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# Comment about the Origin of Micrinite[1]

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**Abstract**

The granular micrinite in coal may result from the same process that acts during the peat stage to form fusain but dispersed humic matter, rather than organized plant tissue, seems to be involved in micrinite formation. The closely sized micrinite granules that occur in cell lumens of fragments of woody tissue in a few Paleozoic coals are exceptional and may be the result of selective infiltration. The morphologic distinction between micrinite and fusinite should not obscure the fundamental genetic relationship of these macerals.

ON the basis of an electron micrographic study of ultrathin sections, McCartney (1970) has recently concluded that the true sizes of the ultimate particles of granular micrinite range from 0.01 to 0.1 microns, most being in the range 0.04 to 0.06 microns. He has not, however, attempted to explain the origin of the particles and has only briefly mentioned the properties attributed to micrinite. Comments about the origin of micrinite may still be in order.

Our conception of the origin of micrinite is complicated by the conclusions Thiessen and Sprunk (1936) arrived at in the course of petrologic study of the Lower Cedar Grove splint coal in West Virginia. Some occurrences of micrinite in this coal are unusual, and Thiessen regarded them as particularly significant and indicative of the mode of origin of micrinite which he referred to as "granular opaque matter." Micrinite usually occurs irregularly dispersed within the fine-textured attrital component in coal. Most of the thin sections of the Lower Cedar Grove coal have high and characteristically variable concentrations of micrinite, but in a few of the sections, micrinite appears as cell lumen fillings, as shown in Figure 1.

No comparable microscopical study of the occurrence of micrinite has appeared since Thiessen and Sprunk's study (1936); this is the example to which McCartney (1970) refers and which he illustrates, although his studies probably are also based on additional examples. A question arises, therefore, whether this one unusual example is otherwise consistent with other known micrinite occurrences and whether its origin should be critically interpreted as Thiessen suggested. Micrinite is commonly a subordinate component in bright coal, but it is present in almost all coal deposits, and it forms a substantial part of the dull luster attrital varieties.

The writer, and no doubt many others, has had occasion to consult these critical thin sections of the Lower Cedar Grove coal. So far as can be determined by microscopical observation, the micrinite inside the cells is reasonably typical in spite of having a more uniform granularity than is common. So far as testing is concerned (see Fieldner and others, 1938), micrinite in this coal bed has normal physical and chemical properties. Thiessen regarded the granules in the layer illustrated in Figure 1 as the altered residues of cellulosic micellar particles of the type described by Farr and Eckerson (1934) (information presented in a lecture by Thiessen at University of Illinois in 1937). As McCartney has intimated, the size of such particles is difficult to estimate by optical microscopy, and Thiessen and Sprunk's original estimate may have been influenced by the micellar sizes indicated by Farr and Eckerson, which were based on material that was different and more favorable for measurement (juvenile cotton fibers, actively growing *Aspergillus* hyphae, etc.). Granules solidly filling the lumens of moderately compressed coalified tissue are more difficult to measure than granules dispersed in aqueous protoplasm at the tip of a rapidly growing plant hair or fungus hypha, and it is even more difficult to compare their sizes with the sizes of normal dispersed opaque granules occurring in attrital coal.

The coniferous wood in the Lower Cedar Grove coal could not have been a rapidly growing tissue when it became peat, and the granules probably are not relicts of the prior period of active plant growth. The walls that remain are commonly too thick to represent solely the primary walls of cells; some walls are thin and may well have been degraded. Bordered pits, which are features of the secondary wall, are clearly represented in some places (see Fig. 1). Thiessen presumed he had a series of cell-wall degradation stages in which the material of secondary cell-wall layers surrounding the lumen had reverted to a size and granular form approximating the micellar particles from which the secondary wall had been formed. In that case some additional

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vestige of a central lumen should be detectable, roughly centered in the central opaque deposit. On the other hand, some loss of material would accompany extensive degradation, and compression might have obliterated a small lumen, causing it to pass unnoticed in much of the material. The plane of section is oblique to the grain of the coalified wood, so one would not expect regularity, but there should be *some* additional indication of a compressed small lumen in these cells if it ever existed. Except for the outline of the opaque fillings, there is no other trace of an organized lumen in these cells; the intracellular granular opaque deposits themselves are ver probably to be interpreted as lumen fillings in thi moderately distorted tissue. These fillings probabl represent one-half to one-third of the original vol ume of the lumens of these cells, and for the most par the visible walls are derived from both primary an secondary wall layers.

The suggestion that these granules might reflec the original micellar size of cellulose was show to be improbable when Bailey and Kerr (1935) dem onstrated that the individual particles studied b Farr and Eckerson were big enough to extend acros

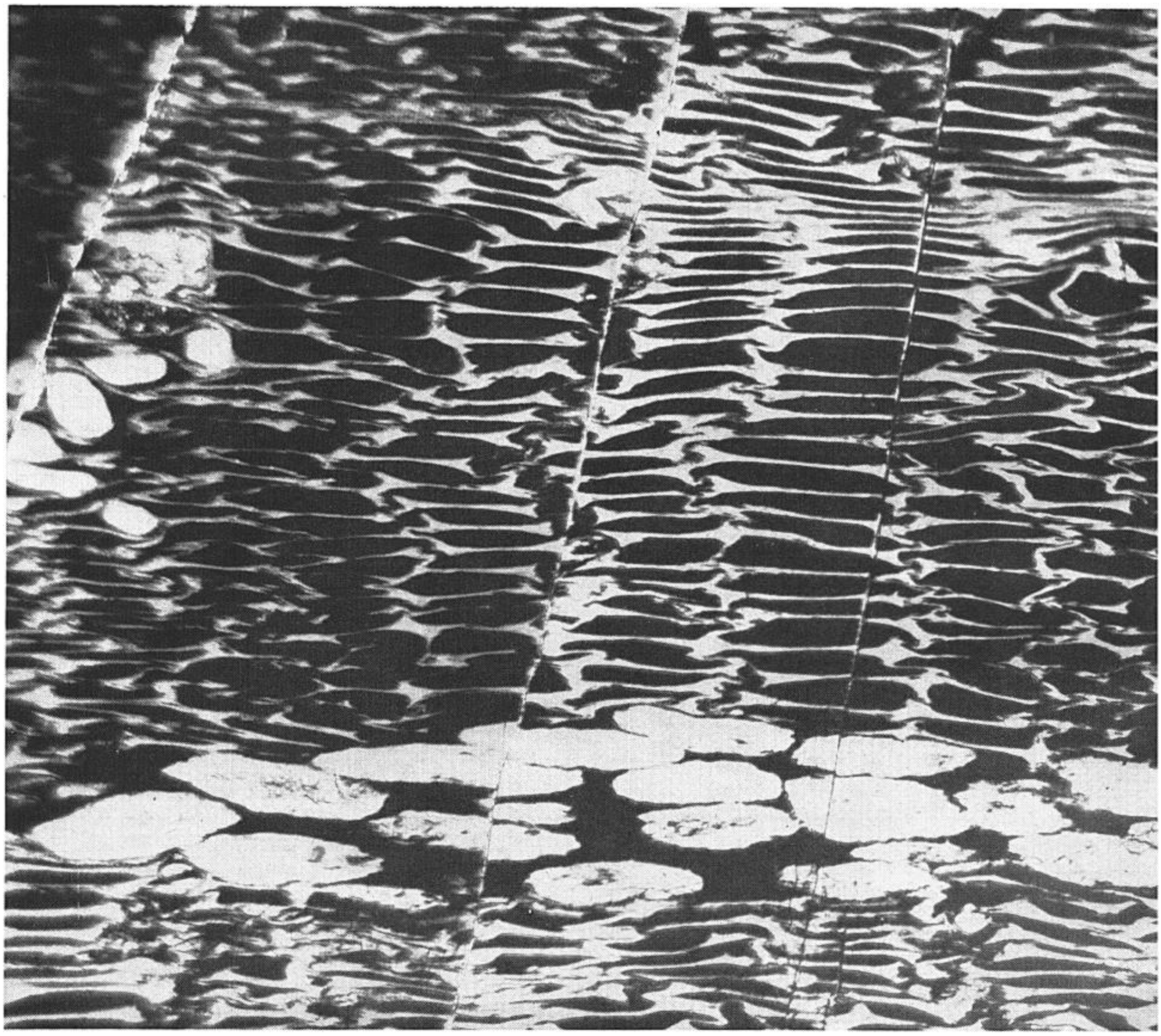

FIG. 1. Micrinite (granular opaque matter) filling lumens of woody cells. The radial plane, as defined by bordered pit and rays, extends vertically across the figure. The "island" of large yellow translucent (white) cellular inclusions is difficult to explain. It may not be related to the wood and merely represent an attrital aggregation between separate woody fragments, such as might be introduced into an original fissure of the wood. The three oblique vertical lines with slight displacement represent cleat planes in the coal. Section 34 of the series from Thiessen and Sprunk column sample, Lower Cedar Grove coal bed, Junior Mine, Red Jacket Consolidation Coal & Coke Co., Red Jacket, Mingo County, West Virginia. (See Fieldner and others, 1938, p. 12.) × 500.

several of the (diurnal?) growth layers in the secondary wall of woody tracheids. Observations on coal can also be interpreted in a different way. Barghoorn (1952) showed that *lignin* residues in cells of decayed wood tended to separate as internal peripheral layers and form a darkened somewhat expanded deposit in the lumens. Thus, a possibility seems to exist that the granular opaque fillings might represent the coalified remnant of lignin residues. Almost certainly this is the appropriate explanation for the collapsed darkened browncoal lumen linings (secondary wall) that Thiessen and Sprunk (1936) illustrated in their Figures 15 and 16. The browncoal lumen linings also correspond well with the distorted lignin residues derived from the secondary walls of coniferous wood in Pleistocene browncoal, as shown in their Figures 13 and 14. In my opinion, however, the browncoal lumen linings do not correspond in form or in origin to the opaque lumen fillings of the Paleozoic West Virginia coal. The wood with lumen fillings does not appear nearly so flattened as the wood showing darkened lumen linings in sections of woody browncoal. The granular texture, which, according to McCartney, is characteristic within a definite range of size, is not evident in the younger, partly decayed woody samples. Thus, the origin of the granular opaque lumen fillings in the Lower Cedar Grove coal still remains essentially unexplained.

Another more general explanation of the origin of micrinite has occurred to me and been tested by observation over a period of several years. In part, this explanation is based on microscopic examination of a large number of examples of boghead and boghead-cannel coals, as well as many other attrital varieties of coal. The bogheads commonly show, surprisingly, a high concentration of micrinite interspersed between remains of the characteristic boghead algae (*Botryococcus braunii* Kuetzing). This association with a colonial alga seems to demonstrate that micrinite commonly originates in a subaqueous environment. The peat of more mixed texture that was transformed to banded coal was deposited in a wet environment rather than the subaqueous one in which *Botryococcus* remains accumulated. All peat accumulations are associated with a relatively high water table and owe their formation and preservation to this cause. In fact, all micrinite occurrences can probably be assumed to have originated under wet conditions that at least approached saturation. However, the reducing, subaqueous environment is fairly typical.

In the study of attrital coal I have also been impressed with the gradual and irregular transitions between what is now known as massive and granular micrinite. This relationship must be considered in characterizing the size of granular micrinite. Thiessen and Sprunk also noticed the irregularity of particle size in some of the attritus in layers of the Lower Cedar Grove coal. Perhaps some of the denser and more massive aggregates of micrinite include fragments of fusinized cell walls as well as micrinite of smaller sizes in an ill-defined arrangement, but not all of them do. That is to say, many "massive" occurrences lack *visible* evidence of granularity, but occasionally the granular appearance is readily defined. Critical observation of opaque materials is difficult, but the difference in appearance probably is significant. Nevertheless, under circumstances in which some form of natural filtration could occur, definite sizing of micrinite particles evidently can be achieved. I believe this is the most likely explanation for the degree of uniformity observed in the lumen fillings of the Lower Cedar Grove coal. Sized micrinite granules could represent an infiltration deposit in lumens of fragmented woody tissue, through microfractures or degraded bordered pit openings, such as those that occur in the woody tissue contributing to the splint coal in West Viriginia. The maximum size of granules might reflect the size of cracks and fissures through which they were infiltrated. However, it is by no means demonstrated and it should not be assumed that the upper size limit of dispersed micrinite in attrital coal is generally so definitely defined.

These observations, and other evidence, have led me to consider that micrinite probably represents one of the alteration products of coagulated humic material that may form in a somewhat variable aqueous medium. Two stages of change are implied following the stage of tissue degradation and humic dispersal. Coagulation of dispersed humic matter (some of it a very highly dispersed colloid) might be caused by electrolytic effects (Eh and pH) within the range of sizes that has been observed. The initial coagulate particles must, of course, be further modified by processes involving condensation and dehydration to form a type of polymeric condensate which has the dense high-carbon character of micrinite. This is a separate problem of organic physical chemistry. Much of the inherent moisture present after initial coagulation would have to be eliminated during the process. It seems clear from the example shown by the Lower Cedar Grove coal section (Fig. 1) that an increase of density occurred in the granules *before* the granules were infiltrated into the cells and that infiltration occurred locally in sufficient quantity to prevent complete cellular collapse. Granulation and condensation of some of the dispersed humic matter of the peat deposit took place very early in diagenesis.

Infiltration would not necessarily be complete or very extensive, and this conforms with observations. The most noteworthy occurrences of micrinite as lumen fillings in the Lower Cedar Grove coal are not very extensive and, despite continued microstudy of coal, such an occurrence has not been fully duplicated. I have occasionally observed less dense intracellular occurrence of granular micrinite in lignite from the Western United States and elsewhere that reminded me of that from West Virginia. In these instances, however, there was no doubt that translucent as well as darker granular material was occupying a cell lumen (*inside* the secondary wall) and that both represented material *that probably was originally foreign* to the cell. Detailed study of the permineralized tissues of the peat stage, as shown by Pennsylvanian-age coal balls, leaves no doubt that infiltration of foreign material into cell lumens can occasionally occur.

Evidence exists that micrinite consists of organic matter that shares some of the attributes of fusinite (Sprunk and others, 1940; Sprunk, 1942). Considering that fusinite is completely inert in hydrogenation, Fieldner and others (1944, p. 35) calculated, for example, that opaque attritus (= micrinite) is about 60 percent inert. Other properties have also been listed in a previous publication (Schopf, 1956, p. 635). In fact, however, micrinite and fusinite are distinguished petrologically on the basis of morphology and nothing more. Micrinite is remarkably recalcitrant to precise experimentation; even small quantities of the most highly selected micrinite concentrates probably include mixtures of other macerals. Such concentrates, however, produce results which can be explained if test samples consist of rather poorly controlled finely dispersed and compacted mixtures of fusinite and vitrinite. On the strength of such data, it seems reasonable to tentatively regard micrinite as a form of *fusinized humic matter*. This, of course, involves the further postulate that some humic matter is susceptible to the same type of alteration that is responsible for fusain. Fusain formation also must involve very early dehydration and condensation in diagenesis.

I have observed so much fusain in coal (the average fusain content of Paleozoic commercial coal is about 6 percent, and some beds include more than 15 percent) and in other types of sedimentary rocks, where it may be variously associated with vitrinized plant fragments without any evidence of ash or burning, that I do not regard the forest-fire origin of fusain as probable. My observations of the geologic occurrences of fusain make an aquatic origin of both fusinite and micrinite seem more reasonable. The inherent similarities between these common components of coal suggests that both formed by the same process, at the same time, in essentially the same way. For those who regard active partial combustion as a probable explanation for the origin of fusain, the relationship between fusinite and micrinite that I have suggested may still seem controversial. It is most difficult to imagine the finely divided micrinite in coal being formed by active combustion. In any event, the general conclusion of Thiessen and Sprunk (1936, p. 315) that micrinite (and other components of opaque attritus) originated "under conditions favorable to the action of biological agencies, thus bringing about a high degree of decomposition and maceration of the plant material" is explanatory and scientifically reasonable.

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