PARTICULARS OF THE STRATA SUNK THROUGH AT COTMANHAY COLLIERY, IN THE PARISH OF ILKESTON, IN THE COUNTY OF DERBY.

No. of Str.	Thickness of Strata.		Name of Strata.	No. of Str.	Thickness of Strata.		Name of Strata.
	yds.	ft. in.			yds.	ft. in.	
1	2	0 0	Soil and clay.	30	0	1 2	Coal
2	0	2 6	Coal.	31	0	1 6	Fire clay.
3	1	0 6	Soft clunch.	32	1	1 0	Strong stone clunch. Tub- bing corb.
4	0	2 6	Brown stone.	33	3	1 0	Strong bind with ironstone.
5	2	1 0	Soft bind.	34	0	1 0	Craw stone.
6	0	0 3	Ironstone.	35	0	0 6½	Ironstone.
7	2	1 0	Stone bind.	36	0	2 0	Black shale with large balls of ironstone
8	0	1 1	Grey stone.	37	0	0 4	Stone (bottom ironstone). } Black rake.
9	0	1 8	Stone bind.				
10	7	1 8	Soft soapy bind.	38	0	2 2	Black shale.
11	1	0 6	Soft bind with black bands of thin ironstone.	39	0	1 6	Clunch.
12	0	2 6	Black shale.	40	1	2 0	Stone bind with ironstone.
13	1	0 7	Soft white bind.	41	0	1 2	Coal (Ell).
14	0	1 8	Jay and coal.	42	0	2 6	Strong stone clunch.
15	1	1 8	Dark clunch.	43	3	0 6	Stone.
16	0	1 1	Stone.	44	0	1 0	Clunch.
17	2	1 0	Stone bind with iron- stone beds.	45	0	1 4	Coal.
18	0	0 3½	Ironstone. (Whetstone rake.)	46	2	0 0	Stone clunch.
19	7	2 0	Broad bind with iron- stone beds.	47	5	0 0	Stone and Cank.
20	1	0 4	Black bind.	48	4	0 0	Strong stone bind.
21	0	0 3	Ironstone.	49	0	2 6	Main smut.
22	12	0 0	Broad black bind.	50	0	0 6	Soft clunch.
23	1	2 6	Soft white bind.	51	1	2 8	Stone.
24	1	0 2	Black shale.	52	3	2 6	Strong broad bind.
25	0	2 9	White bind.	53	1	0 2	Main soft coal.
26	0	0 4	Ironstone	54	0	0 4	Bat.
27	1	0 2	Black shale	55	2	0 0	Stony clunch.
28	0	0 4	Ironstone	56	1	0 0	Dark stone.
29	0	1 6	Bind and shale alter- nately.	57	11	0 0	Strong broad bind with small beds of ironstone.
				58	1	0 4	Hard Pothouse coal (main).

Water in these measures.

BRITISH ASSOCIATION MEETING AT CAMBRIDGE.

ON BITUMINOUS SCHISTS* AND THEIR RELATION TO COAL.

By PROFESSOR D. T. ANSTED, M.A., F.R.S.

Rocks in which naphtha, petroleum, rock oil, bitumen, asphalt, and other mineral hydrocarbons are present in sufficient abundance to cha-

* This term, "bituminous schists," is not altogether correct, as the minerals so called do not contain bitumen properly so called. It is, however, in familiar use, and to be preferred to the term "pyro-schist" suggested by Dr. Sterry Hunt, which is equally incorrect, without having the advantage of being familiar.

racterize the deposit or attract attention, are widely distributed in various geological formations, and belong to no special geological period. Crystalline and metamorphic rocks contain chapopote and other forms of bitumen. Rock oil rises in jets from below Silurian, Devonian, and carboniferous rocks in North America. Bituminous limestones and schists occur in Ireland in Silurian rocks, and at Caithness in Devonian rocks, and elsewhere, not unfrequently in the British Islands, in carboniferous rocks. Bituminous schists are important in the Permian series in Germany, and not absent in the New Red Sandstone. The Posidonia schists of the Lias and other beds are highly bituminous, and in the Oolites, the cretaceous rocks, and even in the Tertiaries, especially in Germany, the same bituminous character often prevails. Asphalte is common in some Tertiaries; oil rises from the nummulitic rocks in the East, and in the West Indies we have the Pitch-lake of Trinidad.

In almost all these cases there is a marked distinction between coal, properly so called, and rocks containing the hydrocarbons. Coal is mineral fuel, from which gas can be obtained by destructive, and occasionally certain oils by slow, distillation. The various bituminous rocks or bitumens contained in rocks are not good fuel, but yield largely certain valuable products by slow distillation. Coal can be coked, and the coke, or unburnt carbon, is a valuable fuel. The best and richest of the bituminous schists will not coke, and the result of an attempt to make it is to produce an ash that will not burn.

Notwithstanding this general distinction, coal passes insensibly into cannel coal, or parrot, and this again appears to pass into those peculiar shales rich in bitumen, known in Scotland as Boghead coal or Torbane Hill mineral. These remain debatable ground. Specimens of them, carelessly collected, have been used as fuel; but parts of the same sample are often coal, while the rest is shale, and thus much confusion has arisen as to the fuel question. They are unusually rich in valuable oils, and form a curious passage between two minerals—coal and shale, or schist—that do not generally bear any resemblance.

The distinction between coal and shale is practically very important, and deserves careful consideration. I wish to direct the attention of the Section to some instances that may help to throw light upon the question.

Two localities in France visited by me in the year 1861 are particularly interesting in this respect, and deserve to be better known by English geologists than they seem to be. The rocks in both are of the carboniferous period. The various places where the Lias schists are now worked for distillation, chiefly in Germany, are also worthy of special reference, and the Tertiary bituminous shales of the Rhine are not less important.

At Feymoreau, a short distance from Fontenay-le-Comte, situated in the Bourbon Vendée, between Nantes and Rochelle, there is a small coal-field, almost classical in respect to the important distillation of light oils by slow distillation of rocks containing hydrocarbons. It was at this spot, then far less accessible than it now is, that M. Selligué, so long ago as in 1830, obtained light paraffine oil, heavier illuminating oil, lubricating oil, and paraffine, by a method identical with that patented by Mr. Young in England in 1851. The works were abandoned owing to the want of communication with a market, and M. Selligué afterwards established works, still carried on successfully, at Autun.

The Feymoreau schists underlie coal of a poor quality, and thus replace underclay, but they contain no vegetable impressions or markings. They are of deep black colour, hard and tough when first exposed, but fall to pieces after a time. They burn freely, with much smoke and a long flame,

but cannot be used as fuel. Externally they much resemble the better qualities of Boghead and Torbane Hill mineral, but they yield only about 15 per cent. of light oil on slow distillation. They contain 60 per cent. of ash, and some water. The schists and coal both vary in thickness, and occasionally seem to pass into each other. The schists are in some places 30 to 40 feet thick, but they do not extend far in any direction, or at least if they extend under the coal, which seems probable, they are not everywhere bituminous.

The Feymoreau schists agree with the rich hydrocarbon minerals of Torbane Hill and Boghead, in Scotland, in appearance, geological position, and in the fact that they occasionally alternate with coal. They differ in being far less rich in useful products, and they are always and readily distinguishable as schists, never putting on the appearance of true coal.

On the other side of France is Autun, where there is also a small coal-field; but where bituminous schists of precisely the same nature as those at Feymoreau generally occur in a part of the carboniferous series considerably above the highest coal-seam, and several hundred yards above any workable bed. Below the coal at Autun are coarse grits of granite and gneiss, alternating with black shales.

The bituminous shales are partly quarried, and partly obtained by drifts or headings reaching the more valuable beds. There are about ten feet of bituminous schist at Cordesse, where I visited the operations of mining and manufacture; and of these five only are valuable. Elsewhere the thickness is greater. The broken schist is black; but at the surface, while in the bed, it is reddish-brown. The percentage of bitumen is very variable, sometimes amounting to 50 per cent. of oils of all kinds, but the average not much exceeding 6 at Cordesse, though much higher at Igornay, a place in the neighbourhood where there are also works. At Chamboy, the rich shales are nearer the coal and alternate with it. A grey limestone and grey ironstone occur in some parts of the Autun coal-field.

The Autun mineral oils are moderately rich in paraffine. The shales will not serve as a fuel, and are never so employed. Some beds are rather pyritous, and others abound with vegetable impressions, differing in this respect from the Feymoreau schist. The general resemblance of the Autun specimens to Boghead is very striking.

The manufacture of schist oils and paraffine candles is carried on extensively in more than one place near Autun, and the quantity supplied is large. The methods adopted are the same as those of Mr. Young in general principle, and are said to have been little altered for twenty years.

The Tertiary shales below the brown coal on the Rhine are found in many places to be very bituminous. They have no resemblance to coal or brown coal, and are easily distinguished from the latter. They are thin, and form the *blätte*, or *paper coal*, of the Germans. They are worked near Linz and elsewhere, and are distilled at Beul, opposite Bonn, the products being precisely similar to those obtained from the other bituminous schists, and in nearly the same proportions; but the yield is small.

The Posidonia schists of the Upper Lias are worked at present for economic purposes at Bamberg, in the north of Bavaria, and at Reutlingen, near Tübingen, in Würtemberg. The manufacture of light paraffine oil, heavy oils for burning, lubricating oil, and paraffine, has been carried on with some success by the distillation of these schists for some years. Recently a similar establishment has commenced work with the schists of similar age at Orawicza in Hungary, near the Danube at Baziasch.

The Eisleben shales, amongst which the copper slate is deposited, are not less remarkable for their bitumen. This is apparently very intimately

connected with the schists, well known to geologists for the abundance of fossil fish found in them. In this case, therefore, there seems great probability of the bitumen being of animal origin. No difference has been observed as to the contents obtained on distillation.

The Kimmeridge "coal" is an unmistakable shale, but some portions resemble lignite. It has occasionally been used for obtaining paraffine; but, being much less rich than the Scotch shales, the result is not sufficiently encouraging to justify a continuance of the experiment.

It is possible that some of the other black shales known in various deposits may be found available, and may come into use for distillation.

It is evident that bituminous schists of various dates, some associated with and resembling coal, some even passing into coal, others totally unlike coal in every respect and far removed from it geologically, exist in various countries in considerable abundance, and admit of profitable distillation at low heat for the purpose of manufacturing, illuminating, and lubricating oils and paraffine. It is important that such substances should be recognized as a class and not mixed up with coal, and that there should be some understanding as to what coal is, and in what it differs from the carbonaceous and bituminous minerals with which it is often loaded.

I append a list of a few of the rocks and localities where bituminous schists and their products are obtained. It would certainly admit of great expansion :—

<i>Lower Silurian</i>	. Ireland and America (Utica Slates).
<i>Upper Silurian</i>	. Ditto.
<i>Devonian</i>	. . . Caithness schists. Shale with 30 per cent. of organic matter, and a residue of 8 per cent. of carbon. American rock oils (some localities).
<i>Carboniferous.</i>	{ American rock oils. Torbane Hill and Boghead, etc., minerals.
Lower, Middle, and Upper	{ Parrots and cannel coal. Terre houille of Belgium. Vauvont or Feymoreau schists, La Vendée.
Above coal	. Autun schists.
<i>Permian</i>	. . . Eisleben shales and Kupfer schiefer. 5 to 20 per cent. of light oils. Mansfeld schists.
<i>Lias</i>	 Posidonia schists, worked in Northern Bavaria, at Banz; in Würtemberg, near Tübingen; at Oravieza in Hungary.
<i>Oolites</i>	 Kimmeridge shale (Dorsetshire), a shale used for distillation to obtain paraffine, and occasionally serving as a very poor fuel.
<i>Cretaceous</i>	. . . Various schists in the Alps.
<i>Tertiary</i>	. . . Paper "coal," near Bonn (under the brown coal). Deposits beneath nummulitic rock in the East.

I have no doubt that a little research would remind us of many other localities, but these are enough to show the presence of a certain quantity of hydrocarbons (the result, there can be no doubt, of organic matter) exhibited in this form, a part of which has sometimes been converted into coal, but which is more usually quite distinct from coal and unconnected with it.

I have not alluded in this paper to the surface accumulations of petroleum or to the asphalté with sand and in sandstone, nor to the chapapote of Cuba—a very remarkable deposit, deserving distinct notice. I have confined my remarks to the bituminous schists, to bring the subject within compass.