STATE OF ILLINOIS
WILLIAM G. STRATTON, Governor
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, Director

MICROSCOPY OF THE RESIN RODLETS OF ILLINOIS COAL

Robert M. Kosanke
John A. Harrison

DIVISION OF THE
ILLINOIS STATE GEOLOGICAL SURVEY
JOHN C. FRYE, Chief URBANA

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ABSTRACT

The original objectives of this investigation were an examination of translucent resin rodlets containing vesicles and a comparison of opaque pitted rodlets and sclerotia of the type reported from the Paleozoic coals of Europe.

Resin rodlets occur in Illinois coals as translucent, transitional, or opaque entities. Therefore, both transmitted-light and reflected-light microscopy were used in this investigation. These methods revealed that the resin rodlets may be with or without vesicles, or may have both vesicles and canals. Opaque resin rodlets with vesicles and canals were seen to resemble structures reported from a number of Paleozoic coals of Europe to be opaque sclerotia.

We have observed translucent and opaque vesicled resin rodlets in Illinois Nos. 2, 5, 6, and 7 coal beds. We also have observed them in Canadian coal sample S. R. 1 provided by Hacquebard (1951, p. 10). Valid sclerotia have not, to this date, been observed in Illinois coals.

INTRODUCTION

This investigation had its origin with the discovery of abundant translucent red resin rodlets containing vesicles or bubbles in Illinois No. 7 coal. Previously McCabe, Mitchell, and Cady (1934) had published a photomicrograph of translucent vesicled resin rodlets from Illinois No. 6 coal. The unique aspect of the translucent vesicled resin rodlets from Illinois No. 7 coal was their abundance. Opaque resin rodlets were found less frequently in this coal but a striking similarity was observed between them and sclerotia of the type reported from a number of the Paleozoic coals of Europe.

The resin rodlets reported upon in this paper are largely of the medullosan type previously discussed by Schopf (1939) and Kosanke (1952). However, the latter report was concerned entirely with the translucent non-vesicled rodlets. Resin rodlets that were fusinized or had adhering fusain were rejected for microchemical analyses in that study. Even so, it is interesting to note that the analyses showed a higher carbon content for resin rodlets than for adjacent vitrain. This corresponds with a greater reflectance for the resin rodlets.

Schopf (1948) reports, "The same type of plant materials and substances in peat that are capable of vitrinized preservation also seem to be susceptible to fusinization. The waxy-resinous phyterals are not commonly involved, but the same types of plant inclusions that are vitrinized also may, on occasion, be found in fusinized conditions. Thus rodlets of medullosans, commonly demonstrable in vitrinized form in coal thin sections, occasionally are substantially opaque to transmitted light and have been essentially converted to fusain."

Our report on opaque resin rodlets is therefore not the first to recognize their fusinized nature. We have observed and illustrated resin rodlets containing pseudostructure showing a marked similarity to structures reported to be sclerotia. The resin rodlets in question and the sclerotia are similar in both their pseudostructure and opacity.

PREPARATION AND METHODS OF STUDY

The method of preparing polished thin sections does not seem to warrant elaboration, and is briefly noted here just to place it on record. We selected samples of coals that contained rodlets visible when viewed in reflected light with either a Greenough type of low power microscope or a microscope equipped with a vertical illuminator. The surface of the specimen was ground smooth, either (wet) with carborundum powder and water or (dry) with two different grades of emery paper. The smoothed surface was polished with No. 1 Alumina and then by No. 3 Alumina. A final polish was given with billiard cloth, with distilled water used as the wetting agent.

The specimens were affixed to glass slides with Lakeside No. 70 cement. The process of grinding and polishing was repeated until the desired thinness was reached.

Isolated resin rodlets obtained from maceration residues were first mounted in blocks of carnauba wax, the whole then ground and polished as outlined above. The results, however, were not totally satisfactory because of the differential hardness of the mounting medium and specimens. Transoptic powder used in place of the carnauba wax gave satisfactory results.

Glycerin was used in place of cedar oil for oil immersion and the prepared polished thin sections were stored with a glycerin coating. The polished thin sections of coal broke free from the mounting medium after a period of from 2 to 4 weeks. It is suggested that another mounting medium be employed when glycerin is used.

The objectives of this investigation required that both transmitted-light and reflected-light methods of analysis be employed. (Illumination was vertical unless otherwise indicated.) It quickly became apparent that certain fundamental aspects of both methods of coal microscopy should be recorded. We agree with Teichmüller (1954) that both transmitted- and reflected-light methods of analysis can be used profitably in the examination of translucent and mixtures of translucent and opaque components of coal. This was apparent to us when we examined resin rodlets with vesicles under transmitted light and saw that they varied progressively from normal red to opaque.

Discrepancies between the two methods of analysis were observed immediately. For example, translucent vesicled resin rodlets could be observed best in sections of normal thickness in transmitted light because rodlets were seen _in toto_, whereas in reflected light only the surface of the rodlet was viewed. This is because virtually no light penetrates the polished surface when the reflected-light method is used. An observer has thicker material on which to base his identification when using transmitted light than when using reflected light, which is an important consideration because most coal constituents are obliquely oriented. By preparing ultra-thin polished sections, it is possible to minimize structural discrepancies. We observed that thin sections of this type reflect light as well as sections of normal thickness, and these thinner sections more nearly approached the surface observed in reflected light.

Conversely, it has been found that the reflected-light method is superior to the transmitted-light method in the examination of opaque pitted rodlets. We would agree with Teichmüller (1954) in her excellent report on the value of these two methods of analysis, but we take exception to the following points: that semifusain in most normal thin sections is as opaque as fusain itself, and that there is little difference in the preparation time between thin sections and polished thin sections.

Regarding the first exception, unless semifusain transmits light, it cannot be called semifusain by definition. If thin sections were too thick to transmit light properly, then Teichmüller's statement would.be correct, but in thin sections of normal thickness, semifusain does transmit light. As to the second point, perhaps it is a matter of individual experience, but we find it is much more difficult to prepare essentially scratch-free polished thin sections than normal thin sections.

OBSERVATION AND DISCUSSION

Abundant translucent vesicled resin rodlets were studied from thin sections of samples of Illinois No. 7 coal. Our attention first centered upon these translucent rodlets because of their resemblance to sclerotia. However, it soon was established that the size and position of vesicles varied tremendously. Some of the rodlets were less than 50 microns in diameter, whereas others were closer to 1000 microns in diameter. Some were non-vesicled, some slightly vesicled, and still others were strongly vesicled. There even was variation in the size of the vesicles within given rodlets and between adjacent rodlets.

We also noticed differences in the color of the resin rodlets. In thin sections of normal thickness, the rodlets were red but in thinner sections they were yellow, or, in some specimens, yellow to very light brown. At first we attributed the color to the thickness of the section, but we soon observed such color differences in single sections. This still might have been attributed to variation in the thickness of a single section but, in some specimens, rodlets within the same field of view, under low power, exhibited striking color differences (pl. 1, figs. 1, 3, 5, and 6). Furthermore, some of the rodlets were slightly granular and nearly black or opaque to transmitted light (pl. 1, figs. 5 and 6). A few of the rodlets, both translucent and nearly opaque varieties, exhibited a lighter peripheral layer (pl. 1, fig. 5).

Thus, without question, we were viewing normal translucent resin rodlets and some that were in part fusinized. The same thin section contained some totally fusinized and opaque resin rodlets. This was true in other thin sections from this coal as well as in thin sections from other coals.

In reflected light we likewise observed variations in size, condition of the vesicles, and variation in reflectance of the rodlets. The reflection of some of the rodlets was only very slightly greater than that of adjacent vitrinite and varied all the way to opaque in other specimens.

While we were viewing translucent vesicled resin rodlets and switching back and forth from transmitted to reflected light, it was apparent that much greater detail could be observed in transmitted light than in reflected light.

Figures 1 and 2 of plate 2 are photomicrographs of the same view taken under transmitted and reflected light. Figure 2 (reflected light) shows only the surface vesicles and outline of the rodlets. This polished section is thin, for if it were thicker the correspondence between it and figure 1 would be even more remote.

Photomicrographs of another opaque resin rodlet from a polished thin section are shown on plate 2, figure 3 (transmitted light) and figure 4 (reflected light). There is little question that the opaque rodlet can best be seen in reflected light. Canals are present in some resin rodlets, and one such is clearly shown in figure 4. Canals apparently are elongated voids usually extending more or less parallel to the long axis of the rodlets, although they may be oriented obliquely or transverse to the longitudinal axis as in figure 4.

A most interesting opaque resin rodlet was observed in a polished block of the Pewee coal from Tennessee. A portion of the specimen is shown on plate 2, figure 6. This resin rodlet extends for a distance of 5,662 microns and is unusual because immediately adjacent to it for a portion of this distance are some fusinized tracheids. It is our opinion that it is simply an opaque rodlet that contains both vesicles and canals with attached fusinized tracheids, which permits us to compare the reflectance of both the rodlet and fusain. These opaque rodlets have the reflectance of fusain.

In an effort to examine the opaque resin rodlets individually, we macerated coal samples containing them from our No. 6 and No. 7 coals, plus a Canadian coal sample, S. R. 1, provided by Hacquebard (1951). Some of the isolated rodlets from Illinois No. 6 coal are shown in plate 2, figure 5. They may be less than 50 microns in diameter, as proved by thin-section examination and as shown in figure 5, or they may be nearly a millimeter in diameter. Rarely are isolated rodlets observed more than a centimeter in length, probably because the maceration process breaks them into fragments. Much longer resin rodlets have been observed on fracture surfaces of coal blocks. Polished surfaces and polished thin sections of isolated resin rodlets are shown on plates 3 and 4.

Some of the isolated rodlets shown on plate 2, figure 5, were mounted in transoptic powder with the aid of heat press, polished, and mounted on a slide. A polished thin section was then prepared. Three of these rodlets may be seen on plate 3, figures 1-6. Figures 1, 3, and 5 show the rodlets viewed with transmitted light, whereas figures 2, 4, and 6 show them in reflected light.

All of the rodlets are opaque in thin section (pl. 3, figs. 1, 3, and 5) although a small amount of translucent organic residue is sometimes present in the canals of the rodlets (fig. 5). The white areas in figure 1 are vesicles or canals. The transmitted-light photomicrograph of the rodlet shown in figure 3 reveals nothing more than an opaque outline and perhaps a crack in the specimen, but the corresponding reflected-light photomicrograph (fig. 4) reveals not only the shape and crack, but small irregularly shaped vesicles. These two photomicrographs rather sharply illustrate the advantage of the reflected light method in viewing opaque entities.

Additional isolated resin rodlets were mounted in transoptic powder and carnauba wax and polished surfaces were prepared. Figures 1-4 on plate 4 are of the Canadian sample. They definitely have the reflectance of fusain, and similar specimens were seen in polished thin sections along with translucent-vesicled resin rodlets. Thus the specimens shown in figures 1-4 are believed to be opaque or fusinized resin rodlets. They possess canals and/or vesicles similar to those seen in resin rodlets from Illinois coals.

Hacquebard (1951) found these entities in the No. 5 seam, St. Rose coalfield, and recognized their similarity to the type of material called sclerotia by Stach. However, he called these entities sclerotioids, explaining (footnote 2, p. 12) that according to definition a sclerotioid resembles or possibly represents sclerotia. He said in part, "They strongly resemble the so-called wood-destroying fungi or sclerotia, which are portrayed in the textbook on coal petrography by E. Stach (13), but as the latter have a definite botanical connotation, the term sclerotioid is preferred here because as yet it has not been established that the features encountered belong to the same botanical entity." He illustrates his sclerotioids in both reflected and transmitted light on his plate 1, figures 3-6, and plate 2, figures 1 and 2.

Hacquebard (1952), in a paper concerned with opaque matter in coal, reported the occurrence of sclerotioids in other coal beds and included some excellent photomicrographs.

Small and large vesicles and canals are shown in portions of opaque resin rodlets from Illinois No. 6 coal on plate 4, figures 5 and 6.

An isolated resin rodlet from Illinois No. 7 coal was mounted in transoptic powder and polished in longitudinal (pl. 4, fig. 7, left) and transverse (pl. 4, fig. 7, right) planes for study of the vesicles and/or canals in two directions. The darker areas of irregular size and shape in the longitudinal section are probably vesicles rather than canals. This figure illustrates the irregular nature of some of the vesicles.

White and Thiessen (1913, p. 264-265) discussed the resinous components of bituminous coal. These are the resin rodlets with which we are concerned in this investigation. As a matter of fact, on plate XLV, figures C and D (from No. 2 coal, Exeter, Illinois), they call the resinous bodies resin rodlets. Their rodlets in these illustrations are dark and in the text they are described as dark brown, which suggests that the thin sections may have been slightly thick. They do not mention the presence of vesicles in the resinous bodies.

White and Thiessen (1913, p. 230-231), discussing the resin particles in lignite, state: "Their color varies considerably, and is from a light yellow to a deep golden yellow. In texture they range from dense to much-vacuolated bodies. The vacuolation varies from minute vacuoles somewhat numerous, to comparatively large ones (Pl. XXV, B, and Pl. XXVI, B), few in number." Thus, they recognized vesicles in the resin, and their photomicrograph of lignitic wood from Wilton, North Dakota, Pl. XXV, fig. B, very nicely shows unquestionable vesicles.

Resin rodlets may occur genetically associated with anthraxylon or fusain, scattered and mixed at random with other coal constituents, or in bony layers of coal. This was generally recognized by White and Thiessen (1913) and White (1914). White, writing about Paleozoic deposits, was mainly concerned with resin rodlets in fusain, which he attributed to the degradation of the original plant material prior to coalification. If the degree of degradation was small, the resin rodlets commonly were *in situ* or contained with the original plant tissue. If the resin rodlets were scattered or isolated, the degree of degradation was extreme but the rodlets remained because they were resistant to decay.

EXPLANATION OF PLATE 1

Figs. 1-6. - Photomicrographs from a thin section of Illinois Danville (No. 7) coal illustrating possible variations in translucence, shape, and presence or absence of vesicles in resin rodlets, viewed in transmitted light.

Fig. 1. - The resin rodlet in the upper left is non-vesicled but the one to the right is strongly marked with vesicles. A portion of another (extreme upper right) is nearly free of vesicles. One clearly translucent resin rodlet (just below center), compressed into an elliptical shape, shows very faint indications of vesicles. Another vesicled rodlet (bottom) is much less translucent and therefore darker in color. X300.

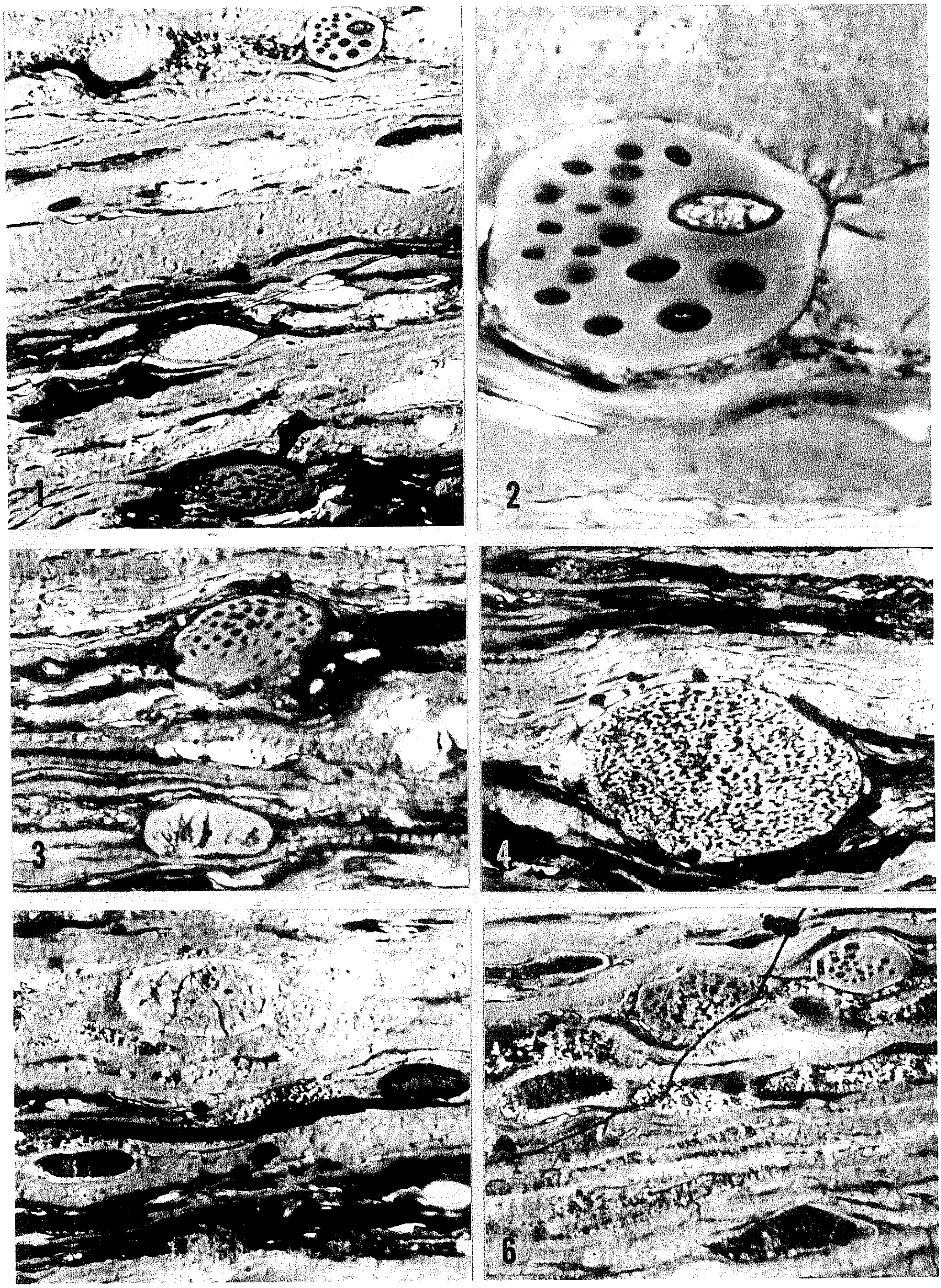
Fig. 2. - Photomicrograph showing details of the strongly vesicled rodlet seen in upper right corner of figure 1. Another translucent rodlet (right) is almost free of indications of vesicles. X1260.

Fig. 3. - The translucent resin rodlet at the top has vesicles in its upper two-thirds but the bottom third is almost free of vesicles. The rodlet at the bottom is less translucent and shows random cracks. X300.

Fig. 4. - This resin rodlet has hundreds of very small vesicles, in contrast to the rodlet shown in figure 2. X300.

Fig. 5. - The rodlet (upper portion) shows cracks, a few vesicles, and a lighter peripheral margin,which contrasts markedly with the less translucent center of the specimen. Two compressed resin rodlets (near center) appear black with a lighter peripheral margin; they are partly fusinized but a small amount of light passes through them. X300.

Fig. 6. - Translucent vesicled resin rodlets (upper right), two partly fusinized rodlets (left), and a third partly fusinized rodlet (bottom) are shown. They illustrate variation of translucence of resin rodlets in one field of view. X300.



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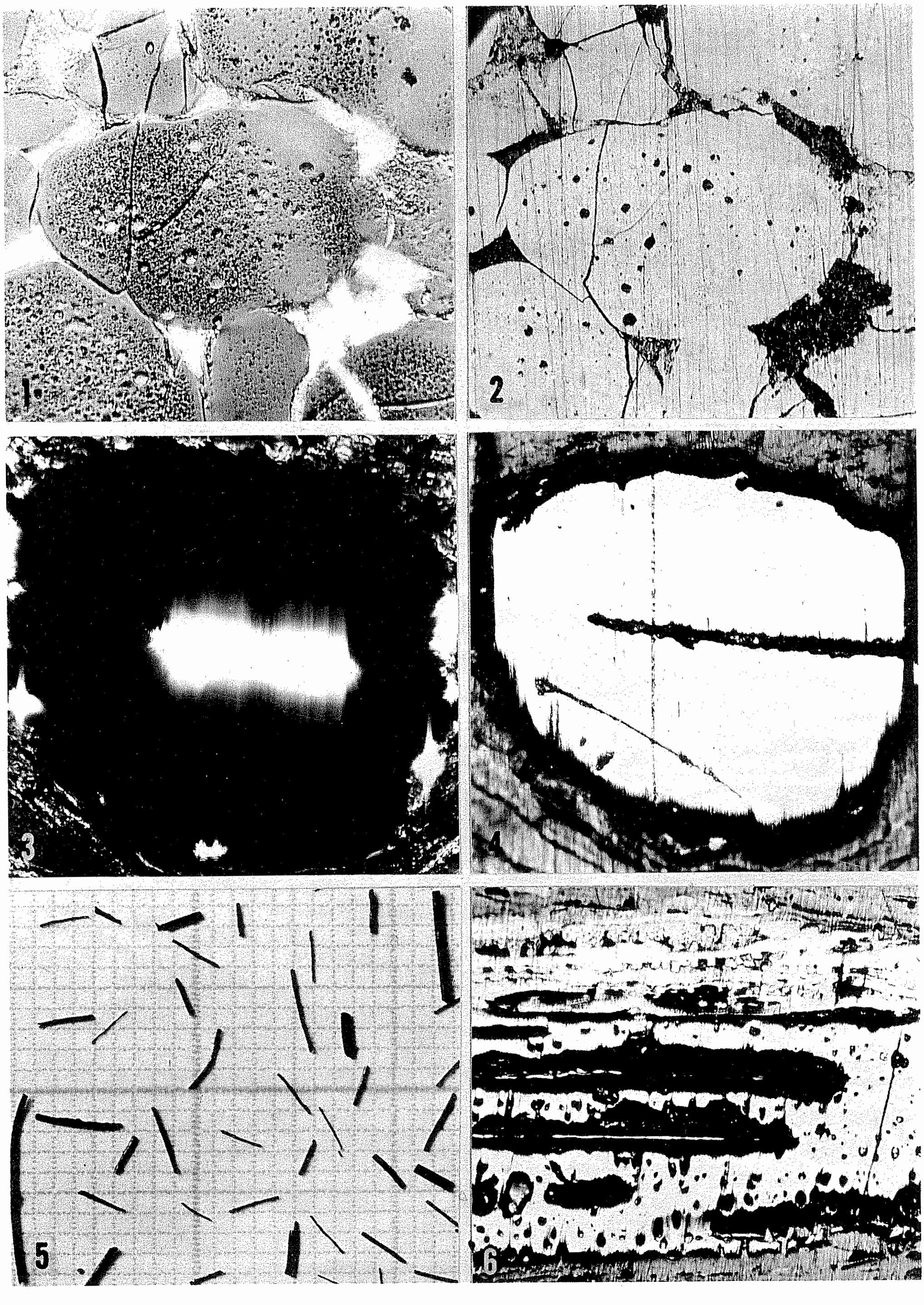

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EXPLANATION OF PLATE 2

Figs. 1-2. - Transmitted-light (fig. 1) and reflected-light (fig. 2) photomicrographs of the same resin rodlet from a polished thin section of Illinois Danville (No. 7) coal. The rodlets are clearly translucent and have many vesicles (fig. 1). Their reflectance (fig. 2) is only slightly more than that of anthraxylon from the same thin section and is much less than that of fusain. X300.

Figs. 3-4. - Transmitted-light (fig. 3) and reflected-light (fig. 4) photomicrographs of an identical resin rodlet from a polished thin section of Illinois Danville (No. 7) coal. This rodlet is fusinized and opaque. The reflected light shows a canal transversing part of the center (fig. 4). Light shining through the canal has fogged the center of the picture in figure 3. X300.

Fig. 5. - The size and shape of isolated resin rodlets from Illinois Herrin (No. 6) coal obtained by maceration is shown on a millimeter grid. The longest specimen is slightly less than one centimeter. They vary in width from less than 50 microns to nearly one millimeter.

Fig. 6. - A polished-surface photomicrograph of the Pewee coal from Tennessee. A fusinized resin rodlet (middle) contains both vesicles and canals that parallel the long axis of the rodlet. Fusinized tracheids appear attached to the rodlet at the top of the illustration. The reflectance of fusinized tracheids and the resin rodlet are about equal. The resin rodlet, about 5,662 microns long, is believed to be opaque. X300.

White (1914) made a number of keen observations in his paper, "Resins in Paleozoic Plants and in Coals of High Rank." However, it should be mentioned that he used the term "high rank" to contrast Paleozoic coals of high volatile bituminous rank with younger coals from western United States. White found resin rodlets in at least four localities in Illinois: (1) from either Illinois No. 2 or No. 1 coal (more probably No. 1 coal) from a mine near Gerlaw; and from Illinois No. 2 coal from (2) near Exeter, (3) at Colchester, and (4) at LaSalle.

In discussing his material from near Gerlaw, Illinois, White had observed convincing evidence that the resin rodlets were casts or fillings of canals oriented longitudinally in the wood and petioles of some of the Pennsylvanian plants.

In a general discussion of the resin rodlets White remarked: "A close examination of the casts under low magnification shows that they resemble very dark brown or slightly orange-brown vulcanized rubber, the fracture being conchoidal and somewhat vitreous. Under strong magnification the casts are found to be composed of an orange-russet or more or less yellowish semitransparent substance." There can be little doubt that White properly recognized these entities as resin casts or rodlets. Further, his illustrations are convincing.

White, in discussing a sample from LaSalle, Illinois, said, "One of the fragments from LaSalle is slightly yellowish, granular, and more opaque than others in the same fragment of coal." Thus, he recognized the variation in color that is discussed in this paper.

White continued his remarks concerning his sample from LaSalle, Illinois, "Another is somewhat irregularly pitted or hollowed, as is shown indistinctly in figure 1, Plate XI." Thus, he recognized pitted or vesicled resin rodlets in bituminous coal.

Gresley (1899) reported a number of interesting observations concerned with the occurrence of resin in coal. He believed he had observed "mineral resin, ambrite or fossil gum of some kind" from coal beds in England, the United States, Canada, and Russia. He also had observed similar material in coal samples from Japan, South Africa, and the United States. He states, "...the bright, clear, amber, garnet-red, and yellowish plays of color which I have repeatedly observed upon or in knife-edges of very thin splinters or flakes of coal, testify to the presence in it of this resinous material. Fragments of woody-looking and more succulent tissues of some of the better preserved black laminae evidently have their cells and tubulous parts filled with solidified liquid hydrocarbons -- the amber-like material." This last sentence suggests he observed resin rodlets _in situ_. Gresley's figure 1, plate 2, (Pittsburgh coal) further adds credence to the fact that he correctly associated this type of material with resin rodlets. Finally, his text-illustration (1922) more or less confirms his identification along with his remarks. His descriptions (1922) of milk-white oblong cell-inclusions is taken to mean that the resin rodlets either contained or had attached mineral matter.

Gresley (1899, p. 76) described his method of polishing coal. He used a quarto volume covered with sheepskin as a polishing surface for his coal specimens, and noted that the friction produced a polished surface that sometimes revealed structures. He also noticed that the rubbing produced a differential polish so that the denser blacker areas were below the level of the material occupying the cells or tubulous parts. Thus, Gresley was one of the earliest workers to polish coal for study of structure.

Francis and Wheeler (1926) reported upon the occurrence of resins in vitrain of the Hamstead coal.

Duparque (1927) wrote an article concerned with resinous bodies in coal. He used the reflected-light method of study, and several of his illustrations and descriptions attracted our attention. His photomicrographs (text figs. 5 and 6) contain entities called resinous bodies that could be related to resin rodlets; however, they reflect light the reverse of what might be expected. The "cellular" pattern is dark and the area of vesicled resin rodlets, usually void, is very bright. These differences might be inherent in the material or they might be related to preparation and equipment available at the time of publication.

Duparque (1956) identified a resin rodlet as a "resinous granule" in his figure 3. In the same illustration are two shreds of cellular structure which he identified as fusain and a layer of cellular structure (xylain) in a ground mass of vitrinite. It is difficult to evaluate this section because the entire section reflects light fairly well. The resin granule or rodlet has a number of very small vesicles and perhaps two large canals or vesicles. The layer of cellular structure (xylain) half surrounds the resin rodlet.

We do not question the fact that fungi have a long geologic history, and that it is reasonable to expect that sclerotia (dormant mass of fungal hyphae) occur in Paleozoic deposits. Tyler and Barghoorn (1954) have given convincing evidence of the existence of fungi in the nonferruginous cherts of the Gunflint formation (pre-Cambrian) of southern Ontario. More specifically concerning the Pennsylvanian strata of Illinois, Andrews and Lenz (1943) reported on a mycorrhizome from the Pennsylvanian of Illinois. They observed this fungal material in the cortical portion of <u>Scleropteris illinoiensis</u> from a coal ball from No. 6 coal. Another discussion of the nature of this fungal material is to be found in another report by Andrews (1942, p. 5-6).

As far as we know, Schulze (1933) published the first description and illustrations in which entities from Paleozoic coals were identified as sclerotia. His illustrations, in reflected light, show "sclerotia" not too dissimilar from our resin rodlets.

Stach (1934), in a paper entitled "Sklerotien in der Kohle," discusses form and importance of sclerotia in peat, brown coal, and bituminous coal, as well as sclerotia and vitrain formation.

Stach's figures 4 and 5 show structures called sclerotia from brown coal, and an even better photomicrograph of this specimen is to be found in Stach (1951), figure 212. This particular entity is identified as <u>Sclerotites brandonianus</u>, which was originally described and illustrated by Jeffrey and Chrysler (1906, p. 200, Pl. L, fig. 12, and Pl. LI, figs. 13-15).

The occurrence of sclerotia in coals of Mesozoic and Cenozoic age is well known in the literature. There are many illustrations of sclerotia from post-Paleozoic deposits. We should like to call attention to those presented by Teichmüller (1952) in which she has both reflected- and transmitted-light photomicrographs. The transmitted-light illustrations are in color (figs. 30b and 31b). The transmitted-light color photomicrographs show the sclerotia

EXPLANATION OF PLATE 3

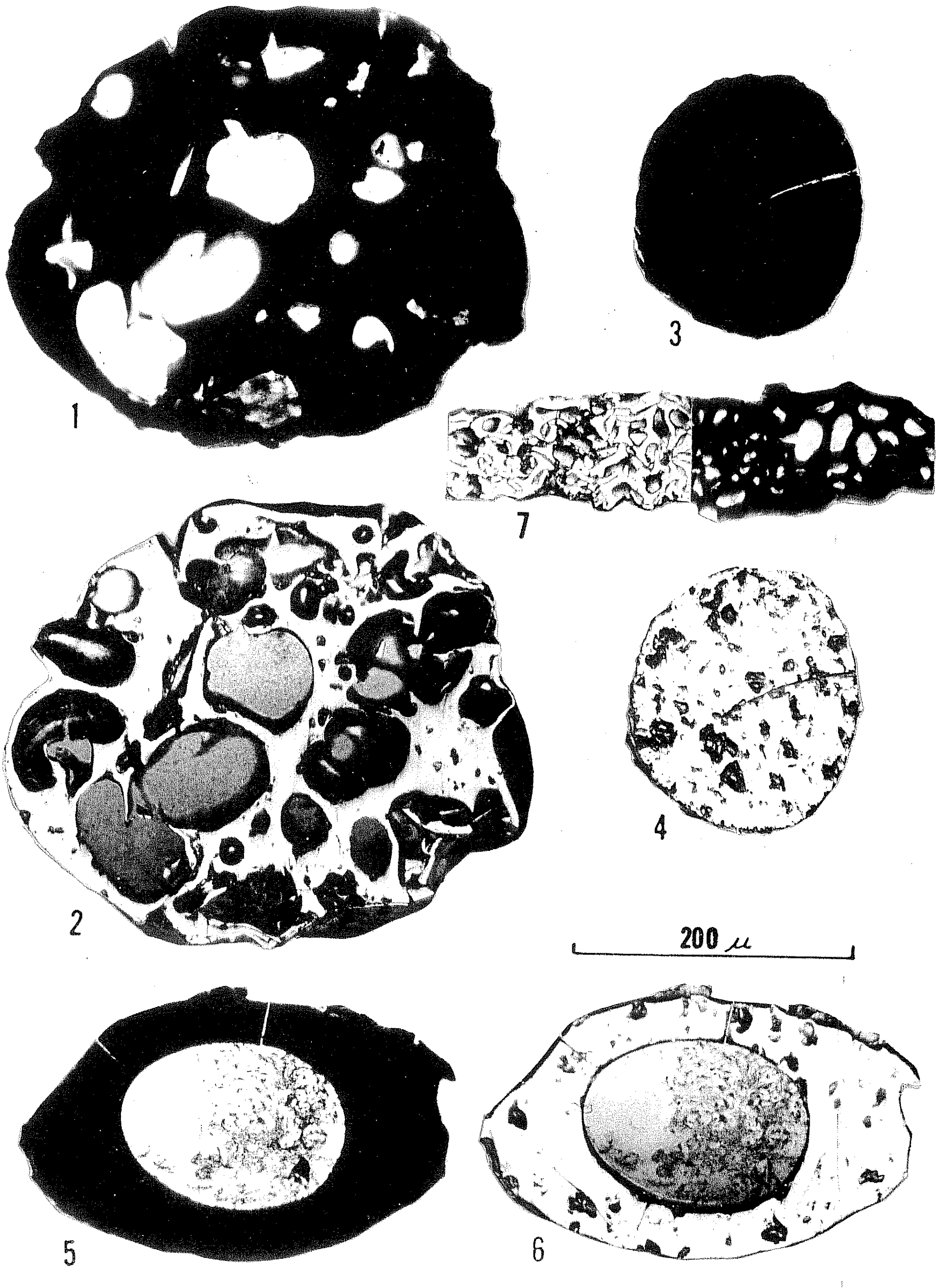
Figs. 1-6. - Polished thin sections of isolated resin rodlets shown in pl. 2, fig. 5. All are from Illinois Herrin (No. 6) coal.

Figs. 1-2. - Transmitted-light (fig. 1) and reflected-light (fig. 2) photomicrographs of an identical resin rodlet reveal the rodlet to be opaque and to contain both large and small vesicles. More detail concerning the size and shape of the vesicles is shown in reflected light.

Figs. 3-4. - Transmitted-light (fig. 3) and reflected-light (fig. 4) photomicrographs of the same resin rodlet. Figure 4 shows the details of small vesicles that do not show in figure 3. The transverse line at the middle of the rodlet may be a canal or a crack.

Figs. 5-6. - Transmitted-light (fig. 5) and reflected-light (fig. 6) photomicrographs of the same resin rodlet show the rodlet to be opaque and to contain a central void, probably a canal. Figure 6 in addition shows scattered vesicles.

Fig. 7. - A portion of a fusiform fragment of fusain as viewed in reflected light, to the left, and in transmitted light, to the right.



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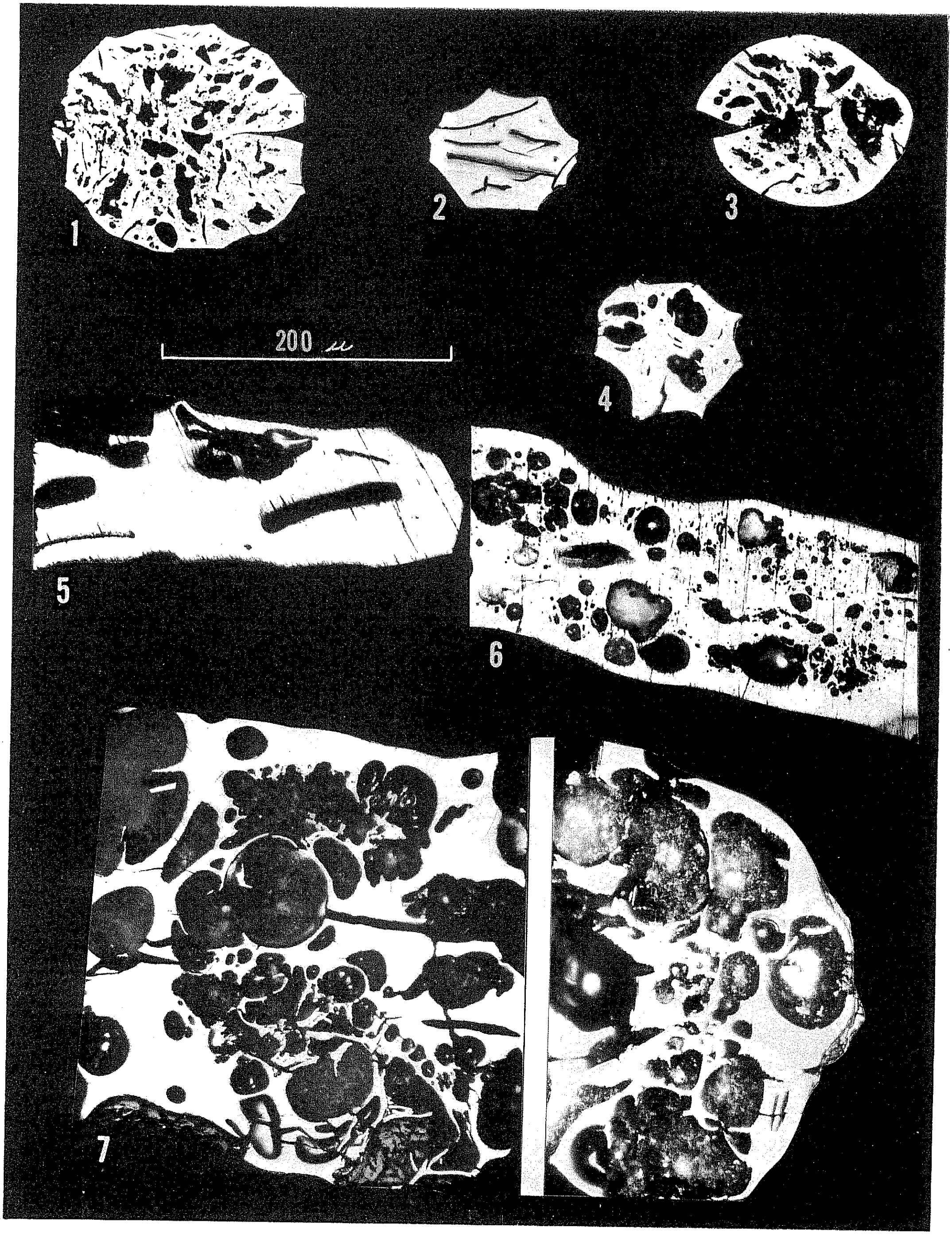

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EXPLANATION OF PLATE 4

Figs. 1-7. - Polished-surface photomicrographs of isolated resin rodlets. All are believed to be opaque because their reflectance is comparable to that of fusain.

Figs. 1-4. - Resin rodlets obtained from maceration residues of the No. 5 seam, St. Rose coalfield, Cape Breton Island, Nova Scotia. Figures 1, 3, and 4 show numerous small vesicles and larger sized vesicles or canals. The canals shown in figure 2 apparently occur at right angles to the long axis of the rodlet.

Figs. 5-6. - Longitudinal views of portions of two resin rodlets from Illinois Danville (No. 7) coal showing canals (fig. 5) and small and large vesicles (fig. 6).

Fig. 7. - One isolated resin rodlet from Illinois Herrin (No. 6) coal that is shown in longitudinal view (left of the vertical white line), and in transverse view (right). The dark irregularly shaped areas are vesicles rather than canals.

to be brown to black in color. This is an interesting point because sclerotia that we have seen from Tertiary coals of western United States likewise transmit a brown color similar to that of semifusain.

We have observed fungal spores of the Basidiomycetes from a brown coal from King County, Washington, that are similar to those of Tertiary age illustrated by Stach (1934, 1952) and Teichmüller (1952). These spores are thought to be teleutospores or teliospores.

Stach (1934), in his discussion of sclerotia from Paleozoic coals, illustrates a number of specimens that he called hyphae and several specimens of sclerotia. His figure 13 is strikingly similar to our specimen (pl. 4, fig. 1), which we believe is a resin rodlet. Figure 6 (pl. 4), if viewed in transverse plane, also would look similar to his specimen.

Stach and Michels (1955, pl. 12, fig. 2) illustrate a sclerotium that we believe could very readily be an opaque resin rodlet.

Stach (1951, 1956a) shows a number of reflected-light photomicrographs of "sclerotia." Some of them could possibly be sclerotia or fungal hyphae, whereas others we would have to consider as possible opaque resin rodlets. In Stach's 1951 publication, the following might be opaque resin rodlets: figures 81, 117, 141; and possibly 51, 52, and 148. These entities are either completely structureless, as are many resin rodlets, or have irregularly sized and shaped vesicles and/or canals.

Stach (1956a, figs. 1-4; 1956b, the same illustrations but figs. 5-8) compares by reflected light the stroma of the recent Xylaria with some similar structure from coal. Stach's samples were from Turkey and the Ruhr. We have observed one piece of fusain from our No. 6 coal that is similar to the specimen from Turkey. However, our specimen is somewhat fusiform in shape and true hyphae cannot be proved to be present. Plate 3, figure 7 shows a portion of this fusain specimen in reflected light (left) and in transmitted light (right).

Stach (1956b, figs. 1-4) illustrates four of Pickardt's specimens to which Pickhardt assigned binomials in his thesis (1954). Stach's figure 1 shows two specimens in reflected light described as Crenasclerotes stachii. They contain linear markings that resemble canals observed in resin rodlets (this report, pl 2, fig 4, pl. 4, figs. 2, 5). Stach, however, gave no magnification so that interpretation is difficult. Stach's figures 2 and 3 (1956b) contain entities that could be resin rodlets with vesicles and canals. One is given the binomial Coronasclerotes australis and the other C. polygonalis. The latter is unusual in that it is angular and has three or four lines that more or less radiate from the center. The specimen shown in figure 4 is called Spongiasclerotes funginus. No magnification is given and so it is difficult to interpret.

CONCLUSIONS

1) Resin rodlets occur in Illinois coals as translucent, transitional, or opaque entities.

2) They may be non-vesicled, vesicled, or may have both vesicles and linear voids that we have called canals.

3) Opaque resin rodlets with vesicles and canals superficially resemble structures reported from Paleozoic coals of Europe to be opaque sclerotia. Valid sclerotia have not as of this date been observed in Illinois coals.

4) A single specimen of fusinized cell structure, similar to what has been termed fungal stroma by Stach, has been observed in Illinois No. 6 coal. This specimen has not been proved to be of fungal origin.

5) Polished thin sections viewed with both transmitted and reflected light have yielded more information than either method alone could have provided.

6) Almost without exception, translucent portions of coal can be best examined in transmitted light and, conversely, the reflected-light method can provide much more information in the study of opaque portions of coal.

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