Coal Balls as an Index to the Constitution of Coal*

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The Herrin (No. 6) coal at Nashville in central Washington County is on the whole fairly typical of what is known as "normally banded" bituminous coal. In many places in the mine at Nashville there is in addition an upper bench of coal which on close scrutiny seems to vary considerably from the rest of the bed. The coal is finely striated somewhat like clarain, but is considerably brighter than usual and breaks with a marked conchoidal fracture similar to normal vitrain. It is apparent that this bench of the coal exhibits features commonly given as characteristic for hand specimens of both of these coal constituents. Microscopic observations on thin sections of the top coal reveal that it is composed to a large extent of small vitrainite bands and lenticles. Waxy constituents such as spores and cuticles are rarer than in ordinary clarain and the cell structure is in general more obscure than in the usual vitrainite observed in thin sections of Illinois coals. The coal balls found in this coal at Nashville occur almost exclusively in top coal of this character.

Ever since the important paper by Stopes and Watson, on the *"Origin of Calcareous Concretions in Coal Seams known as Coal Balls"*,[1] it has been evident that coal balls are formed *in situ* during the peat stage of coal formation. Thus the organic remains within these concretions may be taken as a sample of the plant material which went into formation of the surrounding coal. In recent years a great deal of attention has been given to study of the constitution of coal by use of thin sections, and etched, relief polished and simply polished coal surfaces. Coal balls, however, have received but very slight attention toward the elucidation of this subject although they would seem to be particularly suited to precise studies relating to the composition of coal seams. The present study is based on analysis of the tissues preserved in the Nashville coal balls.

Seven coal balls ranging in size from one about 18 inches across down to the smallest about 3 inches in diameter were selected from the hundred or so which have been sectioned. Nitrocellulose peels were prepared from the sectioned surfaces and the actual studies made from the peels. One horizontal line and one vertical line were ruled on peels from the smallest coal balls; several lines were ruled in each direction on the larger specimens. Care was taken to space the rulings so each would transect new material with the exception of where the vertical and horizontal lines crossed each other. The selection of coal balls and subsequent ruling was done with knowledge that some rather infrequent forms were present and an attempt was made to include some representation of each of these. A wholly random selection would probably have caused some types of vegetable material to be omitted. It seemed better to avoid this possibility although the percentage of area occupied by the rarer forms is naturally quite small. A glass millimeter rule was laid along the ruled lines and clamped in place with spring clips during each observation. The peels were examined under the low power Greenough type microscope, the plant material transected by the ruled lines was classified and its distance in each case along the line of observation recorded to estimated tenths of a millimeter. Over three meters of coal ball surfaces were measured in this way. Plant entities of the different classes were then totaled and the percentages of each computed. This data is presented in the accompanying block diagram which is

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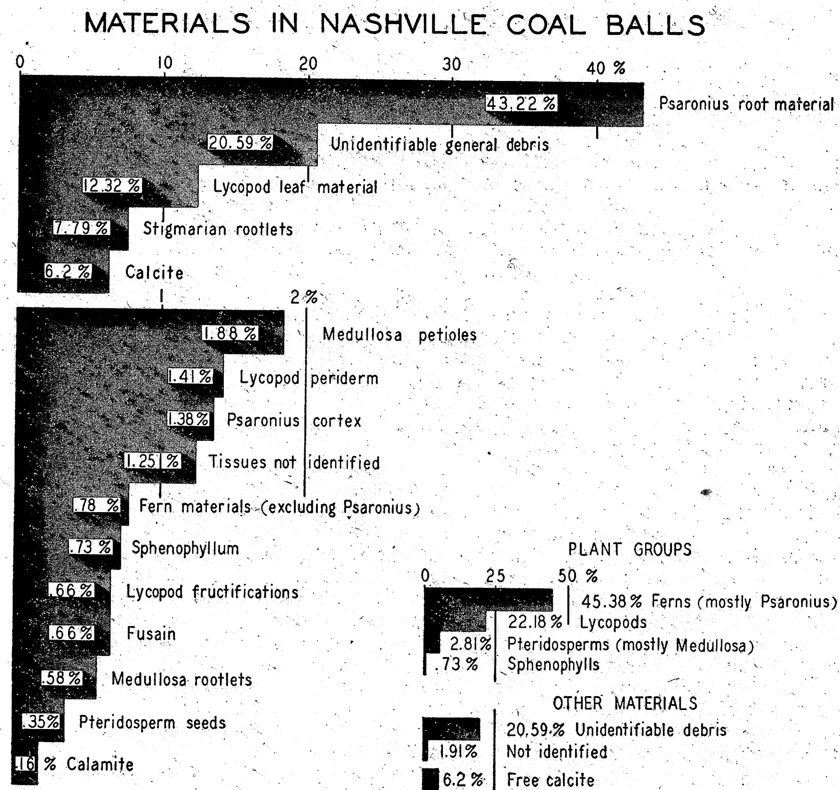
[1] Stopes, M. C. and Watson, D. M. S., Phil. Trans. Roy. Soc. London, B., vol. 200: pp. 167-218, 1909.

largely self explanatory. Percentages of the more infrequent materials (of less than 2 per cent in each case) are blocked in on a larger scale below the 5 more frequent classes. The different plant entitites are combined according to the main groups of plants to which they belong in the smaller diagram at the lower right hand side of the cut.



The most striking thing illustrated by this diagram is the predominance of root material. Rootlets *(Psaronius and Stigmarian)* form 51.01 per cent of the material transected, a far greater percentage than any other individual type of component. The infrequence of woody tissues is also noteworthy and is quite representative of coal balls from this locality. An explanation for the finely striated bright Nashville top coal probably is to be found in the conjunction of these two factors. The rootlets are succulent and composed for the most part of delicate parenchyma cells. The thin-walled cells enclose large air spaces and are very evidently compressible into the characteristic vitrainite strips shown by thin sections from the top coal. These rootlets are lacking in waxy parts such as leaves possess. This, and their manner of introduction into the peat deposit by ramifying growth may account for the dense compact nature of the top coal which gives a good conchoidal fracture similar to that of hand specimens of vitrain.

Unidentifiable general debris is an item of some significance. This material is in the form of disorganized cell and tissue fragments, spores, fusain particles and small masses of humic and waxy material. It bears a strong resemblance to the pulverized residue formed by work of insects in decomposing vegetable matter. No doubt a considerable quantity of this material enters into the constitution of ordinary coal by filling the interstices. The presence of this material in coal contributes to the difficulty of precisely interpreting microscopic preparations of coal by direct observation. In coal balls this comminuted portion is readily distinguished from the more complete plant parts. The amount of unidentifiable debris may reflect the degree to which decomposition was active during early stages of coal formation.

The plant material in the coal balls has not been subject to a greater degree of packing than is evident in the uppermost layers of a modern peat deposit. Consequently many interstitial spaces are filled with free calcite. Such calcite areas free of plant material amount to 6.2 per cent in the specimens studied. This space would be completely eliminated by compaction later in the coal forming process where calcite concretions were not present.

The unidentifiable debris, lycopod leaf material, *Medullosa* petioles and other minor elements probably contribute in the normal formation of clarain when not effectively dispersed by a preponderance of rootlets. Any large slabs of homogeneous tissue either wood or bark would form a corresponding band of vitrain. As shown by the coal balls most of these latter tissues are too small in the Nashville material to form notable macroscopic bands of this sort. Plant organs composed of heterogeneous tissues such as petioles of *Medullosa* probably never would produce normal vitrain bands although under the microscope the individual tissues would be classifiable as vitrainite.

In general it is evident that tree ferns *(Psaronius)* dominated in formation of the Nashville top coal and Lycopods are probably next in importance. However it is somewhat misleading to assign importance in coal formation to particular plant groups as such. A truer relationship would seem to be manifest between the proportionate amounts of essentially similar tissues supplied for coal formation by various plants of the coal swamp flora. The Nashville coal balls seem to indicate that a large amount of succulent root tissues were included in the top coal and it is very likely that this was influential in determining the character of this particular kind of coal.