

ART. XIX.—*A Source of the bituminous matter in the Devonian and Sub-Carboniferous Black Shales of Ohio*; by EDWARD ORTON, Columbus, Ohio.

THERE are three strata of black shale in the Devonian and sub-Carboniferous series of Ohio, viz: the Huron and the Cleveland shales of Newberry and the Waverly Black shale of Andrews. The latter name, I have followed Meek in replacing by the designation Berea shale. It constitutes the base of the Cuyahoga shale of Newberry. The first of these strata is unquestionably Devonian in age, and the last is referred without dispute to the sub-Carboniferous series. To the same division is referred the Cleveland shale by Newberry, on account of the presence in it of fishes of sub-Carboniferous type. In northeastern Ohio the Cleveland shale is separated from the underlying Huron shale by the Erie shale of Newberry, a mass of green and blue shale which ranges from nothing to 1,000 feet in thickness. Dr. Newberry showed, a number of years since, that the Erie shale thinned out as it was followed westward from the northeastern counties, and disappeared altogether in Huron county, letting the black Cleveland shale down, by overlap, upon the underlying Huron shale, which is also black. I have since shown that it is this compound stratum, the Cleveland (Erie), Huron shale, that constitutes the great black shale of Ohio, that extends from Lake Erie southward to the Ohio River and beyond. In central and southern Ohio, at least, it seems impracticable to divide it, and to refer one portion to the Devonian and another to the sub-Carboniferous, from the lack of characteristic fossils or stratigraphical marks in the formation. The average thickness of the compound formation through the State is probably not less than 300 feet.

The Berea shale, which directly overlies the Berea Grit, ranges from 15 to 50 feet in thickness, and is separated from the great black shale by an interval of 100 to 150 feet, the interval being occupied by the Bedford shale and the Berea Grit of Newberry. In northern Ohio the upper boundary of the Berea shale is not well defined. In central and southern Ohio, it is sharp and distinct.

These several beds of shale contain, as their color indicates, a notable quantity of organic matter. The proportion ranges, according to published analyses, from 8 to 21 per cent. the higher proportion having been found in some phases of the Berea shale.

The sources of this bituminous matter have not as yet been made apparent. The presence of conodonts and fish remains

in the upper or Cleveland division of the great black shale, and also in the Berea shale, has been noted as one source of this organic matter, and occasional strap-shaped leaves of fucoidal origin occur in both formations, but neither of these sources seems at all adequate to the supply. Dr. Newberry has referred to a "sargasso sea" as affording the most probable explanation of the facts involved, and offers "the suggestion that the carbon of the shale was derived from vegetation which lined the shores and covered the surface of a quiet and almost land-surrounded sea." This vegetation he is disposed to regard as exclusively marine. (Geology of Ohio, vol. i, pages 155-6.)

Professor E. B. Andrews, in the Ohio Geological Report of 1869, also discussed the problem briefly. He believed that the water in which the shale was deposited must have abounded in minute forms of vegetable or animal life, but he added that a search for these forms had been unrewarded.

Within the last few months I have discovered a new source, and, as I believe, a chief source of the bituminous matter of these shales, in certain minute forms of vegetable origin which they contain in vast numbers. I herewith present a brief account of the discovery and of the facts involved.

In 1881, Mr. J. A. Flickinger, County surveyor of Ashtabula county, Ohio, sent me specimens of the drillings from a deep well which was being sunk at Kingsville, Ashtabula county, in the search for petroleum or gas. For 800 to 900 feet the drill passed through blue shale, quite uniform in appearance, and destitute of fossils. This is evidently the Erie shale of the Ohio scale.

At about 900 feet layers of black shale began to be met, and they continued to occur for 300 feet, when the boring was stopped.

In examining with a microscope the fragments of this black shale I found many of them covered and filled with yellow, translucent discs, ranging from one one-hundredth to one two-hundredth of an inch in their longest diameters. The discs present the appearance of empty and flattened spherical sacs. When the shale is cut transversely, the discs appear as elongated and translucent yellow bars, roughly parallel to the bedding, and sometimes they present the appearance of flattened hoops.

The discs have a decidedly resinous appearance, but they yield but slowly, if at all, to ordinary solvents. When the shale is raised to a red heat, they disappear entirely, leaving empty pits in the shale.

At some points, and especially at a depth of 1,000 feet, the shale is so charged that every fragment contains them, while

some pieces acquire a rusty or yellowish color, even to the naked eye, from their aggregation.

At a later date I found the upper member of the great black shale in the vicinity of Columbus (the Cleveland shale), charged with identical forms. In addition to the discs already described there are occasionally found in this stratum flattened spheroids, considerably larger in size and somewhat darker in color, but obviously referable to the same group of forms. These larger bodies range from one fifty-fourth to one sixty-fourth of an inch in their long diameters, and consequently are discernible by the naked eye when they are well located. They burn with a flame and leave no residue.

I have lately examined specimens of the black slates of the three horizons named, viz: the Huron, the Cleveland and the Berea shale, from every part of the State in which they occur, and I find forms agreeing in general characters with those first described, everywhere present and often in great numbers. I am not now prepared to make computations of the number present in any measured volume of the shale, but the proportion is a notable one in many instances.

As to the nature of these bodies there seems no reasonable room for doubt. They agree in general characters with the spore-cases of several of the lower orders of plants. The descriptions given by Williamson of the lycopodiaceous spores in English coals will apply without change to the general appearance of these forms, in sections parallel and transverse to the bedding, but they lack the peculiar markings and shapes that characterize lycopod spores in particular, and will probably find their place in some lower group.

Different sizes have been recorded for these forms, but there is no doubt that all of them are macrospores. The finely-divided carbonaceous matter that is associated with them in the shale may represent the microspores.

There is nothing new in the detection of spores in formations that agree in general character with these black shales. Williamson records the presence of lycopod spores in great numbers in British fire-clays and iron ores. Binney has urged the view that the Boghead Cannel and other similar deposits must be referred to microspores for their origin.

The two inflammable Australian minerals, white coal and tasmanite, have been shown by microscopic sections to owe their inflammability to the resinous spores of lycopodiaceous plants. These minerals belong to a much later geological period than the Carboniferous. The tasmanite above referred to is a shale containing 26 to 30 per cent of combustible matter. It is therefore but little richer than the best portions of our Berea shale, which contain 21.4 per cent of bituminous matter.

I do not know, however, that spores have heretofore been shown to supply bituminous matter in large amount to any formation older than the Carboniferous.

If the construction placed upon the facts recorded in this paper shall be accepted, and vegetable spores shall be recognized as a chief source of the bituminous matter of these black shales, the perplexing question as to their origin will have been carried one step further back.

These black bands of the Huron shale lie geologically not far below the Venango oil-sands of western Pennsylvania. The resinous substances now described seem to offer an adequate and natural source of the petroleum and gas with which these rocks are charged. Dr. Newberry has long insisted on the adequacy of these beds and of these only for this supply, and he has sagaciously noted the fact that the carbonaceous matter of these shales consists mainly of hydro-carbons. The discovery of an ample supply of resinous spores within the substance of the shales certainly strengthens the claim that has been made for them as the main source of the valuable accumulations of oil and gas of the sandstones and conglomerates that overlie them.

P. S. Since writing the above I have learned, through correspondence with Principal J. W. Dawson of Montreal, that he has already recognized and described the most characteristic of the forms above referred to under the name of *Sporangites Huronensis*. (See this Journal, April, 1871, page 257.) The specimens on which his description was founded came from the bituminous shale of Kettle Point, Lake Huron. A bed of brown shale, burning with much flame, of Upper Devonian age, from twelve to fourteen feet in thickness, occurs here. The spore-cases are described as flattened, disc-like bodies, scarcely more than one-hundredth of an inch in diameter, slightly papillate externally, with a point of attachment on one side and a slit more or less elongated and gaping on the other. In sliced sections of the rock, they appear yellow like amber and show little structure, except that the walls can sometimes be distinguished from the internal cavity and are seen to enclose patches of granular matter which may be the microspores.

Dr. Dawson has kindly furnished me with a piece of the Kettle Point shale. The spore-cases appear to be identical with those first recognized by me, coming from Kingsville, Ohio. In the large range of rock which I have now reported, there are apparently several species of these bodies.

Dr. Dawson refers the spore-cases to Lycopodiaceous plants, and suggests two species of *Lepidodendron*, the remains of which are found at the same horizon, as likely to furnish them, viz: *L. Veltheimianum* and *L. Gasparianum*.

Columbus, Ohio, June 1, 1882.