SOME PLANT STRUCTURES OF COAL*

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INTRODUCTION

The constituents of coal as a rock have long been of interest but their study in America and Europe has received its greatest impetus from the development of the technique of microtome, polished, and thin section preparation. These methods of study have given new conceptions of the deposition and constitution of coals and to some extent of the process of coalification.

The difficulty of the technique and the time required in the preparation of the coals by these methods are, perhaps, obstacles to their general utility.

Students have used solvents from time to time to resolve the coal into a humic solution and an insoluble residue. White and Thiessen[1] have very ably summarized these methods and the results obtained.

The writer has for more than a year used the following schedule in studying coals from thirteen horizons in the Illinois coal basin.

PROCEDURE

The coal to undergo treatment is broken to lumps of twenty millimeters or less and covered with a modified Schultze's solution consisting of one part saturated potassium chlorate solution to four parts concentrated nitric acid. The Illinois coals usually require three or four days for complete oxidation although outcrop or weathered samples may be sufficiently disintegrated after eight or ten hours in the solution. The insoluble materials have been left in the solution for a period of two weeks or more without injury.

After oxidation is complete the acid-chlorate solution is decanted off and the macerated material is washed two or three times in water. A twenty-five per cent solution of ammonium hydroxide is then added to dissolve out the oxidized material. The usual procedure is to let

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[1] White, David, and Thiessen, Rheinhardt, The Origin of Coal, U. S. Bureau of Mines, Bull. 38, p. 216, 1914.

this basic solution remain on the material for five or six hours and add water to increase the volume twenty-five or thirty times. The residue is allowed to settle and the liquid is decanted off. It is then washed several times in a liter or more of water.

At this point a little of the residual material may be observed under the microscope. A watch glass containing a small amount of the material in water has been found convenient for this purpose. If the plant debris is curled or can not be easily separated it should be soaked in a solution of lacto-phenol for 24 to 48 hours. This solution is made by mixing 20 parts of phenol, 20 parts of lactic acid, 40 parts of glycerine, and 20 parts of water. It softens the material and restores it to its original shape. The lacto-phenol is washed out thoroughly with water and the material is placed in absolute alcohol where it may be left indefinitely. Plant fragments left in water for a month or two disintegrated so as to become unrecognizable.

The plant fragments in the alcoholic solution may be conveniently studied with a binocular microscope. In making permanent slides the desirable fragments are located with the microscope and removed with fine tweezers or a pipette. Several pieces are placed on a dry micro-slide and allowed to stand until the alcohol entirely evaporates. Two or three drops of Canada balsam that has been slightly thinned with xylol is put on and the cover glass placed in position. Two or three weeks are required for the balsam to dry as it is not desirable to heat it during the process of mounting.

The material may be stained at the alcohol stage with fast green, saffranin, or phloxine stain but it is perhaps not desirable except when it is necessary to accentuate the cell structure of epidermis. Spore cases and other structures become dark if stained. If the staining is too deep it may be lightened by placing the material for a few seconds into alcohol that has been acidulated with two or three drops of hydrochloric acid. As these stains are usually made up in alcoholic solution the material may be transferred directly to the slide for drying before mounting.

Significance and Character of the Residue

The plant fragments obtained by this method of treatment promise to be of significance geologically as horizon markers. A survey study has been made of residues obtained from the Babylon (Pottsville) coal of Fulton County, Illinois, through the most persistent coal beds to the No. 8 (McLeansboro) coal of Macoupin County. In sampling, an attempt was made to secure quantities representative of the entire seam.

Detailed study has been limited to the Pope Creek and No. 5 coal horizons of Fulton County and, although this investigation is not completed, there appears to be a characteristic plant assemblage for each horizon.

Some of the most delicate anatomical structures, such as pitted vessels (Fig. 1, Plate II) and transverse fragments of the woody parts of vascular plants (Fig. 6, Plate II) have survived coalification. Occasional organizations show characteristics that may prove of value in describing species.

Assemblages

The outstanding characteristic of the Pope Creek coal is the presence of splinters made up of the vessels of woody plants. Fragments 20 millimeters in length are common. Epidermis and cuticle form more than one fourth of the residue but are relatively inconspicuous in comparison to the darker vessels noted above. The coal also contains both microspore and megaspore exines that have not been observed in higher horizons.

The No. 5 seam is characterized by a preponderance of epidermal tissue of many kinds. Megaspores and microspores are abundant but fragments of woody material are less prominent than in the Pope Creek coal.

In all coals studied cryptocrystalline quartz constitutes a small but conspicuous part of the residue. The mineral may fill the lumen of the cell or may occur free in minute grains that often have the form of the cells from which they have become separated. The lack of distortion in the cell walls (Fig. 5, Plate II) suggests that the mineral was present soon after deposition. Much of the ash in these coals may have resulted from a partial silicification of the plants in the early stages of coalification.

Epidermis and Cuticle

(Plate I)

Two types of cell arrangement are reflected by the cuticles shown in figure 1 and figure 5.

An epidermal layer that resembles that of modern grasses in its structure is shown in figure 2.

Figure 3 is of a fragment of epidermis which bears stomata in definite rows. Raised and thickened guard cells surround the openings.

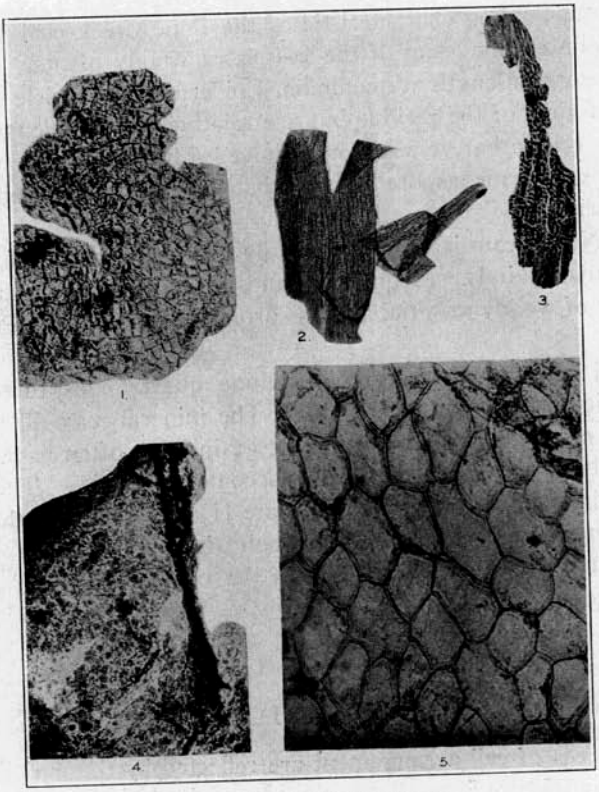
Figure 4 shows the epidermis of a leaf attached to the midrib. A few stomata and glands are present.

Woody Structures

(Plate II)

The organization of woody structures in the identification of living and fossil plants is of great importance. That some such value may obtain from residues won from coal appears probable and it is with this in mind that this material is presented for criticism.

The vessels in the fragment shown in figure 1 are of interest because of the uniseriate bordered pits. Uniseriate pitting is characteristic of the living Abietineae and the similarity of this fossil speci-



EXPLANATION OF PLATE I.

Fig. 1. Cuticle from Pope Creek Coal.

Fig. 2. Epidermis from No. 5 Coal.

Fig. 3. Epidermis from Pope Creek Coal. Stomata with thick guard cells appear in rows.

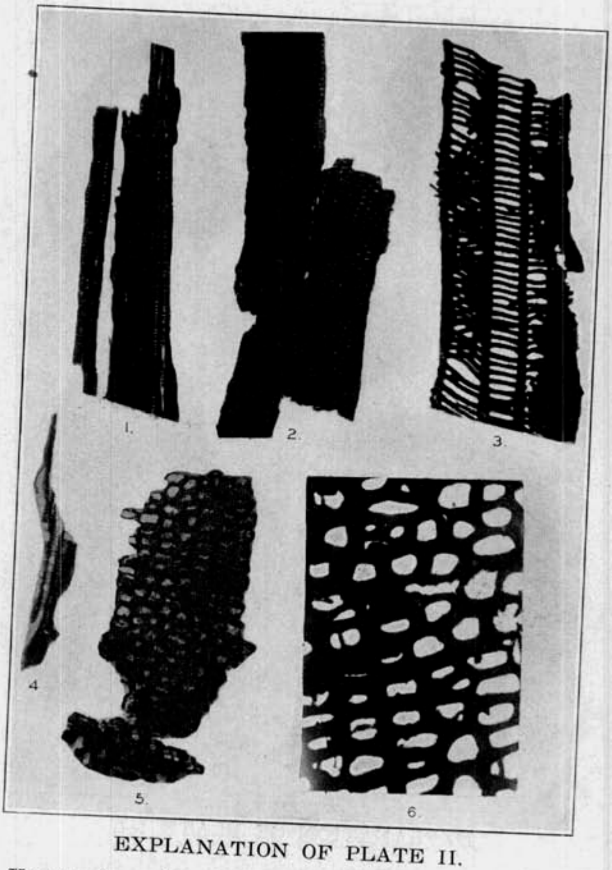
Fig. 4. Leaf epidermis attached to midrib. Small glands and stomata are present.

Fig. 5. Cuticle from No. 6 Coal.

men to corresponding sections of Cedrus[2] is striking. Multiseriate pitting of a vessel is illustrated by a section (Fig. 2) from another coal horizon.

Figure 3 and figure 4 illustrate scalariform vessels from No. 5 and the Pope Creek coals, respectively.

Figure 5 is a transverse section of secondary wood in which cryptocrystalline quartz has replaced the original cytoplasm. Figure 6 is a more highly enlarged section of the same wood.



EXPLANATION OF PLATE II.

FIG. 1. Vessels from Pope Creek coal showing uniseriate pitting.
FIG. 2. Multiseriate pitting in vessels from No. 5 coal.
FIG. 3. Scalariform vessels from Pope Creek coal.
FIG. 4. Scalariform vessels from No. 5 coal.
FIG. 5. Transverse section of secondary wood (No. 5 coal) with quartz filling lumens of cell.
FIG. 6. More highly magnified portion of Figure 5.

[2] Jeffrey, E. C., The Anatomy of Woody Plants, p. 74. University of Chicago Press.

Spores

(Plate III)

Some spore types from No. 5 coal are illustrated by figures 1 to 5. Those bearing wings (Figs. 3 and 4) indicate that the spore was no longer dependent upon water for transportation but was carried by the wind in the manner of the winged pollens of modern conifers.

EXPLANATION OF PLATE III.

Figs. 1, 2 and 5 are unwinged spores from No. 5 coal.
Figs. 3 and 4 are winged spores from No. 5 coal.