Fusain[1]

S. W. Parr, H. C. Hopkins, and D. R. Mitchell

University of Illinois, Urbana, Ill.

FUSAIN, or mother-of-coal, is receiving more attention than formerly because of the various properties now being assigned to it. Certain studies in the laboratories at the University of Illinois have developed additional data which afford further information of value.

The bedding planes which are made of fusain are usually very thin but at times may be found in lenses 8 inches in thickness, although such deposits are exceptional. It is generally soft, friable, leaves soot marks on the fingers, and is more or less unconsolidated as compared with the rest of the coal in the bed. Because of the porous character of fusain in its normal state, it affords an easy passageway for infiltrating waters, and such waters, especially in the thicker bands, are very apt to deposit mineral matter from solution. In this way there will naturally result hard and dense layers quite in contrast to the soft friable layers that characterize most of the cleavage planes. These very thin layers are, therefore, usually the most friable and samples of such material can be removed in sufficient amount for analysis by use of care and a good brush.

It is not intended to discuss here the probable origin or method of formation of this material, but some information in that direction, as well as concerning its properties and chemical characteristics, may be gained by making the usual analysis and calculations for indicating the unit volatile and fixed carbon, as well as the unit B. t. u.

Mines were visited and lumps of freshly mined coal were selected containing fusain bands. Three or four lumps were selected from each mine. These samples were further sampled in the laboratory to obtain fusain samples free from other coal constituents, such as bright coal and dull coal. The lumps were broken along the bands of fusain and clean pieces selected, these pieces further broken down, and samples showing the presence of bright or dull coal discarded. Two kinds of fusain were noted during sampling operations, one a much harder variety than the other, and these two kinds were kept separate and are listed in the accompanying table as "soft" or "hard."

Table I—Proximate Analyses of Fusain from Moisture-Free Illinois Coal

Sample	County	Coal Bed	Volatile Matter	Fixed Carbon	Ash	Sulfur	Fuel Value	Unit Coal	Variety Fusain
			%	%	%	%	B. t. u.	B. t. u.	
7	Vermilion	6	23.95	59.20	16.85	5.73	12,080	14,980	Hard
8	Vermilion	7	26.95	54.25	18.90	8.18	11,800	15,100	Hard
9	Vermilion	6	20.75	71.45	7.80	2.58	13,600	15,050	Hard
10	Vermilion	6	13.78	79.24	6.98	1.56	13,710	14,860	Soft
22	Jackson	2	15.79	69.01	15.20	6.57	12,197	14,833	Soft
23	Jackson	2	13.00	80.33	6.67	1.78	13,794	14,913	Soft
25	Jackson	2	18.69	76.86	4.45	0.75	14,165	14,903	Soft
26	Jackson	2	15.22	71.74	13.04	4.75	12,560	14,851	Soft
29	Perry	6	21.04	65.34	13.62	5.97	12,291	14,635	Soft
30	Randolph	6	18.83	68.63	12.54	1.28	12,795	14,837	Hard
31	Jackson	6	18.30	71.80	9.90	0.77	13,295	14,912	Hard
Average			18.74	69.80	11.44	3.63	12,930	14,890	

The accompanying tables give the results of chemical analyses of eleven different samples from different parts of the state, taken from three different coal beds. These results are on a dry or moisture-free basis. One condition of fusain not given in the tables, but calling for reference, is the amount of moisture in the air-dry condition. Coals of the Illinois type when brought to the air-dry condition in the laboratory will contain from 2 to 6 per cent moisture, and the samples of fusain under similar conditions contained from 0.5 to 2.0 per cent moisture. This would be indicative of the porosity of fusain as compared with the bright and dull coal, since it gives up its moisture much more readily and completely than the other banded constituents.

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Table II—Unit Volatile Matter

Sample	Unit Volatile Matter	Sample	Unit Volatile Matter
7	27.30	23	19.26
8	31.32	26	15.89
9	21.79	29	22.64
10	15.59	30	21.27
22	16.36	31	20.15
		Average	20.44

The volatile matter percentages were from 15 to 20 per cent lower than is general for the rest of the coal bed. It would appear from the data that the volatile matter of fusain is usually about 20 per cent, and the average for ten samples was found to be 20.44 per cent. Ash percentages range from a low of 4.45 to a high of 18.80 per cent. The statement is frequently made that the fusain of the banded constituents of coal contains more ash than the other bands, but this may not always be true as seen from the above. In fact, it would appear that fusain was originally a high grade low-ash material but, owing to infiltration of impurities because of its porous structure, the ash content was increased. Sulfur percentages follow rather closely the ash percentages—that is, a low-ash fusain is generally low in sulfur and, conversely, a high-ash fusain is generally high in sulfur.

The most striking feature to be noted here is the fairly consistent character of the material, and especially the uniformity of the unit B. t. u. values, considering that samples were taken from all parts of the state as well as from different beds. While the material is non-coking, it has too high and too consistent a volatile constituent to admit of its being the product of fire, as might be inferred from some designations applied to it. One of the striking characteristics of fusain is its absorption of water, and this has been referred to elsewhere as furnishing the mechanism for the slacking of bituminous coals (*2*).

Sinnat (*3*) has devised a method for determining the relative volume of absorption on the part of fusain for water and solutions, as compared with the coal substance with which it is associated. In some tests he found that fusain absorbed over 100 times as much as the coal in the same length of time. It is a well-recognized fact that fusain is unevenly distributed, hence we would expect an uneven absorption of water on the part of samples of coal from the same mine. It also indicates that underground waters will travel the most accessible fusain bands. The deposition of mineral salts which accompanies this process readily accounts for the high ash of some of the fusain bands.

The unit volatile matter, calculated by the method of Parr (*1*), gives the amount of volatile matter in the pure coal substance. The lowest value found is 15.59 and the highest 31.32, with an average of 20.44. However, the chief value of the unit volatile matter content lies in the fact that it would seem to refute completely the forest fire theory for the formation of fusain. The unit volatile matter would certainly be very much lower if fusain were formed because of forest fires sweeping over the coal-forming swamps.

Fusain is entirely lacking in agglutinating power. No coke-buttons were formed during the determinations for volatile matter. The residue from the crucible is a fine powder with no evidence of any coking tendency.

Table III—Proximate Analyses of Moisture-Free Face Samples from the Same Mines as Fusain Samples of Table I

Sample	County	Coal Bed	Volatile Matter	Fixed Carbon	Ash	Sulfur	Fuel Value	Unit Coal
			%	%	%	%	*B. t. u.*	*B. t. u.*
7-*a*	Vermilion	6	40.90	54.45	4.65	2.21	13,555	14,297
8-*a*	Vermilion	7	41.64	49.59	8.77	3.46	12,904	14,310
9-*a*	Vermilion	6	39.35	53.40	7.25	1.70	13,390	14,189
22-*a*	Jackson	2	42.60	52.84	4.56	1.06	13,320	14,039
23-*a*	Jackson	2	33.28	48.58	18.14	3.25	11,577	14,705
25-*a*	Jackson	2	39.69	56.72	3.89	0.75	13,857	14,501
26-*a*	Jackson	2	43.62	52.54	3.84	1.94	13,649	14,295
29-*a*	Perry	6	44.48	44.80	10.72	2.62	12,427	14,231
30-*a*	Randolph	6	43.80	42.43	13.77	2.77	12,103	14,312
31-*a*	Jackson	6	41.49	47.56	10.95	1.06	12,672	14,405
Average			41.08	50.29	8.65	2.08	12,945	14,328

Table III gives some information concerning the coal substance proper, face samples of which were obtained in the usual manner when the fusain samples were taken. A striking difference is shown between the fusain and the total coal values for ash and sulfur. The unit coal B. t. u. values also are consistently higher for fusain. Other analyses of coals from the counties and beds given in this paper may be found in numerous publications of the Engineering Experiment Station, University of Illinois, and in Bulletin 56 of the Illinois State Geological Survey, Urbana, Ill.

The authors wish to emphasize the fact that these results, though meager, may point the way to other investigators and certainly shows the need for further fundamental study of the chemical properties of the various bands common to bituminous coal of the Illinois types—namely, vitrain, or bright coal (anthraxylon), dull coal (attritus), and fusain (mineral charcoal).

Literature Cited

(1) Parr, J. Ind. Eng. Chem., **14**, 921 (1922).
(2) Parr and Mitchell, *Ibid.*, **22**, 1211 (1930).
(3) Sinnat, *Trans. Inst. Mining Eng.*, **62**, 156 (1921).

An Electrically-Heated Melting Point Apparatus[1,2]

Charles E. Sando

Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C.

The apparatus shown in the accompanying illustrations has been used for a number of years with such satisfactory results that its general description seems worth while.

It consists essentially of an electrically-heated modified Thiele-Dennis melting point tube, *A*, a lead container, *B*, filled with sand to prevent damage by sulfuric acid in case of breakage, a lamp, *C*, and a rheostat, *D*, all suitably mounted for convenience and portability in the laboratory.

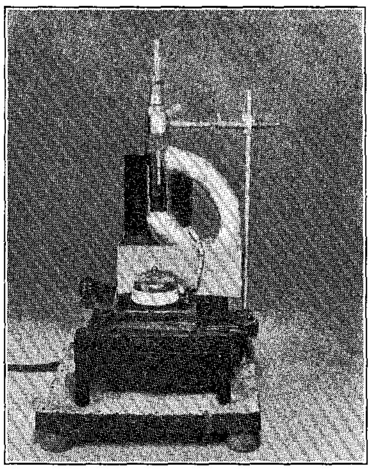

Figure 1—Melting Point Apparatus

The Thiele-Dennis tube is constructed of Pyrex glass and modified by having a smaller tube, *E*, which is closed at the lower end, sealed within the vertical portion, and extends 1 or 2 inches (25.44 or 50.8 cm.) below the point of attachment, *F*, of the side arm. This modified form thus constitutes a combination Roth-Thiele-Dennis apparatus. The side arm, *G*, is wound in the region of its lowest portion with asbestos-covered chromel heating element and insulated with asbestos. The asbestos covering and a portion of the vertical tube are painted with aluminum paint to reduce radiation to the minimum.

Employing a mixture of sulfuric acid and potassium bisulfate as the heating liquid makes it possible to reach a temperature of about 300° C., provided the absorption of moisture by the liquid is prevented by means of a calcium chloride tube at *H* when the apparatus is not in use. With the particular apparatus here illustrated and with a current of 1.4 amperes, about 6 minutes are required to raise the temperature in the inner tube from room temperature to 100° C., about 12 minutes from room temperature to 200° C., and about 25 minutes from room temperature to 300° C. Any desired range in temperature under 300° C., and the rapidity of change from one temperature to another are easily regulated by means of the adjustable rheostat. The melting of the substance itself is plainly observed with the aid of light coming through the small hole in *I* from the lamp *C*.

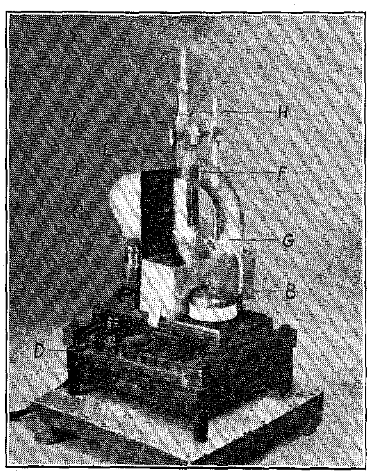

Figure 2—Another View of Melting Point Apparatus

[1] Received October 7, 1930.
[2] Contribution No. 91 from Food Research Division.