siderable proportions of a non-azotized tissue analogous in its composition to that of plants, and that even muscular tissue, plus the elements of water, contain the elements of cellulose and ammonia, it is easy to understand that vegetable and animal remains may, by their slow decomposition, give rise to similar hydrocarbonaceous bodies. Dr NEWBERRY, referring to the same subject, writes*—"Waiting the demonstrative solution of the problem, which patient and exhaustive study will doubtless sometimes furnish, I offer as a possible explanation of the peculiar feature of the Huron shale the suggestion that its carbon was derived from vegetation which lined the shores and covered the surface of a quiet and almost land-surrounded sea." A similar view has been expressed by Professor ANDREWS;† but

* No. I. Vol. "Geol. of Ohio," p. 156.

† "Report of Progress of the Ohio Geol. Survey for 1869," p. 65.

it was not until the spring of 1881 that any confirmation of the theory was obtained, when Professor ORTON discovered in the Huron Shales, 1000 feet below the surface, "minute translucent discs, resinous in appearance, and unmistakably organic," occurring in great numbers, (Figs. No. 4 and No. 5). Later on further proof was produced, by the discovery of these bodies in the "Black Shales" of Columbus, Ohio, and finally they were found to occur throughout the "Black Shales."

The Shales in the Forest of Dean are very insignificant compared with those in Ohio. They are at the top interstratified with limestone, and towards the bottom with argillaceous beds; the total thickness would not exceed twenty feet. Spores occur, however, in the Shales (Figs. 1, 4, 5), and though they are not so large as some from America (Figs. 6, 7), there is great similarity between them; ~~neither are they so well preserved, but a~~ microscopic section of the beds in which they occur shows the strata to be full of decomposed vegetable remains. The Shales are bituminous; a fair average sample gave on analysis 17·15 per cent. of combustible material, 6·85 of which was volatile. I have no doubt that the so called bituminous character of the Shales is due to the vegetable matter contained in them.

As to the spores,—In the Forest of Dean, at Drybrook, two varieties are found, one of which shows triradiate

Proceedings of the Cotteswold Field Club
for 1883–4.

I don't know whether there is anything here which might be useful in your paper to be read at the British Association so send your proof.

E. W.

On the Occurrence of Spores of Plants in the Lower Limestone Shales of the Forest of Dean Coalfield. and in the Black Shales of Ohio United States By EDWARD WETHERED, F.G.S., F.C.S.

Last year I had the honour of communicating to this Club some observations on the Lower Carboniferous Rocks of the Forest of Dean.* In that Paper I showed that the Devonian Period was brought to a close by a change of conditions which caused a remarkable series of many coloured sandy beds and shales to be deposited, and that these gradually passed up into shales and limestone. I further showed that in parts of Scotland there were similar beds, though of greater thickness, which are known as the Calciferous Series; and I ventured to suggest that the strata which rests on the Old Red Conglomerate, and extends up to the base of the Mountain Limestone in the Forest of Dean, were the equivalents in time of the Scotch beds. There was, however, one physical feature wanting in our own district; it was the occurrence† of seams of coal and bituminous shales in the upper portion of the Calciferous Series of Scotland.

* "Quart. Jour. Geol. Soc.," Vol. 39 pp. 211

† This feature, however, is confined to certain districts.

During the examination of the argillaceous bed at the bottom of the Lower Limestone Shales in the Forest of Dean, to which I gave the name of "*Rhynchonella pleurodon* bed," I noticed some small yellow discs, the largest of which measured about ·006 of an inch in diameter. As to what these objects were I was for a time only able to suggest their being the spores of plants. Some time after the discovery Dr DAWSON, F.R.S., of Montreal, was kind enough to show me some spores which occur in the "Black Shales" of Ohio, U.S. On looking at these I at once recognized them as similar bodies to those met with in the *Rhynchonella pleurodon* bed of the Forest of Dean.

That the spores of plants occurred in the "Black Shales" of Ohio was first noticed by Prof. EDWARD ORTON, who referred to them in a Paper read before the American Association for the Advancement of Science, in 1882. I, therefore, wrote to Mr ORTON, who very kindly responded by sending me samples of the material in which they occur. But before I proceed further I must explain the geological position of the Black Shales of Ohio, which will be found to have an interesting relation to the beds in the Forest of Dean in which similar spores can be detected.

and they will be

Above the uppermost Devonian rocks in the State of Ohio comes a development of Shales of very considerable extent. In some parts of the State these deposits are divided into two divisions by a greenish blue shale, known as the "Erie Shales." To the lowest division the name "Huron" has been applied, and to the uppermost "Cleveland." This division appears to be uncertain, and towards the west the Erie Shales disappear. The American Geological Survey have drawn the line between the Devonian and Carboniferous rocks at the Erie Shales, but, owing to this shale not being constant, Professor ORTON points out that the line can no longer be drawn, and therefore the strata becomes debatable ground.

Now the "Black Shales" of Ohio are in the same position as the shales at Drybrook, in the Forest of Dean. The *Rhynchonella pleurodon* bed of ~~that~~ locality is no doubt of true carboniferous age,—the occurrence of the shell which gives the name is sufficient to determine that point. But below come other shales, followed by sandy beds, which rest on the Old Red Conglomerate.

the latter

The Ohio beds are important as a source of mineral oils; they are bituminous, and contain from eight to twenty-two per cent. of organic matter. To account for mineral oils various theories have been advanced. The vegetable origin has been suggested by Dr STERRY HUNT,* but at the same time Dr

* "~~Clinical~~ and Geological Essays," p. 179.

Chemical

HUNT is disposed to assign the origin in some instances to the decomposition of animal remains. He says—"When, however, it is considered that the lower forms of animals contain considerable proportions of a non-azotized tissue analogous in its

EXPLANATION OF PLATE.

Figs. Nos. 1, 2, 3, 4, 5.—Spores of plants from lease of Lower Limestone Shales, Drybrook, Forest of Dean, X 262 diameters.

Figs. Nos. 6, 7.—Spores of plants from the Black Shales of Ohio, United States, X 262 diameters.

Fig. No. 8.—"A large spore of *Tasmarites punctatus*, which has been ruptured, X 50 diameters; shows double certwer, and dotted surface." Copied from Mr E. T. NEWTON's paper, Geol. Mag. 1875, Plate X, Fig. 2.

Fig. No. 9.—"Portion of *T. punctatus*, Australian White Coal X 250 diameters, to show the dots and extremely fine granulation of the intermediate portion of the surface." Copied from Mr E. T. NEWTON's paper, Geol. Mag. 1875, Plate X, Fig. 9.

1

×262

2

×262

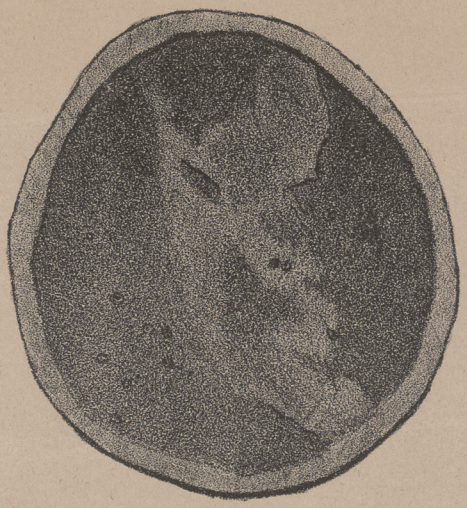
3

×262

6

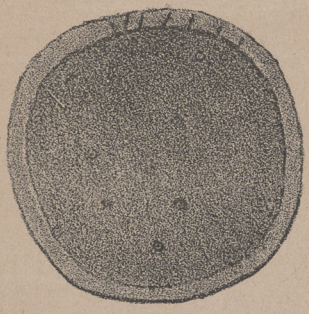
×262

7



×262

4

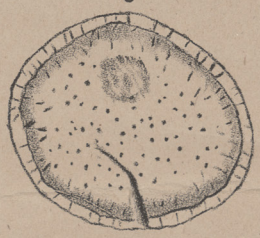


×262

5

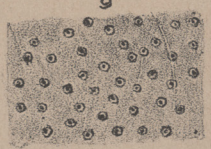
×262

8



×50

9



×250

Wetherell

Lamb

Sprague

Newton

Tessmann

Whitcomb

markings

(Fig. 2.) The largest of the two varieties do not show these markings, and vary in size from ·004 of ~~an inch~~ to ·006 in diameter. Though much decomposed, some of them still retain the outlines of a wall and, as in the case of Nos. 4 and 5, show minute rings or dots on the surface. I was at first inclined to regard these markings as ~~sporangia~~, and the main object as a sporocarp. On examination, however, of a perfect specimen from Ohio, I found the surface covered with what appeared to be ~~spires~~, and where these seemed to be broken off minute discs, with a black mark in the centre, remained to mark the spot (Fig. No. 6.) Mr. E. ~~T.~~ Newton, F.G.S., of H. M. Geological Survey of this country, has described* spores found in Tasmanite and

* "Geol. Mag.," N.S., Decad. 2, Vol. II., p. 337.

"Australian White Coal." I sent him specimens from the Forest of Dean and from Ohio, and he recognized them as similar bodies to those described by him. Mr Newton, in his descripton, notices the dots on the surface of the spores, and gives a figure of them, which I have copied (Figs. Nos. 8, 9.) Mr Newton says, in reference to them, "When examined with a power of about 250 diameters, the dots

can be resolved into minute circles $\frac{1}{3000}$ of an inch in diameter, with a still smaller dot in the centre. It may be thought that these dots are comparable to the granules to be seen upon the surface of some of the macrospores of Flemingites; but the study of transverse sections shows at once that these dots are not mere surface-markings, for they can be distinctly traced as minute lines (tubes,) passing from the outer to the inner surface." The second variety of spore I have not seen described. They are much smaller than those before mentioned, and, as I have said, show triradiate markings.

from Drybrook

Next let us consider to what order of vegetation the spores described are allied. Principal Dawson, F.R.S., of Montreal, in a Paper entitled† "Spore Cases in Coal," has mentioned bodies found in shale of the Eran formation, at Kettle Point, Lake Huron, to which he gives the name "Sporangites." Later on Dr Dawson identifies the spores discovered in Ohio by Professor Orton as similar to those found at Kettle Point. Still later, in a Paper read before the American Association for the Advancement of Science, at Montreal, on "Rhizocarps in the Palæozoic Period," he suggests the possibility of "Sporangites" being allied to Rhizocarps, but he leaves the matter open for further investigation. Mr Newton refers, in his Paper to which attention has been called, to the relation of the spores in Tasmanite and Australian White Coal to modern vegetation, and concludes as follows:—"There can be no question as to the Tasmanite sacs being of vegetable origin, although at present we do not know the plant to which they belong: their size and form seem to indicate that they are more nearly allied to Lycapodiaceous macrospores than to anything else." For my own part I prefer to give no opinion beyond that the larger spores from the Forest of Dean belong to a lower order of Crytogamia

† "Amer. Jour. Sci.," 1871, and "Canadian Naturalist," N.S., Vol. V.

It may now be well just to summarise the geological position of the strata in which the spores referred to in this Paper occur. The Black Shales of Ohio, as I have said, are debatable ground. The American Geological Survey consider them as part Carboniferous and part Devonian: the Erian formation

of Kettle Point, Lake Huron, is looked upon as Upper Devonian. In the Forest of Dean the shales in which the spores occur are in part certainly Carboniferous and in part debatable ground, It is clear, then, that in America and in England, so far as the Forest of Dean Coal-field shows, there must have been a very similar state of conditions—a condition which allowed of the growth of allied vegetation.

In conclusion, I may say that I am not aware of the spores described in this Paper having been found in this county before. Further, that the occurrence of bituminous shales at the base of the Carboniferous Limestone in the Forest of Dean adds to the correctness of the view ~~which~~ I express in my ~~Paper~~ last year, namely, that the beds which lie between the Old Red Conglomerate and the Carboniferous Limestone are the equivalents in time of the Calciferous Series of Scotland. It is true we have not seams of coal at the base of the Carboniferous Limestone in the Forest of Dean, but we have vegetable remains and bituminous shales.