PALÆONTOLOGICAL REPORT

OF THE

FOSSIL FLORA OF THE COAL MEASURES

OF THE

WESTERN KENTUCKY COAL FIELD:

BY

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PALÆONTOLOGIST.

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INTRODUCTORY LETTER.

DEAR SIR: I herewith submit my report on the identification of the veins of the Southwestern Coal Measures of Kentucky.

Permit me first to most gratefully acknowledge the liberal and enlighteded support that I received from you, to ensure the success of my researches. It is by following exactly your directions, that with the co-operation of Mr. E. T. Cox, your able assistant, we are able to point out now, for the first time, some general and reliable characters, which may prove of practical advantage for the identification of the richest beds of coal of Kentucky, and of the whole coal-fields of the United States.

It was understood that I should only have to collect and examine the fossil plants of the Western Coal Fields of Kentucky, with essential references to the peculiar species of each bed of coal. You wanted thus to ascertain the practicability of establishing the order of superposition, and by this means, the identification of the beds. I had been engaged during two years, in following the same researches for the state survey of Pennsylvania, in the anthracite coal-fields of that state, and had obtained some interesting and practical results from the study of the fossil plants found in connection with the shales of each bed of coal. But as soon as we began our explorations, in the bituminous coal-fields of Kentucky, it became evident that the marine element was predominant in the shales of most of the beds, and that it would be of little advantage to limit our researches to the fossil botany only, since shells and remains of fishes were mostly found in the shales, without any plants whatever. For that reason, and confident that the general principles exposed hereafter, would prove reliable for the distribution of the shells, as well as of plants, I determined to carefully examine the marine remains of each bed, and to collect them for comparison and study.

Mr. E. T. Cox, who is entitled to his share of the practical results of our explorations, being better acquainted with the shells than I am, took especial care of this part of our work, and by his unremitting researches, and arduous labor, we have been able to collect a large number of specimens, which have been subjected to your examination. From them it is evident that the distribution of the species of shells in the shales of a bed of coal is as reliable, for its identification, as the distribution of the species of fossil plants.

The following introductory remarks may appear out of place in a local report like this, but I think that they are not without a practical advantage. They will give not only an answer to a question scarcely understood as yet, and often put to us by persons interested in the coal business, viz: what is the coal, and how has this fuel been formed? But they will also enable the reader fully to understand the practical deductions, and to test their value.

It is unnecessary to dwell on the advantages of undoubtedly ascertaining the geological level of a bed of coal, since it is evident that profitable explorations for coal can be made, with some chances of success, only from the directions of a previously ascertained and well established geological level. When this is exactly ascertained, a single glance at a vertical section of the measures gives an answer to the question: at what distance above or below shall we expect to find another coal, and what will possibly be the thickness of the bed?

The few quotations and references to researches previously made by myself, in the coal-fields of Pennsylvania and Ohio, will be easily excused, since they tend to solve the problem of the coeval formation, even of the primitive connection of all the coal-fields of the United States—a question most interesting for geology, and eagerly discussed just now. And as for the right I may have to quote a few lines of a report delivered in 1854, to the director of the Geological State Survey of Pennsylvania, and of which a small pamphlet, "*Description of new species of fossil plants, &c.*," has only been published, I do not think that it can be denied me. This report, elaborated with great care, and the arduous labor of two years, was to appear in the final report of the Geological State Survey of Pennsylvania, but it is a question if it will ever be published. Therefore, I do not think that I am bound to entirely disregard some scientific results, which may be of general advantage, for the only reason that they have been made under the direction of another state.

I am, sir, most respectfully, yours,

LEO LESQUEREUX.

Dr. D. D. OWEN, *Director of the State Survey of Kentucky.*

INTRODUCTORY REMARKS.

In tracing the features, and studying the rocks and compounds of the earth's surface, no problem has more frequently occupied the mind of geologists than the formation of coal. Where does this black substance come from, hard as stone, and nevertheless inflamable as wood; half bitumen, half charcoal, encased between beds of shale and rock, which, by their fossil remains, their fishes, shells, or plants, attest the highest antiquity? Has coal been originated in the bowels of the earth by some volcanic agency, and deposited in a fluid state, like the lavas or the primitive rocks of many mountains? No! for it is stratified, laminated, extended in horizontal beds, covering very large surfaces with a nearly constant thickness. Moreover, the shales in which it is ordinarily incased bear evident proofs that they have been slowly deposited in a quiet water basin, and that subterranean fire has had no action upon them, except perhaps as a hardening agency. Or, perhaps, has coal been made of the remains of extensive forests, overthrown, transported, and deposited again in valleys and hollows, by an universal flood. But, by such a cataclysm, those remains could not have been distributed in an harmonious manner, in extensive beds of equal thickness, and especially in such purity that they scarcely contain any particle of mud, sand, or any substance that does not belong to the chemical compounds of the wood. For the same reason, also, the beds of coal cannot be the result of heaps of drift-wood along the banks of the large rivers, or on the shores of the sea. It is then necessary to admit, with most of the best living geologists, that the coal beds have been formed nearly in the same manner as the peat-bogs of our own time, and that the coal itself is nothing else but decomposed and hardened woody matter, remains of immense and successive forests, grown, decayed, heaped up, and then entombed on the spot, in their gigantic shrouds of black slate, of black, white, and grey limestones, or of yellow sandstone.

But such an explanation is too general, too indefinite, to be easily understood, and especially to give a satisfactory account of the various accidents which have accompanied the formation of the coal. And since it is, from the nature of the shales of the coal-beds, and from the remains, whether plants or animals, found in connection with them, that the writer of this report intends taking the characters that may help to their identification, or to the ascertaining of their geological level, it is necessary to give, at least, the details that may be justly required, as reliable proofs of the validity of his opinion.

The vegetable is cotemporary with the animal kingdom. Plants and animals have appeared at the same time on the earth, and grown together in parallel lines—for the remains of marine plants or fucoides are found in the oldest stratified rocks, in connection with the petrified remains of shells. As soon as a part of the earth's surface has been thrown out of the sea, like a new-born child, nature, its kind mother, has covered it with the green carpet of another vegetation. But the rise of a solid surface above the sea does not appear to have been a sudden and paroxismal event. Impelled by the action of an internal fire, the crust of the earth, still thin and scarcely solid, was continually swelling here and there, with a variety of undulating movements—ascending and then subsiding at the same place—either propelled by the internal fire, or depressed by its own weight, when the force lost its energy. In this manner, ranges of hills began to appear, breaking the monotonous horizon of an universal ocean; and at their base, immense plains, leveled by the long protracted action of the waves, being by and by raised to the surface and separated from the sea by heavy banks of sand, were thus transformed into shallow marshes, prepared for another kind of vegetation. Such marshes though. of a far more limited extent, are seen in our time along the shores, both of the Atlantic and of our great lakes, the Dismal and Alligator swamps of the south; the Sandusky, Montezuma, and Toledo marshes of the north.

But before those immense plains were thus slowly elevated and separated from the vast deep, the sea came for a long time, breaking its waves against the primitive hills, or at least, was long engaged in depositing around their base the mud with which its waters were charged. Those gigantic deposits of red sandstone, bordering the coal basin on its eastern margins, are especially the work of the tides. Like the conglomerates which were afterwards deposited upon them, they thicken to the east, and nearly disappear in the contrary direction, evidently showing where then were the first shores of the ocean—the first outline of the Alleghany mountains perhaps.

The conglomerates of the anthracite basins of Pennsylvania are about fifteen hundred feet high, composed of sand and pebbles of quartz, which are sometimes as large as hens' eggs. On the contrary, in the western part of the Coal Measures, in Indiana, Kentucky, and Tennessee, they are comparatively thin, and of a finer texture—just as it happens that near the shallow shores of our lakes, or of the Atlantic, the gravel and coarse materials of the bottom are heaped by the waves nearer to the margin, in proportion to their size, the finest particles of sand being necessarily drawn farther from the shores where the action of the waves is less violent. It was in this manner that the first basin of the coal was prepared. Bordered to the east by a chain of hills, the bottom was slowly upheaved, and the ocean damed far away to the west, began there, by its perpetual movements, to build again its new shores, and to close in the coal basin with high banks of sand and gravel. This separation was necessary, for a shallow, quiet, water, of a constant level, is the first condition of the formation of peat, and consequently of coal.

The plants of the bogs have a peculiar growth and a peculiar composition. They live ordinarily half immersed in water, and raise their stems, branches, leaves, and flowers above the surface. They are generally of a woody texture. Even the mosses and the grasses of a peat-bog contain, comparatively to their size, as much woody fibre as the hardest oak. The trees are most of them resinous. In the northern part of the United States the balsam-fir, the black and white spruce, the tamarack, the arbor-vitæ and the white cedar; in the south, the bald cypress, the great and small laurel magnolias, the tulip-tree, are commonly seen growing on the cedar swamps, with birches, alders, poplars, and other resinous shrubs. The peat bogs of Europe are abundantly covered with a kind of dwarf-pine, from the leaves and twigs of which the rosin trickles upon the mossy ground, forming all around the trees a hard floor of tar many inches in thickness. Most of the plants of those marshes, except a few trees, belong to that peculiar station; they do not grow out of their bogs, neither can they be transported and cultivated out of them. For that reason the vegetation of the cedar swamps cannot be taken as a true representative of the flora of a whole country. It has its place in the harmony of nature, like the fruits and flowers of our gardens, the grass of the prairie, the trees of the forest. It was destined for the condensation, the preservation of carbon, for the formation of coal. For truly, when we examine fossil plants that have been preserved in the shales of the coal, or when we analyze the substance of the coal itself, we find that the plants which formed it have the greatest likeness to those of our actual peat-bogs, viz: the ferns, the club-mosses, the horse-tails, the rushes, the reeds, and especially the resinous trees. The most remarkable difference is that all these plants, compared with those of our time, were of a monstrous size. They were, indeed, the mastodons, the mammoths, of the vegetable world.

Every body is now acquainted with Liebig's explanation of the combustion and decomposition of wood. When heat is applied to it, it burns with flame, developing carburetted hydrogen. When woody fibre is brought into contact with air, in a moist condition, it is gradually decayed, viz: changed into mould or humus, by the conversion of the oxygen of the air into the same volume of carbonic acid. Its carbon is then not only preserved, but augmented. When the access of air is restrained, decay, or a slow burning of the wood, is in like manner produced, but the process is different. The disengagement of carbonic acid, though continuous, is slight, and the final result is charcoal, wood-coal, lignite, mineral-coal, anthracite, even diamond, according to the conditions under which this slow burning has taken place—the quantity of water, the more or less free access of the oxygen of the air, compression, heat, &c. Says Liebig: "A slow but continual removal of oxygen in the form of carbonic acid, from layers of wood-coal, or of wood immersed and decomposing in water, transforms necessarily the woody substance into mineral coal. On the contrary, the removal of all the hydrogen of mineral coal, converts it into anthracite." From this we draw the conclusion, that for the formation of coal, a large production of woody fibre, at a constant water level, is a necessary condition.

The presence of the water, and its constant level, are necessary not only to prevent a too rapid decomposition of the wood, but also for the vegetation, itself, of the marshes. Plants living entirely immersed in water, do not have a larger proportion of woody fibre in their tissues.

The fucoides, or marine weeds, are of this kind. To elaborate wood, the plant wants the contact of the air with the porous surface of its leaves. The marsh plants, then, having their roots fixed in the ground below water, expand their leaves either on the surface of the water or above it. Trees need, for their vegetation, the absorption of air through their roots. Hence, those which grow on the bogs, extend their roots and rootlets in a large circuit, let them run near the surface among the mosses, and ordinarily plant themselves on a higher level, either on the decayed trunks of other trees, or on some heap of matter. In any case, a formation of peat is impossible in a marine basin not entirely secured against the action of the tides, or in the marshes of rivers, which, though covered with high water in the spring, become dried by the heat of the summer months. Along the shores of the ocean, of our lakes or our large rivers, there are extensive marshes, inaccessible during the spring, and even during part of the summer, covered with rushes and reeds, the bottom of which is constantly and slowly elevated by thin layers of mud or clay, but never covered with peat.

The same phenomenon is produced in lakes and bayous, where water is too high for the growth of the plants, and on the borders of which the water level is not constant. The matter deposited at the bottom of those deep marshes is constantly a fine mud.

There is perhaps no place in the world where the process of the formation of coal may be studied, with better chances of a clear elucidation of all its phenomena, than in the Dismal and Alligator swamps of southern Virginia and North Carolina. The extent, though truly nothing compared with the area of the coal-fields of America, covers nevertheless, thousands of square miles. They are separated from the bays and sounds that surrounds them by broad hills, and large banks of sand, bordering the Atlantic, in a continuous row, from Cape Henry, or Norfolk in Virginia, to the mouth of Cape Fear river, or Wilmington in North Carolina. They contain, in their wide area, sand hills, deep deposits of peat, and lakes. The hills are covered with the vegetation of dry land. The peat, from one to fifteen feet thick, follows at its bottom the irregularities of the surface on which it rests, thinning and disappearing entirely where it abuts against the hills: for a bed of peat, depending for its formation on the level of the water, has just the same appearance, or at least, by a cross-section, would present the same front as the transverse soundings of a shallow sheet of water.

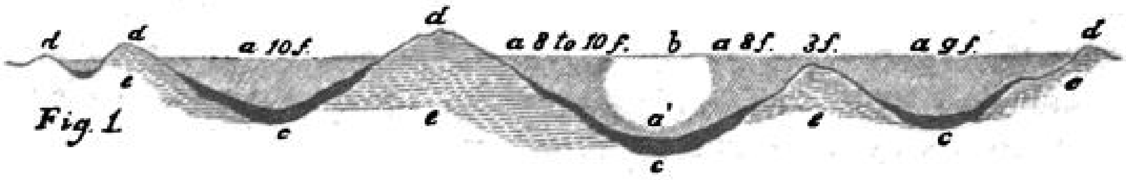


*Fig. 1. *Approximate section across the Dismal Swamp*—a Deposits of peat. a'. Deposits of trees at the bottom of Drummond's lake. b. Surface of lake Drummond. c. White clay of the bottom. d. Hills of sand. e. Sand below the marshes.

As for the vegetation itself, and its action on the formation of the peat, let any tourist try to find his way directly across the swamp, from some point on the canal to Drummond's lake and he will understand at once all about the mystery of the heaping of vegetable matter. Wading at least knee deep in water, or in a black soft mud, or sinking at every step deeper and deeper in the hillocks of green mosses, where he thought to find a dry and solid footing for a minute's rest, he has literally to cut a path through a wall of canes, of reeds, and of shrubs. The only place where he finds firm stepping and a clear space, is on the roots of the bald cypress, which raise themselves above the water around each tree, like the scalped skulls of a tribe of Indians; or, perhaps, on the prostrated trunk of a huge magnolia tree, covered with mosses, and slowly sinking in its muddy grave, not to decay, but to be embalmed and preserved like an Egyptian mummy. Every year the mingled mass of vegetation, the mosses, the canes, the reeds, the trunks, branches and leaves of the trees and shrubs, are heaped and deposited on the surface of the bog, to be, by and by, transformed into combustible matter, by the process of slow decomposition.

Some of the lakes now open on the surface of the marshes have certainly been hidden, formerly, by a thick coat of vegetation. Drummond's lake is only fifteen feet deep, and its bottom is strewn with the remains of an overthrown forest, which has probably sunk by its own weight. Phenomena like this are frequent in the large peat-bogs of northern Europe, especially in Sweden, Denmark—even in the mountains of Switzerland. The green carpet of vegetation which, by

*The figure is drawn without reference to any exact proportions; in depth it represents about one foot in the 8th part of an inch; in length one inch would represent more than two miles.

the agency of floating mosses, spreads on such lakes, is sometimes so thin that it breaks under a light pressure, and men and animals are frequently engulfed and irretrievably lost in their treacherous waters. The rich cabinets of Lund and Copenhagen are filled with antiquities collected in the peat-bogs of that country—weapons and armor; ornaments of copper, silver and gold; tools and instruments of every description; bones and skulls of extinct or living races of animals; of men also; even the whole skeleton of a woman, with her clothes, have been found imbedded in the peat.

Drummond's lake has now been open for many hundred years; its black water has entombed its sunken forest under a bed of mud. The surface of the lake, like the general surface of the Dismal swamp, is only 16½ feet above mid-tide of the Atlantic. If we suppose a slow depression of all the space covered by the Alligator and Dismal swamps, of say only a few feet in a hundred years, what would be the result? At first the water rises above its former level, since its outlets are necessarily obstructed, and the remains of the plants still growing here and there upon the hillocks of the marsh, fall every year into the water and sink to the bottom—not to add any more matter to the bed of the peat, but to be incorporated with the soft mud continually deposited by the water. If the downward movement continues, every trace of vegetation must disappear, and the marsh forms an extensive lake, connected by some outlet with the sea, which brings to it a few species of its inhabitants, either fishes or molluscs; and, by and by, after a still lower depression, either the sea spreads quietly over the whole space, and its water covers it with a deposit of limestone, wherein are imbedded the remains of the shells and animals of the deep; or, perhaps, after a sudden cataclysm, there is a depression of a few feet, and the sea, overcoming its barriers, rushes into its old level, sweeps over its old bed with impetuosity, and brings with its waves the banks of sand and the gravel of its shores, to scatter them more or less irregularly over the whole surface. Let the land rise and the water recede again, and the formation may be repeated many times, with many modifications. This simple work of nature, operating in this wise for an immense number of centuries, will necessarily result in the transformation of the whole stratum to true Coal Measures. The compressed and crystallized peat will be the coal; the soft mud slowly deposited upon it by quiet and shallow waters, will be hardened to black shales, and show us the petrified remains of plants, shells, or fishes. The deposits of the deep, quiet, marine waters, have formed a bed of limestone above it, and if, afterwards, sand has been brought in by the currents of the sea, the whole measures—coal, shales and limestone—become covered with sandstone.

The only thing not explained above, is the formation of the fire-clay of the bottom, which, by a cross-section, would certainly be found under the coal of the Dismal Swamp, as it is found under nearly every bed of the old Coal Measures.

As we have seen before, the woody matter deposited in a basin can only be preserved and transformed, if the water is of a constant level. Resting on the sand, the water percolates through it, and consequently is subject, by a constant motion, to a perpetual change of chemical constituents, and to a renewal of the particles of air which it contains. This change is opposed to the formation of peat, since water, before being prepared for the preservation and transformation of woody substance, has to become saturated with a peculiar acid—*the ulmic acid*—produced by the decomposition of wood itself. Thence it follows, that a peat or coal basin has to be separated and prepared to keep its water, like a well cemented cistern. This work is done by very small animals —*infusoria*—and by peculiar species of plants. In the peat formations of the present day the clay bottom of the bogs is prepared by fresh water molluscs and infusoria, and by the vegetation of the *characeæ* and *confervæ*, two families of cryptogamous plants, which disappear entirely, as soon as the peaty vegetation begins. They fix in their shells, or in their tissue, the carbonate of lime or the silica, abundantly dissolved in some water, and by their decomposition they deposit those substances at the bottom of the water in the form of a very fine mud. In Denmark, there are some perfectly isolated ponds, where this soft mud or clay is formed, by the agency of the above named animals and plants, at the rate of one foot and more in every five years.

As there is no bed of peat, but is underlaid by soft white clay, so there is no bed of mineral coal without its bottom of fire-clay, except when it has been deprived of it by some accidental circumstance. This fire-clay is free from remains of animals and shells, but it contains very abundantly the stems and leaves of a species of plant, *Stigmaria ficoi-*

des, (plate 7, fig. 2.) which undoubtedly, like the *Chara* and the *Horsetail* of our time, has especially contributed to fix the silica, and to precipitate it to the bottom with its remains.

In this abridged exposition we cannot discuss the value of any of the above made assertions. Nevertheless, not one of them has been admitted without a critical examination, and after its truth has been ascertained by serious researches, or by reliable authorities.

The formation of the coal being thus understood in its whole, it is easy to draw from it the explanation of the different modifications of the Coal Measures, and to deduce some general rules for the identification of the veins.

1st. THE FIRE-CLAY.

This clay, ordinarily full of rootlets and stems of stigmaria, so generally underlays every bed of coal, and its general appearance and chemical elements are so much the same, that except, perhaps, for its general thickness, it cannot become a very reliable guide for the identification of the beds. Even its thickness is variable. It depends on the depth of the basin in which it is formed, and on the regularity of its bottom—thickening in the hollows, and sometimes entirely disappearing near the margins of the basin. Variously tinctured by more or less of oxide of iron, it is generally whitish, but sometimes as red as ochre, and even variegated like marble, in the same bed. The quantity of *stigmaria* found in it is as variable as its color, and as for its chemical elements they depend, like the color, on the mixture of iron and lime, especially silica and alumina, which are never uniformly distributed in a wide expanse of shallow water. This fire-clay of the Coal Measures appears sometimes alone, and without any bed of coal above it. In which case it may be intermixed with layers of shales, covered with the remains of plants, especially of ferns. Then it indicates only the place which was prepared for the vegetation of a bed of coal. Some accident—the shallowness of the water perhaps, or some disturbance of its level—has prevented the growth and accumulation of vegetable matter in sufficient abundance to form the coal. But the plants, growing upon the marsh, have been imbedded and preserved in the shales above the fire-clay as testimony to its natural destination. Nevertheless, those isolated beds of fire-clay, overlaid by plants, are not always barren of coal, and by following them to some distance the coal is often found somewhere reposing on their surface. The fire-clay is generally a reliable guide for the identification of veins, when it separates two beds of coal, forming what is generally called a clay parting. In this case, it is ordinarily found, though of variable thickness, over a wide extent. But it is then formed like the shales; in some cases, it is even a true shale, and it is in the examination of the shales that the reason of its formation, and of its appearance, ought to be looked for.

2ND. THE COAL.

There is no substance of which so many chemical analyses have been made, and none, also, of which the chemical elements are so well known. The general result of all these analyses has proved a curious fact, viz: that two pieces of coal, taken from the same bed, at only a few feet distance, have scarcely ever presented exactly the same proportions in the quantity of their essential compounds. The reason of this is easily understood: each plant, especially each kind of tree, has for its wood a peculiar composition; each one is more or less resinous, hard or porous, has more or less of woody matter in an equal volume, and each plant has a peculiar acid; all the essential elements are locally preserved in the coal. The same remark is true of beds of peat, of which two slices cut either horizontally or vertically, at a distance of one or two feet from each other, never present exactly the same appearance, nor exhibit exactly the same proportion in their chemical elements. Some plants of the coal—the *Calamites* and the *Stigmaria* especially, fix in their tissue the silica of the water, and the quantity of ash varies in proportion to their abundance in the coal. Some others are porous, and when lying on the surface of a bed of coal, they let particles of mud percolate through, or within their tissue, and produce the same result in another way, and at another place. From these different causes, the ashes of the coal have a different color, and the distinction of white ash and red ash coal, which may be of great moment in the identifieation of the beds of part of a basin, is, when considered in a general point of view, of little value. If we may rely on the sections of the anthracite basins of Pennsylvania as they are generally given, the upper beds of it belong to the red, the intermediate ones to the grey, and the lower ones to the white ash series. In the coal-fields of western Kentucky and of Illinois, the upper beds of coal are white ash, the middle ones red, and the lower grey or reddish.* The classification of the colors could not be more completely reversed.

This color of the ashes is probably, also, in immediate connection with the nature of the vegetation which has formed the coal. In the peat formations the matter formed by the heaping and decomposition of trees gives white ash; a compound of small herbaceous plants, ferns, rushes, canes, mosses, gives red ash; and a mixture of both forms the grey color of the ashes of some beds.

The external appearance of the coal is as much varied as its chemical elements. The trees, sometimes, when they are very resinous, have formed, by their decomposition, such a compact and homogeneous mass, that the coal receives a peculiar appearance; it is then known by the name of *cannel coal*. Another species of wood preserves, even in the coal, some trace of its primitive texture, and shows, in its fracture, a peculiar reflection of light, called, by the miners, the *birds eye*.

The coal is mostly stratified in thin laminæ or coats, alternately shining and dull—an appearance which clearly indicates an annual deposit of decayed vegetable matter, and the action of the water on it, during the winter time, or before the beginning of a new vegetation. The stratification of peat is exactly the same as that of coal; but the layers are variable in thickness, from the sixth of an inch to one inch and more, becoming natuarally thinner under a great compression, and nearer to the bottom of the beds.

The laminated appearance of coal is already a proof against the often repeated opinion, that it has been formed by the overthrow of vast forests; but there is a more conclusive argument against it. One acre of ground, covered with dense forest, and when its yield is carefully estimated, would afford, in 120 years, 10,450 cubic feet of wood; supposing the growth of peat to be only one foot in the same number of years, one acre of bog would produce 19,660 cubic feet of peat, (measured dry, and ready for burning.) A thick forest, overthrown by a cataclysm, and buried in the sand, would scarcely make three inches of coal. But some peat-bogs of Ireland, Germany and Switzerland, which have continuous beds of peat twelve to fifteen feet thick,

*Table of analyses of coal from saline and other localities, in the Geological report of saline coal mines and Manufacturing Co. p. 60, *by D. D. Owen, Cincinnati*, 1855.

would, if they were transformed into coal, produce three to five feet of hard mineral coal.

For a better understanding of the different features and various appearances of coal, it is necessary to remember that the woody substance in its decomposition or slow burning, and before arriving at its hardened state of mineral coal, is ordinarily subjected to a softening process. The low part of a bed of peat is, in most cases, a black paste In the old lignite deposits of Germany, large trunks of trees, perfectly blackened, are heaped and flattened into beds of six feet to nine feet thick, and their woody substance has become so soft that the workmen can easily cut it with their shovels; hence the flattening of all the stems in the coal and the shales; the remarkable appearance of immense pieces of bark rolled and pressed together, like sheets of paper; hence, again, the compactness of some coals; the evident stratification or lamination of others; the remarkable action of the sulphuret of iron, in transforming into pyrites whole flattened stems, or in preserving in the cannel coal of Breckinridge the outlines of the stigmaria, and of their leaves, with such neatness that they look as if they had been painted in yellow, on a ground of black.

The thickness of a coal bed, notwithstanding contrary assertions, is scarcely a reliable guide for identification; though as it has been previously explained, the coal is formed on a continuous surface, and not deposited here and there in hollows of various extent, depth, and directions—for this thickness depends on the evenness of the bottom upon which it rests. When a bottom of sand, or of any other loose substance whatever, has been for a long time covered by a deep sea, it is mostly even and unbroken; a bed of coal formed upon it is generally of continous and of equal thickness. But when two beds of coal are only separated by a thin formation of sandstone, and consequently have been formed at a short interval from each other, the sandstone covering the lower bed often bears, on its surface, numerous wrinkles and furrows, as an evidence of the action of turbulent waters. In this case, the coal formed above it is only piecemeal, in separate layers, thick in places, then rapidly thinning until it disappears, to be again found at a distance of a medium thickness, and continue for a while.

3RD. THE SHALES OR ROOF SLATES.

The shales are mostly a compound of the finest particles of matter, deposited in such a way that they are generally laminated in thin sheets, probably a result of periodical influences. If the movement of depression, marked by the formation of the shales, has been as slow as all the appearances lead us to believe it, the water raised above the marshes, was at first nearly of the same depth, and covered the whole field. If we suppose that some essential elements of this water had the power of consolidating themselves, and of imbedding and preserving all the low plants and the leaves falling on the marshes from the trees; if we suppose further, that by breaking the hardened mould, we could still now find the remains of those plants perfectly well preserved in the stones, we cannot but admit that those prints of plants would give us a pretty exact idea of the vegetation of the marshes of the coal epoch. It is just what has happened. Whenever, during the formation of the shales, the movement of depression has been so slow that for a length of time the marine water has not invaded the marshes, the deposited shales contain remains of plants only; but when the depression has been somewhat more rapid, the deeper water has arrested the vegetation, and the scantily preserved remains of plants are old, much broken, mostly stems, fruits, and pieces of bark of a hard texture, mixed with some shells.

The presence of the shells in the shales, proves the access of the marine water; it is ordinarily accompanied with some fucoid plants and fishes. The fucoid plants are generally scarce in the coal slates, and the shells, though often represented by an immense number of individuals, are limited to a few species, which differ from those of the limestone, and seem to be of the kind generally living in the contact of the tides with the fresh water of the lakes or rivers. The slow propagation of those species lead us to suppose that they were distributed on a vast area, upon the beds where their remains are found. Therefore, if we can admit, that after the formation of each bed of coal, either the plants, or the animals that lived in the water which covered them. were of peculiar species, or at least that some species of plants or shells have either appeared for the first time in each bed of shale, or that identical species have been distributed in each of them in a different proportion, it is evident that the examination of the top or roof shales of the coal, and the study of their remains, whether plants or shells, must give the most reliable character for the identification of the beds of coal.

There is no doubt, but after the formation of each bed of coal all the plants, and the animals belonging to it, have been destroyed, or at least removed far away. The vegetation of the marshes has been covered by thick bed of shales; the shales themselves, with their own inhabitants, have been again covered either by marine deposits of limestone, showing the remains of other peculiar species of organized beings, or by sandstone swept in by the high sea, and entirely destitute of animal remains. But even, when a bed of coal has again been formed over the marine shales, without any intermediate stratum, the formation of the fire-clay and the vegetation of the coal, both entirely barren of marine animals, both indicate a condition of things and a lapse of time which would, in all probability, have destroyed even their germs. If then, after the formation of a new bed of coal, and after an immense number of years, the downward movement of the surface brings again over it, the marine water and its inhabitants, is it rational to expect that this water will be still charged with the same species of animals as before, and that those animals will be distributed in the same proportion? Is it even rational to suppose, that all the circumstances producing the overflowing will be the same, with the same proportion in the quantity of marine water, the same chemical elements, the same depth, the same temperature, &c., &c. If there is only a small change of the elements dissolved in the water, (and truly, all the shales at different levels present different appearances,) it is certain that this change ought to have influenced the life, viz: the distribution of animals in the shales.

It is even so with the plants. The surface of a marsh having been overflowed, and its vegetation destroyed, we cannot but admit that if it begins again in a new sheet of water, and after a number of centuries, the distribution of this new vegetation will be somewhat different from the former. If there are no new species of plants, and certainly there ought to be some, at least some of the former plants have entirely disappeared and those which have been left are grouped in another proportion. Nature bears in one hand its scythe of death, and in the other its cup of life. At every geological change that closes the career of some living species, there appear some others, that were prepared for existence and begin their mission. And although human life is limited to a day, in comparison with the innumerable ages of our world, we can sometimes observe those changes, and even analyze their causes. In the peat bogs of some high valleys of Switzerland, the bottom of the marshes is strewn with large trunks of oaks, and there the climate is so cold now, that the pines alone can grow. In Denmark this change of vegetation is also remarkably observed in deep bogs, which the proprietors find profitable to dry with hydraulic machines for the timber which they exhume. One of the most remark- of them has been explored and described, more than ten years ago, by the writer of this report* as its bottom, over the fire-clay, was first found four or five feet of very black peat, overlaid by a forest of pines, lying in the direction of the dip of the basin, viz: their roots against the sides. The diameter of many of their trunks was about one foot. Over the pines a bed of black peat, five to six feet thick, was still covered by an overthrown forest of white birch trees. A new bed of peat, six to eight feet thick, had buried it under its formation, and was overlaid by a third forest of oaks, of which the trunks, three to four feet in diameter, were so well preserved that they were sawed on the place and used for timber. Over this lay five to six feet more of peat, and the whole deposite was covered with humus, and a living forest of beach trees. The whole formation measured about thirty feet.

Along the shores of the Ohio and Mississippi river there has been deposited here and there, in different places, a quaternary formation remarkable for its thickness. Near Columbus, Kentucky, it elevates its white banks 160 feet above the level of the Mississippi river.† In its upper bed—a fine silicious loam—there is an abundance of shells, which, except one species, are still found living in the river below. This single species, either entirely disappeared or transported to some distant region, is sufficient to prove that if a new bed of loam was deposited now above the one mentioned, a close observer would already find a difference in their fossils. The lower bed of this quaternary deposit contains a quantity of leaves, already carbonized, the outlines of which are perfectly well preserved in the hardened white clay. Among them, the predominant species is an oak, (*quercus virens*), which, in our times, has its peculiar station along the shores of the ocean, and

*Explorations in the north of Europe, for the study of the coal formations. (Neuchatel, 1846.)

†First report on the Geological Survey of Kentucky.

scarcely grows out of the reach of marine water. There is in those remains of fossil plants very few of the species now living along the Mississippi and the Ohio rivers. A new deposit of leaves, now, would show a great difference between the vegetation of this last with the former one. Such difference in the recent formations may be observed in many places. From this it seems rational to admit, that two beds of coal, separated by various and sometimes thick strata of another nature, ought to present certain differences, in the remains preserved in their shale—some peculiar character which may enable a palæontologist to identify each of them, or to know their geological level at every place where it is possible to see them open for a careful examination.

Though the exposition of those principles is new, the best living geologists—Lyell, Brongnart, Burat, &c. &c.—have acknowledged their truth. For they have admitted that the palæontology of the shales would in time direct the identification of each bed of coal. M. de Humboldt, himself, says in his Cosmos: "That where several series of coal strata lie over one another, the genera and species of plants are nct generally mixed, but arranged in a peculiar order for each bed."

The roof shales are subjected to some variation like the other formation, but they are rarely liable to modifications that can prevent their identification. Their thickness varies according to the depth of the water in which they are found. This depth of water, as we have before stated, would be nearly the same through the whole extent of a coal basin, if there had not happened some local depressions, caused either by volcanic commotions or by peculiar sinkings of the floating mass of vegetation. Those local depressions have caused the separation of a bed of coal into two or more branches, and sometimes its entire disappearance among high banks of black shales. Such cases are not very rare. Then the shales, though thick, being of the same age, and their inhabitants not having been subjected to any destructive change, they preserve identity in their fossil remains.

A short depression, or perhaps an accidental inundation of short duration, makes upon marshes the beginning of a formation of shales, which, if it is soon stopped by a new vegetation, produces in the bed of coal a separation or a clay parting. As these partings are formed upon the surface of a vegetable stratum, they ought to be generally on a large scale, and follow the same rules as the shales. They may also thicken, or entirely disappear, or accidentally separate into two or three branches.

The shales may be wanting, either from erosion, or from the upheaval of a part of the surface above the water, or from the more active growth of the vegetable matter in a peculiar spot. The two last causes are scarcely observed: the first and more frequent one shall be mentioned again with the sandstone. Generally speaking, the absence of the shales is local, and ordinarily, even where they seem to be entirely wanting, if the mine be worked to any extent, they are discovered in some places.

4TH. THE LIMESTONE.

This formation can be regarded as a continuance, and sometimes as an equivalent, of the shales, since it is established only in an undisturbed sheet of deep marine water, by the continuous labor of marine animals, especially moluscs, and by the decomposition and accumulation of their remains. The essential reason of its formation, viz: deep, quiet, marine water, is nevertheless a cause of great variety—not in its chemical elements, perhaps, but in its persistency, its thickness, and its general distribution. It is often found in the Coal Measures in an unfinished state, in irregular masses, which can scarcely take the name of beds, so limited are they. For this reason the limestone, by its presence above a bed of coal, is scarcely a reliable guide for identification.

As long as the shales of the coal were deposited in low water, the influence of the sea, especially its currents, were scarcely appreciable. But in the limestone formation it is very visible indeed. The unequal distribution of the matter, and especially the remarkable erosions of the beds or isolated masses of it, are due to slow currents.

The limestone of the western coal-fields of America, contain a great amount of organic remains, plants, shells, or fishes. But the plants cannot give a reliable criterion for the geological level of each peculiar strata, since all the remains found till now are only broken, deformed, and undeterminable parts of stems, with few marine fucoids. The remains of shells and fishes would probably afford some reliable data for tracing the geological level of the beds of limestone. They are only too numerous in their species, and have never been subjected to a careful study. The animals of the limestone belong, evidently, to the sea, and are brought in with it. In a change of level they are destroyed as individuals, not as species. Nevertheless, after a length of time, a new invasion of the sea ought to bring with it, upon the coal-fields, other species, since its neighboring sea and its inhabitants ought to have been subjected to changes.

Thick beds of limestone, interposed in many places between beds of coal and shales, offer the most certain indications of the slowness of the oscillations in the level of the coal-fields at the time of their formation. Not only the great number of species—the myriads of animals of which the remains have been literally heaped together—but the introduction of madrepores, and their constructions, marked in the limestone strata, call for an inconceivable length of time.

5TH. THE SANDSTONE.

In its general appearance, thickness, and composition, this formation is the most unreliable of all. A substance, of which the elements have been transported and intermixed by currents, can never be an homogeneous one, especially when these currents are abnormal, the result of a cataclysm, and have exercised their action over a very extended surface, following numerous diversified phenomena. The movements of the waters, which have brought and deposited the sand, are made appreciable not only by the nature of the strata, but by traces of remarkable erosions. In some places the immediate contact of the sandstone with the coal cannot be explained but by an erosion of the beds of shales and limestones which were extended upon it. Even the coal has been sometimes swept away, then bruised, and deposited again with the sand by the energetic action of those turbulent waters. Beds of hard sandstone are so blackened by the broken fragments of coal and plants, with which they are intermixed, that they cannot be used for building purposes. No wonder that such mighty currents have dragged with them, and buried under heaps of sand, large trunks of trees, torn from the dry land of the shores, or from the forests of the marshes; or that they sometimes entombed in their ponderous deposits parts of forests, which are still now found standing and petrified like the pillars of some old Babylon of trees.

From this we may conclude, that the remains of vegetation found in the beds of sandstone cannot show, generally speaking, their geological level. Beds of sandstone appear, particularly marked with the remains of broken plants. It may be that by a mighty cataclysm, immense marshes, covered with trees, have been entirely swept over, and that their remains, bruised and ground by a prolonged action of the waves, have eventually been carried and deposited over the whole area of the basin. It may be, also, that the large trunks, either standing or heaped up together, in some parts of the coal-fields, where they are found now in great abundance, bear evidence of a general and remarkable cataclysm; and that they may thus indicate a constant geological level in their position. Some incomplete observations tend to confirm this supposition, but they are still too scanty, and need to be pursued over a wide area.

It is scarcely necessary to explain why, in the beds of sandstone, the trunks of trees are mostly petrified, preserving their general outline, and not flattened as in the coal. Not only the sand is too porous a matter to prevent entirely the access of the air, but its mineral elements have exerted a constant action on the woody matter, and destroyed it entirely, or taken its place, leaving only its outline carved like a mould in the stone. Or they have transformed it to some stony substance—either silex or carbonate of lime and spar—preserving thus partially, not only the external features, but even the internal structure of the wood, to the most delicate fibres and vessels.

It has been asked many times, why, since the sandstone is a marine formation, it does not contain any shells, any remains of marine animals? Indeed, this question would be unanswerable if we were to suppose that the materials carried by the sea had formed its bottom. This supposition is not inadmissible. Though the depression of an immense plain near the sea shores would take it below the level of the water, it could not raise the bottom of the sea, and spread its sand over it. But every one knows that the sea shores are every where bordered by hills of sand, sometimes several hundred feet high, and extening many miles, like huge inland waves. Near the mouth of the Elbe and of the Rhine, those hills penetrate the country for hundreds of miles. The sand of which they are composed—coarse or fine—is sometimes mixed with gravel, but contains no shells or animal remains. Such sand hills have probably furnished the materials for the sandstones of the Coal Measures; at least this is to me the only satisfactory explanation of their formation and composition.

The other rocks of the Coal Measures, like the deposits of iron, under their different forms and compounds, are purely local, and have no relation to our subject, viz: the identification of coal veins by palæontology. The discussion of their formation and distribution would be out of place here.

To conclude these preliminary remarks, we need only expose, in a few words, the general rules which are drawn from them:

1st. The black shales, immediately resting upon a bed of coal, viz: the roof shales, furnish, by their remains of fossil plants, shells, and fishes, the most reliable indications for the identification of their geological level.

2d. The remains of plants give for this the best characters, since the vegetation of the coal beds was more generally and uniformly distributed on large surfaces, and since the plants, by their progressive modifications, are subject to atmospherical influence, and also to the chemical changes of the water.

3d. The geological distribution of the plants or shells cannot be modified in a sudden and striking manner at each change of level. Therefore, the presence or absence of a species in the shales may be accidental, and cannot be a conclusive evidence of a change of level, except after a long and careful examination over a wide area. The grouping of fossil species in the shales and its variations, afford a more reliable indication than the presence or absence of a single species.

This sufficiently shows the difficulty of the work of identification, in a country where a small number of beds of coal have been opened and worked, and where palæontological researches have been scarcely begun; in fact, this report is only the introduction to an important work, which ought to be pursued with interest by every true geologist, for the history and perfect acquaintance, not only of the coal fields in their general features, but of every bed of coal in particular. But it must be said, that a collection of specimens, made only for the beauty and the great number of specimens for show, is of little use. It ought to be made with a careful record of the place, and, if possible, of the true geological level in which the fossil remains are found. And thus it may, by and by, help to solve some of the most interesting problems of the formation of the coal, viz:

Is there any true marine formation of the coal? From long explorations pursued in Europe and in America, the writer says, contrary to many assertions, that there does not exist a bed of true marine peat, viz: peat formed entirely of fucoides and marine plants; and that he has never seen a piece of coal with evident marks of marine origin.

Have all our American coal-fields been formed in a continuous basin, or is there any local one with an appreciable difference in the flora and fauna of the shales?

Is there any trace of a permanent current of fresh water, of some river having flowed either through the coal-fields during some time of their formation, or in their vicinity?

Were the coal-fields the first land surface protruded like an island from the sea, or were they true marshes, low shores of a continent, of which the outlines had been already elevated above the ocean?

These are not the only questions that are to be answered. Beside the mere practical advantage to be derived from the palæontology of coal, there is the nature of the vegetation, its relation to the atmospherical phenomena of the epoch, its comparison with the flora of our peat formations, and also with the coal flora of other continents, and many other subjects, which open up to the geologist a most interesting field for the exercise of the mind.

Horizontal exposition of the different coal beds examined in the western coal field of Kentucky.

Coal No. 12.	Airdrie 2 ft. 8 in. rash 1. 4 coal.	A. Town's rash coal, ft?	Near Curdsville, 6 in. rash coal.	McNary's 4 ft. rash coal.	Peaks of Otter, 4 ft. rash coal.	Pigeon Run, 2 ft. rash coal.	
Coal No. 11.	Airdrie 6 ft. coal.	A. Town's 6 ft. coal.	Near Curdsville, 4 ft. coal.	McNary's 7 ft. coal.	B. Sisk, 6 feet.	Pigeon Run, 8 ft.	Providence, 6 ft.
Coal No. 10.		Seen	only	at	Shawnee	town.	
Coal No. 9.	Airdrie 4½ feet.	A Town's 5 feet.		McNary's 4½ feet.	Gamblin, 4½ feet.	Jakefield, 4½ feet.	Captain Wings, 2 ft.
Coal No. 8.		Not	seen.				
Coal No. 7.		A. Town's black band coal.					
Coal No. 6.							
Coal No. 5.		Not	seen.				
Coal No. 4.		Not	seen.				
Coal No. 3.							
Coal No. 2.							
Coal No. 1 *b*.	Bell 5 ft.	Cook 5 ft.	Casey 4 ft.	Old distillery 3 ft?	Union Co., 3 feet.	Hawesville, 4 ft.	Breckinridge, 3 ft.

Horizontal exposition of the different coal beds examined in the western coal field of Kentucky.

Coal No. 12.							
Coal No. 11.	Watson's, 6 feet.	Thompson 6 ft.	Arnold's, 8 ft.	Miller's, 6 ft.	Bonharbor, 5 ft.	Curlew, 3 ft.	Mulford, 3 ft.
Coal No. 10.							
Coal No. 9.	Isaac Luce's, 4 ft.	Hartford, 2 ft.	Lewisport, 4 ft.	Henderson, 4.3		Curlew, 5 ft.	Mulford, 5 ft.
Coal No. 8.							
Coal No. 7.							
Coal No. 6.		Barrett's, 4 ft.					Mulford, 3 ft.
Coal No. 5.							
Coal No. 4.							
Coal No. 3.							Mulford, 2½ ft.
Coal No. 2.							Mulford, 1 ft.
Coal No. 1 b.							Mulford, 2⅓ ft.

Examination of some veins in the Western Coal-fields of Kentucky, in relation to their palæontological characters.

As during the time of our explorations we passed over different parts of the country, with a continuous change of level, any description of the veins of coal, in the order in which they came under our observation, would be not only an arduous task, full of useless repetitions, but, by constantly transporting the reader to a different geological level, would confuse his mind about his exact position. The better plan, therefore, is to admit as correct a vertical section of the western coal-fields, and, beginning from the bottom of the measures, take each bed in the order of formation; then, describing the general characters of each of those beds, and mentioning afterwards all the places where the same coal has come under our examination, with the local and peculiar differences of each. In this way all will be clear, and a single glance at the horizontal section No. 1, will show, at once, the localities, with their true geological level, and suggest, at the same time, to the reader, precise conclusions with regard to the probable position of other beds of coal, and enable him to make other deductions for the greater certainty of future researches.

No. 1. Vertical diagram of your first report, from Anvil Rock down to Battery Rock, is certainly the best that can be made, and, with some local changes, it will prove reliable in all the extent of the western coal-fields of Kentucky. Following your suggestions, we will admit the nomenclature of the veins of it, as follows:

Beginning at the base of the measures, and omitting Battery-rock coal—a view which is scarcely developed any where in Kentucky—our No. 1 coal takes the place of both Cook coal, and 7th Bell's coal, indicating their probable relative position by A and B—No. 1, B, being the Bell's coal. The reason why both those veins are united in the same number, will be apparent hereafter. Our No. 2 is a thin coal, marked on the diagram between two shales with iron stone. No. 3 is the 6th, or Ice-house coal of the diagram. No. 4 the Curlew coal. No. 5 four foot bed. No. 6, the little vein. No. 7, a thin coal above it. No. 8, Well coal. No. 9, 3d or five-foot Mulford coal. No. 10, 2d or middle coal. No. 11, the first coal under Anvil Rock. No. 12 the true first bed below Anvil Rock, in Hopkins and Muhlenburg counties, omitted in the diagram, because it is scarcely developed in Union county.

Battery-rock coal. Though in the eastern coal-fields some workable beds of coal have been found, not only in and below the conglomerates, but even in the red sandstone, there is not, apparently, in the western coal-fields of Kentucky, a true bed of coal formed in this position. Opposite Caseyville, below the conglomerate rocks, hanging over the landing on the Illinois side, there is a thin black shale, itermixed with thin layers of coaly matter. This shale does not contain any fossils. The same shale has been reached at Caseyville, by boring a well below the conglomerates; but it does not contain any trace of coal, neither did the shales, though of soft texture and nearly black, show any remains of fossils of any kind. In Pennsylvania, the shales of the bituminous coal, or of the anthracite, exposed below the conglomerates, contain specimens of large pieces of *Calamites* and *Lepidodendron*.

No. 1 *Coal.* Above the conglomerates, and often reposing on them, there is a thick formation of black shales, varying in thickness from 20 to 70 feet, or more. It sometimes contains two beds of coal, one well developed, from 3 to 6 feet thick, and a thin one below. Generally the position of the large bed No. 1, B, depends on the thickness of the shales. From the topographical observations it ought to be 70 feet above No. 1, A. But the palæontology of the opened coal, topographically indicated as No. 1, A, having proved exactly the same as those indicated as No. 1, B, the only conclusion to which I can come is this, either in the western coal-fields of Kentucky there is a single bed of coal, formed in the shales above the conglomerates, and then, No. 1, A, and No. 1, B, are the same; (this is my settled opinion;) or the palæontological characters of the shales are the same in their whole thickness, which is scarcely possible. In Pennsylvania, where the bed of shales contains two, and sometimes three, seams of coal, the shales of each peculiar bed of coal present a different appearance, and different fossil plants are found in connection with them. These fossil plants are especially the prints of the bark of large trees, *Sigillaria*, *Calamites*, especially *Lepidodendron*, (pl. 7, figs. 1, 4, 10); the cones of these last trees, *Lepidostrobi*, (pl. 7, fig. 3;) many other fruits of the genera *Trigonocarpon*, *Cardiocarpon*, and *Carpolithes*, (pl. 7, figs. 5 to 9.) These fruits are generally compressed, resembling flattened almonds, peanuts, or peas.* The ferns imbedded in the shales are generally of the largest species. The genus *Sphenopteris*, (pl. 6, fig. 1,) is represented in this low coal by most of its species, which are scarcely found above it, and some large *Tecopteris*, especially *Tecopteris lonchitica*, (pl. 6, fig. 3,) belong also to this bed only. *Neuropteris hersuta*, &c., (pl. 6, fig. 4,) is generally found in the shales; but this plant appears in the whole thickness of the Coal Measures; as well in Europe as in America. We mention it only to prevent mistaking it as the characteristic plant of a certain level, or admitting, for peculiar species, the numerous forms of its curious leaves scarcely ever found attached to the stems. These leaves are ordinarily lanceolate-oval, with a heart-shaped base, and have two small round kidney-shaped leaflets attached at its base, but sometimes they become either large, and nearly round, (*Cyclopteris*,) or narrow lance-shaped, or palmately cut in two or three linear divisions. Since its surface is ordinarily strewn with scattered hairs, all these forms can easily be referred to their species.

It has been asserted by many that *Stigmaria ficoides*, (pl. 7, figs. 2 and 2a,) is a plant, or rather a root, found in the fire-clay only, where it has sprung, supporting the trees that have formed the coal above it. This is a great mistake, which would be corrected by a single look at our bed, No. 1 coal, where the coal itself, and the shales above it, contain most abundant specimens of those *Stigmaria*.

A remarkable peculiarity of the black shales of this coal is, that they contain, also, in immense numbers, the remains of a single species of shell, a small oval *Lingula* (*Lingula umbonata*,) which, by its appearance, indicates the first traces of the marine element in the shales. A few badly decayed leaves of ferns, and the *Lepidostrobi*, (pl. 7, figs. 3, 5, 6,) are found on the same shales with the shells, evidently showing that the vegetation had not entirely disappeared when the marine water began to cover the marshes. This small *Lingula*, always the only shell found at the same geological level in the shales, not only in all the beds of the first coal in western Kentucky, but in Ohio, at Nelsonville and other places; in Virginia, at great Kanawha Salines; in Pennsylvania, at Rochester, Johnstown, &c.; indicates

*This description is given only to facilitate the comprehension, but not at all as a scientific and real one. The fruits of the coal, though their appearance may sometimes be the same, do not have, in reality, the slightest analogy with those of our time.

the vast range of distribution of this species, and this peculiarity of a vein of coal preserving, in its shales, a palæontological identity, for more than five hundred miles distance in a direct line.

Bell's mine, Crittenden county, is extensively worked. This bed has a mean thickness of five feet. The coal has ordinarily one or two inches of cannel at the top of the bed. It is mostly covered by thick sandstone shales, full of leaves of *Stigmaria*, preserved in their natural round or cylindrical form, and scarcely flattened. These sandstone shales are not the original roof shales, which are generally wanting here, but they have accidentally taken their place, after denudation of the first roof. The same case is observable at Minersville, Pa., in the corresponding bed of anthracite, viz: the second bed above the conglomerates. The true roof shales are seen in some part of the mines at Bell's, and contain *Lingula umbonata* in abundance. Near the base of the coal there is a thin bed of rash-coal, containing well preserved specimens of *Lepidodendron, Sigillaria,* and *Stigmaria.* This rash-coal is certainly a peculiar and reliable character, and has been seen at all the places where we had opportunity to examine No. 1 coal—always containing laminated bark of *Lepidodedron* and *Calamites.* It is also well marked in the coal fields of Ohio and Pennsylvania, at the same geological level.

Half a mile southeast of Bell's we were shown the old opening of a vein previously worked, but now abandoned. They called it Cook's vein, and said that it was at a different level from Bell's, viz: about 70 feet below. The palæontological remains of the shales prove that this supposition is a mistake. The roof-shales of this coal are the same thick sandstone shales, full of *Stigmaria,* as at Bell's, and the bottom has the rash-coal, with the *Lepidodendron.* We did not explore the interior of this vein, which is full of water, but the characters were evident enough in the shales heaped at its mouth.

Between Bell's and Tradewater river, the same vein has been opened and worked, and there also we found the sandstone shales, with round *Stigmaria,* and the rash coal with *Lepidodendron.*

Casey's mine, on the west side of Tradewater river, has its roof shales more developed than Bell's, and shows, in their composition, all the essential characters of the coal on this level. The black slates of the coal contain not only a great abundance of *Lingula umbonata,* but also the fruits of *Lepidodendron*, viz: *Lepidostrobus*, and its detached leaves *Lepidophyllum*. The rash coal at the bottom has the *Lepidodendron*, *Stigmaria*, and *Calamites* in abundance, and the coal itself is topped as at Bell's, by one or two inches of cannel. Moreover, at some places in the mines the black shale is wanting, and its place is taken by the sandstone shales with round leaves of *Stigmaria*. The distance between the two mines of Casey's and Bell's being short, a few miles only—the exact resemblance of the shales and of the fossil remains, is not a remarkable coincidence; but it is otherwise when we compare the fossils with those found at the same geological level in far distant localities. We have seen that the *Lingula* abounds in many places in the low coal of Ohio and Pennsylvania. The *Lepidostrobus* has, till now, never been found but in the corresponding low coal at Johnstown, at the base of Portage Railroad, in the bituminous coal-fields of Pennsylvania, and at Wilkesbarre, in the anthracite basin. The presence of those fruits or cones, in the same shales as the *Lingula*, evidently shows that they were the last remains of the vegetation of this coal, and that they had been detached from some trees still standing above the shallow water, and living in it when the vegetation of the surface had already disappeared.

Old Distillery coal, just above Caseyville, has its place at the same level, evidently marked by the abundance of *Lepidodendron* in the rash coal of the bottom, and by the *Lingula* and *Stigmaria* in the shales of the roof. That there may be near by the same place, a shaft to a lower bed of coal, is possible. But we did not see it, and the position of this coal of the Old Distillery, would scarcely lead to the supposition of another bed of coal below it.

A recently opened vein, one and a half miles north of Caseyville, on the property of the Kentucky Coal Company, though supposed to be also at a lower level, afforded another favorable opportunity of testing the value of a palæontological identification. We found this coal covered with a shaly sandstone, full of *Stignaria*, and by three to four inches of black shales, with *Lepidodendron* and *Lepidostrobus*. Its thickness is only two feet six inches. It has some cannel at its top, and a rashy bottom, with fine remains of *Lepidodendron*, *Calamites* and *Stigmaria*.

Opposite Caseyville, on the Illinois side of the Ohio river, there is a bed of coal belonging to Dr. Long, which, following topographical indications, is placed below the conglomerates, and indicated as Battery-rock coal. This coal is, without doubt, above the conglomerates, and from the plants and fossil remains of the roof shales, is the same as our No. 1. The appearance of the shales is, however, different. The marine element being less predominent, the shales grayish colored, and full of well preserved remains of plants. The whole flora of the low coal is there—*Stigmaria*, *Lepidodendron*, *Lepidostrobus*, and many other fruits, with large leaves of ferns, especially *Pecopteris lonchitica*. As the bed is not worked, and the shales are very brittle, we had to study them on the place, and it was not possible to collect good specimens, except a very large and well preserved root of *Stigmaria*.

At Union mines, Crittenden county, twenty miles below Caseyville, the characteristic fossils of No. 1 coal, are still more numerous, and in a better state of preservation. The shales there are thick and well developed. First, the sandstone shales, with *Stigmaria;* then, in some places above the coal, the black shales, with *Lepidostrobus* and the *Lingula*; and still oftener, the gray soft shales, full of plants, especially *Pecopteris lonchitica* and *Sphenopteris*. The coal itself is ordinarily topped by a few inches of cannel, and its bottom has always the rash coal, with the same remains of plants, as we have enumerated before. The shales at Union mine would have afforded a good opportunity for collecting and studying a great number of species of fossil plants, had they not been softened by rain, and our specimens nearly all broken by transportation. The species which were left entire enough to be just distinguishable, are the following: 1. *Alethopteris sinuata, Brg't.* 2. *Alethopteris lonchitica, Brg't.* 3. *Sphenopteris tridactilites, Brg't.* 4. *Spenopteris intermedia, Lsq'x.* 5. *Asterophillites avalis, Lsq'x.* 6. *Calamites Suckovii, Brg't.* 7. *Lepidodendron politum, Sp. Nov.* 8. Two other species of *Lepidodendron*, (broken.) 9. *Lepidophloios rugosus, Lsq'x.* 10. *Lycopodites Sticlerianus, Gopp ?*

Hawesville coal. Passing to the eastern part of the western coalfields of Kentucky, we had first a good opportunity of exploring the lowest bed of coal at Hawesville, Hancock county, where it is extensively worked. The coal, three feet ten inches to four feet thick, is cannel at the top, and reposes upon six inches of rash coal, containing still the same plants—*Lepidodendron*, *Calamites*, and *Stigmaria*. The black shales above the coal are full of *Lingula umbonata*, and have also some remains of broken plants, especially *Lepidostrobus*, of which we obtained good specimens at Mayo's vein. In connection with this bed, and above it, are also the gray shales, with a few fern leaves of the same species, as at Union mines.

About seventy feet above the main coal at Hawesville, there is, following the assertions of Mr. Taylor, director of the mines, a bed of rash coal, with large stems of *Calamites* and *Lepidodendron*. It ought to be separated from the main coal by thirty feet of sandstone shales, and thirty feet of black shales, containing the above mentioned fossil shells and plants. Does this rash coal, if its position is exactly marked, indicate the place of another bed of coal, or is it still a continuance of the interrupted black shales which, at some places, are seventy feet thick? Or, perhaps, has it been displaced by one of the numerous faults which break the level of the Hawesville vein? These are questions that remain to be solved.

Breckinridge coal The appearance and chemical composition of this coal would indicate, for this vein, a far different level. Nevertheless, a short examination of the fossil plants of the shales, suffices to ascertain that its geological position is the same as that of the Hawesville. The coal, twenty-eight to thirty inches thick, is entirely cannel, and full of stems and leaves of *Stigmaria*, the outlines of which have been preserved by sulphuret of iron. Under it the rash coal is seen, with its *Lepidodendron*, *Calamites*, and *Stigmaria*, and it is topped by a heavy bed of black bituminous shales, with *Lingula umbonata*, and some specimens of decayed fern leaves. As it generally happens, in very bituminous shales, the plants are scarcely preserved. Their outline only is indicated here and there, but with such indistinctness that they cannot be exactly determined; the coal itself, however, has preserved beautiful prints of *Lepidodendron*. We have previously mentioned that the *Stigmaria* have probably been plants of a strong texture —a kind of creeping roots, especially active in the preparation of the fire-clay. If this were so, they could not contain much bitumen, and yet they are found in abundance, and well preserved in outlines, in the richest oil producing coal of Kentucky, and perhaps of the United States. Since it is proved that the *Stigmaria* were of the nature of roots or, as I think, were creeping rootstocks, producing trees under favorable circumstances, their presence in a bed of coal, where they could not creep, as in the water, and where their direction was necessarily changed by many circumstances, indicates that there were plenty of trees living at the time of the formation of this coal. If the trees had had the same hardened silicious bark as the *Stigmaria*, their outline would also have been preserved; but being especially of coniferous or resinous species, they have been entirely transformed into coal. This shows that the cannel coal results from the abundance of some kinds of trees, especially *Sigillaria* and *Lepidodendron*, or perhaps *Lepidodendron* only. Moreover, the chemical composition of some plants, especially of roots, depends on the place where they grow; on the water which they absorb. The needles or leaves of coniferous trees, for example, living on the limestone, contain only two per cent. of silica, when the same species, living on silicious ground, have as much as five to six per cent. of it. We must therefore suppose, that according to their habitation, the *Stigmaria* would necessarily show a difference in their composition.

The analysis of the Breckinridge coal proves, nevertheless, that though it has been formed of resinous trees, since it contains sixty-three per cent. of volatile matter, there were abundantly mixed with it plants highly charged with siliceous matter—the *Stigmaria* certainly—for it gives by combustion as much as eight per cent. of ashes. The main coal of the Shawneetown Company, at quite a different level, is also very bituminous, does not show any trace of *Stigmaria*, and has only one half per cent. of ashes.

If it had been possible to see at once, and opened, all the beds of the Coal Measures in successive order, the true characteristic fossils of every one of them could perhaps have been examined and described; but in a level country, where the highest hills do not exceed three hundred feet, such an examination is no where possible. In both places where, according to your directions, we could expect to see a succession of coal beds, at different levels, viz; at Shawneetown, and at the Saline Mining Company's works, in Illinois, we had good opportunities to study the fossils of vein Nos. 9, and 11. At the Kentucky Coal Company mines, we saw open one bed still lower—No. 6, or Little vein. But we did not find any place where beds 2, 3, 4, 5, 7, and 8, were opened, and their geological level fixed with such certainty that we could take them as a point of comparison for the examination of others.

Coal No. 2. We have not yet seen this bed satisfactorily in place in Western Kentucky; in fact, this coal may be united in the west with No. 1, B, since I found at Beaver, at Johnstown, at Nelsonsville, and other places, a coal which I think will prove the equivalent of Lesley's cannel coal C, which contains apparently the same *Lingula umbonata* as was found in the shales over No. 1, B, of Union county. There appears to be a gradual diminution of the space between this cannel bed C, of Pennsylvania, and the great bed below it going west; for, though at some places in that state the distance is seventy feet, at Zanesville, Ohio, it is only twelve feet; at Hopwelltown, Ohio, five feet; and at Nelsonsville, Ohio, only one foot, and sometimes only four inches. Therefore, it would not be very remarkable if, in Kentucky, it should be united with coal No. 1, B. Moreover, this bed is often wanting either in its separate state or in conjunction with No. 1, B. In the last case, the shales of the coal No. 1, B, are less bituminous, grayish, full of plants only, and without shells. At the Breckinridge mines, it seems to occupy the whole place of No. 1, B, and has influenced its transformation into cannel.

Coal No. 3. Near Mulford's mines we were shown, as being probably the Ice-house coal, a scarcely opened bed, of which the remarkably hard, greyish colored shales were marked with well preserved stems of ferns, especially of *Neuropteris hirsuta*, (pl. 6, fig. 4.) Being unable to see more of this coal than a few shales, and being uncertain as to its true level, we could make no characteristic and reliable description of it. But judging from a palæontological point of view, No. 3 coal, seen at Hawesville, is not the same as the one mentioned at Mulford, as the probable Ice-house coal. It is much more likely referred to coal D, of Lesley's manual, which is extensively worked at Zanesville, (two to four feet thick,) where its shales are full of shells, especially of large *Productus* and *Spirifer*. I should not have a doubt of their being coeval if it was not for the absence of limestone above this coal at Zanesville, where the eight feet shales are covered with forty feet of sandstone. But the limestone of this coal is a local formation. In his general description of the lower coals, Mr. Lesley indicates a limestone E, separated from coal D by fifty feet shales. And even at

Zanesville, there is above this coal, on the top of Putnam hills, a thin fossiliferous bed of limestone. As for the value of the limestone as a character for identification of the coal beds, a look at both vertical sections, No. 1 and No. 2, of the first report of the Geological Survey of Kentucky, will show its deficiency. The bed of limestone, only four feet thick, of the first diagram, is represented in the second by a heavy formation of two beds of limestone, the one thirty-three feet, and the other eight feet thick, separated by five feet of shales.

This 3rd coal at Hawesville is about two hundred and ten feet above No. 1, B, the main coal at this place. It has been opened and worked for a time and is now abandoned—its thickness being only twenty-two inches. It is covered by a black shale one foot thick, which decomposes in powder under the atmospheric action, and shows no trace of fossils, either shells or plants. Upon the shales there lies another soft and still looser sandy, micaceous, buff-colored shale, insensibly passing into limestone, and full of large *Productus* and *Spirifer*. This shale is like a rotten limestone, and the fossils that it contains, though badly preserved, are easily separated from it. It is overtopped by a bed of limestone.

Coal No. 4. We had no better opportunity to study this coal than the former, in the coal-fields of western Kentucky. The coal with two clay partings, that is referred by order of superposition to this geological horizon in Curlew hill, with limestone at a distance of fifteen feet beneath it, I had no opportunity of examining, as the old opening into this coal was entirely filled up, and the roof shales quite inaccessible.

At Giger's hill, Union county, we examined a coal three feet thick, with two clay-partings, covered with a bed of five to six feet shales, differently colored, grey or black, becoming soft and finely grained in the proximity of the coal, and entirely covered with prints of *Neuropteris flexuosa*, Brt., (pl. 6, fig. 2.) This species, like *Neuropteris hirsuta*, Lsq'x., is generally too far distributed in the whole thickness of the Coal Measures to afford, by its presence alone, a true reliable character for the geological position of a vein. Though it is most abundant in the Pomeroy coal of Ohio, which would correspond with our coal No. 4, I have found it also in the barren measures between Athens and Marietta, Ohio, above the Pittsburg vein, and even in the shales of a higher level near Greensburg, Penn. In Posey county Indiana, there is a bed of barren shales, abundantly covered with this same plant, which is also in a much higher geological position than the coal No. 4. As there is then some evidence going to show that the coal of Giger's hill occupies a higher position in the Coal Measures, we must leave this for the present undecided, until further data are collected.

The 4th coal, which has the same geological horizon as the Pomeroy coal of Ohio, and the Gates and Salem vein of Pennsylvania, is generally covered with greyish-black, hard, somewhat micaceous shales, in which the greatest number of species of fossil plants are preserved. We have already mentioned *Neuropteris flexuosa*, which is there in the greatest abundance, but it is necessary to name some other species, more or less generally distributed in this bed, and which may serve to its identification in different places of the coal-fields: 1st. *Pinnularia*—a large confervoid plant, resembling a much branched thread-like root. 2nd. A brownish yellow fucoid, of which fragments only are found, detaching easily from the stone, like a thin skin—these are both found especially in the Ohio coal-fields, at Pomeroy and Federal creek. 3rd. *Asterophillites*—plants resembling our *Horsetails* (*Equisetacea*,) with long whorled branches, bearing, at short and equal distances, whorls of short narrow linear leaves. 4th. *Sphenophyllum* and *Annularia*—floating plants, with whorls of flattened, entire or diversely cut leaflets. 5th. Many species of *Neuropteris* and *Pecopteris*, especially *Neuropteris fimbriata*, Lsq'x., and *Pecopteris arborescens*, Brt. 6th. *Flabellaria boracifolia*, Sternb—a plant which, by its long ribbon-like leaves, closely and very finely ribbed, embracing the stem at the base, bears a strong likeness to a species of palm. The stem is seldom found—I obtained this year, for the first time, a specimen of it, at Salem vein, of Port-carbon, near Pottsville, Penn.; but the leaves are most abundant in all the shales of this 4th coal, and may be considered a true characteristic of it. In the lower beds I have seen some fragments of another larger species, but none of this. At Giger's we did not find any, and the only species discovered there, except *Neuropteris flexuosa*, is another fine *Neuropteris*, probably referrable to *Neuropteris conjugata*, Gopp. This vein has, also, some species of *Calamites*, *Sigillaria*, and *Stigmaria* in its shales, but I never saw in them any *Lepidondendron* nor *Lepidostrobus*.

The abundance of fossil plants preserved in this 4th coal, is truly astonishing. At Pomeroy the roof is in some places totally covered with those remains. In some pieces of shales, less than half a foot square, taken from Salem vein, at Pottsville, I have counted fifteen to twenty species. It might appear extraordinary that Pomeroy coal of Ohio, and Salem vein, of Pennsylvania, the highest bed of the anthracite coal basin, ought to be referred to the same geological level; but if we believe palæontological evidence, we cannot come to another conclusion, most of the fossil plants being of the same species, and these species being found no where else. Besides, its palæontological characters, No. 4 coal is marked by its one or two clay partings, which eastwards, become very thick, and form true strata, separating the vein into two or three, and also by the superposition of heavy beds of sandstone.

Coal No. 5, has not been satisfactorily seen, as the old opening, like that of No. 4, is now entirely filled, and the shales that were taken out not only disintegrated, but mixed up with those of No. 6 coal lying above.

On section 24, T. 3, R. 2 W., about a mile southeast of the Mulford's mines, Mr. Cox examined a coal, and obtained some fossil ferns from its shale roof. These I find to be prints of *Neuropteris teneuifolia, Brg't.*, a species so very like *Neuropteris flexuosa, Br't.*, (Pl. 6, fig. 2,) that is unnecessary to give a drawing of it. It differs only in the thinness of the veinlets, scarcely visible to the naked eye. This coal vein is cannel at the top, passing insensibly into four feet of black shales, in which the above plants were found. These species of ferns remind me of those which occur in the roof of a bed of anthracite coal, which I examined in Shamokin Valley, Pennsylvania.

Coal No. 6, has been opened at Mulford's mines, Union county, Kentucky, where we first examined it, and where it is called Little vein. The coal is somewhat rashy, mixed with an abundance of pieces of charcoal, and colored brown with oxide of iron. It has above it a thin layer of black brittle slates, with remains of stems covered by arenaceous, micaceous, yellow, or chocolate colored shales, marked with innumerable remains of much broken, nearly ground up plants. In ascending the bed of shales, they became whitish, passing insensibly into sandstone shales, and the remains of plants more and more pulverized, cover them in an indistinct mass. Though I cannot name any peculiar species, in connection with this bed of coal, since all the examined remains were too much broken to be recognizable, the general appearance of the shales is peculiar enough to serve as a reliable character. We knew this coal again at first sight when we came to it with Mr. Cox, two and an half miles from Hartford, Ohio county, Kentucky, where it is worked near the Owensboro' road; and still again, lately, while on a tour of exploration in the southern part of the coal basin of Ohio, I knew it at once when I saw it at Steiger's vein, near Athens, and from the inspection of the shales alone, fixed at once its true geological level.

Coal No. 7, is a thin bed, which we did not see any where in the western coal-fields of Kentucky, but of which we examined the shales exposed in a rivulet on the Saline Coal Company's property, in Illinois. These shales contain a few shells, but particularly some very small scales and teeth of fishes. These teeth are sharp, straight, and of a different form from those found in the beds above. I thought at first that it was not worth while mentioning this coal, since it is generally very thin—for it has been passed through by a shaft at Mulford's, and has been found to be there about thirty inches thick; at Holloway's boring, near Henderson, its place is occupied by a black shale, with only some trace of coal; and in the Illinois coal-fields, it is only a few inches thick. But though not valuable in a material point of view, this bed becomes important by its characteristic fossils, and its geological position. Being lately at Athens, on an exploring tour through the coal-fields of southern Ohio, I had the opportunity to survey, on the property of Horace Willson, Esq., a bed of shales which was thought to contain a vein of coal. I collected there teeth and scales of fishes, and after a comparative examination, I found them to be of the same species as those which we collected with Mr. E. T. Cox on the Saline Company's property. This bed of shales near Athens, Ohio, contains only a few inches coal, and its position is about one hundred feet below the Pittsburg coal, which is worked somewhat higher in the hills. The identity of both these beds, of western Kentucky and Ohio veins, as we said before, is of great importance, since it enables us to point out, with some accuracy, the place that the Pittsburg coal occupies in the western coal-fields. This place, as we will show more evidently in the examination of coal No. 9, is very probably the one occupied by the following No. 8, or Well coal.

Coal No. 8. This coal has been crossed in the shaft at Mulford's, where it is two feet six inches thick. But we could not see it, nor examine any of its shales, as the shaft was not accessible. It has been passed through, also, at the Holloway's boring, and has been mentioned in the survey of the Saline Company, always with the same thickness. This indicates a reliable and extensively formed vein of coal, and for this reason, it is especially to be regretted that we did not find a single opportunity of comparing the fossils of its shales with those of the great Pittsburg coal. The characteristic plants of this remarkable bed are not well defined. The shales immediately above the coal, are very black, bituminous, and covered with stems of ferns without leaves; these stems are very numerous, and sometimes heaped together in a confused mass. The vein of coal is divided into two, (rarely three strata,) by clay partings, or shales of various thickness, and it is only above its upper roof shales that some leaves of ferns, especially of *Neuropteris hirsuta, Lesq'x.*, and *Pecopteris heterophylla, Brg't.*, are preserved in a reddish ferruginous hard shale.

It may appear strange that we can refer to a coal, generally acknowleged as the thickest and most extensive one, such a thin bed as our No. 8; but, if we follow the Pittsburg coal from its eastern limits, where it attains its greatest thickness, we see it gradually thinning westward, in a remarkably uniform manner. In the Cumberland basin of Pennsylvania it is fourteen feet thick; in Elk Lick township, Sommerset county, eleven feet; in Legonnier valley, Fayette county, and at Pittsburg, nine feet;* at Wheeling, it is already reduced to a little more than six feet, viz: coal one foot, shales one foot, coal five feet five inches; and at Athens, Ohio, to about five feet, viz: two feet five inches coal, one foot and an half fire-clay or shales, and three feet coal. From Cumberland, Penn., to Athens, Ohio, the distance in a direct line is about one hundred and eighty miles, and from Athens to Mulford's, in western Kentucky, three hundred and fifty miles. If the gradation in the decreasing thickness of the vein had continued, without change, the great Pittsburg vein would have been reduced to nothing long before reaching the Kentucky coal-fields.

*See Lesley's Manual of the coal, p. 84.

Coal No. 9. This is, in western Kentucky, a reliable bed, and its coal is generally of very good quality. It is so well characterized by the fossil remains of its shales, that it is easily identified. Its thickness varies from three to five feet, and it is covered with a thick bed of black, hard, laminated and slaby shales, which contains a quantity of vegetable, but especially of animal, remains. The plants preserved in the shales are mostly stems of ferns, and pieces of the bark of *Sigillaria*. The shells, much more numerous, at least as individuals, have two species, which may be taken, among others, as characteristic, viz: *Avicula rectalateraria* and *Productus muricatus*. Teeth, scales, and fins of fishes, (*Icythyodorulites*) are also found in the shales of this coal, with the shells, but those remains are in great abundance only where the shells have disappeared; we have found them in all the places where we had an opportunity for the examination of the vein, ordinarily accompanied by a conical, regularly-ribbed print, about half an inch deep, and nearly as broad at its base. This fossil has been referred to a peculiar scale, which covers the head of a kind of fish, *Cephalapsis*, of which the caudal square and shining scales, are also found on the same shells with remains of small *Pterichthys*, another species of fishes of the Coal Measures.* Sometimes, also, these remains were accompanied with well marked small *Calamites*, which, from their length and their slenderness, appear to have lived in deep water.

The remains of fishes which abound in the shales of coal No. 9 are also found, apparently of the same species in the shales of coal No. 11. In this way, if the identification of both these veins should repose on palæontology alone, it would be sometimes impossible to make a distinction between them, except by means of the shells, which, however, are not found everywhere. The shells themselves are numerous, and of species so very like that it requires a good deal of scientific perspicacity to distinguish them. But the identification, or rather the distinction of the beds is easily made out from this difference, that No. 11 coal is ordinarily separated into two by a clay parting, and that its shales are covered by limestone, either as a more or less well developed continuous or interrupted limestone, or indicated by a ferruginous clay, containing the shells of this limestone. Moreover, the shales of No.

*Lyell's Manual of Geology, p. 344, 345.

9 are generally of a coarser texture than those of No. 11; under the microscope they appear covered with small whitish spots, which are either very small shells or crushed grains of sand.

In regard to the distribution of the shells, it is necessary to recall here what we have said on the distribution of the plants. In the shales, of two beds formed near each other, all the species cannot be different, therefore, the change in them ought to be examined with the greatest care, before we decide that a palæontological distinction is impossible, because some species of shells or remains of fishes are identical in both beds.

Though the fire-clay of the bottom cannot give precise indications, we may mention that below coal No. 9 this clay is thick—from ten to twenty feet and more, and insensibly passes into a hard rock, resembling a variegated limestone. At Hartford it forms along the river true perpendicular cliffs. This particular hardness, thickness, and color of the fire-clay, attracted lately my attention to a bed of coal, exposed in a cut of the Pennsylvania Railroad, about three miles east of Greensburg. Supposing that it might perhaps indicate an identical horizontal level with our No. 9 coal, I had the black roof shales opened, and by examination found them to contain the same remains of fishes as those enumerated above. This bed of coal, only one foot thick, is separated, by limestone, shales, and sandstone, from another thick vein of coal, which is exposed still higher, and it is in the vicinity of this last coal, and just at the eastern end of the tunnel, that I collected, in great abundance, and in a perfect state of preservation, many species of shells which, after examination, Mr. E. T. Cox pronounced to be all of the same species as those of our 11th coal. Thus we have here the thick, hard, colored fire-clay, and the remains of fishes of coal No. 9, and with the coal above it the characteristic shells of No. 11, to show evidently the concordance of the geological level at both places, in the Pennsylvania and western Kentucky coal-fields. The veins of coal mentioned above, and exposed in the great cut before the first tunnel east of Greensburg, have evidently their place in the great limestone of the upper Coal Measures of Pennsylvania—the lowest about one hundred feet above the Pittsburg coal, the other somewhat higher, between two beds of limestone, of which the inferior is more than twenty feet thick. This is a new and remarkable coincidence, since, in the Holloway's boring, near Henderson, Ky., our 11th coal is found also between two strata of limestone, the upper four feet thick, the inferior eight feet. Thus the supposition that the Pittsburg vein is represented by the 8th coal, in the western Kentucky coal-fields, is confirmed, since the distance to No. 9 is the same as that marked in Lesley's Manual, between the Pittsburg vein and the 1st coal of the great limestone.*

Before entering the western coal-fields of Kentucky, we had good opportunity to study the shales of No. 9 coal, first at the Shawneetown Mining Company's mines, and then at the Saline Company's mines, Illinois. At this last place, especially where the coal is extensively worked, we saw the characteristic shells in the shales, especially *Avicula rectalateraria* and *Productus muricatus*, with some remains of fishes and large nodules of iron, sometimes perfectly round and of immense size, containing at some places a great number of shells, and even fine pieces of petrified wood. They are especially formed of sulphuret of iron, and so hard that they can only be broken after they have been roasted in the heaps of burning shales.

Curlew mines, Union county, Kentucky, No. 9, is here the main coal, four feet thick, covered with thick black shales, in which are imbedded large nodules of sulphuret of iron. With the remains of fishes. *Avicula rectalateraria*, is the only shell that we found in the shales, and even it is scarce here. Generally speaking, this shell is unequally distributed—sometimes extraordinary abundant, and sometimes entirely wanting over extensive surfaces. At Curlew mines, the shales contain also large pieces of *Sigillaria.*

Mulford's mines, Union county. The main coal here is still No. 9; it is four to five feet thick, covered with the same thick black shales as at Curlew, but with a much greater abundance of fossil shells. *Avicula rectalateraria*, and especially *Productus muricatus* are accumulated in the shales in such quantities that they cover them sometimes entirely. The large nodules of iron, also, of which some had been burnt and broken, were seen to contain quantities of different species of shells, especially large bivalves and fine pieces of wood.

Jackfield's coal, at Capt. Davis', Hopkins county. Though the coal No. 9 is not worked here, it has been opened and its shales exposed

*See Lesley's Manual of the coal, p. 64.

well enough to permit its identification. The coal is four to five feet thick, and the black shales above it contain the teeth and remains of fishes, characterizing both No. 9 and No. 11 coals. The coal has no clay parting, and no limestone above it. About half a mile above Pidgeon run coal bed, in a rivulet near Capt. Davis' residence, there is an out-crop of coal, which appears to belong to the same No, 9, opened by Thom. Davis.

Peaks of Otter coal, on the head waters of Steward's creek, Hopkins county, is four to five feet thick, and is covered with shales of exactly the same appearance, and with the same fossil remains as the former. It has no clay parting, and no trace of limestone above the shales.

Coal No. 9 is also open and worked four to five feet thick, at the Peaks of Otter, near Alfred Town's house, with exactly the same shales as above.

McNairy's coal, Pond river, Muhlenburg county. No. 9 coal crops out here, in the bed of a rivulet, 'here we could examine a few shales only. They contained the remains of fishes. The coal is not opened, and appears to be five feet thick.

Near the road from Greenville to Paradise, about two miles east of Greenville, we examined two beds of the coal No. 9. The first, Capt. Wing's bank, is two feet thick; the other, Isaac Luce's bank, one mile distant on the other side of the road, five feet in thickness. Both beds are without clay partings and limestene, and are covered with black slaby shales, marked with the same numerous remains of fishes belonging to this coal.

Airdrie, Muhlenburg county, Kentucky. No. 9 coal is not worked now at this place, but it has been, in a shaft sunk from the top of the hill. The shales of this bed are still heaped up near the opening, and were easily identified. Though there can be no doubt about the position of this bed here, since it is marked by the section of the shaft, it was interesting to ascertain the identity of the fossils. The coarse grained shales of this bed, exactly of the same texture as those of all the beds before mentioned, contain also exactly the same remains.

Hartford, Ohio county, Kentucky. The same No. 9 coal is seen at this place, on the banks of Rough creek. The coal is only two feet thick. It has the same shales, the same remains of fishes, a few shells, *Avicula rectalateraria* only. We have mentioned before, that at this place the thick fire-clay below the coal insensibly passes into a hard rock, cut in bluffs, along the river.

Lewisport, Hancock county, Kentucky. The main coal opened near this place, one and a half miles from the Ohio river, still belongs to No. 9. The vein is not worked now, but the old shales, though very much decayed, afford materials enough for identification. Among the shales there are some boulders of limestone, or rather nodules of iron, which contain an abundance of the same shells that we found at Mulford's, especially *Productus muricatus.* One mile further west of this place, the same coal is worked now in a small way, for the demand of the town. It has here the same slabby shales, with the same fossils. The main thickness of the coal at both places is four feet to four feet four inches.

Henderson shaft, Ky. The 9th coal is reached here about one hundred and ninety feet from the top of the shaft, as marked in the section, p. p. 36 to 39 of the first report. The shales of this bed are easily distinguishable in the rubbish, having in them the fossil remains of fishes, and the *Avicula rectalateraria.* The palæontological identification is here of small interest, because the shales of the shaft are all mixed together in a heap, and also because the section itself gives the best indication about the place of this coal. This section agrees nearly foot by foot with No. 1, vertical diagram of the report of the Saline Company, Ind. The distance from the coal, two feet four inches, little Newburg coal, which is No. 11, is one hundred and eight feet, showing the total absence of the middle coal. At Saline Company it is one hundred and two feet, and at Shawneetown Company, Ind., one hundred and ten feet.

Coal No. 10. This vein appears to be the most unreliable and inconstant of all. It looks like a wandering bed, sometimes high up, sometimes descending, most of the time entirely absent or joined to No. 11. I would have omitted its description if we had not seen it at Shawneetown Company mine, where it has been scarcely opened. The coal, two to three feet thick, looks brittle and oxidated, an appearance possibly caused by atmospheric influence, and disintegration of the outcropping part. The roof shales are black, hard, compact, not slabby, but irregularly breaking, and without any traces of shells. The bottom is a micaceous coarse fire-clay, full of *Stigmaria*, resembling sandstone shales. This is all that we can possibly say of this bed, which entirely disappears, at least as an isolated bed, in all the part of the coal-fields that we have explored. The shaft of the Henderson Company shows there its total absence; at the Holloway boring its place only is marked by a three feet two inches bed of black shales, with some little coal; at the Airdrie shaft there is no trace of it; at Curlew and Mulford's, coals No. 9 and No. 11 are open on the same hills, and the place of No. 10 is indicated only by a coal dirt. If we had found it at any other place the remarkable conformation of its fire-clay would have afforded an easy identification of it. The only way of accounting for its disappearance is by supposing that it is generally part of coal No. 11, and that at Shawneetown Company mine, where it is separated from it by forty-three feet of shales, it has somewhat gone out of its way. Perhaps this is the cause of the irregular and sometimes large thickness of No. 11, and of its one and sometimes two clay partings, also very variable in their thickness.

There is about the position of this bed a difference between the topographical assertions and our own. But this difference is probably caused by mistaking, in some places, No. 11 for No. 10. With such beds, unreliable in their directions, the topography, by itself, and without the aid of the palæontology, must necessarily lead to error.

Coal No. 11. This is a peculiar, generally very fine and well developed bed of coal, though varying from two to nine feet in thickness. We have previously observed, that as regards the remains of fishes, especially, there is a remarkable identity in the palæontological characters of this and No. 9 coal. The shells appear to be generally of different species, and especially distributed in a different proportion. From the notes of Mr. Cox, who may perhaps change the nomenclature of the shells after a more careful examination, No. 11 coal is especially characterized by an abundance of *Pleurotomaria* of various species; *Productus Rogeri?* (N. and P.;) *Nucula Hameri?* and by a large *Avicula*, resembling *Avicula rectalateraria*, but larger and with a difference in the ribs of the side wings. The fossil plants are not so generally distributed in those shales as in No. 9, especially the *Sigillaria* seems to be wanting. The shales also are of finer texture, more bituminous, and not so easily separated into slabs. The remains of shells are generally much more numerous, and the number of species much greater. This bed can generally be recognized by its parting. But it should be observed that when the vein thickens much the clay partings are double, and when it thins to two or three feet, there is, ordinarily, none; but this last case is very rare.

Curlew mine, Union county, Kentucky. At this place, about one hundred feet above the main coal, we had the first good opportunity of studying the coal No. 11, and of collecting the fossil shells of its shales. All the characters above described are found there. The coal at Curlew, as of Shawneeton Company, Illinois, is mostly bird-eye. In the anthracite coal-fields of Pennsylvania, there is also a peculiar bed, in which this kind of coal is generally seen. It would be very interesting to ascertain if both these beds are on the same geological level. This I was unable to do, since I saw only specimens of the coal in cabinets, but never the place where they had been taken.

At the Curlew mine, above the shales of No. 11, there is a bed of fossiliferous limestone.

Thompson's mine, Union county, Kentucky. Coal No. 11, is open at this place. It is six feet thick, has a clay parting, and the shales contain the remains of fishes, and some of the above mentioned shells. There is above it a bed of limestone, passing into brown ferruginous, hardened clay, full of fossil shells of the same species as in the limestone.

Llewellyn mines, Union county, Kentucky. Same coal at this place, about six feet thick, with clay parting, and limestone above the shales. The shales, though thin, have the same fossil remains as the former.

Providence, Hopkins county, Kentucky. At this place the coal No. 11, crops out around the hill, on which the town is built. Its characteristics are exactly the same as at Thompson and Llewellyn, viz: coal five to six feet thick, with clay parting, covered with black slabby shales, with remains of fishes, and some shells, and above them the limestone, passing into rotten ferruginous brown stone or shale, full of fossil shells, especially of a *Productus Rogersi*, marked with short spines. About one mile west of the town, among the hills, there has been opened a bed of coal, four to six feet thick, which has the same shales, but wants the limestone above them. Nevertheless, the place of this limestone being indicated by a thin bed of yellow ferruginous clay, with fossil shells, we referred this bed to the same coal 11, with some doubt.

Pigeon's Run, Hopkins county. This coal is No. 11, eight to nine feet thick. It has a clay parting, and is covered with four to five feet of black shales, always containing the same fossil remains as those mentioned above. The limestone above it is irregular, mostly in boulders or large slabs, as at Thompson's mines, and at the Shawneetown Company's mines.

In Hopkins county, Kentuky, No. 11 coal is opened at the Sisk bank, and seen at some other places around in Town's property, with the same shales and limestone.

Arnold's mine, four and a half miles south of Madisonville, Hopkins county. No. 11 coal is here eight feet thick, has two clay partings, and a thick bed of black slabby shales, with an abundance of fossil remains, fishes, and shells, which give character to this coal. The slabs are covered with limestone.

McNairy's coal, Pond river, Muhlenburg county. No. 11 coal is opened here at two places, seven feet thick. The clay parting, the shales, with their characteristic fossils, and the limestone above them, are found at each place. Here, also, coal No. 12 is present, and comes so near No. 11, that it is separated from it only by its floor of two feet six inches of fire clay, and by the limestone (one foot thick,) of No. 11 coal.

Miller's coal, on Isaac's creek, Muhlenburg county, belongs to No. 11. It is six feet thick, has its usual black shales, with the before mentioned fossil remains, its superimposed limestone, and a clay parting. The brown ferruginous and fossiliferous clay or shale is also present here, covering the limestone. This ferruginous shale is sometimes above, sometimes below the limestone, and sometimes takes its place.

Airdrie, Muhlenburg county. Coal No. 11 is here the main coal, six feet thick, with clay parting. The black shales contain an abundance of beautifully preserved shells, and also scales, fins, and teeth of fishes. They are covered with a limestone bed three feet thick.

Bonharbour, Daviess county, Kentucky. There is no place where No. 11 coal is so easily identified by palæontological observations. The coal about five feet thick, has an occasional clay parting, or is separated by a thin layer of sulphuret of iron and charcoal. It is topped by the black slaby shales, with great abundance of shells, and some remains of fishes; and above it, has a soft calcareous rock, also full of beautifully preserved shells, all species characteristic of this coal. Near Curdsville, opposite this place, on Green river, in Henderson county, No. 11 coal has been worked, and is here called Cook's upper coal. The coal, four feet thick, has a clay parting; its black shales are full of shells, as at Boularbour, and it is covered by two beds of limestone, separated by a bed of coal-dirt and fire clay, six inches thick. The inferior bed of limestone is full of shells, but the superior one is black and without remains of fossils.

Coal No. 12. The general features of this coal recall the same observations as for No. 10. Its formation has followed too near that of No. 11. It is an unreliable bed, as well for its thickness as for its position. It sometimes comes so near No. 11, that it looks like a part of it, and sometimes it is found twenty or thirty feet above it. Its palæontological characters are well marked by an abundance of remains of fossil fishes, especially large scales, and large (mostly double) teeth. In Nos. 9 and 11, the remains of fishes belong only to very small species; in this they are much larger. The double teeth, found in abundance at Airdrie, are of a peculiar structure, viz: divided into two hooked points, about half an inch long, diverging from the base.

Exclusive of its fossil remains, coal No. 12 is easily identified by the composition of its coal, which is mostly a dirty, rashy, coaly matter, a compound of flattened *Stigmaria*, *Calamites*, and some scarce *Sigillaria*, well preserved in their outlines. Coal and shales are covered by a black band, or bed of calcareous iron stone, passing to a black limestone, which sometimes takes its place. This limestone is not fossiliferous, as far as has yet been observed.

Airdrie, Muhlenburg county, is the first, and truly the only place, where we had a good opportunity of studying No. 12 coal. It is opened here for the black band from which the material is supplied to C. H. Alexander's furnace. The bed of coal about four feet, has two to three feet of coal-rash, apparently entirely formed of *Calamites*, *Stigmaria*, and *Sigillaria*. I could not find a *Lepidodendron* among those vegetable remains. Below the coal-ash there is one to one and an half feet good coal. The shales, one foot thick, are parted by the black band, which sometimes disappears, sometimes occupies the whole thickness of the shales. The black band itself does not contain any fossil remains; but at all the places where it is not formed, the shales contain, in abundance, the remains of fishes mentioned above.

Besides at Airdrie, we observed this 12th coal over the limestone in the peaks of Otter, on Town's property, Hopkins county, Kentucky, where it is a rashy coal, three to four feet thick, and has a black band parting shale, with the remains of fishes. At McNairy's, Muhlenburg county, Kentucky, where it comes within two feet and a half of No. 11, and is a rashy coal, with black limestone between it and No. 11; opposite New Curdsville, in Henderson county, where it has only six inches coal dirt, comes to within three feet of No. 11, and has limestone both above and below it, and probably also at the top of Gamblin hill, Hopkins county, where we saw its out-crop only, in a hole full of water, which prevented closer examination. This bed is no where open in such a manner that it could be studied satisfactorily. It is indicated at other places, but always as a rash and unreliable coal.

This terminates the series of local information that we were able to collect in one month of palæontological survey in the western coal-fields of Kentucky. Perhaps the results may not be accepted as entirely satisfactory; but, considering the short time, and the extent of country surveyed, we think that it was hardly possible to obtain a larger amount of useful information. Not only the true vertical extent or the thickness of the Coal Measures of Kentucky is at once fixed, but the geological level of many important stations is ascertained, and these may serve as points of comparison for future investigation. Moreover, the first basis for the determination of the coal-fields, by palæontological remains, is laid down in this report, and every observer may test its value, and find out every fact that can modify or consolidate it. For, though the most valuable beds of coal of Kentucky have had their essential characters pointed out in such a manner that every geologist will easily know them again every where, yet there is a great thickness of the Coal Measures that is still nearly unexplored. This part contains, without doubt, the less important and less valuable veins; nevertheless, the study of coals Nos. 2, 3, 5, and 8, may be of great interest in a scientific point of view. For this the collection of all the fossil remains, plants, shells, fishes, with reference to the place where they have found, and if possible to the supposed geological level of it, will prove the most valuable contribution.

I thought at first to examine, in detail, the question of the identity of all the coal-fields of the Mississippi valley, including the great Apalachian and the anthracite fields of Pennsylvania. But a scientific discussion would take too much space in a local report like this, and I can only offer out some general remarks, which will at least explain this belief: that the western Kentucky, Illinois, and Indiana coal-fields were formed in continuity with the great Apalachian basin, and the anthracite fields of Pennsylvania. The comparison will be better understood by looking at the description of the lower coals, as it is given on pp. 94 and 95 of Lesley's excellent Manual of coal. His coal A, a thin bed, the first above the conglomerates, is sometimes present in western Ohio, as at Nelsonville, where it is about two feet thick, and in Virginia, as on the great Kanawha, near Charlestown, where it is eigteen inches thick; but, nevertheless, it is scarcely seen or penetrated in the borings for salt. As the system of the lower coals is less developed at the west, a circumstance easily explained by our general remarks, this bed of coal, when formed in the eastern coal-fields of Kentucky, is only a thin layer. In a shaft of the Old Distillery mines, at Caseyville, this bed is said to have been reached, and found to be one to two feet thick. But truly we could not find any reliable account of this.

Coal B, of Lesley's Manual, viz: our coal No. 1, B, is in the western Kentucky coal-fields, as well as in Ohio, Virginia, and Pennsylvania, a most reliable vein, and undoubtedly the *best* of the whole series, considering the extent of the surface where it becomes exposed. It thickens to the east, and in the anthracite fields it forms the Mammoth vein, and many others of the largest veins which have been worked. As a proof that its characters are everywhere the same, I quote a few lines of my palæontological report prepared and delivered in 1852, for the Geological State Survey of Pennsyivania:

"As soon as we come to the lower strata, the presence of large vegetables becomes apparent, first in the great quantity of *Stigmaria* abounding in the shales of the Diamond and Primrose veins, then in the *Lepidodendron*, and some large ferns which distinguish the Mammoth vein. This vein especially merits to be mentioned for its peculiar flora. The roof slates, of gray color, ordinarily charged with nodules of iron, have preserved the impressions of fossil plants in a very good state. The ferns, when present, belong to the largest species. With the *Lepidodendron* and their fruits, found in great abundance at Wilkesbarre, Carbondale, Minersville, Tamaqua, and Summit Lehigh, the ferns mostly seen in these low veins are *Alethopteris Serlii*, with its near relative *Alethopteris* (*Pecopteris*) *lonchitica*, and also with *Neuropteris hirsuta* and *Neuropteris Clarksoni*, Lsq'x. The fruits and needles of *Lepidodendron*, viz: *Lepidostrobus* and *Lepidophillum*, are also very abundant in the Mammoth vein of the anthracite, and since we did not find any specimens of these fruits any where else, viz: in any other bed above, their presence may be relied upon as a true character of the lowest beds of the coal basin in general, (p. 8 to 9, MSS.)

"We have already alluded to the identity of the great Apalachian coal with the anthracite formation, asserting that this identity is especially striking by comparison of the flora of the different strata.

"The lowest bed of the basin (our coal No. 1, B,) rests on the conglomerates, and crops out at Summit Portage, where we collected some *Lepidodendron* and *Lepidophillum*; at Johnstown, where the black slates of the roof are charged with *Lepidostrobus*, especially with *Lepidostrobus brevifolius*, Lsq'x., and also with *Lepidodendron*, at Cuyahoga Falls, Ohio, where the shales abound with the same plants, and also with *Pecopteris lonchitica*, and some *Sigillaria*. There is also there plenty of fruits—*Cardiocarpon*, *Carpolithes*—as at the low vein of Trevorton, Penn. The last place where we had opportunity to examine this vein, so rich in fine fossil vegetables, is on the great Kanawha river, three miles above Charlestown, where we found the roof shales covered with *Alethopteris Serlii*, and with some fine *Lepidodendron*, and *Lepidostrobus* in abundance. From this we shall necessarily be permitted to draw this conclusion: that this vein of coal, preserving so well it characteristic fossil plants, and at so great distances, was formed at the same time, and under the same circumstances, as well in the whole extent of the great Apalachian coal as in the anthracite coal-fields." (Pages 10, 11, MSS.)

This is nearly a repetition of what we have said about the lowest bed of coal, viz: No. 1, B, of the western coal-fields of Kentucky; and for this basin, also, we must necessarily draw the same conclusions as above.

The correspondence of No. 2 coal with cannel coal C, of Pennsylvania, of our No. 4 with the Pomeroy vein of Ohio, and with the Gates and Salem veins of the anthracite, at Pottsville, as also the relation of No. 6 coal with the Steiger's bed of Athens, Ohio, have been already and sufficiently pointed out.

The barren measures, from the Pomeroy coal up to the great Pittsburg vein, are perhaps not as well developed in the western coal-fields of Kentucky as in the great Apalachian basin; but, following our general remarks, all the strata have necessarily thinned somewhat westwards. Nevertheless, the space occupied in Kentucky by these barren measures, is three hundred feet thick, which is as much as in some places of Pennsylvania and Ohio. It is true that the measures are not entirely barren in western Kentucky, since there is a coal, No. 5, four feet thick, at ninety-five feet above No. 4. But the same vein is well developed in Ohio, near Athens, at one hundred feet above the Pomeroy coal, and in Pennsylvania, where the barren measure take their greatest developement; the same coal, one foot thick, is generally found at about fifty feet above the Mahoning sandstone, which rest upon the Pomeroy coal, and is seventy feet thick. This great sandstone, which is sometimes a bed of conglomerates, follow westward the same decreasing progression as the true conglomerates of the coal measures.

Nos. 6 and 7 coal, generally thin beds, have, in the western coal-fields, taken the place of the limestone of Pennsylvania, according to this principle, that where a quiet water is high, and the marine element predominating, a limestone may be formed, when at the same time, in more shallow marshes, the plants will grow, and their remains make a deposit of coal or shales; for it is evident that though the whole of the Coal Measures appears to have been horizontal, at least at some periods of formation, there has been, in different places, some depressions, forming lakes in the peat growing marshes, and that these lakes had to be filled by sand or by formation of shales, or of limestone, before they could again be covered with vegetation, and consequently with coal.

If the examination of the fossils of No. 8 coal, shows it to be the true coeval of the Pittsburg vein, we have, from it to the highest point of the Coal Measures, as far as they have been surveyed in the United States, another striking analogy in the position of the veins of coal, and their respective distance in both the coal-fields of western Kentucky and Pennsylvania. Admitting the coal marked three feet five inches, in the great limestone of Pennsylvania, as our No. 11, with which it is in perfect concordance by its fossils, and admitting that our

No. 12 is either united with it or not formed as in western Kentucky, we find in Pennsylvania, according to Lesley's *description of the upper Coal Measures*, a bed of coal, one foot thick above the great limestone, covered by two thick formations of sandstone, one fifteen feet, the other thirty-five feet, separated by shales, and a thin bed of limestone—the whole thickness of these strata being sixty-five to seventy feet. In Kentucky, between 12 coal, and the first coal above, there is ninety-five feet of sandstone and blue slate; and from this coal, which, for convenience sake, we will call No. 13, there is thirty-six feet of shales and limestone, to a five feet black slate, which contains some coal, and then thirty-seven feet of brown slate and limestone, to a bed of coal, (say No. 14,) which is thirteen inches thick. In Pennsylvania, we find, in the same space, fifty feet of sandstoue and shales, to a coal eighteen inches thick, and then fifty-five feet of limestone and shales, to another coal one foot thick, covered by four feet of brown shales, and twenty feet of sandstone. And more, if we count the whole thickness of the strata from the highst vein of coal in Pennsylvania to the Pittsburg vein, we find it to be marked by Lesley at four hundred feet, and the distance from our 14 coal to No. 8, or Well coal, is nearly exactly the same, viz: three hundred and ninety-five feet.

Truly this extraordinary concordance of the Coal Measures, at many hundred miles distance, is a very remarkable geological fact; and may be accepted as a proof, not only of coevity, but of continuity of the now separated coal-fields.

It may be said that a coevity of formation would, perhaps, call in existence the same formations, on both separate basins, as well as on a continuous one. This is possible, but there is nothing to prove it. On the contrary, we find, on the true borders of the great Apalachian coal-fields, viz: on its eastern and northern limits, many peculiar accidents of formation, great irregularity of thickness in the strata, distortions, cavities, subdivision of the bed of coal, which show the action of the sea on its shores, where the sand is unequally distributed, and where some small basins are closed and separated from the main one; and also on the western borders of the Apalachian, as well as on the eastern limits of the western Kentucky coal-fields, the veins of coal, and even the intermediate strata, have a remarkable uniformity of thickness. From Massillon, Ohio, to the Ohio river, at Nelsonsville and other places, coal No. 1, B, is from four to six feet thick, and along the eastern borders of the Illinois coal-field, as at Hawesville and Breckinridge, the same coal is four to five feet in thickness. As far as I have been able to extend my explorations till now, I have not seen any part of the coal-fields, east of the Mississippi, which give indications of having been separated from the general coal-fields at the time of their formation, except the anthracite basins of Pennsylvania; and I still think, that even these were connected by channels with the general basin, and that these channels have been often obstructed. That the high and quiet water of the sea has never covered them, is evident, from the total absence of limestone and shells in their strata, and also from the great thickness and the subdivision of the beds of coal; while in the general basin, the growth of the vegetation of the coal was sometimes stopped by the slow invasion of marine water, in the enclosed marshes of the anthracite fields, the growth of the vegetable materials was continuous for a longer period, and stopped only by the invasion of the sand brought upon them by a greater depression of the whole surface. In this case, we may find the fossil plants to represent the same species in the beds of coevel formation; but these species may be distributed in another manner, viz: appear identical in two or three veins close to each other, when in the general basin, they belong to a single vein. The case is observable near Pottsville, Wilkesbarre, and a few other places. and can be explained only by supposing that while the coal-field was submerged, some disturbance has strewn a bed of sand upon the already growing marshes of the borders, and that the vegetation beginning again, before a general change by depression or upheaval, the plants were of the same species as the former. I still persist in the affirmation of my report to the Pennsylvania geological survey, that the Salem and the Gates veins, as well as the Black and the Lewis veins around Pottsville, belong to the same bed of coal. But if this assertion should be proved a mistake, the identity of the fossils of those veins could not be explained but by the above supposition.

But, it is asked: if the upraising of the lower formations, which has caused the coal-fields to be separated by about two hundred miles of Devonian and Silurian strata, was posterior to the formation of the coal, what has become of the upraised Coal Measures, and where is the proof that they have been destroyed by subsequent erosion? The proof is found in the quaternary formations, all along the Ohio and the Mississippi rivers. The loam deposited by these rivers is sometimes mixed with broken and rolled pieces of coal; there are even some deposits of alluvial rolled coal, or pebbles of coal, heaped in strata in such a way that they have been taken, by unexperienced observers, for true coal beds. I had opportunity to examine one at low water of the Ohio river, below Vevay, Ind., in an alluvial formation, just upon the Lower Silurian Measures, and I have heard of some others.

But here we must close this already too lengthened discussion, and let the reader draw his own conclusions from the facts enumerated above, and also apply the general rules to the different localities open for his examination. There are, no doubt, some phenomena of the formation of the coal that are not yet satisfactorily explained, and some local accidents which will baffle every effort toward a generalization. But the science of the coal is still new, especially in the United States, where the coal-fields have been till now regarded only as true mines of wealth, very good for working, but scarcely worth a careful scientific study.

Explanation of the Plates.

PLATE VI.

FIG. 1. *Sphenopteris tridactylites*, Brongt? Our species, found at Union Company mines, somewhat differs from the European species, by its longer *tertiary pinnules* and its broader punctulate rachis; it is probably a peculiar species; 1a shows a tertiary pinnule; twice the natural size.

FIG. 2. *Neuropteris flexuosa*, Sternb. Giger's vein, Greenup county, Ky.

FIG. 3. *Pecopteris lonchitica*, Brongt. Upper part of a frond. The secondary pinnæ like *a* are mostly found. Low coal. Union Company mines, &c.

FIG. 4. *Neuropteris hirsuta*, Lsqx., with stem. The leaflets are mostly found separate. Common in the whole extent of Coal Measures. Very variable in its outlines.

PLATE VII.

FIG. 1. *Lepidodendron politum*, spec. nova. General scars oval lanceolate pointed curved at both ends with broad inflated, scarcely ribbed margins. Impressions rhomboidal, obtuse above, narrowed at the base, marked with three obsolete points; appendages two, united to the margin; no medial line nor wrinkles on the smoth scars. Union Company mines, Ky.

FIG. 2. *Stigmaria ficoides*, Sternb., with flattened leaves as it is ordinarily found in the coal and the shales. Fig. 2a shows part of a round leaf as preserved in the sandstone.

FIG. 3. *Lepidostrobus*. Low coal. Bell's mines, Hawesville, &c.

FIG. 4. *Sigillaria obovata*, Lsq'x. MSS. in Pennsylvania report. Low coal.

FIG. 5. Cross section of a small *Lepidostrobus*.

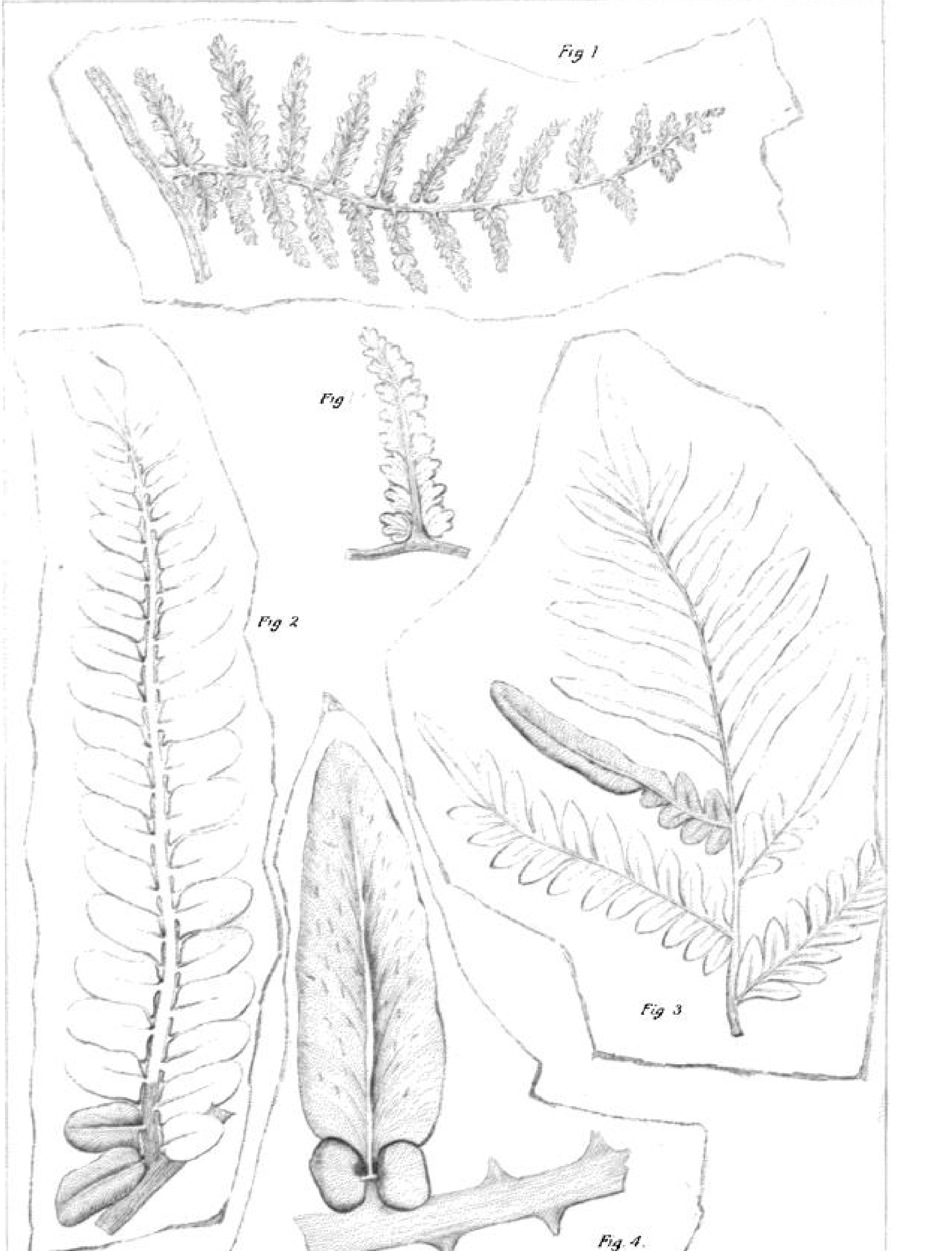
FIG. 6. *Lepidophyllum crevifolium*, Lsq'x. MSS. Pennsylvania report, pl. 23, fig. 6.

FIG. 7. *Lepidophyllum lanceolatum*, Brgt. These three last species are generally found in the low coal.

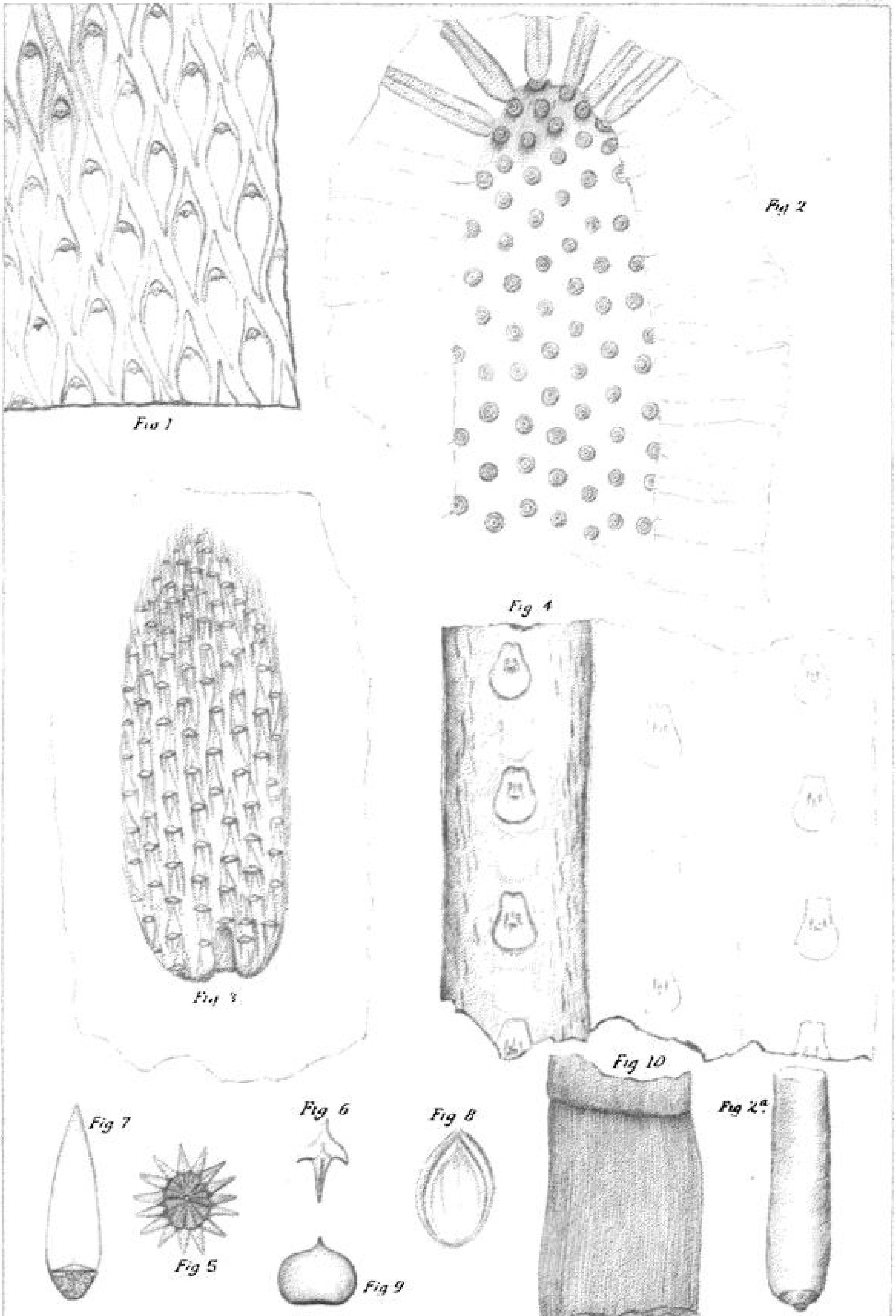
FIG. 8. *Carpolithes plati-marginatus*, Lsq'x. MSS. in Pennsylvania report, pl. 23, fig. 12. Low coal. Union Company mines, &c.

FIG. 9. *Carpolithes bicuspidatus*, Sternb., common in the low coal of Kentucky.

FIG. 10. *Calamites tuberculosus*, Gutb. Rash coal, Kentucky.



1 Sphenopteris tridactylites Brong! 1'. 3 Pecopteris lonchitica Brong!
2. Neuropteris flexuosa Stern^b 4. Neuropteris hirsuta Lsq^x



1. Lepidodendron politum Sp. nov. 2 Stigmaria ficoides Sternb. 3 Lepidostrobus 4 Sigillaria obovata Lesqx. 5 Lepidostrobus brevifolius Lesqx. 6 Lepidophyllum brevifolium Lesqx.
7. Lepidophyllum lanceolatum Brong! 8 Carpolithes platimarginatus Lesqx.
9. Carpolithes bicuspidatus Sternb. 10 Calamites tuberculosus Gutb.