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Technical Report

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PETROGRAPHIC CHARACTERIZATION OF
KENTUCKY COALS:
QUARTERLY PROGRESS REPORT

MASTER

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INTRODUCTION

The project "Petrographic Characterization of Kentucky Coals" consists of research in three specific areas of coal petrology: spectral fluorescence of liptinite macerals, properties of semi-inert macerals, and size/form/microlithotype association of pyrite/marcasite. Additional research on the Mannington (No. 4, also known as Mining City and Lewisport) coal will apply techniques developed in the first three areas. Certain suites of coals from other states will also be studied to expand the variability in the samples.

SPECTRAL FLUORESCENCE OF WESTERN KENTUCKY COALS

The petrology laboratory at the University of Kentucky's Institute for Mining and Minerals Research has both a Leitz MPV-II and a Leitz MPV-Compact equipped for spectral fluorescence. Both units have been repaired and recalibrated during the last quarter, correcting problems which had previously prevented us from obtaining valid results. For purposes of internal consistency, only the MPV-Compact is being used in this study.

Work has been completed on most of the western Kentucky coals selected for investigation, and the results will be reported next quarter. In a few cases substitution of coals has been necessary due to a lack of a sufficient number of the proper type of sporinite. Although we do not use megaspores in the compilation of the fluorescence parameters, we have noted that the megaspore spectrums fall within the range of miospore spectrums. The spectrums measured in our laboratory differ from those reported elsewhere for coals in the same rank range. While some of the difference in results may be due to the difficulty in obtaining corrected spectra from measured values, it is also possible that the difference may be attributable to the problems in comparing coals from different basins. With this in mind we will be studying a set of high volatile A and medium volatile bituminous coals from western and north-central Pennsylvania. High volatile A bituminous coals overlap the upper rank range for western Kentucky, and medium volatile bituminous coals will significantly expand the range of our study. The Allegheny

Formation coals from Pennsylvania also overlap the age of most of the western Kentucky coals so that the identical spore species should be expected, an important consideration if exact comparisons are to be made.

NATURE OF SEMI-INERT MACERALS IN KENTUCKY COALS

Study on the nature of pseudovitrinite continued with petrographic work determining the percent and reflectance of pseudovitrinite in eastern and western Kentucky coals. However, the primary accomplishment towards a better understanding of pseudovitrinite involved discussions with other coal petrographers. These discussions included the participation in an international "round-robin" concerned with establishing uniformity in the nomenclature of all types of vitrinite.

Other ideas on the nature of pseudovitrinite were discussed at the 1981 meeting of the North American Coal Petrographers (hosted by the Institute for Mining and Minerals Research in Lexington on December 2-4). Representatives from National Steel (Weirton, West Virginia) and Union Oil (Brea, California) (the latter petrographer discussed work done while at The Pennsylvania State University) have conducted research on the coking behavior of pseudovitrinite and cited examples where pseudovitrinite does not react during the coking process. Senftle (of Union Oil) did note that pseudovitrinite will often react when subjected to the hydrogenation of coal liquefaction. Representatives of Bethlehem Steel (Bethlehem, Pennsylvania) (where early work on pseudovitrinite was conducted) have suggested that differences in original plant composition, rather than differential coalification of similar humic materials, may be responsible for the development of pseudovitrinite. Accordingly, they suggest a study of lignites, in which original plant material and structure

is better preserved, may provide clues to the origin of pseudo-vitrinite. A diversity of opinions on pseudovitrinite will be sought throughout this study so that our research can reflect the information needs of the coal petrographers concerned with the origin and behavior of macerals.

PYRITE IN WESTERN KENTUCKY COALS

Pyrite (and marcasite) has been characterized in western Kentucky coals using three parameters of size categories (rather than absolute size), morphology, (framboidal, euhedral, dendritic, cleat, and massive), and microlithotype (organic) association.

The study to date has focused on the Springfield (No. 9) and Herrin (No. 11) coals. Eighteen samples (Table 1) were collected within the coal field (Figure 1) to represent each coal in each of three separate structural basins (Henderson Basin, Webster Syncline, and the Moorman Syncline).

The purpose of this study phase is to analyze pyrite morphology, size, and microlithotype association in such a way as to determine if there is a pattern of distribution across the Western Kentucky Coal Field.

Each mine is represented by three whole-channel samples with two mines per basin (No. 9 and No. 11) to provide a balanced sample set for statistical analysis. The sample numbering system reflects the same numbers used on the locator map (Figure 1).

For the initial analysis, the variables used for statistical testing were framboidal, dendritic, and euhedral pyrite forms occurring in size categories of $<5\mu\text{m}$, $5-10\mu\text{m}$, and $10-40\mu\text{m}$, as found in the combined microlithotypes of vitrite and clarite. The percentages of these variables have been calculated based

on the total pyrite content of each sample (1000 counts), and these figures are presented in Table 2.

Data were analyzed on a Hewlett-Packard 9815 calculator. Company developed software was used to run both the F-tests and t-tests discussed in this paper.

The percentages of pyrite (from Table 3) were subjected to an F-test. Hypothesis testing was employed to determine the relationship of pyrite populations as found in the channel samples (channels represent the entire population from which the samples are drawn). For the first study, population is defined as pyrite morphology exposed on the surface of a sample pellet.

The results of these tests are seen in Table 4. For this study, the null hypothesis states that the populations have equal variances and are the same throughout the field. For several populations the calculated F value exceeds the table value (Arkin and Colton, 1950, Table 13), and the null hypothesis is rejected (the populations are not equal). These values indicated that at the 95% level of confidence (some at the 99% level of confidence) there are significant differences in the occurrence of pyrite populations in the Western Kentucky Coal Field.

The occurrence of all three size fractions of framboidal pyrite displays a systematic change across the coal field. In both the Springfield (No. 9) and the Herrin (No. 11) coals, framboidal pyrite shows a marked decrease in abundance from the Henderson Basin to the Moorman Syncline (Table 4). The decrease might be in part present because framboids in the Moorman Syncline frequently appear as recrystallized spheres and are

counted in the massive category.

Dendritic pyrite also demonstrates a trend across the field (Table 4), however, the pattern is not as clear as that of framboidal pyrite. Within the No. 11 seam, dendritic pyrite remains relatively constant among basins with a slight increase in abundance as dendritic size increases. The No. 9 coal shows a more obvious pattern of variation. In the <5 m and 5-10 m category, there is little variation among basins; however, in the 10-40 m fraction, Basin 3 shows a greatly increased percentage of dendritic pyrite.

The occurrence of the euhedral pyrite fraction remains relatively constant through the coal field (Table 4) among the basins and between the seams.

Total pyrite counts (Table 5) were also subjected to an F-test. Analysis of the data resulted in the rejection of the null hypothesis that the populations were the same. The results from Table 5, show significance levels of 95% among basins and 99% between seams. Again, these values indicated that there are significant differences in the abundance and patterns of occurrence of the pyrite populations in western Kentucky.

Statistical analysis has provided some important information dealing with the relationship of sulfur distribution and pyrite morphology. The abundance and types (morphology) of pyrite present in the Springfield (No. 9) and Herrin (No. 11) coals, do not appear to be directly controlled by the percentage of sulfur occurring in the same sample. Whatever does control pyrite morphology seems to be outside the influence of sulfur content

in the coal.

At this time, the study of western Kentucky coal is being expanded to include samples from preparation plants. Both the No. 9 and No. 11 (as well as other coals) have been collected from four basins (including the Owensboro Basin) and are presently being analyzed using three parameters of size, morphology, and microlithotype association.

It is expected that, with an expanding data base, more information will be generated which could prove to be beneficial in planning the best methods of exploiting the valuable high sulfur coals of western Kentucky.

In order to enhance our knowledge of the influence of depositional environments on the nature of the pyrite in coals, a study will be conducted on a set of samples from Pennsylvania. The Lower Kittanning coal has been extensively studied, and in our collection we have a set of samples (collected in 1977 by Roger Hornberger and others at The Pennsylvania State University) from this seam representing four mines with three channels each. The mines in Somerset, Jefferson, Armstrong, and Butler counties were selected to represent a known variation in the depositional environment. The sites suspected to represent marine depositional environments would be expected to compare well with the western Kentucky sites discussed above (but also noting the variation seen between sites within single coals in western Kentucky).

EXPANDED STUDY

The study of the Mannington (No. 4) coal of the Tradewater Formation in western Kentucky will provide a basis to further apply the principles learned in the above studies, particularly in the study of pseudovitrinite and of pyrite variations. The No. 4 coal is known to exhibit variations in total sulfur from greater than 3% in Muhlenberg County to less than 1% (also less than 3% ash) in adjacent Butler County, and discussions with Allan Williamson, John Beard, and David Williams (1981, at Henderson office, Kentucky Geological Survey) further confirm that this coal was deposited under a wide variety of environments. In addition to providing an opportunity to further test the facets of petrography we are investigating, the study of the No. 4 coal should provide important information on the nature of a coal which is likely to become a more important resource in the future.

REFERENCE CITED

Arkin, H., and Colton, R. R., 1950, Tables for statisticians
(1963 edition): New York, Barnes and Noble, 168 p.

FIGURE 1. SAMPLE LOCATION

Table 1. Coal Sample Identification

<u>Sample Number</u>	<u>Seam</u>	<u>Quadrangle</u>	<u>County</u>	<u>Sample Type</u>
KCER 1-3	W. Ky. #11	Waverly	Union	Channel
KCER 4-6	W. Ky. #11	Providence	Webster	Channel
KCER 7-9	W. Ky. #9	Nebo	Webster	Channel
KCER 10-12	W. Ky. #9	Henderson	Henderson	Channel
KCER 13-15	W. Ky. #9	Millport	Hopkins	Channel
KCER 16-18	W. Ky. #11	Millport	Hopkins	Channel

Table 2. Pyrite Form-Percent in Vitrite plus Clarite

	<u>Seam No. 9</u>	<u>Basin 1</u>	<u>Basin 2</u>	<u>Basin 3</u>
Fr. <5 μ m	3.65	6.13	3.73	1.10%
Fr. 5-10 μ m	7.62	12.13	8.10	2.63
Fr. 10-40 μ m	2.07	3.27	1.97	0.97
Eu. <5 μ m	10.71	13.03	10.0	9.1
Dend. <5 μ m	1.22	1.17	0.6	1.9
Dend. 5-10 μ m	5.0	5.27	4.13	5.6
Dend. 10-40 μ m	10.01	7.6	7.4	15.3

	<u>Seam No. 11</u>	<u>Basin 1</u>	<u>Basin 2</u>	<u>Basin 3</u>
Fr. <5 μ m	3.73	4.97	3.83	2.40
Fr. 5-10 μ m	8.11	10.83	9.97	3.53
Fr. 10-40 μ m	3.77	4.6	4.57	2.13
Eu. <5 μ m	11.7	9.0	13.37	12.73
Dend. 5-10 μ m	0.2	0.1	0.43	0.07
Dend. 5-10 μ m	1.01	1.17	0.6	1.27
Dend. 10-40 μ m	2.76	3.4	3.2	1.67

Fr - framboidal
 Eu - euhedral
 Dend - Dendritic

Table 3. Pyrite and Sulfur Occurance in Vitrite plus Clarite

<u>Seam</u>	<u>Basin</u>	<u>Channel</u>	<u>% Fr.</u>	<u>% Eu.</u>	<u>% Dend.</u>	<u>Total</u>	<u>% Sulfur Total</u>	<u>% Sulfur Pyritic</u>
No. 9	1	1	15.7	13.7	11.5	40.9	5.00	2.17
No. 9	1	2	18.4	12.6	19.2	50.2	4.70	2.25
No. 9	1	3	30.5	12.8	11.4	54.7	3.70	1.59
No. 9	2	4	12.4	10.8	13.4	36.6	3.82	1.64
No. 9	2	5	14.0	10.4	10.2	34.6	3.55	1.47
No. 9	2	6	15.0	8.8	12.8	36.6	4.24	1.94
No. 9	3	7	4.4	8.4	22.4	35.2	5.15	2.41
No. 9	3	8	6.7	10.6	22.6	39.9	4.22	1.92
No. 9	3	9	3	8.3	22.6	33.9	3.68	1.77
No. 11	1	10	19.2	9.3	2.2	30.7	5.41	2.57
No. 11	1	11	23.8	9.1	6.6	39.5	5.01	2.32
No. 11	1	12	18.2	8.6	5.2	32.0	5.48	2.59
No. 11	2	13	11.4	13.4	3	27.8	6.45	3.11
No. 11	2	14	14.6	10.3	5.2	30.1	5.38	2.70
No. 11	2	15	29.1	16.4	4.5	50.0	3.46	1.43
No. 11	3	16	5.8	15.4	2.6	23.8	4.36	1.66
No. 11	3	17	8.4	11.4	3.8	23.6	3.89	1.56
No. 11	3	18	10.0	11.4	2.6	24.0	5.24	2.42

Basin 1 - Henderson Basin
 2 - Webster Syncline
 3 - Moorman Syncline

Table 4. PERCENTAGE PYRITE MORPHOLOGY NO. 9 AND NO. 11 VITRITE PLUS CLARITE (F-TWO-WAY ANALYSIS OF VARIANCE)

<u>Factor</u>	<u>Degrees of Freedom</u>	<u>Sum of Squares</u>	<u>Mean Square</u>	<u>F</u>	
Framboidal Pyrite					
C-Seam	1	23.1200	23.1200	0.8174 #	
R-Basin	2	661.2211	330.6106	11.6885 **	F2, 12
sxb	2	27.0900	13.5450	0.4789 #	
error	12	339.4200	28.2850		
Dendritic Pyrite					
C-Seam	1	677.1200	677.1200	136.6692 **	F1, 12
R-Basin	2	68.0833	34.0417	6.8709 **	F2, 12
sxb	2	120.4233	60.2117	12.1531 **	F2, 12
error	12	59.4533	4.9544		
Euhedral Pyrite					
C-Seam	1	4.4006	4.4006	1.4734 #	
R-Basin	2	2.0844	1.0422	0.3490 #	
sxb	2	56.8044	28.4022	9.5097 **	F2, 12
error	12	35.8400	2.9867		

* Significant at 5% level

** Significant at 1% level

Not significant

(Arkin and Colton, 1950, Table 13)

Table 5. PERCENTAGE TOTAL PYRITE COUNTS NO. 9 AND NO. 11 COALS
VITRITE PLUS CLARITE (F-TWO-ANALYSIS OF VARIANCE)

<u>Factor</u>	<u>Degrees of Freedom</u>	<u>Sum of Squares</u>	<u>Mean Square</u>	<u>F</u>	
C-Seam	1	365.4006	365.4006	9.4316 **	F1, 12
R-Basin	2	381.0633	190.5317	4.9179 *	F2, 12
sxb	2	187.0544	93.5272	2.4141 #	
error	12	464.9067	38.7422		

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