

*On the frequent occurrence of Ankerite in coal.*

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*MODE of occurrence.*—There occurs frequently in coal a white carbonate which, when it is referred to at all by scientific writers on coal, is usually described as calcium carbonate. It occurs as a rule in the form of thin layers infilling the joint-cracks which lie normal to the bedding-planes, though at times it may be seen infilling other divisional planes which may cut across the bedding obliquely.

The layers flake off very readily, and show in a well-marked way the impress of the joint-faces on which they have been deposited. They are planes of weakness in the coal; and blocks in which they are well developed yield with comparative readiness to mechanical strain and the influence of the weather.

Specimens of coal sometimes contain as much as from 5 to 10 per cent. or more of this mineral impurity, in the form of thin parallel layers. The average thickness of these layers is less than 1 mm., but occasionally they are much thicker. Some varieties of London house-coal contain the mineral in abundance, and one may safely say that many tons of this carbonate are placed weekly on London fires.

*Identity of the mineral.*—Having for some time noticed an abundance of the mineral in my house-coal (stated by the coal-merchant to come from Leicestershire), I was curious to know the exact identity of the mineral, and to what extent, if any, it varied in character. This curiosity was stimulated by the fact that, although it appeared in all cases to be a carbonate, very little of it had the properties of calcium carbonate. It showed little or no effervescence in a cold dilute solution of hydrochloric acid, but dissolved readily on warming. The solution thus obtained was colourless, but gave a strong ferrous reaction, suggesting the presence of far too much iron for an ordinary dolomite. In this respect, indeed, its behaviour was more like that of siderite. The

presence of ferrous iron explains the fact that the mineral turns brown as a result of weathering.

A determination of the specific gravity, using methylene iodide and a Westphal balance, gave the result 3.01. The specific gravity proved to be fairly constant, and suggested that the mineral was probably ankerite. This view was confirmed by the fact that, though white, the mineral is weakly magnetic, and when heated in a reducing flame it becomes black and strongly magnetic. Conclusive proof that the mineral is ankerite is provided by an analysis, given below, of crystalline fragments.

*Crystalline condition of the ankerite.*—The mineral has not crystallized very freely, as is shown by the granular condition of the layers. The clearer layers show a sort of pearly lustre. The stoutly developed grains exhibit curved cleavage-faces resembling those frequently seen in dolomite and siderite.

The granular condition is well seen when the clearer layers are examined microscopically. Between crossed nicols the individual grains show a lack of uniform extinction, a fact in keeping with the curvature of the cleavage-faces. One also sees, between crossed nicols, that the grains as a whole tend to arrange themselves in radial aggregates. The thicker layers, in some cases, show a fibrous structure.

*Chemical composition.*—The crystalline ankerite, having a specific gravity 3.01, gave the following analysis (see also p. 222):

		per cent.
CaO	...	30.75
FeO	...	15.33
MnO	...	1.15
MgO	...	8.96
CO <sub>2</sub>	...	43.99
		100.18

Allocating to the lime, ferrous oxide, magnesia, and manganous oxide the amounts of carbon dioxide required by them, and calculating the molecular ratios, we get:

		per cent.		molecular ratios.
CaCO <sub>3</sub>	...	54.91	...	0.549
FeCO <sub>3</sub>	...	24.70	...	0.213
MnCO <sub>3</sub>	...	1.86	...	0.016
MgCO <sub>3</sub>	...	18.84	...	0.224

This result shows a molecular excess of calcium carbonate over that required by the formula 2 CaCO<sub>3</sub>. Fe(Mn)CO<sub>3</sub>. MgCO<sub>3</sub>, which is the one

usually taken as representing normal ankerite. The amount of this excess corresponds to about 9.6 per cent. of calcium carbonate. One naturally inquires, therefore, as to the condition in which this excess of calcium carbonate is present.

The association of calcite with the ankerite (see below) gave rise to the impression that, in spite of the fairly constant density, the excess of calcium carbonate might be present as definite grains of calcite mixed with the ankerite. Microscopical examination, however, gave no encouragement to this view. To test this point, the ankerite layers were immersed in a solution of logwood and aluminium chloride, calcite being used for control, and no part of the ankerite layers took on the stain. Following on this result, several partial analyses of the ankerite from various specimens were made. The results proved conclusively that the chemical composition of the mineral in that particular lot of house-coal was practically constant, as its fairly constant specific gravity led one to expect.

From these results, therefore, it may be safely inferred that the excess of calcium carbonate over the amount required to form normal ankerite is present in a state of intimate molecular admixture; and that the mineral in this case may be regarded as consisting of about 9.6 per cent. of calcite isomorphously intergrown with about 90.4 per cent. of normal ankerite.

*Minerals associated with the ankerite.*—

*Calcite.*—The amount of free calcite present in the house-coal examined is comparatively small. Moreover, there is no difficulty in distinguishing it from the ankerite. The calcite is characterized by the fact that it frequently forms highly transparent layers. It has evidently crystallized very freely as compared with the ankerite, and, unlike the latter, it forms non-granular layers, in which the cleavages are seen to be continuous over comparatively large areas. The calcite is typical in all its characters, and appears to be quite pure.

Occasionally, calcite and ankerite are seen in the same layer; but in such cases of this as were observed, there was a sharp line of demarcation between the calcite and ankerite portions of the layer. As a rule, however, the calcite and ankerite occur in independent layers.

*Zinc-blende and galena.*—These two minerals occur associated with the ankerite layers. In the specimens examined the zinc-blende was present in comparatively much larger quantity than the galena. One small specimen of coal,  $5 \times 3\frac{1}{2} \times 1\frac{1}{2}$  cm. in size, showed the association of ankerite, calcite, iron-pyrites, and zinc-blende. The layer of zinc-blende

in this specimen occupied an area of  $2 \times 1$  cm., and was about 0.25 mm. thick.

*Barytes.*—A considerable amount of this mineral occurs scattered through the ankerite layers in the form of crystalline plates; and these plates apparently occupy the entire thickness of the layers. On coarsely crushing about 30 grams of the ankerite, it was found that about 1.2 grams (i. e. about 4 per cent.) of the crushings sank in methylene iodide of maximum density. This 1.2 grams consisted almost entirely of plates of barytes, together with a few grains of zinc-blende, galena, and iron-pyrites. The plates of barytes are clear and transparent, but contain numerous lines of inclusions.

Gypsum was not observed in any of the specimens examined. Ordinary dolomite was looked for, but not found.

*Specimens obtained from various coal-fields.*—The mineralogy of house-coal as outlined above having proved so interesting, it seemed worth while to find out a few definite localities where ankeritic coal occurs. Specimens were obtained from the following sources<sup>1</sup>:

Collins Green Colliery, Newton-le-Willows, Lancashire.

Haydock Collieries, near St. Helens, Lancashire.

Allerton Bywater Collieries, Castleford, Yorkshire.

Pleasley Collieries, near Mansfield, Nottinghamshire.

Gwaun-cae-Gurwen Colliery, Llanelly, South Wales.

Donisthorpe Colliery, Ashby-de-la-Zouch, Leicestershire.

In all these specimens, white layers of ankerite were present as in-fillings of the joint-cracks. In the Pleasley specimen, which was one of cannel-coal, calcite predominated over the ankerite, but in the other specimens calcite was absent, or present only in small amount. Specific gravity determinations made on crystalline fragments of the ankerite in various specimens gave results ranging from 3.01 to 3.05.

In the Collins Green specimen, small crystalline fragments, free from impurity, had a specific gravity 3.05. An analysis of the ankerite of this specimen gave the following result:

		per cent.		molecular ratios.
CaCO <sub>3</sub>	...	51.26	...	0.513
FeCO <sub>3</sub>	...	25.21	...	0.217
MnCO <sub>3</sub>	...	1.46	...	0.013
MgCO <sub>3</sub>	...	22.55	...	0.268
		100.48		

<sup>1</sup> I am indebted to the various colliery proprietors for kindly sending specimens. For the Llanelly and Ashby specimens, I have to thank Mr. F. H. Butler and Mr. L. F. Wallis respectively.

The composition in this case corresponds very closely to that of normal ankerite.

The abundance of ankerite in many varieties of London house-coal, and its proved occurrence in specimens from the Lancashire, Yorkshire, Midland, and Welsh coal-fields, indicate that the mineral has a wide distribution in coal.

In accounting for the origin of these ankeritic infillings in the joints of the coal, one thinks naturally of the abundance of carbonates of calcium, iron, and magnesium in the strata overlying the coal-seams, and especially those of the coal-measures themselves. Moreover, barytes, zinc-blende, and galena are known to be freely disseminated through the iron-ores of the coal-measures.

The mode of occurrence and the overwhelming preponderance of ankerite and calcite among the minerals occurring in the joints of the coal point to the immediate origin of these minerals by downward infiltration, i. e. by deposition from solutions which have traversed the strata overlying the coal-seams.

#### *Summary.*

The white layers which occur frequently as infillings of joint-cracks in English coal are miniature mineral-veins. Though averaging less than a millimetre in thickness in ordinary specimens, these veins are in many cases very numerous, and their presence constitutes an important feature in the composition of the coal. As a rule, the dominant mineral is ankerite, which may be normal in composition (i. e. correspond to the formula  $2 \text{CaCO}_3 \cdot \text{Fe}(\text{Mn})\text{CO}_3 \cdot \text{MgCO}_3$ ), or may contain a small excess of calcium carbonate, apparently in the form of an isomorphous growth. Calcite also occurs, and is sometimes the dominant mineral. The other associated minerals are iron-pyrites, barytes, zinc-blende, and galena.

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