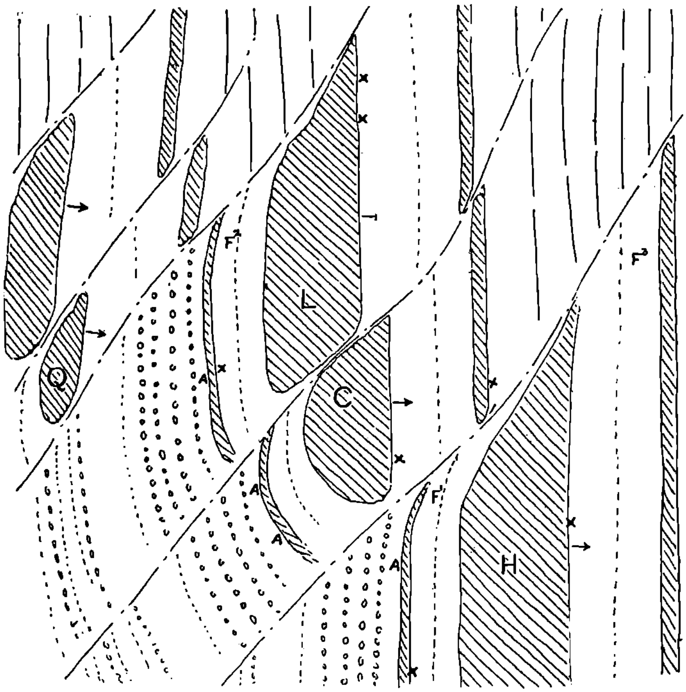

FIGURE 3—*Sketch Map of about ten Square Miles Area to illustrate the Monocline near Meriden, Connecticut.*

Showing parts of the Higby (*H*), Chauncey (*C*), Lamentation (*L*) and Quarry (*Q*) blocks. The known localities of the fossiliferous anterior shales in this area are at the northern edge of the Higby block (F^1) and northern part of the Lamentation block (F^2); and of the posterior, near the northern side of the Higby block (F^3). Beds of ashes and bombs are found in the anterior trap at *A*, and contacts of the trap sheets with the overlying sandstones at *X*.

begun in the blocks next toward the northwest, and, although much embarrassed by the drift that so generally occupies the anterior valley in which the black shale crops out, we were successful in finding it at three other points, and in securing fossils from it by digging to a moderate depth. It occupies essentially the same position in the stratified series at all these points. The extreme points now identified in this bed are about fifteen miles apart, and ten well proved faults occur between them.

Another bed of dark shales with impressions of fish and plants has been known for many years in a small brook north of the village of Westfield, Connecticut, and about half a mile southwest from the station of that name on the Berlin-Middletown branch of the New York, New Haven and Hartford railroad. This lies about one hundred and fifty feet below the posterior trap sheet, or about a quarter way from the posterior to the main sheet. It will be referred to as the posterior black shale. Outcrops of what seems to be the same bed have been opened at four different places, the distance between the extreme points being about fifty miles, including twelve or more faults. Its position is everywhere two or three hundred feet above the main trap sheet.

A more precise statement of the location of the fossiliferous strata and a provisional list of the fossils found in them is presented by Mr. Loper.

On examining the tables of species as made out by Mr. Loper, there appears to be good reason for concluding that different outcrops of the two beds of shale might be distinguished as belonging to two horizons on paleontological grounds alone; but it should be borne in mind that there is still much possibility of finding various species, now known only from one of the beds, in the other. The large number of species from the old Durham locality means in part good conditions for their preservation, but it means also that this locality has been more carefully worked and for a longer time than any other. It may also be suggested that while the stratigraphic correspondence of the several outcrops of the anterior and posterior shales was very satisfactory, so far as determination by rough pacing measures would determine, it is quite possible that they do not represent precisely equivalent horizons, although they are certainly as nearly equivalent as the so-called geological horizons commonly are. It is not unlikely that there may be several fossiliferous layers at slightly different horizons of the anterior and posterior shales, and that our openings touch one of them at one point and a second at another. Indeed, it may be that there are various fossiliferous black shales scattered through the formation, yet not visible owing to their weakness and the heavy drift cover that so effectively blankets over the surface; but the main question of the repetition of certain fossiliferous beds at definite positions in the various faulted blocks seems to be settled. The occurrence of the two shales at predicted localities and the correspondence in the fossils of each horizon at various localities so fully conform to the requirements of the theory of the faulted monocline that this structure may now be regarded as established for Connecticut on paleontological as well as on structural evidence.

HARVARD COLLEGE, CAMBRIDGE, MASS., *December*, 1890.

FOSSILS OF THE ANTERIOR AND POSTERIOR SHALES: BY S. WARD LOPER.

THE AREA EXAMINED.

In accordance with instructions received from Professor Davis last June, I have endeavored to test the continuity of the anterior and posterior fossiliferous shales associated with the trap ranges of the Triassic formation of the lower Connecticut valley. I have examined carefully the shale outcrops lying between the anterior and main trap ridges for nearly the whole distance across the state (about 50 miles), and have also looked for the posterior shales over a considerable part of this distance.

Although the work assigned me is not fully completed, I am able to report much that is of a satisfactory nature. Openings have been made along both the anterior and the posterior shales in several of the faulted blocks of the formation, and the beds thus disclosed, as well as the fossils obtained from them, show an indisputable correspondence in the stratigraphy.

About 450 specimens have been collected, exclusive of many hundred fossils which have been taken during the past twenty years from the shale beds of Durham and vicinity. About twenty-four species of fishes and plants, some hitherto undescribed, are now known from these localities. A comparison of the species from the different localities of the anterior and the posterior shales shows a correspondence in the fauna and flora, clearly sustaining the theory of the original continuity of the horizons through all the now faulted blocks of the Triassic formation.

Along the middle and southern ranges there has not been much difficulty in finding available points for making openings; but toward the northern line of the state, above the gap of the Farmington river at Tarriffville, the shales have been generally inaccessible on account of the great amount of drift by which they are buried. The red sandy beds and the blue shales associated with the black shales, are, however, traceable entirely across the state; and with sufficient time for closer search at certain points, there is little reason to doubt that the fossiliferous shales might be uncovered in the northern area.

The method of searching for the shales has been to walk over all the strip of country between the anterior and main trap ridges, and also, so far as has been possible in a single season, between the main and posterior ridges, making a thorough examination for outcrops of the fossiliferous beds in their appropriate positions. Several new localities yielding many valuable fossils have thus been discovered. The anterior shales were found at one point in the Lamentation block by excavating where there were no outcroppings, but where it was judged the fossiliferous beds ought to occur.

The Localities explored.

Anterior Shales: 1. Durham.—The anterior black shales are found in a stream bed on the western slope of Totoket mountain, near its northern curve in the southern limit of the town of Durham, where I have worked them for the past twenty years. The shales are now difficult to reach on account of water that fills the pits, and no search has been made here this year. The species heretofore found at this point have, however, been included in the tabular list given below. They are described as from "Durham" in Professor Newberry's monograph.

2. Bluff Head.—This is another outcrop in the same Totoket block and of the same bed as the preceding, but about two miles east of it, and north of the bold northeastern end of the main trap ridge, known as Bluff head. It lies near the northern line of Guilford. I found this bed about two years ago by following up a stream in which a boy had picked up a fossil fish. The shales are much decomposed and need careful handling, but the specimens are in good form. They closely resemble those from Durham.

3. Higby.—Black shales with fish scales were found by Professor Davis and myself last June in a ravine between the anterior and main trap ridges at the northern end of Higby mountain, about half a mile south of Highland station, on the Meriden, Waterbury and Connecticut River railroad. This was the first point at which discovery of fossils rewarded our search on a predicted horizon in the formation. An excavation in the bank secured a number of fragmentary specimens of fishes and plants. Large foot-prints were found in an associated sandstone.

4. Berlin.—No natural outcrops of black shales were found in the Lamentation block; but an excavation made at their expected horizon, about fifty feet above the anterior trap sheet, resulted in finding them, although of small thickness. This was in the southern part of Berlin, east of the Berlin-Meriden road, on land belonging to Mr. George Hall, near the house of Mr. Robert Hurlburt. The specimens were few in number and of poor condition, but sufficed to identify the shales.

5. Southington.—An old cement quarry on the back of the anterior trap ridge in the Ragged Mountain block (called South High rock in Professor Davis' paper on the faults near Meriden) contains some dark shales in which a number of plants were found. Fossil fishes are said to have been found here years ago. One specimen was discovered last summer by Mr. J. B. Woodworth, of the United States Geological Survey.

Besides these localities, there is good opportunity for opening the shales in the proper horizon above the back of the anterior trap sheet in the Bradley mountain block, at the outlet of the Plainfield reservoir; and dark shales were found by digging above the anterior ridge on the western slope of Rattlesnake mountain, near Farmington, though no fossils were secured here. These and other localities further north may be examined at a later date.

Posterior Shales: 1. East Haven.—Mr. E. O. Hovey, while at work on the geology of the New Haven topographic map sheet last summer, found an outcrop of fossiliferous black shales in a stream running into Saltonstall pond from the east near its southern end. The bed lies a hundred feet or more beneath the posterior trap sheet, and belongs in the Pond mountain block. A number of good specimens were secured by digging into it.

2. North Guilford.—Several years ago I found some fish scales in black shales exposed in a stream near the posterior trap sheet of the Totoket block. No opening has yet been made in these shales, but they may be provisionally referred to the posterior series.

3. Stevens.—An old locality, posterior to Paug mountain, near a shaft sunk for coal, on land belonging to S. G. Stevens, in the town of Durham. No work was done here last summer, but the species previously secured are entered in the list.

4. Westfield.—The posterior shales are exposed in a stream bed, a quarter of a mile northwest of Westfield village and half a mile southwest of Westfield station on the Berlin and Middletown railroad. These belong in the Higby block, near the fault that cuts it on the northwest. They lie about 100 feet below the posterior trap. The locality has been known for many years; a representative collection was secured from it last summer.

5. South Bloomfield.—Black shales were found at Gillett's Mills, lying posterior to the Talcott mountain range of the main trap sheet, but fossils are not yet discovered here.

6. North Bloomfield.—One mile east of Tarriffville, an extensive bed of black and blue shales was discovered, about 100 feet under the posterior trap, in the bed of a small stream, sixty rods south of its junction with the Farmington river, just above the Bloomfield and Winsor bridge. Many plant impressions were found here, but no fish remains.

The long distance from Westfield to South Bloomfield has not as yet yielded any posterior black shales.

There are black shales, sometimes fossiliferous, seen or reported at Little Falls, south of Middletown reservoir, in Middlefield, at Zoar, and in Middletown, Rocky Hill and Glastonbury. Some of these appear to constitute a second or higher horizon on the posterior; but their position is not yet well determined.

Species collected.—All the specimens collected last summer have lately been arranged according to localities and species at the Museum in Cambridge, Massachusetts, and provisionally determined by comparison with figures in Newberry's and Fontaine's monographs. The accompanying table presents the results thus obtained.

Provisional Table of Species of Fishes and Plants from the Anterior and Posterior Shales.

Species.	Anterior Shales.						Posterior Shales.				
	Durham.	Bluff Head.	Higby.	Lamentation.	Southington.	Anterior localities.	Posterior localities.	East Haven.	Stevens.	Westfield.	North Bloomfield.
Fishes.											
Diplurus longicaudatus, Newb.	+	0	0	0	0	1	1 (?)	0	0	(?)	0
Ptycholepis marshii, Newb.	+	+	0	0	0	2	0	0	0	0	0
Catopterus redfieldi, Egerton	+	+	0	0	0	2	2 (?)	+	0	(?)	0
" *gracilis*, J. H. R.	+	+	+	+	+	5	3	+	+	+	0
" *anguiliformis*, W. C. R	+	(?)	0	0	0	2 (?)	0	0	0	0	0
" *minor*, Newb.	+	0	0	0	0	1	0	0	0	0	0
" *ornatus*, Newb.	+	(?)	+	0	0	3 (?)	0	0	0	0	0
Ischypterus fultus, Ag.	+	(?)	0	0	0	2 (?)	0	0	0	0	0
" *micropterus*, Newb.	+	+	+	+	0	4	3	+	+	+	0
" *minutus*, Newb.	+	0	0	0	0	1	0	0	0	0	0
" *gigas*, Newb.	0	0	0	0	0	0	2	0	+	+	0
Undetermined ovate form	+	+	0	0	0	2	1	+	0	0	0
Plants.											
Pachyphyllum simile, Newb.	+	0	+	+	+	4	0	0	0	0	0
" *brevifolium*, Newb.	+	0	+	0	+	3	0	0	0	0	0
Otozamites latior, Sap.	+	0	0	0	+	2	1	0	0	0	+
" *brevifolius*, F. Br.	+	0	0	0	0	1	1 (?)	0	0	0	(?)
Clathropteris platyphylla, Bg.	+	0	0	0	0	1	0	0	0	0	0
Loperia simplex, Newb.	+	+	+	0	+	4	3	+	+	+	0
Cycadinocarpus chapini, Newb.	+	0	+	0	+	3	1	0	0	+	0
Equisetum rogersi (?), Sch.	0	0	0	0	0	0	4	+	+	+	+
" sp. und.	0	0	+	+	+	3	3	+	+	0	+
Baiera münsteriana, Ung.	+	+	+	+	+	5	0	0	0	0	0
Ctenophyllum braunianum, Sch.	0	0	0	0	0	0	1	0	0	0	+
Calamite-like stems, with head	+	0	+	+	0	3	0	0	0	0	0
Undetermined stem, with spines	+	0	0	0	+	2	0	0	0	0	0

Distribution of Species.

It appears from the table that the following five species of fish and five species of plants are common to both the anterior and posterior shales, as represented in the collections from the localities here considered:

Fishes . .
- *Diplurus longicaudatus*, Newb. (doubtful in posterior).
- *Catopterus redfieldi*, Egerton.
- *Catopterus gracilis*, J. H. Redfield.
- *Ischypterus micropterus*, Newb.
- Undetermined ovate form.

Plants . .
- *Otozamites latior*, Sap.
- *Otozamites brevifolius*, F. Br. (doubtful in posterior).
- *Loperia simplex*, Newb.
- *Cycadinocarpus chapini*, Newb.
- A small undetermined *Equisetum* (?).

The anterior shales alone have afforded the following six species each of fish and plants:

Fishes . .
- *Ptycholepis marshii*, Newb.
- *Catopterus anguilliformis*, W. C. Redfield.
- *Catopterus minor*, Newb.
- *Catopterus ornatus*, Newb.
- *Ischypterus fultus*, Ag.
- *Ischypterus minutus*, Newb.

Plants . .
- *Pachyphyllum simile*, Newb.
- *Pachyphyllum brevifolium*, Newb.
- *Clathropteris platyphylla*, Brong.
- *Baiera münsteriana*, Ung.
- Calamite-like stems, with head.
- Undetermined stem, with spines.

The posterior shales have produced the following single species of fish and two species of plants, not yet found in the various openings on the anterior shales:

Fishes . . *Ischypterus gigas*, Newb.

Plants . .
- *Equisetum rogersi*, Sch.
- *Ctenophyllum braunianum*, Sch.

The most marked features of this comparison are the absence of *Ischypterus gigas* from the anterior shales, where so many other species of fish are found, and the limitation of several species of plants to the anterior shales, although the flora of the posterior shales embraces a number of species common to both.

RESULTS.

The work has, therefore, been not only clearly confirmatory of the theory of a faulted monocline, but it has also secured many fine specimens for the National Museum, and it has shown that systematic exploration may yet reveal much of interest where it was supposed that but little remained to be discovered.

WASHINGTON, D. C., *December*, 1890.

DISCUSSION.

Professor C. H. HITCHCOCK: Being greatly interested in the facts of this paper, I desire to ask Professor Davis where, judging from his conclusions as to Connecticut, we should expect to find the fish beds in connection with the Holyoke-Tom range in Massachusetts?

Professor W. M. DAVIS: The location of the belts of shale in Massachusetts will depend on the correlation of the trap ridges of Connecticut and Massachusetts. Without being able at present to settle the question, I am inclined to believe that the anterior sheet in Connecticut thickens northward and becomes the main sheet north of the state line, while the main sheet of Connecticut thins and becomes a subordinate posterior further northward. If this is correct we should look for the anterior shales of Connecticut on the back of the Mount Tom-Holyoke range; and the Bear's Hole locality, a mile or two north of the Westfield river, appears to confirm this suggestion. The posterior shales of Connecticut should lie further east, but they are not yet identified.

Professor B. K. EMERSON: Further northward, in Massachusetts, a band of black shale occupies the same horizon above the Holyoke traps, but has furnished only plant remains. In northern Massachusetts the Sunderland and Turners Falls fish beds also occur just above the Deerfield trap sheet.