Energy

F
O
S
S
I
L

190
4/10/84
LB

1

DR-2 250-0

DOE/PC/30223-11
(DE84007013)

PETROGRAPHIC CHARACTERIZATION OF KENTUCKY COAL

**Final Report, Part III: Petrographic Characterization of the Upper Elkhorn
No. 2 Coal Zone of Eastern Kentucky**

By
Richard P. Raione
James C. Hower

January 1984

Work Performed Under Contract No. FG22-80PC30223

Institute for Mining and Minerals Research and
Department of Geology
University of Kentucky
Lexington, Kentucky

Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Printed Copy A09
Microfiche A01

Codes are used for pricing all publications. The code is determined by the number of pages in the publication. Information pertaining to the pricing codes can be found in the current issues of the following publications, which are generally available in most libraries: *Energy Research Abstracts (ERA)*; *Government Reports Announcements and Index (GRA and I)*; *Scientific and Technical Abstract Reports (STAR)*; and publication NTIS-PR-360 available from NTIS at the above address.

PETROGRAPHIC CHARACTERIZATION OF
KENTUCKY COAL:
FINAL REPORT: PART III:
PETROGRAPHIC CHARACTERIZATION OF THE
UPPER ELKHORN NO. 2 COAL ZONE
OF EASTERN KENTUCKY

by

Richard P. Raione
University of Kentucky
Department of Geology
Lexington, Kentucky 40506

James C. Hower
University of Kentucky
Institute for Mining and Minerals Research
and
Department of Geology
Lexington, Kentucky 40506

Prepared under
U.S. Department of Energy
Contract DE-FG22-80 PC30223
Report No.: DOE/PC/30223-11
January 1984

ACKNOWLEDGEMENTS

We would like to recognize the United States Department of Energy (USDOE) for funding under project number DE-FG22-80-PC30223 (which examines the petrographic characterization of Kentucky coals). Much gratitude is expressed to Dr. John C. Ferm and Dr. William Dennen for their expertise and contributions. Appreciation also goes to the following persons of the University of Kentucky Institute for Mining and Minerals Research (IMMR): Eric Trinkle, Garry Wild, Kathleen Frankie, Faith Fiene, and Carla Pryor of the Coal Petrology Section; Margaret Grider and others of the Inorganic and Classical Analysis Section; and members of the Computer and Sample Preparation sections. Indebtness is also expressed to Dr. James Cobb, Don Chesnut, Wayne Frankie, Richard Smath, and others of the Kentucky Geological Survey (KGS) for their professional assistance and interpretations. Finally, we would like to thank Dr. Gerald Weisenfluh of the University of Kentucky Department of Geology for his constructive comments.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	ii
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	v
LIST OF TABLES.....	vii
LIST OF PLATES.....	viii
ABSTRACT.....	ix
INTRODUCTION	
Purpose.....	1
Study Area.....	2
General Stratigraphy.....	3
Regional Structures.....	3
Previous Studies.....	8
FUNDAMENTALS OF COAL PETROLOGY	
Three Maceral Groups.....	10
Description and Origin of the Maceral Types.....	10
Rank Determination by Vitrinite Reflectance.....	13
Vicker's Microhardness.....	14
STUDY METHODS AND TECHNIQUES	
Sampling Procedure.....	17
Petrographic Procedures.....	23
Statistical Analyses.....	24
RESULTS	
Megascopic.....	27
Petrographic.....	36
Chemical.....	53
Statistical Associations.....	58
DISCUSSION.....	61
CONCLUSIONS.....	69
REFERENCES.....	72

APPENDIX 1	
(Field Description and Sample Locations).....	77
APPENDIX 2	
(Maceral and Reflectance Data).....	140
APPENDIX 3	
(Maceral and Reflectance Data, Weighted Average).....	144
APPENDIX 4	
(Chemical Analytical Data).....	147
APPENDIX 5	
(Chemical Analytical Data, Weighted Average).....	155
APPENDIX 6	
(Bench Thickness Versus Ash and Sulfur).....	157

LIST OF FIGURES

	Page
1. Upper Elkhorn No. 2 KCER Sample Location Map.....	4
2. Stratigraphic Columns (Martin Quadrangle).....	5
3. Structure Contour Map Drawn on the Base of the Pennsylvanian System.....	7
4. Structure Contour Map Drawn on the Base of the Lower Elkhorn Coal Seam.....	9
5. Vitrinite Vicker's Microhardness Curve.....	16
6. Geologic Quadrangle Maps Used in this Study.....	20
7. Correlation Diagram of Coals in the Belfry Quadrangle and Adjacent Areas.....	31
8. Location Map for Upper Elkhorn No. 2 Cross Sections...	32
9. Cross Section of Upper Elkhorn No. 2 in Floyd County...	33
10. Cross Section of Upper Elkhorn No. 2 in Pike County...	34
11. Upper Elkhorn No. 2 Coal Zone Isopach Map.....	35
12. Total Vitrinite Percentage Map.....	38
13. Total Inertinite Percentage Map.....	39
14. Total Liptinite Percentage Map.....	40
15. Vitrinite (Telocollinite) Percentage Map.....	42
16. Pseudovitrinite Percentage Map.....	43

	Page
17. Fusinite Plus Semifusinite Percentage Map.....	44
18. Fusinite Percentage Map.....	45
19. Semifusinite Percentage Map.....	47
20. Vitrinite Maximum Reflectance Map.....	48
21. Pseudovitrinite Maximum Reflectance Map.....	49
22. Microhardness Sample Location Map.....	50
23. Vitrinite Microhardness Map.....	51
24. Pseudovitrinite Microhardness Map.....	52
25. Moisture-Free Ash Percentage Map.....	56
26. Moisture-Free Total Sulfur Percentage Map.....	57

LIST OF TABLES

	Page
1. Rank Classes as Defined by Vitrinite Maximum Reflectance..	15
2. Geologic Quadrangle Maps Used in this Study.....	19
3. Coal Lithotypes (Modified Stopes System).....	22
4. Total Vitrinite and Fusinite Plus Semifusinite Analysis of Variance Results.....	25
5. Summary of Maceral, Reflectance, and Microhardness Data...	37
6. Vitrinite and Pseudovitrinite Vicker's Microhardness Results.....	54
7. Summary of Chemical Analytical Results.....	55
8. Summary of Bivariate Analysis Results.....	59

LIST OF PLATES

	Page
1. Vitrinite tested for Vicker's microhardness.....	18
2. Pseudovitrinite tested for Vicker's microhardness...	18
3. Upper Elkhorn No. 2 (Knott County, KCER4326-27).....	28
4. Upper Elkhorn No. 2 (Magoffin County, KCER3320).....	28
5. Upper Elkhorn No. 2 (Floyd County, KCER3257-58).....	29
6. Upper Elkhorn No. 2 (Floyd County, KCER3242).....	29

ABSTRACT

This report presents the study of the Upper Elkhorn No. 2 coal zone in the Big Sandy Reserve District and the surrounding area of eastern Kentucky. The seams were analyzed using megascopic and microscopic petrography and chemical methods.

The Upper Elkhorn No. 2 consists predominantly of clarain. A fair degree of correlation of fusain bands and clay partings between data sites is apparent. Microscopically, the vitrinite group of macerals are dominant. A rank increase from high volatile B to high volatile A bituminous to the southwest was noted. Pseudovitrinite is associated negatively with vitrinite and has a higher reflectance and microhardness than vitrinite. Both factors may indicate source material and/or environmental differences in the respective origins of the maceral. High inertinite and lipinite areas, low ash and sulfur contents, and the distribution of thin coals may be indicative of paleotopographic highs.

INTRODUCTION

Several megascopic and chemical analytical studies have been conducted with various eastern Kentucky coal beds to establish reserve estimates and characterize coals for technological uses. Coal petrographic investigations of eastern Kentucky coals; however, have only recently been initiated (1979) by the University of Kentucky Institute for Mining and Minerals Research (IMMR). Several coals have been analyzed for maceral content and rank as determined by vitrinite maximum reflectance. Preliminary work conducted by the IMMR with the Upper Elkhorn No. 1-3 coals, in particular, has shown a possible rank increase from northwest to southeast across a portion of the eastern Kentucky coal field. The Upper Elkhorn No. 2 coal bed, the sixth largest coal seam in eastern Kentucky in terms of original tonnage (Huddle and others, 1963), was chosen for further study.

Purpose

Three basic analytical methods were: 1) megascopic petrography, 2) microscopic petrography, and 3) chemical analysis. The megascopic study describes the Upper Elkhorn No. 2 coal with regard to seam thickness and vertical and lateral variation in coal lithotypes. Channel and bench samples of the seam were used in the laboratory study of maceral, rank, and chemical variations. Microscopic analysis included measuring of the vitrinite maximum reflectance to establish overall rank trends. Pseudovitrinite maximum reflectance was also determined along with the vitrinite reflectance measurements. These reflec-

tance comparisons, together with measurement of the Vicker's microhardness for vitrinite and pseudovitrinite, were used to study the problem of pseudovitrinite origin.

Finally, chemical analytical data including proximate and ultimate analyses, free swelling index, and Btu analyses were determined and compared to variations with rank or geographic location. Possible associations of maceral and microhardness data with chemical analytical results were tested. Finally, the distribution of the moisture free ash and total sulfur between sites and between coal benches were analyzed.

Study Area

The high volatile bituminous Upper Elkhorn No. 2 coal seam of eastern Kentucky is located mainly in the southern portions of Johnson and Magoffin counties, eastern Knott and Letcher counties, and throughout most of Floyd and Pike counties. As Huddle and others (1963) indicate, the Upper Elkhorn No. 2 is one of thirty-three recognized coal beds that have been tentatively correlated throughout eastern Kentucky. It is the sixth largest coal seam (in terms of original reserves) containing an estimated 2.2 billion short tons.

This study was conducted primarily in the Big Sandy Reserve District, which includes Pike, Floyd, Johnson, and Martin counties. The heaviest concentration of samples was obtained within Floyd and Pike counties. In addition to the Big Sandy Reserve District area, a few samples were also obtained from Magoffin and Knott counties. Fifty data sites were established.

Ten of these were previously sampled with subsequent petrographic and chemical analyses performed by IMMR researchers. Figure 1 shows the study area and the location of the 50 samples sites.

General Stratigraphy

Rocks outcropping in the Big Sandy Reserve District area are mostly Pennsylvanian in age. The coal-bearing Pennsylvanian rocks are divided into the Lee and Breathitt formations. The Lee Formation of early Pennsylvanian age is predominantly sandstone, with some siltstone, conglomerate, and shale. Most of the Breathitt Formation of middle Pennsylvanian (Desmoinesian) age is shale and siltstone with some massive sandstone and calcareous beds. Both formations thicken southward. Figure 2, taken from the Martin (Rice, 1966) and Hellier (Alvord, 1971) quadrangles, illustrates the stratigraphic section for much of the Breathitt Formation.

Regional Structures

The elevation of the base of the Pennsylvanian System is shown on Figure 3. The Eastern Kentucky Syncline (defined at base of Fire Clay coal) extends through northern Floyd and Martin counties. Rocks dip about one degree, or 100 to the mile, to the northwest on the southern limb of the syncline. Rocks of the northern limb of the Eastern Kentucky Syncline dip less than one degree to the southeast. The Paint Creek Uplift is located in parts of Magoffin and Johnson counties. The Pine Mountain and the Russell Fork faults are located at the southern border of Pike County.

Figure 1. Upper Elkhorn No. 2 KCER Sample Location Map

5

[illegible]

Figure 2. continued

Figure 3. Structure Contour Map Drawn on the Base of the Pennsylvanian System

Since no structure contour maps have been drawn on the base of the Upper Elkhorn No. 2 coal seam, the best structure contour map available is by Hunt and others (1937). Structure contours are drawn on the base of the Lower Elkhorn coal. This is about 100 to 200 feet below the Upper Elkhorn No. 2 (Huddle and others, 1963). In Figure 4, the dip of the strata in Pike County is displayed by contours drawn in 200 foot intervals on the Lower Elkhorn coal bed. These contours show the northwest dip of the strata and the broad folds.

Previous Studies

Previous studies of the Upper Elkhorn No. 2 have been concerned with both reserve tonnage estimates and proximate and ultimate analyses of coal seams (Crandall and Hodge, 1887; Brown, 1900; Stone, 1908; Browning and Russell, 1919; Fieldner and others, 1922; McFarlan, 1926; Hunt and others, 1937; Fieldner and others, 1944; Dowd, 1951, 1952; and Huddle and others, 1963).

From 1979 on, coal samples were collected by the Kentucky Geological Survey (KGS) under contract to the U.S. Geological Survey and by the IMMR, and they were analyzed chemically and petrographically. Eleven of these samples are incorporated into this study.

The KGS (funded by the Kentucky Energy Cabinet through the IMMR and the U. S. Geological Survey), has been active in measuring various coal thicknesses in eastern Kentucky to update coal reserves estimates and produce coal isopach maps of the area.

Figure 4. Structure Contour Map Drawn on the Base of the Lower Elkhorn Coal Seam

FUNDAMENTALS OF COAL PETROLOGY

Three Maceral Groups

The microscopically identifiable constituents of coal as characterized by appearance, chemical composition, and optical properties were first named by Stopes (1935) and are termed macerals. Macerals belong to one of the following three maceral groups: 1) vitrinite, 2) liptinite or exinite, and 3) inertinite. Vitrinites originate from the coalification products of humic substances (e.g., the lignin and cellulose derived from plant cell walls) and are usually the dominant maceral group. Liptinites are derived from sporopollenin, resins, waxes, and fats. Generally, inertinites are formed from the same plant substances as vitrinites, but inertinites undergo a different mode of preservation called fusinitization consisting of charring, oxidation, mouldering, and fungal action. Fusinitization produces inertinite macerals which have higher hydrogen and carbon contents and a generally higher reflectivity than the vitrinite macerals (see also Stach and others, 1975).

Description and Origin of the Maceral Types

The three maceral groups are further classified by a series of macerals. The vitrinite group of macerals are called telocollinite, collinite, telinite, vitrodetrinite, and pseudovitrinite. Telocollinite and telinite are derived from the woody tissues, bark, and cortical tissues of plants. Collinite is a structureless vitrinite group maceral formed

from humic gels. Collinite is commonly associated with telinite, where the collinite occurs as cell fillings surrounded by the cell walls consisting of telinite. Vitrodetrinite is a rarer vitrinite group maceral and is comprised of finely dispersed vitrinite detrital material (Stach and others, 1975).

Pseudovitrinite is distinguished from other vitrinite on seven observations, listed in order of decreasing importance:

- 1) pseudovitrinite has a higher reflectance than vitrinite;
- 2) pseudovitrinite may frequently have slightly curved, slit-like openings within it; 3) pseudovitrinite may contain remnant cell structures; 4) it may have a stepped or ragged grain boundary;
- 5) it may contain internal cracks and look brittle; 6) it has a higher relief than telocollinite; and 7) it has no primary pyrite association (Benedict and others, 1968). The origin of pseudovitrinite is not fully understood, but it may be the product of partial oxidation that occurred early in the coalification stage. Another possibility for the difference between telocollinite and pseudovitrinite could have been differences in the vegetation (Smith, 1980).

The liptinite group of macerals consists of sporinite, cutinite, resinite, alginite, and liptodetrinite. Sporinite is the remains of spores and pollen and is usually the most abundant of the liptinite macerals. Cutinite is derived from the cutin which is the outer layer of leaves, stems, or other aerial plant parts. Resinite is formed primarily from plant resin, but is also formed from plant waxes, balsam, latex, oils, and fats. Resinite occurs as cell fillings, layers, or as finely dispersed

oval or spindle-shaped bodies. Alginite, composed of algal remains, is not frequently found in humic coals.

Liptodetrinite is the liptinite counterpart of vitrodetrinite. Liptodetrinite, composed of finely dispersed liptinite detrital material, is commonly associated with coals that were deposited under water (Stach and others, 1975).

Fusinite, semifusinite, micrinite, macrinite, sclerotinite, and inertodetrinite are the macerals that comprise the inertinite group. Pyrofusinite, degradofusinite, rank fusinite, and primary fusinite are four types of fusinite. Pyrofusinite, the result of wood or peat fires, represents fossil charcoal. Under reflected-light, oil-immersion microscopy, pyrofusinite is often yellowish and frequently displays a good remnant cell structure as opposed to degradofusinite (which generally has more poorly preserved cell structures and is whiter). Degradofusinite forms through dehydration, oxidation, or as a result of microorganisms decomposing wood. The geochemical coalification of huminitic or liptinitic cell tissues is responsible for rank fusinite. Primary fusinite, formed from highly-reflecting dark pigments in the cell walls, are generally not altered throughout the coalification process (Stach and others, 1975).

Semifusinite is a transitional maceral between fusinite and telinite. It has a lower reflectance value than fusinite and is commonly light gray to white. The fusinite-semifusinite-telinite transition is a continuous series based on the oxidation level where fusinite represents the most oxidized material.

Semifusinite represents the partial charring of plant tissues while fusinite undergoes complete charring and telinite experiences no recognizable charring (Stach and others 1975).

Micrinite is a fine-grained, high-reflectance maceral that may form from liptinite macerals. Unlike other macerals, micrinite is probably formed during coalification. It usually first appears in the bituminous coal stage and is found in abundance in sapropelic coals (Stach and others, 1975). ASTM-D2796 (ASTM, 1982) defines micrinite as less than 10 μm .

Macrinite is an amorphous maceral forming from fusinitized gels derived from woody materials of plants. Macrinite is more closely related to fusinite and semifusinite than is micrinite. Sometimes referred to as massive micrinite, macrinite is larger than micrinite (Stach and others, 1975).

Sclerotinite is composed of fungal spores, fungal sclerotia, and fungal tissue, although the majority of sclerotinite in Carboniferous coals appears to have formed from oxidized or weathered plant cell secretions (Stach and others, 1975).

Inertodetrinite, fine detrital, redeposited inertinite macerals, is generally strongly reflecting. Less than 30 microns, inertodetrinite can be abundant in cannel coals (Stach and others, 1975).

Rank Determination by Vitrinite Reflectance

Macerals can be characterized by their morphologies and reflectance. Reflectance measurements of banded vitrinite (meaning banded telocollinite), as opposed to pseudovitrinite, are

taken to determine the coal rank. The volatile matter and carbon content have also been used to determine coal rank, but since they are influenced by the petrographic composition of the coal, they are less reliable indicators of the degree of coalification or coal metamorphism that a particular coal has undergone. In contrast, the reflectance is independent of petrographic composition and thereby represents a more accurate determination of coal rank (Stach and others, 1975). Table 1 illustrates the rank classes as defined by the maximum reflectance of vitrinite (ASTM, 1976). Pseudovitrinite reflectance measurements can be used in comparison with vitrinite reflectance and in vitrinite-pseudovitrinite microhardness considerations to learn more about the properties and possible origin of pseudovitrinite.

Vicker's Microhardness

Differences in the polishing hardness of the macerals can be noted on polished surfaces of the coal pellet since the harder macerals show greater relief than softer macerals. As pseudovitrinite shows a higher relief than vitrinite, pseudovitrinite is probably harder than vitrinite. The Vicker's microhardness technique can be used to quantitatively determine the microhardness of these macerals. As Figure 5 from van Krevelen (1961) illustrates, Vicker's microhardness values of vitrinite reach a minimum between 88% and 92% carbon [daf] (24% to 15% volatile matter [daf]). The minimum microhardness region is called the brittle-hardness area, whereas vitrinites having less than 88%

Table 1. Rank Classes as Defined by Vitrinite Maximum Reflectance

<u>Rank</u>	<u>Vitrinite R(max)</u>
anthracite	≥3.00
semi-anthracite	2.05 - 3.00
low volatile bituminous	1.50 - 2.05
medium volatile bituminous	1.10 - 1.50
high volatile A bituminous	0.71 - 1.10
high volatile B bituminous	0.57 - 0.71
high volatile C bituminous	0.47 - 0.57
sub-bituminous	≤0.47

Figure 5. Vitrinite Vicker's Microhardness Curve

carbon [daf] (40 to 24% volatile matter [daf]) display a ductile hardness. An elastic hardness is observed for vitrinite containing greater than 92% carbon [daf] (less than 15% volatile matter [daf]). Plates 1 and 2 illustrate vitrinite and pseudo-vitrinite samples that have been tested for Vicker's microhardness.

STUDY METHODS AND TECHNIQUES

Sampling Procedure

Prospective locations where samples of the Upper Elkhorn No. 2 coal seam could be obtained with a wide geographic distribution were first determined by examining various eastern Kentucky geological 7½' quadrangle maps. These maps showed roadcut and mining areas where the Upper Elkhorn No. 2 coal seam was exposed. Table 2 lists the geological quadrangle maps used in this study and Figure 6 shows their locations.

Mining records from the Kentucky Department of Mines and Minerals also helped determine areas where the Upper Elkhorn No. 2 seam was presently being mined or had been mined recently. Then mining areas were compared with the outcrop contours of the geologic quadrangle maps to see if the seams being mined were located and named correctly.

Because the Upper Elkhorn No. 2 seam splits in many locations and its precise identification is not always certain, the term "zone" probably best applies to this particular seam. For this study, reference is made to the Upper Elkhorn No. 2

Plate 1. Vitrinite tested for Vicker's microhardness

Plate 2. Pseudovitrinite tested for Vicker's microhardness

Table 2. Geologic Quadrangle Maps Used in this Study

<u>Quadrangle Map</u>	<u>Author(s)</u>
Belfry	Rice, Ping, and Barr (1977)
Broad Bottom	Alvord (1965)
Dorton	Barr and Arndt (1968)
Elkhorn City and Harman	Alvord and Miller (1972)
Harold	Rice (1965)
Hellier and Clintwood	Alvord (1971)
Ivyton	Rice (1969)
Jamboree	Outerbridge and van Vloten (1968)
Majestic, Hurley, and Wharncliffe	Outerbridge (1968)
Martin	Rice (1966)
Matewan	Trent (1965)
McDowell	Rice (1968)
Meta	Wolcott and Jenkins (1966)
Millard	Jenkins (1967)
Paintsville	Outerbridge (1966)
Pikeville	Alvord and Holbrook (1965)
Prestonburg	Rice (1967)
Wayland	Hinrichs and Ping (1978)
Wheelwright	Outerbridge (1975)

Figure 6. Geologic Quadrangle Maps Used in this Study

coal zone instead of the Upper Elkhorn No. 2 coal seam.

Samples of the Upper Elkhorn No. 2 were obtained from unweathered outcrops from which all surface coal was removed. After a fresh surface was obtained and any loose roof material was discarded, the seam description was recorded by measuring the thicknesses of the lithotypes of humic coals as well as noting the position of any partings or mineralized zones. The roof and floor lithologies were also noted. Table 3 lists the seven lithotypes of coal based on the Stopes System (Stopes, 1919).

After the first seam description was completed, samples were obtained either in the form of a channel sample, where a three to four-inch wide cut was made into the seam and the whole seam was sampled. Bench samples, where each separate bench of the seam was sampled (the partings serving as boundaries between benches), were also collected. Unless otherwise specified, partings were not included with the collected samples. In some cases, if the seam did not contain benches or partings, samples were arbitrarily taken in roughly equivalent units. Following sampling, the seam was observed once more to determine if anything was missed or in error from the first description. Seam descriptions are listed in Appendix 1.

If more than one sample was taken at a particular site, the reported value is a weighted (by thickness) average of the benches. All data obtained from the field work were expressed weighted averages for the construction of the various maceral and

Table 3. Coal Lithotypes (Modified Stopes System)

<u>Lithotype Name</u>	<u>Megascopic Description</u>
vitrain	Bright with glassy luster; black, usually brittle; frequently with fissures.
clarain	Moderately bright with satiny luster; finely striated; black; may include thin non-satiny bright and dull bands; bright and dull varieties of clarain can be distinguished.
fusain	Dull and dusty with silky luster; black; and somewhat fibrous; black, sooty streak; resembles charcoal.
durain	Dull with somewhat greasy luster; gray-black to brown-black; tough mat surface; very fine-grained, low ash content.
bone coal	Very dull with earthy luster; gray-black, often with coarser, coal fragments in fine-grained, clay-rich groundmass; brownish, earthy streak.
carbonaceous shale	Earthy luster; black, gray, or brown; often quite plastic and water sensitive.
laminated pyrite	Bright, metallic luster; golden; powdery white oxidation residue; occur as laminae often filling collapse structures from compaction of fusain or vitrain.

chemical maps. Microhardness determination used bench samples since microhardness values should not vary significantly from the top to bottom benches of a coal seam.

Petrographic Procedures

Vitrinite reflectance is conducted by determining the reflectance measurements from 50 particles of banded vitrinite per sample. Oil immersion microscopy is used with a reflected light wavelength of 546 nm. The spot size in which the reflectance measurement is taken from the maceral surface is less than ten microns in diameter. The photomultiplier on the Leitz microscope is calibrated against a glass pellet standard. Pseudovitrinite reflectance is determined in the same manner as vitrinite reflectance. See ASTM-D2798 (ASTM, 1982) for further information on the procedures and equipment necessary for conducting reflectance measurements.

Vitrinite and pseudovitrinite microhardness values were determined using a Vicker's microhardness tester on a Reichert inverted microscope. Suitable particles of vitrinite and pseudovitrinite should be large enough so the Vicker's imprint diamond pyramid is greater than four diagonal lengths of the imprint away from any impurity or boundary of the maceral. After meeting this requirement, the diamond is lowered onto the maceral surface and a load of 32 grams (in this study, but not necessarily the load used for all studies) is applied for 15 seconds and then the diamond is removed from the maceral. The two diagonals of the diamond imprint are measured with the micrometer mounted inside

the eyepiece. This measured value is used in the Vicker's microhardness formula:

$$\text{Microhardness} = \frac{1854.4 \times 32 \text{ grams}}{d^2}$$

where the d value is the average diagonal length of the diamond imprint. Microhardness values or MHv are expressed in terms of kilograms per square millimeter (kg/mm^2). Unless otherwise indicated, 25 measurements of microhardness per sample were performed. More information about the Vicker's microhardness procedure can be found in van Krevelen (1961), Stach and others (1975), and (ASTM E384 ASTM, 1981).

Statistical Analyses

Statistical analyses have been applied to four major areas including maceral, chemical, rank, and microhardness determinations. A two-way analysis of variance statistical test was performed on a Hewlett-Packard 9815-S program package for the total vitrinite percentage and the fusinite-plus-semifusinite percentage obtained from the maceral counts. This test was conducted to determine if the variations observed in maceral counting are more varied from sample site to sample site, pellet to pellet, or from 100-point interval to 100-point interval. The numbers generated from each 100 point counts were used from 25 randomly selected samples. The result of this test for the total vitrinite and fusinite-plus-semifusinite percentages are shown in Table 4. The results show that the greatest variation is between coal sites. The variation between intervals

Table 4. Total Vitrinite and Fusinite Plus Semifusinite
Analysis of Variance Results

<u>Total Vitrinite</u>	<u>Degrees of Freedom</u>	<u>Sum of Squares</u>	<u>Mean Square</u>	<u>F</u>	
(1) coal site	24	27875.45	1161.47	66.36*	F _{24, 200}
(2) pellet	1	0.10	0.10	0.01**	F _{1, 200}
(3) (1) x (2)	24	382.10	20.13	1.15**	F _{24, 200}
(4) error (replicates)	200	3500.40	17.50		
(5) total	249	31859.15			

Fusinite Plus Semifusinite

(1) coal site	24	13556.77	564.86	58.04*	F _{24, 200}
(2) pellet	1	7.05	7.05	0.72**	F _{1, 200}
(3) (1) x (2)	24	245.54	10.23	1.05**	F _{24, 200}
(4) error (replicates)	200	1946.40	9.73		
(5) total	249	15755.77			

* Significant at 1% level

** Not significant

of 100 maceral counts is greater than the variation in the maceral counts conducted between pellets of the same pair. Hence, the maceral variation is greatest between different data sites and, as a general rule, is statistically significant.

Bivariate correlations were made on other maceral data to establish if any intrarelationships between the macerals exist, and to see how the macerals respond to various chemical parameters. Maceral-versus-maceral and maceral-versus-chemical comparisons were made. Also, bivariate analysis was used in relating the vitrinite maximum reflectance to the pseudovitrinite maximum reflectance. This same statistical procedure was also used for comparing chemical data to itself and rank to determine if any intrarelationships were apparent within the chemical data, as well as observing if the chemical data was affected by rank. Finally, bivariate analysis was applied to the micro-hardness data to see if vitrinite and pseudovitrinite micro-hardness values changed with rank or were influenced by the chemical data.

Bivariate analysis has also been used as a method to correlate the similarity between a pair of maps. Several authors including Davis (1973), Robinson (1968), and Neft (1966) have outlined this map correlation procedure in which the correlation coefficient is used to indicate the similarity between maps. The correlation coefficient will have a value close to positive one if the map pairs are similar, and a value of negative one if the map pairs are not similar. Maps must contain the same number of data points and location sites to be analyzed correctly.

RESULTS

Megascopeic

Figure 1 illustrates the location of the 50 sample sites. The samples were named and catalogued in terms of KCER numbers. One sample site each was obtained from Magoffin and Johnson counties, two sample sites were located in Knott County, eighteen sample sites were from Floyd County, and Pike County had twenty-eight sample sites. The 11 sites represented by triangles include those samples previously collected by the IMMR and the KGS while the solid dots represent samples collected for this study.

The Upper Elkhorn No. 2 coal zone consists mainly of clarain, with varying amounts of vitrain and fusain, and minor quantities of durain. Showing much variability in thickness, from a reported low of 21.1 cm to a high of 172.6 cm (both measurements from this study), most of the sample site locations were associated with a medium-gray shale roof with siderite nodules and layers commonly present. A coarse-grained sandstone roof was only noted at five sites (four sites in Pike County and one in Floyd County). Generally the roof lithologies made a sharp contact with the coal seam.

In all but two instances, the floor was composed of an underclay, commonly light gray with plant fossils present. However, at one Pike County site, the floor consisted of a shale and at one Floyd County site the floor was a siltstone. Plates 3, 4, 5, and 6 (KCEP samples 4326-27, 3320, 3257-58, and 3242,

Plate 3. Upper Elkhorn No. 2 (Knott County, KCER4326-27)

Plate 4. Upper Elkhorn No. 2 (Magoffin County, KCER3320)

Plate 5. Upper Elkhorn No. 2 (Floyd County, KCER3257-58)

Plate 6. Upper Elkhorn No. 2 (Floyd County, KCER3242)

respectively) illustrate the Upper Elkhorn No. 2 coal zone in Knott, Magoffin, and Floyd counties.

Partings and mineralized zones were only minor portions of the seam. Partings usually consisted of shale or clay. Pyrite was present in minor amounts and occurred as lenses, nodules, or interspersed with fusain layers.

Thin rider beds were found in a few localities, but were generally not present. KCER samples 3257-58 and 3259-62, are examples of locations where thin rider beds were present.

The Upper Elkhorn No. 2 coal zone regionally is difficult to correlate. Figure 7, after Rice and others (1977), illustrates how the compilers of the Meta, Belfry, Williamson, Matewan, Lick Creek, and Jamboree Geologic Quadrangle Maps interpreted the correlations of coals in the Upper Elkhorn zone, from which the problems of splitting and nomenclature are apparent. Figure 8 shows the location of the cross sections of the Upper Elkhorn No. 2 zone illustrated in Figures 9 and 10. Figure 9 displays eight cross sections from Floyd County which demonstrates that some partings have some lateral persistence. Figure 10, showing perhaps better correlation between sites, displays six sections in Pike County where clay partings persist to some extent laterally.

From the field work conducted for this study and the field data obtained from work done by the KGS (courtesy of Dr. James C. Cobb) an isopach map of the Upper Elkhorn No. 2 coal zone was constructed. Shown in Figure 11, this isopach map shows a

Correlation diagram showing relations between coal beds of the Elkhorn coal zone in the Belfry and adjacent quadrangles

o, Alma coal bed
 c, unnamed coal bed
 kg, Lower Cedar Grove coal bed
 lc, Lower Elkhorn coal bed
 lcr, Lower Elkhorn rider coal bed
 hh, Lower Thacker coal bed
 n, Nothen coal bed
 pc, Pond Creek coal bed
 pcr, Pond Creek rider coal bed
 sn, Sidney coal bed
 ucg, coal bed in Upper Cedar Grove coal zone
 uth, Upper Thacker coal bed
 1, Upper Elkhorn No. 1 coal bed
 2, Upper Elkhorn No. 2 coal bed
 2, 1, coal bed in Upper Elkhorn No. 2, 1 coal zone
 3, coal bed in Upper Elkhorn No. 3 coal zone

Figure 7. Correlation Diagram of Coals in the Belfry Quadrangle and Adjacent Areas

Figure 8. Location Map for Upper Elkhorn No. 2 Cross Sections

UPPER ELKHORN NO. 2 COAL ZONE CROSS SECTIONS: FLOYD COUNTY

Figure 9. Cross Section of Upper Elkhorn No. 2 in Floyd County

UPPER ELKHORN NO. 2 COAL ZONE CROSS SECTIONS: PIKE COUNTY

Figure 10. Cross Section of Upper Elkhorn No. 2 in Pike County

Figure 11. Upper Elkhorn No. 2 Coal Zone Isopach Map

general southeastward increase in the thickness of the coal zone, with the thickest coals located in the southeast portion of Pike County. The solid dots represent data points and are included to show the amount of data control or density.

Petrographic

The maceral percentages are shown in Appendix 2 on a sample by sample basis while Appendix 3 contains maceral percentages on a sample site (weighted average) basis. Table 5 summarizes the ranges and averages of the maceral, reflectance, and microhardness data.

Figure 12 is a map illustrating the total vitrinite. There appears to be a general northeastward increase in total vitrinite to central Pike County. On this map as well as the following contour maps, lines drawn across areas of low sample density are speculative.

Figure 13 illustrates the total inertinite content. Showing trends in about the same places as the total vitrinite map, generally the total inertinites are at their highest amounts where the total vitrinite is lowest. This high inertinite-low total vitrinite relationship is discussed further in the statistical section.

The total liptinite percentage shown on Figure 14 exhibits patterns similar to the total vitrinite map (Figure 12). Generally total liptinite appears to increase toward central Pike County.

A map of the vitrinite (telocollinite) percentage is shown on

Table 5. Summary of Maceral, Reflectance, and Microhardness Data

	<u>Total Vitrinite</u>	<u>Total Inertinite</u>	<u>Total Liptinite</u>
low	56.3	3.4	4.7
high	86.7	39.0	12.4
mean	71.3	13.2	9.2

	<u>Vit</u>	<u>Pvit</u>	<u>Fus</u>	<u>Sfus</u>	<u>Mic</u>	<u>Mac</u>	<u>Ex</u>	<u>Res</u>
low	44.4	3.0	1.3	0.4	1.9	0.0	4.6	0.0
high	79.3	29.9	31.1	9.8	7.2	0.3	11.9	3.4
mean	65.2	12.2	6.5	5.2	3.6	0.1	8.2	1.0

	<u>Vit R(max)</u>	<u>Pvit R(max)</u>	<u>Vit MHv</u>	<u>Pvit MHv</u>
low	0.60%	0.67%	23.45	25.86
high	1.05%	1.14%	34.14	37.75
mean	0.79%	0.89%	32.01	34.70

Figure 12. Total Vitrinite Percentage Map

Figure 15. As expected, the trends that the total vitrinite map (Figure 12) display are also seen on for the vitrinite (telocollinite) map. Vitrinite increases in a general northeastward direction, reaching a high in a northwest to southeast belt across central Pike County.

Pseudovitrinite content is mapped on Figure 16. Pseudovitrinite appears to be present in high amounts where vitrinite content is relatively low. Comparison to the total inertinite content (Figure 13) shows that pseudovitrinite is generally abundant where the total inertinites are abundant. This same trend is also apparent for the fusinite-plus-semifusinite percentage map (Figure 17), the fusinite plus semifusinite content being high where the pseudovitrinite content is high.

Figure 18 illustrates the fusinite content. Like the total vitrinite-total inertinite relationship, fusinite generally is abundant in areas where vitrinite is not abundant. The highest fusinite contents are located mostly in southern Floyd and southwestern Pike counties.

Figure 15. Vitrinite (Telocollinite) Percentage Map

Figure 16. Pseudovitrinite Percentage Map

Figure 17. Fusinite Plus Semifusinite Percentage Map

Figure 18. Fusinite Percentage Map

The semifusinite percentage is mapped on Figure 19. It appears that the highest semifusinite areas relate to the lowest pseudovitrinite (Figure 16) areas. This may reflect different manifestations of the same phenomena, (i.e., partial oxidation).

Figure 20 illustrates the vitrinite maximum reflectance. The vitrinite maximum reflectance generally increases from the northwest to the southeast, reaching a high in the Elkhorn City Quadrangle in Pike County. A northeast to southwest reflectance increase is also noted for eastern Pike County. The pseudovitrinite maximum reflectance distribution is displayed on Figure 21 and shows the same trends as Figure 20. Pseudovitrinite reflectance values were consistently higher than those of vitrinite, averaging about 0.11% reflectance difference between the two macerals. This is well within the reflectance range difference of 0.02% to 0.18% which Smith (1980) reports for vitrinite and pseudovitrinite (also Stach and others, 1975; Thompson and Benedict, 1974).

The microhardness sample location map is shown on Figure 22. Sample sites were chosen from different geographic locations throughout the study area in order that rank, chemical, and petrographic variances would be optimized. A total of 20 samples from 19 different quadrangles were tested. Vitrinite microhardness values are mapped on Figure 23 while pseudovitrinite microhardness results are mapped on Figure 24. With the exception of KCER samples 3271, 3359, and 3360, in which depressed microhardness values were noted (probably) because these samples were weathered, little variation was noted for the respective values

Figure 19. Semifusinite Percentage Map

Figure 20. Vitrinite Maximum Reflectance Map

Figure 21. Pseudovitrinite Maximum Reflectance Map

Figure 22. Microhardness Sample Location Map

Figure 24. Pseudovitrinite Microhardness Map

of both maps. Pseudovitrinite microhardness values were consistently higher than those of vitrinite, showing that pseudovitrinite is the harder maceral of the two. The vitrinite-pseudovitrinite difference averaged about 7.7% or 2.75 kg/mm². Table 6 illustrates the microhardness of the samples along with their respective standard deviations.

Chemical

Table 7 summarizes the ranges and averages of the chemical analytical results. Appendix 4 lists the chemical data on a sample basis, and Appendix 5 contains the chemical data results on a site (weighted averaged) basis.

Figure 25 illustrates the distribution of moisture-free ash. The higher amounts of ash are generally present in the Floyd County area and seem to decrease in a general southeast direction. Moisture-free ash as it relates to other maps and variables is discussed further in the statistical portion of this chapter.

The distribution of the moisture-free total sulfur is shown on Figure 26. There is an overall decrease in sulfur from the north or northwest to the south or southeast, with the highest sulfur values recorded in the southern Johnson County area and the north- to south- central portions of Floyd County. How the moisture-free total sulfur relates to other variables is discussed in the statistical section.

Twenty-eight location sites, in which separate bench data were available, were used to plot the bench thicknesses versus the

Table 6. Vitrinite and Pseudovitrinite Vicker's Microhardness Results

<u>KCER #</u>	<u>Vit MHv</u>	<u>Vit S.D.</u>	<u>Pvit MHv</u>	<u>Pvit S.D.</u>
3242	33.45	0.509	36.53	0.653
3258	34.03	0.599	36.82	0.679
3263	32.99	0.484	35.42	0.462
3271	23.45	0.373	25.86	0.565
3285	32.22	0.656	34.96	0.834
3287	32.74	0.763	35.20	0.798
3301	32.05	0.760	34.40	0.818
3306	32.78	0.666	35.61	0.767
3311	33.48	0.606	36.52	0.584
3326	32.82	0.697	36.46	0.821
3330	33.35	0.629	37.75	0.716
3331	34.14	0.696	36.62	0.644
3335	32.21	0.776	35.23	0.446
3345	33.37	0.609	35.93	0.601
3350	32.35	0.588	34.95	0.693
3353	32.64	0.435	34.96	0.574
3357	33.06	0.573	35.34	0.465
3359*	26.27	1.009	26.91	0.699
3360	29.69	0.596	32.85	0.648
3364	33.01	0.682	35.58	0.810

*Data based on 15 points each rather than 25 points

Table 7. Summary of Chemical Analytical Results

	<u>A-F Moisture</u>	<u>A-R Ash</u>	<u>Daf VM</u>	<u>Daf FC</u>	
low	0.95	1.95	33.83	51.38	
high	10.97	23.01	48.19	66.74	
mean	3.22	7.88	41.95	58.25	
	<u>Daf C</u>	<u>Daf H</u>	<u>Daf N</u>	<u>Daf S</u>	<u>Daf O</u>
low	75.45	4.58	1.14	0.55	4.27
high	90.56	6.10	2.30	4.40	27.02
mean	82.98	5.49	1.61	1.64	12.15
	<u>MMmf BTU</u>		<u>FSI</u>		<u>Weight % MM</u>
low	12522		0.0		2.14
high	16073		8.5		25.14
mean	14872		4.0		8.56

Figure 25. Moisture-Free Ash Percentage Map

moisture-free ash and moisture-free total sulfur contents. It was found that the highest ash contents were contained in the uppermost bench unless clay or shale partings were present, which increased the ash and sulfur contents in the benches adjacent to the partings. The relationship of the total sulfur to the coal benches was not as clear. In many cases, the sulfur did not vary much from bench to bench within a particular location site and no correlation with the ash content was apparent. Appendix 6 shows the bench data versus the ash and sulfur amounts.

Statistical Associations

The bivariate analysis results are summarized in Table 8. The first three items listed in Table 8 are actually 'pseudocorrelations'. Since the three maceral groups sum up to 100%, a closure problem is encountered. Hence, through exclusion, as something increases in amount (total vitrinite) something else must decrease (total inertinite), and a 'pseudocorrelation' is established. Other correlations are listed in Table 8.

Table 8. Summary of Bivariate Analysis Results

<u>Variables</u>	<u>Number of Data Points</u>	<u>Correlation Coefficient</u>
total vit-total lip	51	-.06
total vit-total inert	51	-.95*
total inert-total lip	51	-.24
pvit-vitrinite	51	-.55*
fusinite-vitrinite	51	-.51*
fusinite-pseudovitrinite	51	-.24
semifusinite-vitrinite	51	-.51*
semifusinite-pvit	51	-.16#
semifusinite-fusinite	51	+.30#
micrinite-exinite	51	+.10
micrinite-total lip	51	-.15
micrinite-resinite	51	-.34*
M-F total S-total vit	51	+.16#
M-F total S-total inert	51	-.12
M-F total S-total lip	51	-.14
M-F total S-vitrinite	51	+.09
M-F total S-pvit	51	+.07
M-F total S-fusinite	51	-.13
M-F total S-semifusinite	51	-.03
M-F ash-vitrinite	51	+.16#
M-F ash-pseudovitrinite	51	-.23
M-F ash- fusinite	51	-.02
M-F ash- semifusinite	51	+.09
Vit R(max)-Pvit R(max)	40	+.97*
FSI-Dmmf BTU	49	+.70*
C-Dmmf BTU	40	+.96*
H-Dmmf BTU	40	+.82*
N-Dmmf BTU	40	+.37*
S-Dmmf BTU	123	+.25*
VM-Dmmf BTU	123	-.32*
M-F total S - M-F ash	123	-.48*
O-Dmmf BTU	40	-.67*
C-Vit R(max)	123	+.33*
H-Vit R(max)	123	-.03
N-Vit R(max)	123	+.18#
O-Vit R(max)	123	-.32*
S-Vit R(max)	123	-.30*
VM-Vit R(max)	123	-.47*
BTU-Vit R(max)	123	+.28*

* Significant at the 1% level (Snedecor, 1946)

Significant at the 5% level (Snedecor, 1946)

Table 8. (continued)

<u>Variables</u>	<u>Number of Data Points</u>	<u>Correlation Coefficient</u>
Vit MHv - Pvit MHv	20	+.80*
Vit MHv - Vit R(max)	20	-.18
Vit MHv - Vit R(max)	17	-.52#
Pvit MHv - Pvit R(max)	20	-.24
Pvit MHv - Pvit R(max)	17	-.57*
Vit R(max) - Pvit R(max)	20	+.98*
Vit MHv - C	20	-.12
Vit MHv - H	20	-.16
Vit MHv - N	20	-.03
Vit MHv - O	20	+.19
Vit MHv - S	20	-.48*
Vit MHv - Ash	20	-.05
Vit MHv - VM	20	+.03
Vit MHv - BTU	20	+.04

* Significant at the 1% level (Snedecor, 1946)

Significant at the 5% level (Snedecor, 1946)

DISCUSSION

Aside from the study of the Upper Elkhorn No. 2 coal, one of the primary goals of this study was the establishment of a set of samples in which the response of the character of semi-inert macerals, to other factors, could be evaluated. Ideally, we would hope to find a coal seam where as coal rank changed in a north-south direction another parameter, such as sulfur, exhibited a systematic east-west change. A balanced subset of samples then could easily be selected for detailed testing, such as the Vicker's microhardness examinations. In this investigation, a reasonable variation of coal characteristics was obtained. Wider variations, while desirable, are not always obtainable within a restricted geographic region.

Most maceral comparisons made conformed to normal and expected results. Total vitrinite, being the most abundant maceral group, would tend to increase as the total inertinites (which are the second most abundant group) decrease. This is generally apparent in Figures 12 and 13. Where high total vitrinite-low inertinite areas are not seen, the moderating effect of the total liptinite content is apparent. The total liptinites also decrease with an increase in the total vitrinite macerals, but again this may be more related to the original high abundance of the total vitrinite and the low abundance of the liptinite macerals.

Fusinite content generally increased as semifusinite increased. Since these macerals are transitional, this rela-

tionship is not surprising. The conditions that form fusinite also form semifusinite.

The trend of the total vitrinite being abundant in those areas where the total inertinites are low may be due to the paleotopography at the time of peat deposition. These high inertinite areas may represent topographic high areas in the coal basin since the processes of charring caused by peat fires, oxidation, and fungal action would have a better chance of occurring in those regions of the coal basin which were drier and better drained. The paleotopographic highs were probably on the order of a few inches to a few feet higher than the rest of the swamp. Generally, the total inertinites increased as the total liptinites increased. As Figures 13 and 14 illustrate, the high liptinite contents are found in the high inertinite areas.

As previously suspected from Figures 15 and 16, and as Table 8 indicates, pseudovitrinite has a strong negative association with vitrinite (telocollinite), since pseudovitrinite decreases as vitrinite increases. While a closure problem undoubtedly influences this relationship, it is probable that this relationship indicates that the conditions that formed these two macerals were different. Further evidence that the conditions that formed these pseudovitrinite were different than those that the conditions that formed pseudovitrinite were different than those that formed vitrinite (telocollinite) come from the vitrinite-fusinite, vitrinite-semifusinite, pseudovitrinite-fusinite, and pseudovitrinite-semifusinite relationships. Vitrinite (telocollinite) content decreased more than the pseudo-

vitronite content decreased as the fusinite and semifusinite contents increased. This would seem to suggest that the oxidative processes that form fusinite and semifusinite are more destructive to vitronite precursors than to the pseudovitronite precursors or that pseudovitronite may form under similar conditions as fusinite and semifusinite. This in turn may indicate that the vitronite-pseudovitronite differences are due to oxidation potential. The above discussion indicates that vitronite differs from pseudovitronite both in terms of distribution and in relation to fusinite and semifusinite.

The moisture-free total sulfur and moisture-free ash comparisons to macerals are shown in Table 8. Of special interest is the relationship of ash to vitronite and pseudovitronite. The differences seen with the ash contents when compared to vitronite and pseudovitronite may serve to further delineate the origins of these two macerals. Moisture-free ash has a positive association to vitronite while having a negative association to pseudovitronite. It is well established that ash accumulates in topographic low areas (Williams and Keith, 1963; Williams and Bragonier, 1974; King, 1978). If pseudovitronite is formed in more elevated, oxidized environments, then the ash content in these areas would be expected to be less than those in topographically lower areas where vitronite is formed and higher ash contents are found. Thus, the different ash associations with vitronite (telocollinite) and pseudovitronite may reflect different modes of formation for these two macerals.

Further evidence for paleotopographic highs come from the relationship of sulfur and ash with paleotopography. Many authors, including Fraser and Crentz (1946), Reidenouer and others (1967), and Williams and Bragonier (1974), have noted that the highest ash and sulfur contents are found in the topographic low areas of the coal basin. It is believed that the sulfur content is low in topographic high areas because much oxygen is available in these high areas thereby enabling more complete decay and removal of plant material. In topographic low areas iron, which is transported as colloidal particles or adsorbed on clay, may react with sulfur to form pyrite. King (1978) noted that topographic low areas should be high in ash because mineral matter in suspension as a result of flooding throughout the peat swamp would naturally tend to accumulate in low areas. High ash regions may also reflect periods of slow plant accumulation due to adverse environmental conditions or a reduced organic preservation level. For the Upper Elkhorn No. 2 coal the ash contents increased as the total sulfur contents increased. Also, sulfur and ash contents tended to decrease as the fusinite and semifusinite contents increased. From the above discussion, it is probable that high ash areas in the Upper Elkhorn No. 2 coal zone relate to paleotopographic lows.

The ash-free total sulfur content increased as the total vitrinite amount increased perhaps in part because pyrite originates from bacterial action on vitrinite-precursor humic materials which contain plant proteins (Stach and others, 1975; Altschuler and others, 1983). Conversely, total sulfur content

decreased as the total inertinite content increased probably because the oxidation of humic materials to produce inertinite macerals may be responsible for releasing any sulfur present in the form of sulfur dioxide which is subsequently lost to the atmosphere. Oxidation may also serve to destroy the sulfur-producing bacteria and is not favorable for pyrite formation (which requires reducing conditions).

Several authors have related the distribution of sulfur in coal to different marine and fresh water conditions, including White and Thiessen (1913), Jillson (1920), Williams and Keith (1963), Horne and Ferm (1978), and King (1978). Generally it is believed that high sulfur areas are related to marine influences. As the sulfur distribution (Figure 25) suggests, if a marine influence was exerted, it was apparently located in the Floyd County area since the highest sulfur coals are located there.

It was found that the highest ash contents were usually associated with the uppermost bench. This may be due to flooding caused from subsidence or other factors because no correlation was found between the ash and sulfur contents of the same coal bench. Several authors (Fraser and Crentz, 1946) and (King, 1978, Cheek, 1969) have reported high sulfur amounts in the uppermost benches of the coals, but no clear pattern developed in this study for the sulfur content in the coal benches. Sketches of the ash and sulfur by bench are presented in Appendix 6.

Thickness variations of coal may be because paleotopography, as well as differential sedimentation and compaction (Williams

and Bragonier, 1974). Thin coals are deposited on paleotopographic highs and thicker coals may be deposited in the lower regions of the coal basin. It is also possible that thicker coals may be deposited on topographic high areas, with the water table level exerting a major determining factor. The distribution of thin coals shown on Figure 11 may be partially due to paleotopographic highs, and it would be expected that thin coals would be present in areas where sulfur and ash would be low, and the inertinite contents would be high. This is not always the case, so other environmental factors must have been in effect.

Figure 20 illustrates the rank increase of the Upper Elkhorn No. 2 coal zone as based on vitrinite (telocollinite) maximum reflectance. Lateral variations in rank within a seam may be caused by geothermal gradient changes or by changes in depths of burial. Changes in burial depths influence rank because coal rank increases with an increase in burial depth (Hilt's Law); therefore, variations in depth of burial across a particular seam can influence rank variations. The thickening of strata to the southeast to the southeast in the study area must be inferred since all of the overburden is not present. Hower and Davis (1981) speculated that the Appalachian coal measures reached their deepest level of burial at the end of the Permian which probably corresponds to the time of maximum metamorphism. For the northern Appalachian coal field Hower and Davis (1981) found that coal rank varied more between tectonic areas than within tectonic regions. However, as Hower and Trinkle (in review) reported, most of the tectonic structures visible at the

surface in eastern Kentucky do not appear to have influenced coal rank. The rank increase observed with the Upper Elkhorn No. 2 coal zone may be due to a southeastward increase in the geothermal gradient and/or increase in depth of burial.

The reflectance difference between vitrinite (telocollinite) and pseudovitrinite also helps to establish the differences between the two macerals. Since both macerals experience the same temperature-pressure-time history during coalification, their differences in reflectance must be due to either differences in source material (Smith, 1980) or partial oxidation that occurred early in the biochemical phase of coal formation in the peat swamp (Thompson and Benedict, 1974). Either interpretation of the origin of pseudovitrinite would account for its higher reflectance, oxygen content, and its behavior as an inert or semi-inert substance in the coking process.

Similar to the vitrinite-pseudovitrinite reflectance association, the vitrinite-pseudovitrinite microhardness relationship further indicates the difference between these two macerals since pseudovitrinite was found to be consistently harder than vitrinite (telocollinite). Both macerals decrease slightly in their microhardness with an increase in rank from high volatile B to high volatile A bituminous. The difference in the vitrinite-pseudovitrinite microhardness values were found to decrease with an increase in rank. The decrease in the vitrinite-pseudovitrinite microhardness differences could be because as rank increases, the molecular structure of coal

becomes more stable (Jasienko, 1978), so that the structural chemistry of vitrinite (telocollinite) and pseudovitrinite becomes more similar as rank increases.

Microhardness versus chemical comparisons were not significant with the exception of the vitrinite (telocollinite) microhardness versus the total sulfur content, which was significant at the 5% level. This relationship had a negative association and is probably due to the total sulfur content decreasing as rank increases, while the vitrinite (telocollinite) microhardness decreases with an increase in the ranks found in this study. The total sulfur versus rank relationship is probably coincidental since the sulfur distribution is influenced by depositional environment rather than by rank. The relationship between vitrinite microhardness and the sulfur content is somewhat unclear since only the total sulfur value was known for most of the samples (time constraints and equipment breakdowns eliminated the possibility of obtaining forms-of-sulfur analyses for the complete sample set). It should be instructive to compare microhardness values for coals of a narrow reflectance range (say 0.05% $R_{\max}$) but with a wide variation in organic sulfur content. Using electron microprobe techniques for the determination of organic sulfur (as discussed by Raymond, 1982), it should be possible to determine the organic sulfur on the same particles tested for microhardness.

CONCLUSIONS

1. The Upper Elkhorn No. 2 coal zone consists predominantly of clarain with minor amounts of vitrain and fusain, and rare durain. No sapropelic lithotypes were found with this seam, indicating that this seam was formed from a woody peat mass.
2. The Upper Elkhorn No. 2 coal zone increases in thickness to the southeast where 96-inch thick seams are reported. An isolated thinning of the seam is observed in the central portion where coals less than 28-inches thick are found.
3. Vitrinite was the most abundant maceral group followed by the inertinite and liptinite macerals. This indicates a high abundance of woody plant tissues were available and preserved.
4. Pseudovitrinite-vitrinite comparisons indicated that pseudovitrinite has: a) a negative association with the vitrinite (telocollinite) distribution; b) a stronger negative association to ash while vitrinite has a positive association to ash; c) a higher reflectance than vitrinite; and d) a higher microhardness than vitrinite. These differences are probably due to a combination of both source material differences and partial oxidation of the pseudovitrinite-precursor materials during the peat formation stage. Pseudovitrinite also decreased less than vitrinite with an increase in fusinite and semifusinite, indicating that the origins of these two macerals may be controlled by different oxidizing environmental conditions.

5. Fusinite and semifusinite have a positive association as a result of their similarity in origin.
6. Total sulfur has a positive association with the total vitrinite and a negative association with the total inertinite macerals. This association is related to how sulfur forms in the peat mass. Also, total sulfur contents decreased to the southeast, indicating more marine or brackish water conditions were present in Floyd County than in Pike County.
7. The general southeastward rank increase from high volatile B to high volatile A bituminous is probably due to geothermal gradient changes and/or differences in burial depths of the coal. Most of the tectonic structures visible at the surface in eastern Kentucky do not appear to have influenced coal rank.
8. Vitrinite-pseudovitrinite microhardness decreased from the high volatile B to high volatile A bituminous rank increase probably as a result of a corresponding decrease in density at this range. Microhardness relationships to carbon, hydrogen, and volatile matter are rank dependent.
9. The high inertinite, low ash and sulfur regions, and the distribution of some thin coals probably relate to paleotopographic highs which influenced the petrography, chemistry, and thickness of the seam.

10. High ash contents associated with the uppermost coal bench are probably a result of flooding, perhaps caused by subsidence or other factors. No relationship was found to exist between the ash and sulfur contents of the same coal bench. Also, no trends were apparent with the sulfur contents contained in the coal benches, perhaps indicating rapid environmental fluctuations.

REFERENCES

- Altschuler, Z. S., M. M. Schnepfe, C. C. Silber, and F. O. Simon, 1983, Sulfur diagenesis in Everglades peat and origin of pyrite in coal: *Science*, v. 221, p. 221-226.
- Alvord, D. C., 1965, Geologic map of the Broad Bottom Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-422.
- Alvord, D. C., 1971, Geologic map of the Hellier and Clintwood Quadrangles, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-950.
- Alvord, D. C. and C. E. Holbrook, 1965, Geologic map of the Pikeville Quadrangle, Pike and Floyd Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-480.
- Alvord, D. C. and R. L. Miller, 1972, Geologic map of the Elkhorn City-Harman Quadrangles, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map G. Q.-951.
- Alvord, D. C. and V. A. Trent, 1962, Geologic map of the Williamson Quadrangle, Pike and Martin Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-187.
- American Society for Testing of Materials, 1976 Annual book of ASTM standards, Part 26, Gaseous fuels: Coal and coke: American Society for Testing of Materials, Philadelphia, p. 250-291.
- _____, 1981, Annual book of ASTM Standards, Part 26, Gaseous fuels: Coal and Coke: American Society for Testing of Materials, Philadelphia, p. 324-357.
- _____, 1982, Annual book of ASTM Standards, Part 26, Gaseous fuels: Coal and Coke: American Society for Testing of Materials, Philadelphia, p. 369-383, 392-445.
- Barr, J. L. and H. H. Arndt, 1968, Geologic map of the Dorton Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-713.
- Benedict, L. G., R. R. Thompson, J. J. Shigo, and R. P. Aikman, 1968, Pseudovitrinite in Appalachian coking coals: *Fuel*, v. 47, p. 125-143.

- Brown, C. N., 1900, Mineral wealth of the Big Sandy Valley from Louisa to the head of navigation: Kentucky State Inspector of Mines Annual Report, p. 203-273.
- Browning, I. B. and P. G. Russell, 1919, Coals and structure of Magoffin County, Kentucky: Kentucky Geological Survey, Series 4, v. 5, 552 p.
- Cheek, R. B., 1969, Sulfur facies of the Upper Freeport coal of northwestern Preston County, West Virginia (Unpublished M. S. thesis): Morgantown, West Virginia University, 121 p.
- Coskren, T. D. and C. L. Rice, 1979, Contour map of the base of the Pennsylvanian System, eastern Kentucky: U. S. Geological Survey Map MF-1100.
- Crandall, A. R. and J. M. Hodge, 1887, Preliminary reports on the southeastern Kentucky coal field: Kentucky Geological Survey, 114 p.
- Davis, J. C., 1973, Statistics and data analysis in geology: Wiley, New York, p. 390-411.
- Dowd, J. J., 1951, Estimate of known recoverable reserves of coking coal in Pike County, Kentucky: U. S. Bureau of Mines Report of Investigation 4792, 34 p.
- _____, 1952, Estimate of known recoverable reserves of coking coal in Knott County, Kentucky: U. S. Bureau of Mines Report of Investigation 4897, 20 p.
- Fieldner, A. C., J. D. Davis, and G. C. Sprunk, 1922, Analyses of Kentucky coals: U. S. Bureau of Mines Technical Paper 308, p. 16-89.
- Fieldner, A. C., D. A. Jung, and E. B. Kester, 1944, Analyses of Kentucky coals: U. S. Bureau of Mines Technical Paper 652, 323 p.
- Fraser, T. and W. Crentz, 1946, Washing characteristics of the Pittsburgh coal in a high-sulfur area of Greene County, Pennsylvania: U. S. Bureau of Mines Technical Paper 689, 85 p.
- Hinrichs, E. and R. Ping, 1978, Geologic map of the Wayland Quadrangle, Floyd and Knott Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-1451.
- Horne, J. C. and J. C. Ferm, 1978, Carboniferous depositional environments in the Pocahontas Basin, eastern Kentucky and southern West Virginia: A Field Guidebook: Columbia, University of South Carolina, 129 p.

- Hower, J. C. and A. Davis, 1981, Application of vitrinite reflectance anisotropy in the evaluation of coal metamorphism: Geological Society of America Bulletin, Part 1, v. 92, p. 350-366.
- Huddle, J. W., E. J. Lyons, H. Smith, and J. C. Ferm, 1963, Coal reserves of eastern Kentucky: U. S. Geological Survey Bulletin 1120, 120 p.
- Hunt, C. B., G. Briggs, A. Munyan, and G. Wesley, 1937, Coal deposits of Pike County, Kentucky: U. S. Geological Survey Bulletin 876, 92 p.
- Jasienko, S., 1978, The nature of coking coals: Fuel: v. 57, p. 131-146.
- Jenkins, E. C., 1967, Geologic map of the Millard Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-659.
- Jillson, W. R., 1920, Low sulfur coals of Kentucky: American Institute of Mining, Metallurgical and Petroleum Engineers, Transactions: v. 63, p. 723-726.
- King, H. M., 1978, The morphology, maceral association, and distribution of iron disulfide minerals in the Waynesburg coal at a surface mine (Unpublished M. S. thesis): Morgantown, West Virginia University, 148 p.
- Krevelen, D. W. van, 1961, Coal: Amsterdam, Elsevier, p. 412.
- McFarlan, A. C., 1926, Carbon-ratio map of the Eastern Kentucky Coal Field: Kentucky Geological Survey.
- _____, 1943, Geology of Kentucky Lexington, University of Kentucky, 531 p.
- McKay, E. J., and D. C. Alvord, 1969, Geologic map of the Lick Creek Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-716.
- Neft, D. S., 1966, Statistical analysis for areal distribution: Monograph 2, Regional Science Research Institute, Philadelphia, Pennsylvania, 172 p.
- Outerbridge, W. F., 1966, Geologic map of the Paintsville Quadrangle, Johnson and Floyd Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-495.

- _____, 1968, Geologic map of the Majestic-Hurley-Wharncliffe Quadrangles, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-748.
- _____, 1975, Geologic map of the Wheelwright Quadrangle, Floyd, Pike, Knott, and Letcher Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-1251.
- Outerbridge, W. F., and R. van Vloten, 1968, Geologic map of the Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-775.
- Reidenouer, D., E. G. Williams, and R. R. Dutcher, 1967, The Relationship between paleotopography and sulfur distribution in some coals of western Pennsylvania: Economic Geology, v. 62. p. 632-647.
- Rice, C. L., 1965, Geologic map of the Harold Quadrangle, Floyd County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-441.
- _____, 1966, Geologic map of the Martin Quadrangle, Floyd County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-373.
- _____, 1967, Geologic map of the Prestonburg Quadrangle, Floyd and Johnson Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-732.
- _____, 1968, Geologic map of the McDowell Quadrangle, Floyd and Pike Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-732.
- _____, 1969, Geologic map of the Ivyton Quadrangle, Magoffin, Johnson, and Floyd Counties, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-801.
- Raymond, R., Jr., 1982, Electron microprobe analysis: a means of direct determination of organic sulfur in coal, in E. L. Fuller Jr. ed., Coal and coal products: analytical characterization techniques: American Chemical Society, Symposium Series 205, p. 191-203.
- Rice, C. L., R. G. Ping, and J. S. Barr, 1977, Geologic map of the Belfry Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-1369.
- Robinson, A. H., 1968, Mapping the correspondence of isarithmic maps, In: Berry, B. J., and D. Marble, editors, Spatial Analysis: Englewood Cliffs, New Jersey, Prentice-Hall, p.301-312.

- Smith, A. H. V., 1980, An appraisal of the work carried out on pseudovitrinite by the International Committee of Coal Petrology and the direction of future work: Internal communication of the International Committee of Coal Petrology, 6 p.
- Snedecor, G. W., 1946, Statistical methods (first edition): Ames, Iowa State College Press, 351 p.
- Stach, E., Mackowsky, M.-Th., Teichmüller, M. Taylor, G. H. Chandra, D., and Teichmüller, R., 1975, Coal Petrology (second edition): Berlin, Gebrüder, 428 p.
- Stone, R. W., 1908, Coal resources of the Russell Fork Basin in Kentucky and Virginia: U. S. Geological Survey Bulletin 348, p. 9-78.
- Stopes, M. C., 1919, On the four visible ingredients in banded bituminous coal: Proceedings of the Royal Society, Serial 13, v. 90, p. 470-487.
- Stopes, M. C., 1935, On the petrology of banded bituminous coals: Fuel, v. 14, p. 4-13.
- Thomas, E. N., 1968, Maps of residuals from regression, In Berry, B. J., and D. Marble, editors, Spatial Analysis: Englewood Cliffs, New Jersey, Prentice-Hall, p. 326-352.
- Thompson, R. R. and L. G. Benedict, 1974, Vitrinite reflectance as an indicator of coal metamorphism for coke making, In R. R. Dutcher and others, Carbonaceous materials as indicators of metamorphism: Geological Society of America Special Paper 153, p. 95-108.
- Trent, V. A., 1965, Geologic map of the Matewan Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-373.
- White, D. R. and R. Thiessen, 1913, The origin of coal: U. S. Bureau of Mines Bulletin 38, 390 p.
- Williams, E. G. and W. A. Bragonier, 1974, Controls of Early Pennsylvanian sedimentation in western Pennsylvanian, In Briggs, G., editor, Carboniferous of the Southeastern United States: Geological Society of America Special Paper 148, p. 135-152.
- Williams, E. G. and M. L. Keith, 1963, Relationship between sulfur in coals and the occurrence of marine roof beds: Economic Geology, v. 58, p. 720-729.
- Wolcott, D. E. and E. G. Jenkins, 1966, Geologic map of the Meta Quadrangle, Pike County, Kentucky: U. S. Geological Survey Quadrangle Map, G. Q.-497.

APPENDIX 1

Field Description and Sample Locations

Appendix 1

Field Description and Sample Locations

Previously sampled sites:

<u>KCER</u>	<u>Quadrangle</u>	<u>Carter coordinate section</u>
3045	Harold	17-M-83
3063 ¹	Martin	18-M-81
3076	Dorton	22-J-84
3079	Dorton	18-K-84
3097	Dorton	14-J-84
3105	McDowell	4-L-82
3132	McDowell	4-K-82
3147	Pikeville	3-K-84
3167	Hellier	10-J-85
3169	Broad Bottom	20-M-84
3225	Pikeville	20-L-83

¹Lower Bench

KCER Sample 3242

County: Floyd

Quadrangle: Wayland

Carter Coordinate: 10-L-80

FSL: 2850 FEL: 4500

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	913+ 22.9		sandstone shale, medium gray, coal stringers present, sharp contact with coal
coal:	25.4 0.3 6.0 1.3 8.9	<hr/> 3242 <hr/>	bright clarain fusain bright clarain fusain clarain
floor:	7.7+		underclay, plant fossils

KCER Sample Thicknesses (cm)

3242: 41.9

Total Seam Thickness (cm)

41.9

KCER Sample 3245

County: Floyd

Quadrangle: Martin

Carter Coordinate: 10-M-81

FSL: 3550 FEL: 4800

Comments: roadcut

thickness (cm)	KCER sample	lithotype
roof: 762+		shale, medium gray, sharp contact with coal
coal: 7.6	3245	bright clarain
3.8		dull clarain
3.8		bright clarain
0.2		fusain
10.0		bright clarain
10.2		fusain
2.5		bright clarain
3.8		shale
5.1		clarain
floor: 59.7+		underclay

KCER Sample Thicknesses (cm)

3245: 41.9

Total Seam Thickness (cm)
(including parting)

41.9

KCER Sample 3248, 3249, 3250

County: Floyd

Quadrangle: Martin

Carter Coordinate: 24-M-81

FSL: 2350 FEL: 4500

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	305+		shale, medium gray
	183		sandstone
	305		shale, sharp contact with coal
coal:	2.5		bright clarain
	0.2		fusain
	0.5	3248	bright clarain
	0.2		fusain
	1.7		bright clarain
	5.1		shale
	33.0		clarain
	0.2		fusain
	4.9		clarain
	0.2		fusain
	16.4		clarain
	0.2		fusain
	6.2		clarain
	2.5		pyrite
	3.8	3249	clarain
	0.2		fusain
	3.6		clarain
	0.2		fusain
	3.7		clarain
	0.1		fusain
	3.6		clarain
	0.2		fusain
	2.4		clarain
	15.2	3250	dull clarain
	2.5		clarain
floor:	7.6+		underclay

KCER Sample Thicknesses (cm)

3248: 5.1
3249: 81.3
3250: 17.8

KCER Sample 3248, 3249, 3250 (Continued)

Total Seam Thickness (cm)
(including partings)

109.2

KCER Sample 3251, 3253, 3252

County: Floyd

Quadrangle: Martin

Carter Coordinate: 25-M-81

FSL: 350 FEL: 200

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	243+		shale, sharp contact with coal
coal:	12.7		bright clarain
	0.2		fusain
	3.7		clarain
	0.2		fusain
	2.4		clarain
	0.2	3251	fusain
	1.1		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	4.9		clarain
	2.5	3253	carbonaceous shale
	1.3		clarain
	0.2		fusain
	3.6	3252	clarain
	0.2		fusain
	13.8		clarain
floor:	7.5+		underclay, plant fossils

KCER Sample Thicknesses (cm)

3251: 26.7

3253: 2.5

3252: 19.1

Total Seam Thickness (cm)

48.3

KCER Sample 3254, 3255, 3256

County: Floyd

Quadrangle: Martin

Carter Coordinate: 19-N-81

FSL: 1900 FEL: 1350

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	45.7+		shale, medium gray, some siderite, sharp contact with coal
coal:	2.5		clarain
	0.2		fusain
	0.3		vitrain
	0.8		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	3.0	3254	clarain
	0.3		vitrain
	1.0		clarain
	0.2		fusain
	0.5		clarain
	0.2		vitrain
	4.8		clarain
	8.9		clay
	3.2		dull clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	0.5		clarain
	0.5		vitrain
	0.8		clarain
	0.2	3255	fusain
	1.1		clarain
	2.5		fusain, pyrite
	0.6		vitrain
	0.2		fusain
	0.5		clarain
	3.8		carbonaceous shale
	3.8		clarain
	0.4		vitrain
	0.9		clarain
	0.2		fusain
	6.0		carbonaceous shale
	0.5		vitrain

KCER Sample 3254, 3255, 3256 (Continued)

thickness (cm)	KCER sample	lithotype
6.5		carbonaceous shale
5.1		pyrite
12.7		carbonaceous shale
0.3		vitrain
4.8		carbonaceous shale
0.3		vitrain
2.2		carbonaceous shale
0.2		fusain
3.0		clarain
0.2		fusain
3.0		clarain
0.2		fusain
3.0		clarain
0.2		fusain
3.0		clarain
0.2	3256	fusain
3.0		clarain
0.2		fusain
4.8		clarain
0.2		fusain
12.2		clarain
0.3		vitrain
floor: 7.7+		underclay

KCER Sample Thicknesses (cm)

3254: 16.5

3255: 20.3

3256: 30.5

Total Seam Thickness (cm)
(including partings)

151.1

KCER Sample 3257, 3258

County: Floyd

Quadrangle: Martin

Carter Coordinate: 19-N-81

FSL: 2150 FEL: 600

Comments: roadcut

thickness (cm)	KCER sample	lithotype
roof: 122+		sandstone, some siderite and coal stringers, wavy bedding
0.6	_____	vitrain
0.2		fusain
3.0	3257	bright clarain
0.2	rider #1	fusain
0.3		vitrain
0.2		bright clarain
0.3		vitrain
0.3	_____	bright clarain
5.1		underclay
59.7		shale, dark gray
0.7		vitrain
8.2		shale, dark gray
0.7		vitrain
7.0	_____	shale, dark gray
coal: 12.7		clarain
5.1	3258	bright clarain
0.3		fusain
9.9	_____	bright clarain
floor: 10.2		underclay

KCER Sample Thicknesses (cm)

3257: 5.1

3258: 27.9

Total Seam Thickness (cm)

27.9

KCER Sample 3259, 3260, 3261, 3262

County: Floyd

Quadrangle: Martin

Carter Coordinate: 19-N-81

FSL: 2550 FEL: 600

Comments: roadcut

thickness (cm)	KCER sample	lithotype
roof: 457+		shale, light gray, siderite abundant
1.3		clarain
0.2	3259	fusain
2.4	rider #1a	clarain
0.5		pyrite
8.4		clarain
0.3		vitrain
4.8		shale
0.2		vitrain
1.1		shale
2.5		dull clarain
0.3	3260	vitrain
2.2	rider #1b	dull clarain
0.3		fusain
1.0		dull clarain
20.3		underclay
0.6		vitrain
0.3		dull clarain
0.3		vitrain
0.6		dull clarain
3.2		shale
0.3		vitrain
0.6		clarain
0.3		vitrain
2.9	3261	clarain
0.2	rider #1c	fusain
1.1		clarain
0.2		fusain
1.1		clarain
0.6		vitrain
0.6		clarain
0.2		fusain
1.7		clarain
3.2		carbonaceous shale
0.3		vitrain
8.3		clarain
7.6		shale
0.3		vitrain
2.2		shale
0.6		vitrain

KCER Sample 3259, 3260, 3261, 3262 (Continued)

	thickness (cm)	KCER sample	lithotype
	8.9		shale
	0.3		vitrain
	10.5		shale
	0.3		vitrain
	8.6		shale
		<hr/>	
coal:	0.3		vitrain
	3.5		bright clarain
	0.2		fusain
	2.1		bright clarain
	0.2		fusain
	4.0	3262	bright clarain
	0.3		vitrain
	2.2		clarain
	0.3		vitrain
	4.8		clarain
	0.2		fusain
	10.6		clarain
		<hr/>	
floor:	7.6+		underclay

KCER Sample Thicknesses (cm)

3259: 12.8
 3260: 6.3
 3261: 26.6
 3262: 28.7

Total Seam Thickness (cm)

28.7

KCER Sample 3263, 3264, 3265, 3266

County: Pike

Quadrangle: Millard

Carter Coordinate: 16-L-85

FSL: 1900

FEL: 1250

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	167+		shale, abundant siderite sharp contact with coal
coal:	0.6	3263	clarain
	0.3		vitrain
	0.3		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	2.2		clarain
	1.3		vitrain
	5.7		clarain
	0.3		vitrain
	0.3		clarain
	0.3		vitrain
	1.0		clarain
	0.2		fusain
	0.3		vitrain
	0.8		clarain
	0.2		fusain
	3.7		clarain
	1.3		carbonaceous shale
	0.6		vitrain
	3.2		clarain
	0.3		vitrain
	1.6		clarain
	0.7		vitrain
	0.2		fusain
	0.3	3264	vitrain
	0.8		clarain
	0.2		fusain
	3.7		clarain
	0.2		fusain
	2.4		clarain
	0.3		vitrain
	2.3		clarain
	0.3		vitrain
	0.9		clarain
	0.3		vitrain

KCER Sample 3263, 3264, 3265, 3266 (Continued)

thickness (cm)	KCER sample	lithotype
3.5	3264	clarain
0.3		vitrain
4.8		clarain
0.3		vitrain
6.0		clarain
0.3		vitrain
1.0		clarain
0.3		fusain
7.3	3265	clarain
0.2		fusain
1.1		clarain
0.2		fusain
6.2		clarain
0.3		vitrain
7.3		clarain
20.3		clarain
0.2	3266	fusain
2.4		clarain
floor: 5.1+		underclay

KCER Sample Thicknesses (cm)

3263: 20.4
 3264: 34.8
 3265: 22.6
 3266: 22.9

Total Seam Thickness (cm)
 (including parting)

102.0

KCER Sample 3267, 3268

County: Pike

Quadrangle: Pikeville

Carter Coordinate: 9-L-84

FSL: 2700 FEL: 900

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	122+		shale, siderite present
	137.2		shale, coal stringers,
		<u>3267</u>	sharp contact with coal
	6.4	<u>rider #1</u>	dull clarain
	15.2		shale, dark gray
coal:	17.8		clarain
	0.1		fusain
	15.1		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	2.4		clarain
	0.1	3268	fusain
	1.1		clarain
	0.2		fusain
	1.1		clarain
	0.1		fusain
	2.4		clarain
	0.1		fusain
	2.2		clarain
	0.2		vitrain
floor:	25.1		underclay

KCER Sample Thicknesses (cm)

3267: 6.4

3268: 45.7

Total Seam Thickness (cm)

45.7

KCER Sample 3270

County: Pike

Quadrangle: Millard

Carter Coordinate: 19-L-85

FSL: 4600 FEL: 4450

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	31+		shale, siderite present, sharp contact with coal
coal:	5.1	<hr/> 3270 <hr/>	clarain
	0.3		vitrain
	0.3		clarain
	0.3		vitrain
	1.6		clarain
	0.3		vitrain
	8.6		clarain
	0.2		fusain
	1.1		clarain
	0.3		vitrain
	1.0		clarain
	0.2		vitrain
	3.6		clarain
	0.3		vitrain
	12.4		clarain
	0.3		vitrain
	14.9		clarain
	0.3		vitrain
	3.5		clarain
	1.3		carbonaceous shale
	2.5		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	2.2		clarain
	0.3		vitrain
	9.9		clarain
	0.3		vitrain
	30.2		clarain
floor:	10.1+		underclay

KCER Sample Thicknesses (cm)

3270: 109.3

KCER Sample 3270 (Continued)

Total Seam Thickness (cm)

109.3

KCER Sample 3271, 3272, 3273

County: Pike

Quadrangle: Hellier

Carter Coordinate: 16-K-85

FSL: 4000 FEL: 700

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	152+		sandstone
	304		shale, siderite present, sharp contact with coal
coal:	1.3		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.1		fusain
	1.1		clarain
	0.3		vitrain
	4.8		clarain
	0.2		fusain
	2.4		clarain
	0.1		fusain
	1.1		clarain
	0.2		fusain
	0.2		vitrain
	0.9		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.1		fusain
	2.4		clarain
	0.2	3271	vitrain
	2.3		clarain
	0.3		vitrain
	2.9		clarain
	0.3		vitrain
	1.6		clarain
	0.1		fusain
	0.3		vitrain
	2.1		clarain
	0.2		fusain
	4.9		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	1.1		clarain

thickness (cm)	KCER sample	lithotype
1.3	3272	clarain
0.2		fusain
1.1		clarain
0.2		vitrain
1.1		clarain
0.2		vitrain
1.0		clarain
0.2		fusain
1.1		clarain
0.2		fusain
1.1		clarain
0.2		fusain
2.4		clarain
0.2		vitrain
1.1		clarain
0.3		vitrain
7.3		clarain
0.3		fusain
2.2		clarain
0.3		vitrain
8.6		clarain
0.3		vitrain
2.2		clarain
0.3		fusain
2.2		clarain
0.3		fusain
2.2		clarain
0.3		clarain
2.2		vitrain
1.3		clarain
0.3		vitrain
7.3		clarain
0.2		vitrain
6.1		clarain
0.2		vitrain
4.9	3273	clarain
0.2		vitrain
4.8		clarain
0.2		vitrain
9.9		clarain
0.3		vitrain
7.0		clarain
0.2		vitrain
floor: 13.0		underclay

KCER Sample Thicknesses (cm)

KCER Sample 3271, 3272, 3273 (Continued)

3271: 38.1
3272: 40.6
3273: 42.9

Total Seam Thickness (cm)

121.6

KCER Sample 3275, 3276, 3277

County: Pike

Quadrangle: Millard

Carter Coordinate: 6-K-86

FSL: 2250 FEL: 2000

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	305+		shale, siderite present, sharp contact with coal
coal:	3.2		bone coal
	0.6		clarain
	0.3		vitrain
	0.7		clarain
	0.5		fusain
	1.4		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.2	3275	vitrain
	0.7		clarain
	0.3		vitrain
	1.6		clarain
	0.2		fusain
	0.1		vitrain
	2.3		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	1.0		clarain
	0.3		vitrain
	3.5		clarain
	0.3		vitrain
	1.0		clarain
	0.2		vitrain
	1.1		clarain
	0.2		fusain
	0.2		vitrain
	4.7		clarain
	0.1		fusain
	0.5		clarain
	0.3	3276	vitrain
	1.6		clarain
	0.3		vitrain
	2.9		clarain
	0.3		vitrain
	4.1		clarain

KCER Sample 3275, 3276, 3277 (Continued)

thickness (cm)	KCER sample	lithotype
0.1	3276	fusain
0.3		vitrain
0.8		clarain
0.3		vitrain
2.2		clarain
0.2		fusain
2.2		clarain
0.3		vitrain
3.5		clarain
0.3		vitrain
1.0		clarain
2.5		carbonaceous shale
0.3		vitrain
7.3		clarain
1.3		carbonaceous shale
0.3	3277	vitrain
7.3		clarain
0.3		fusain
0.3		clarain
0.3		vitrain
1.6		clarain
0.3		vitrain
1.0		clarain
0.3		fusain
9.9		clarain
0.3		vitrain
1.6		clarain
0.3		vitrain
0.3		clarain
floor: 50.0+		shale

KCER Sample Thicknesses (cm)

3275: 24.4
3276: 28.5
3277: 33.0

Total Seam Thickness (cm)

85.9

KCER Sample 3279, 3280, 3281, 3282

County: Pike

Quadrangle: Hellier

Carter Coordinate: 13-K-85

FSL: 2800 FEL: 450

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	610+		sandstone
	457		shale, coal stringers, sharp contact with coal
coal:	3.8		bright clarain
	0.1		fusain
	7.6		bright clarain
	3.8		clarain
	0.6		vitrain
	5.7		clarain
	0.6		vitrain
	0.7	3279	clarain
	0.2		fusain
	3.7		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	2.4		clarain
	0.6		vitrain
	0.2		fusain
	0.5		clarain
	1.3		clarain
	0.2		fusain
	8.7		clarain
	0.6		vitrain
	3.2	3280	clarain
	0.5		fusain
	0.8		clarain
	0.2		fusain
	12.5		clarain
	0.2		fusain
	0.3		vitrain
	0.8		clarain
	0.3		vitrain
	0.2	3282	fusain
	16.0		clarain
	0.6		fusain
	0.3		vitrain
	1.6		clarain
	0.2		fusain
	7.5		clarain

KCER Sample 3279, 3280, 3281, 3282 (Continued)

thickness (cm)	KCER sample	lithotype
0.6	3282	fusain
9.5		clarain
0.2		vitrain
2.3		clarain
0.2		fusain
2.4		clarain
0.2		vitrain
6.2		clarain
0.6		vitrain
13.4		clarain
floor: 2.5+		underclay

KCER Sample Thicknesses (cm)

3279: 33.3
 3280: 28.0
 3281: 28.6
 3282: 35.0

Total Seam Thickness (cm)

124.9

KCER Sample 3283, 3284, 3285, 3286

County: Pike

Quadrangle: Elkhorn City

Carter Coordinate: 21-K-86

FSL: 900 FEL: 4300

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	91+		sandstone
	76		shale, siderite present
	61		sandstone
	152		shale, siderite present
coal:	2.5		bright clarain
	0.2		fusain
	7.5		bright clarain
	0.6	3283	vitrain
	8.3		clarain
	0.6		vitrain
	9.6		clarain
	2.5		fusain
	1.9		vitrain
	23.5	3284	clarain
	1.9		fusain
	0.6		vitrain
	1.3		clarain
	0.2		fusain
	1.1		clarain
	0.3	3285	vitrain
	12.4		clarain
	0.3		vitrain
	4.8		clarain
	0.2		fusain
	8.7		clarain
	2.5		clarain
	0.3		vitrain
	7.3		clarain
	0.3	3286	fusain
	4.8		clarain
	0.4		fusain
	9.7		clarain
	0.3		fusain
	9.9		clarain
floor:	30.5+		underclay

KCER Sample Thicknesses (cm)

KCER Sample 3283, 3284, 3285, 3286 (Continued)

3283:	31.8
3284:	27.3
3285:	29.9
3286:	35.5

Total Seam Thickness (cm)

124.5

KCER Sample 3287, 3288, 3289, 3290, 3291

County: Pike

Quadrangle: Meta

Carter Coordinate: 22-M-85

FSL: 5500 FEL: 2200

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	610+		sandstone, light colored, sharp contact with coal
coal:	24.1		bright clarain
	3.8	<u>3287</u>	clay
	8.9		clarain
	5.1	<u>3288</u>	clay
	3.8		clarain
	3.8	<u>3289</u>	clay
	0.2		fusain
	1.1		clay
	0.2		fusain
	4.9		clay
	3.8		clarain
	0.2	<u>3290</u>	fusain
	26.5		clarain
	3.8		clay
	16.5	<u>3291</u>	clarain
floor:	30.0+		underclay

KCER Sample Thicknesses (cm)

3287: 24.1
3288: 8.9
3289: 3.8
3290: 30.5
3291: 16.5

Total Seam Thickness (cm)

83.8

KCER Sample 3292, 3293, 3294, 3295

County: Pike

Quadrangle: Millard

Carter Coordinate: 8-L-85

FSL: 5400

FEL: 500

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	457+		silty shale, light gray, some siderite present, sharp contact with coal
coal:	8.9		bright clarain
	0.2		fusain
	2.4		bright clarain
	0.2	3292	fusain
	1.1		bright clarain
	0.3		vitrain
	6.0		bright clarain
	2.5		carbonaceous shale
	0.6		clarain
	0.3		vitrain
	1.0		clarain
	0.6	3293	vitrain
	1.3		clarain
	0.3		vitrain
	2.9		clarain
	0.3		vitrain
	0.3		clarain
	3.8		carbonaceous shale
	12.7		clarain
	0.3		fusain
	3.5		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	1.1	3294	clarain
	0.2		fusain
	7.5		clarain
	0.3		fusain
	4.8		clarain
	0.3		vitrain
	8.6		clarain
	0.3		vitrain
	3.5		clarain
	0.2		fusain
	8.7		clarain
	2.5		clay
	16.5	3295	clarain

KCER Sample 3292, 3293, 3294, 3295 (Continued)

thickness (cm)	KCER sample	lithotype
0.2	<u>3295</u>	
10.0		
floor: 15.2+		underclay

KCER Sample Thicknesses (cm)

3292: 19.1
3293: 7.6
3294: 58.6
3295: 26.7

Total Seam Thickness (cm)
(including partings)

117.0

KCER Sample 3296, 3297, 3298, 3299

County: Pike

Quadrangle: Meta

Carter Coordinate: 10-M-85

FSL: 4800 FEL: 1225

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	305+		silty shale, sharp contact with coal
coal:	1.9	<u>3296</u>	dull clarain
	5.5		clarain
	0.2		fusain
	1.3		clay
	1.3		bright clarain
	0.3		vitrain
	9.9		bright clarain
	0.6	3297	vitrain
	0.6		fusain
	2.6		bright clarain
	0.3		vitrain
	4.1		bright clarain
	0.3		fusain
	2.2		bright clarain
	0.6		fusain
	4.4		clarain
	5.1	<u> </u>	clay
	1.9		clarain
	0.3		vitrain
	0.3		clarain
	3.8		clay
	2.5	<u> </u>	clarain
	0.6		vitrain
	1.9		clarain
	0.2		fusain
	1.7		clarain
	0.3		vitrain
	5.4		clarain
	0.3	3298	vitrain
	3.5		clarain
	0.2		fusain
	11.3		clarain
	0.5		fusain
	0.3		vitrain
	3.0		clarain
	0.2		fusain
	0.3		vitrain
	0.8		clarain

KCER Sample 3296, 3297, 3298, 3299 (Continued)

thickness (cm)	KCER sample	lithotype
0.3	<u>3298</u>	vitrain
6.1		clarain
5.1		clay
0.2		fusain
0.3		vitrain
0.8		clarain
0.3		vitrain
0.4		clarain
0.3		fusain
0.3		clarain
0.3	3299	vitrain
0.3		fusain
1.9		clarain
0.3		vitrain
4.8		clarain
0.3		vitrain
0.3		clarain
0.2		fusain
0.5		clarain
floor: 9.0+		underclay

KCER Sample Thicknesses (cm)

3296: 1.9
 3297: 34.2
 3298: 44.5
 3299: 11.5

Total Seam Thickness (cm)
 (including partings)

103.5

KCER Sample 3300, 3301

County: Magoffin

Quadrangle: Ivyton

Carter Coordinate: 14-0-79

FSL: 2100 FEL: 500

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	100+		sandstone
	22.9		shale
coal:	0.6		dull clarain
	0.3		vitrain
	0.3		dull clarain
	0.3		vitrain
	1.0		dull clarain
	0.6	3300	vitrain
	1.9		dull clarain
	0.3		vitrain
	5.4		dull clarain
	0.6		vitrain
	5.1		dull clarain
	8.9		dull clarain
	0.2		fusain
	0.3	3301	vitrain
	2.1		dull clarain
	0.2		fusain
	2.4		dull clarain
	0.6		vitrain
	1.9		dull clarain
floor:	30.5+		underclay

KCER Sample Thicknesses (cm)

3300: 16.4

3301: 16.6

Total Seam Thickness (cm)

33.0

KCER Sample 3305, 3306, 3307, 3308

County: Pike

Quadrangle: Pikeville

Carter Coordinate: 12-K-83

FSL: 3300

FEL: 1650

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	510+		sandstone, light colored, coarse to medium grained, wavy contact with coal
coal:	1.6		carbonaceous shale
	1.4		clay
	0.8		carbonaceous shale
	0.2		vitrain
	2.1		carbonaceous shale
	3.2		dull clarain
	0.5		vitrain
	2.2	3305	dull clarain
	1.7		clarain
	0.1		fusain
	1.4		clarain
	0.2		fusain
	1.4		clarain
	0.1		fusain
	1.3		clarain
	0.3		vitrain
	1.3		clarain
	0.5		vitrain
	1.0		clarain
	0.2		vitrain
	1.8		clarain
	0.2		fusain
	2.4		clarain
	0.4	3306	vitrain
	2.6		clarain
	0.5		vitrain
	1.1		clarain
	0.2		fusain
	2.9		clarain
	0.3		vitrain
	5.9		clarain
	0.5		vitrain
	20.8		clarain
	1.6		clarain
	3.0	3307	carbonaceous shale
	0.5		vitrain
	2.5		clarain

KCER Sample 3305, 3306, 3307, 3308 (Continued)

thickness (cm)	KCER sample	lithotype
0.2	3307	fusain
1.4		clarain
0.2		fusain
2.8		clarain
0.2		fusain
8.9		clarain
0.2		fusain
1.9		clarain
0.2		fusain
15.7		clarain
0.2	<u>3308</u>	fusain
13.8		durain
floor: 7.6+		underclay

KCER Sample Thicknesses (cm)

3305: 19.8
 3306: 41.3
 3307: 39.5
 3308: 13.8

Total Seam Thickness (cm)

114.6

KCER Sample 3309, 3310, 3311, 3312, 3313

County: Pike

Quadrangle: Dorton

Carter Coordinate: 6-J-84

FSL: 3650

FEL: 200

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	610+		sandstone
	457		siltstone, some shale and siderite, sharp contact with coal
coal:	6.0	<u>3309</u>	clarain
	3.2		clay
	1.4		clarain
	4.6		clay
	24.4		clarain
	0.2		fusain
	2.8	3310	clarain
	0.2		fusain
	7.4		clarain
	0.2		fusain
	1.3		clarain
	0.2		fusain
	1.4		clarain
	0.2		fusain
	1.4		clarain
	0.1	<u> </u>	fusain
	2.9		clarain
	0.2		fusain
	18.1		clarain
	0.2		fusain
	2.8	3311	clarain
	0.2		fusain
	1.4		clarain
	0.2		fusain
	1.2		clarain
	0.2		fusain
	18.2	<u> </u>	clarain
	0.3		fusain
	14.9		clarain
	0.3	3312	fusain
	2.7		clarain
	0.2		fusain
	18.2		clarain
	35.5	<u>3313</u>	clarain
floor:	7.6+		underclay

KCER Sample 3309, 3310, 3311, 3312, 3313 (Continued)

KCER Sample Thicknesses (cm)

3309:	6.0
3310:	48.9
3311:	45.7
3312:	36.5
3313:	35.5

Total Seam Thickness (cm)
(including partings)

172.6

KCER Sample 3314, 3315, 3316, 3317

County: Pike

Quadrangle: Dorton

Carter Coordinate: 11-J-83

FSL: 5700 FEL: 3150

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	457+		sandstone, medium to coarse grained, cross bedded, sharp contact with coal
coal:	3.0	3314	bright clarain
	1.6		carbonaceous shale
	2.9		bright clarain
	0.2		fusain
	3.0		bright clarain
	4.6		carbonaceous shale
	4.6	3315	clarain
	0.2		fusain
	2.9		clarain
	0.2		fusain
	10.5		clarain
	0.2		fusain
	4.4		clarain
	0.2		fusain
	4.4		clarain
	0.2		fusain
	2.9		clarain
	0.2		fusain
	2.9		clarain
	0.2		fusain
	1.4		clarain
	0.2		fusain
	1.3		clarain
	0.2		fusain
	1.5		clarain
	0.2		fusain
	2.9	3316	clarain
	0.2		fusain
	10.5		clarain
	0.2		fusain
	1.4		clarain
	0.2		fusain
	16.6		clarain
	0.2		fusain
	11.9		clarain
	0.2		fusain

KCER Sample 3314, 3315, 3316, 3317 (Continued)

thickness (cm)	KCER sample	lithotype
4.4	<u>3316</u>	clarain
10.7	<u>3317</u>	clarain
6.7		dull clarain
floor: 15.2+		underclay

KCER Sample Thicknesses (cm)

3314: 19.9
 3315: 37.1
 3316: 45.8
 3317: 17.4

Total Seam Thickness (cm)

120.2

KCER Sample 3320

County: Magoffin

Quadrangle: Ivyton

Carter Coordinate: 5-N-80

FSL: 5350 FEL: 250

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	610+		sandstone
	30.5		shale
	12.7		sandstone
	68.6		shale, dark gray
			sharp contact with coal
coal:	2.5		clarain
	0.2		fusain
	0.6		vitrain
	0.5		clarain
	0.2		fusain
	1.7		clarain
	0.3		vitrain
	0.3		clarain
	0.6		vitrain
	0.2		fusain
	0.5		clarain
	0.2		fusain
	3.0		clarain
	0.1		fusain
	1.1	3320	clarain
	0.3		vitrain
	2.2		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	0.3		vitrain
	1.5		clarain
	0.2		fusain
	0.5		clarain
	0.2		fusain
	0.3		vitrain
	2.1		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	3.0		clarain
	0.3		vitrain
	0.3		fusain
	4.4		clarain
	0.2		fusain

KCER Sample 3320 (Continued)

	thickness (cm)	KCER sample	lithotype
	3.7	<u>3320</u>	clarain
floor:	12.7+		underclay

KCER Sample Thicknesses (cm)

3320: 35.7

Total Seam Thickness (cm)

35.7

KCER Sample 3325, 3326, 3327

County: Floyd

Quadrangle: Prestonburg

Carter Coordinate: 3-N-81

FSL: 400 FEL: 700

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	152+		sandstone
	762		shale, some siderite, sharp contact with coal
coal:	6.3	<u>3325</u>	clarain
	7.6	<u> </u>	carbonaceous shale
	2.5		clarain
	0.2		fusain
	2.4	3326	clarain
	0.2		fusain
	3.7		clarain
	0.2		fusain
	7.5	<u> </u>	clarain
	5.1	<u> </u>	shale
	2.5		dull clarain
	0.2		fusain
	3.6	3327	dull clarain
	0.2		fusain
	2.4		dull clarain
	16.5	<u> </u>	clarain
floor:	30.5+		underclay

KCER Sample Thicknesses (cm)

3325: 6.3

3326: 16.7

3327: 25.4

Total Seam Thickness (cm)
(including partings)

61.1

KCER Sample 3328, 3329

County: Pike

Quadrangle: Harold

Carter Coordinate: 14-N-82

FSL: 2000 FEL: 2500

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	305+		shale
	61		sandstone
	121.9		shale
coal:	5.1		bone coal
	7.6		carbonaceous shale
	1.3		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	2.4		clarain
	0.2	3328	fusain
	1.1		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	7.5		clarain
	0.2		fusain
	6.2		clarain
	0.2		fusain
	4.9		clarain
	0.5	3329	fusain
	2.0		clarain
	0.2		fusain
	17.6		clarain
floor:	51.1+		underclay

KCER Sample Thicknesses (cm)

3328: 32.1

3329: 25.4

Total Seam Thickness (cm)
(including parting)

62.6

KCER Sample 3330

County: Floyd

Quadrangle: Harold

Carter Coordinate: 16-N-82

FSL: 350 FEL: 600

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	200+		sandstone
	457.2		shale, abundant siderite, sharp contact with coal
coal:	0.3	3330	clarain
	0.2		fusain
	7.1		clarain
	0.2		fusain
	8.7		clarain
	0.2		fusain
	4.9		clarain
floor:	8.0+		underclay

KCER Sample Thicknesses (cm)

3330: 21.6

Total Seam Thickness (cm)

21.6

KCER Sample 3331, 3332

County: Pike

Quadrangle: Broad Bottom

Carter Coordinate: 13-M-84

FSL: 800 FEL: 400

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	90+		shale, medium gray, sharp contact with coal
coal:	0.6	3331	clarain
	0.2		fusain
	0.5		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	3.6		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	1.1		clarain
	10.0		dull clarain
	0.2		fusain
	5.1	3332	clarain
	0.3		fusain
	3.5		clarain
	0.3		fusain
	4.8		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	13.2		clarain
	0.3		fusain
	11.1		clarain
floor:	30.5+		underclay

KCER Sample 3331, 3332 (Continued)

KCER Sample Thicknesses (cm)

3331: 34.6

3332: 42.0

Total Seam Thickness (cm)

76.6

KCER Sample 3335

County: Johnson

Quadrangle: Paintsville

Carter Coordinate: 9-P-81

FSL: 2300 FEL: 2000

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	450+		sandstone, medium to coarse grained, scours into coal in some places
	12.7		shale, medium gray, sharp contact with coal
coal:	2.5	3335	clarain
	0.2		fusain
	0.2		vitrain
	2.9		clarain
	0.2		fusain
	5.5		clarain
	0.2		vitrain
	3.6		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	4.0		clarain
	0.3		fusain
	3.4		clarain
	0.2		fusain
	1.4		clarain
	0.2		fusain
	7.5		clarain
	0.2		fusain
	1.6		clarain
	0.2		vitrain
floor:	30.5+		underclay

KCER Sample Thicknesses (cm)

3335: 35.8

Total Seam Thickness (cm)

35.8

KCER Sample 3336, 3337, 3338

County: Floyd

Quadrangle: Harold

Carter Coordinate: 7-M-82

FSL: 4300

FEL: 3400

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	110+ 61.0		sandstone, some siltstone shale and siltstone, some siderite, sharp contact with coal
coal:	3.1		clarain
	0.2		fusain
	3.1		clarain
	0.2	3336	fusain
	3.0		clarain
	0.2		fusain
	1.7		clarain
	5.1		bone coal
	5.1		clarain
	0.2		fusain
	3.6		clarain
	0.2		fusain
	4.9		clarain
	0.2		fusain
	2.4		clarain
	0.3		fusain
	0.3	3337	clarain
	0.2		fusain
	13.2		clarain
	0.2		fusain
	1.8		clarain
	0.2		fusain
	1.7		clarain
	0.2		fusain
	0.5		clarain
	0.2		fusain
	0.5		clarain
	0.6		fusain
	0.7		clarain
	6.3		clarain
	0.2		fusain
	13.8	3338	clarain
	0.2		fusain
	8.7		clarain
	0.2		fusain
	8.7		clarain
	0.6		fusain

KCER Sample 3336, 3337, 3338 (Continued)

thickness (cm)	KCER sample	lithotype
4.3	3338	clarain
0.2		fusain
9.7		clarain
floor: 8.1+		siltstone

KCER Sample Thicknesses (cm)

3336: 11.5
 3337: 37.2
 3338: 52.9

Total Seam Thickness (cm)
 (including parting)

106.7

KCER Sample 3342, 3343, 3344, 3345

County: Pike

Quadrangle: Belfry

Carter Coordinate: 21-N-86

FSL: 4300

FEL: 650

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	127+		shale, abundant siderite, sharp contact with coal
coal:	6.4	_____	clarain
	0.3		vitrain
	4.8		clarain
	0.2		fusain
	1.1		clarain
	0.2		fusain
	4.9		clarain
	0.2	3342	fusain
	3.6		clarain
	0.2		fusain
	4.9		clarain
	0.3		vitrain
	6.0		clarain
	0.3		vitrain
	1.0		clarain
	0.2		fusain
	13.8		clarain
	5.1	_____	shale
	2.5	_____	durain
	5.1		clarain
	0.6		fusain
	9.6	3343	clarain
	0.6		fusain
	5.1		clarain
	0.6		shale
	2.5		clarain
	7.6	_____	shale
	3.2	_____	clarain
	0.2		fusain
	6.8		clarain
	0.2		fusain
	2.4	3344	clarain
	0.6		vitrain
	1.9		clarain
	0.2		fusain
	4.9		clarain
	14.0	_____	shale
	3.8	_____	clarain

KCER Sample 3342, 3343, 3344, 3345 (Continued)

thickness (cm)	KCER sample	lithotype
0.6	3345	shale
12.1		clarain
0.6		fusain
8.3		clarain
1.3		durain
7.6		clarain
6.3		dull clarain
floor: 15.2+		underclay

KCER Sample Thicknesses (cm)

3342: 48.4
 3343: 26.6
 3344: 20.4
 3345: 36.2

Total Seam Thickness (cm)
 (including partings)

162.7

KCER Sample 3346, 3347, 3348

County: Pike

Quadrangle: Belfry

Carter Coordinate: 16-N-87

FSL: 600 FEL: 3700

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	305+		sandstone
	152.4		shale, siderite present, sharp contact with coal
coal:	2.5	_____	bone coal
	5.1		clarain
	0.2		fusain
	15.1		clarain
	0.2		fusain
	6.8	3346	clarain
	0.2		fusain
	9.4		clarain
	0.2		fusain
	12.5		clarain
	0.2		fusain
	8.7		clarain
	1.3	_____	shale
	16.5	_____	clarain
	2.5	3347	pyrite
	5.1		clarain
	5.1	_____	shale
	17.8		clarain
	4.4	3348	shale
	3.2		clarain
	10.8		dull clarain
	33.6	_____	clarain
floor:	7.6+		underclay

KCER Sample Thicknesses(cm)

3346: 61.1

3347: 24.1

3348: 69.8

Total Seam Thickness (cm)
(including partings)

161.4

KCER Sample 3349, 3350, 3351

County: Pike

Quadrangle: Belfry

Carter Coordinate: 17-N-87

FSL: 1100 FEL: 2100

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	30.5+		shale, some siderite, sharp contact with coal
coal:	11.4	3349	clarain
	0.6		fusain
	11.5		clarain
	0.6		vitrain
	1.3	3350	clarain
	22.9		bone coal
	0.2		fusain
	2.4		clarain
	0.2		fusain
	4.9		clarain
	0.2		fusain
	8.1		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	16.3		clarain
	0.3		fusain
	4.8		clarain
	0.2		fusain
	1.8	3351	clarain
	0.2		fusain
	13.2		clarain
	0.2		fusain
	25.2		clarain
	2.5		mineral zone
	17.8		durain
floor:	8.0+		underclay

KCER Sample Thicknesses (cm)

3349: 25.4

3350: 86.7

3351: 20.3

Total Seam Thickness (cm)

(including parting) 155.3

KCER Sample 3352, 3353, 3354

County: Pike

Quadrangle: Matewan

Carter Coordinate: 17-M-89

FSL: 1200 FEL: 5700

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	305+		sandstone
	10.2		shale, coal stringers, sharp contact with coal
coal:	10.2		clarain
	0.6		vitrain
	8.2		clarain
	0.6	3352	fusain
	0.7		clarain
	0.6		vitrain
	0.6		fusain
	1.3		clarain
	3.8		shale
	2.5		clarain
	0.2		fusain
	8.7		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	8.1	3353	clarain
	0.2		fusain
	14.4		clarain
	0.6		fusain
	8.3		clarain
	0.6		fusain
	0.7		clarain
	0.2		fusain
	1.1		clarain
	10.2		clay
	3.8		clarain
	0.2		fusain
	11.3		clarain
	3.8	3354	dull clarain
	17.1		clarain
	0.2		fusain
	15.7		clarain
floor:	30.5+		underclay

KCER Sample Thicknesses (cm)

KCER Sample 3352, 3353, 3354 (Continued)

3352: 22.8

3353: 48.4

3354: 52.1

Total Seam Thickness (cm)
(including partings)

137.3

KCER Sample 3355

County: Pike

Quadrangle: Jamboree

Carter Coordinate: 13-L-89

FSL: 50 FEL: 1800

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	91.4+		shale, sharp contact with coal
coal:	6.4	3355	clarain
	0.2		fusain
	3.1		clarain
	0.3		fusain
	13.1		clarain
	0.2		fusain
	9.4		clarain
	0.2		fusain
	5.5		clarain
floor:	30.5+		underclay, plant fossils

KCER Sample Thicknesses (cm)

3355: 38.4

Total Seam Thickness (cm)

38.4

KCER Sample 3356, 3357, 3358

County: Pike

Quadrangle: Hurley

Carter Coordinate: 9-L-89

FSL: 200 FEL: 1500

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	800+		sandstone
	61.0		shale, sharp contact with coal
coal:	1.3		clarain
	0.6		vitrain
	0.4		clarain
	0.6	3356	vitrain
	0.4		clarain
	1.3		shale
	1.9		clarain
	0.6		carbonaceous shale
	5.1		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	1.7	3357	clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	7.4		clarain
	0.2		fusain
	3.6		clarain
	2.5		carbonaceous shale
	12.7		clarain
	0.2		fusain
	7.5		clarain
	0.2		fusain
	7.5		clarain
	0.2	3358	fusain
	1.1		clarain
	0.2		fusain
	2.4		clarain
	0.2		fusain
	3.0		clarain
	0.2		fusain
	2.4		clarain
floor:	8.0+		underclay

KCER Sample 3356, 3357, 3358 (Continued)

KCER Sample Thicknesses (cm)

3356: 7.1

3357: 24.2

3358: 37.8

Total Seam Thickness (cm)
(including parting)

71.6

KCER Sample 3359

County: Pike

Quadrangle: Jamboree

Carter Coordinate: 16-L-89

FSL: 5350 FEL: 2550

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	305+		sandstone, wavy contact with coal
coal:	12.1	3359	clarain
	0.7		fusain
	3.5		clarain
	0.2		fusain
	0.3		carbonaceous shale
	4.8		clarain
floor:	7.6+		underclay

KCER Sample Thicknesses (cm)

3359: 21.1

Total Seam Thickness (cm)

21.1

KCER Sample 3360, 3361

County: Floyd

Quadrangle: Wheelwright

Carter Coordinate: 22-K-82

FSL: 3600

FEL: 4200

Comments: house-cut

	thickness (cm)	KCER sample	lithotype
roof:	152+		shale, sharp contact with coal
coal:	17.8	<hr/> 3360	clarain
	0.2		fusain
	11.3		clarain
	0.2		fusain
	8.8		clarain
	3.8	<hr/> 3361	clarain
	0.2		fusain
	31.6		clarain
floor:	7.6+		underclay

KCER Sample Thicknesses (cm)

3360: 38.3

3361: 35.6

Total Seam Thickness (cm)

73.9

KCER Sample 3362, 3363, 3364

County: Floyd

Quadrangle: McDowell

Carter Coordinate: 2-K-82

FSL: 2800 FEL: 4250

Comments: mine highwall

	thickness (cm)	KCER sample	lithotype
roof:	305+		sandstone
	2.5		shale, sharp contact with coal
coal:	12.7		clarain
	0.2	3362	fusain
	2.4		clarain
	5.7		shale
	4.4		clarain
	0.3		fusain
	1.0		clarain
	3.8		dull clarain
	0.6		vitrain
	1.9		clarain
	8.9		bone coal
	0.2	3363	fusain
	2.4		bone coal
	0.2		fusain
	1.1		bone coal
	0.2		fusain
	7.5		clarain
	0.2		fusain
	12.5		clay
	0.6		clarain
	3.2		clay
	0.6		clarain
	7.0		clay
	5.7		sandy shale
	3.8		sandstone
	0.6		sandy shale
	13.3	3364	clarain
floor:	7.6+		underclay

KCER Sample Thicknesses (cm)

3362: 15.3

3363: 56.6

3364: 13.3

KCER Sample 3262, 3263, 3264 (Continued)

Total Seam Thickness (cm)
(including partings)

101.0

KCER Sample 4324, 4325

County: Knott

Quadrangle: Wayland

Carter Coordinate: 9-L-80

FSL: 575 FEL: 1750

Comments: roadcut

thickness (cm)	KCER sample	lithotype
roof: 304+		shale, some siderite and coal stringers, sharp contact with coal
coal: 2.5	4324	bright clarain
0.3		vitrain
6.1		bright clarain
1.6		fusain
1.8		bright clarain
0.2		fusain
4.7		bright clarain
0.6		vitrain
0.6		bright clarain
0.6		vitrain
0.6		bright clarain
0.6		vitrain
1.9		bright clarain
0.2		fusain
0.5		bright clarain
0.2		fusain
3.0	4325	bright clarain
5.1		bright clarain
1.6		fusain
12.5		bright clarain
0.2		fusain
0.6	4325	vitrain
4.3		bright clarain
floor: 29.8+		underclay, plant fossils

KCER Sample Thicknesses (cm)

4324: 20.3

4325: 22.9

Total Seam Thickness (cm)

43.2

KCER Sample 4326, 4327

County: Knott

Quadrangle: Wayland

Carter Coordinate: 9-L-80

FSL: 650 FEL: 2200

Comments: roadcut

	thickness (cm)	KCER sample	lithotype
roof:	90.4+		sandstone, coal stringers present, scours into coal in some places
	30.5		shale, coal stringers, sharp contact with coal
coal:	3.8	4326	bright clarain
	0.2		fusain
	2.4		bright clarain
	0.2		fusain
	2.5		bright clarain
	0.2		fusain
	1.0		bright clarain
	0.6		vitrain
	3.2		bright clarain
	0.2		fusain
	3.0		bright clarain
	0.2		fusain
	1.7		bright clarain
	0.2		fusain
	1.1	4327	bright clarain
	2.5		bright clarain
	0.1		fusain
	0.5		vitrain
	7.0		bright clarain
floor:	49.9+		underclay, plant fossils

KCER Sample Thicknesses (cm)

4326: 20.3

4327: 10.2

Total Seam Thickness (cm)

30.5

APPENDIX 2
Maceral and Reflectance Data

Maceral and Reflectance Data

KCER#	1 VIT	2 PVT	3 FUS	4 SFS	5 MIC	6 MAC	7 EX	8 RES	9 V MAX R	10 V MAX SD	11 PVT R	12 PVT SD
1 3045	58.4	8.0	6.6	8.2	11.7	0.9	5.4	0.8	0.978	0.028		
2 3063	66.6	11.6	6.2	2.7	5.6	0.2	6.4	0.7	0.683	0.029		
3 3076	67.7	7.3	10.8	2.4	4.5	0.0	6.9	0.4	0.984	0.039		
4 3079	64.4	4.7	12.3	4.1	6.1	0.0	8.4	0.0	0.934	0.040		
5 3097	61.7	12.4	6.7	6.2	5.4	0.3	6.7	0.6	0.992	0.048		
6 3105	62.9	13.6	3.3	5.1	6.5	0.1	7.0	1.5	0.653	0.045		
7 3132	60.6	8.4	7.6	9.8	4.7	0.2	7.5	1.2	0.771	0.061		
8 3147	56.1	17.0	7.6	3.7	7.1	0.0	8.1	0.4	0.897	0.069		
9 3167	59.9	10.2	5.7	7.8	7.2	0.2	7.3	1.7	1.026	0.068		
10 3169	62.7	15.5	5.8	4.2	4.9	0.3	4.6	2.0	0.851	0.034		
11 3225	60.5	19.2	4.2	4.0	3.8	0.2	6.0	2.1	0.849	0.052		
12 3239	49.3	4.5	4.7	2.3	13.5	0.0	26.3	0.4	0.611	0.032	0.719	0.023
13 3240	60.7	17.2	5.2	4.3	4.4	0.0	8.0	0.2	0.728	0.047	0.847	0.033
14 3241	19.3	0.0	2.2	5.7	50.7	0.0	21.7	0.4	0.631	0.039		
15 3242	61.5	19.3	3.0	2.0	5.3	0.0	8.9	0.0	0.696	0.033	0.825	0.024
16 3243	60.1	17.2	3.7	1.9	8.2	0.0	8.9	0.0	0.710	0.037	0.825	0.030
17 3244	57.2	23.4	4.4	2.5	4.1	0.0	8.4	0.0	0.685	0.031	0.811	0.033
18 3245	60.4	21.0	4.1	2.9	3.8	0.0	7.8	0.0	0.675	0.041	0.811	0.031
19 3246	36.0	0.0	5.5	3.0	34.7	0.0	20.8	0.0	0.581	0.042		
20 3247	62.5	16.0	2.5	1.0	6.4	0.0	11.4	0.2	0.616	0.036	0.799	0.021
21 3248	59.8	4.0	9.8	6.8	3.2	0.0	15.7	0.7	0.703	0.032	0.839	0.034
22 3249	65.2	10.6	6.0	2.7	4.8	0.0	10.7	0.0	0.709	0.025	0.874	0.040
23 3250	57.2	3.8	9.1	8.2	7.2	0.0	14.5	0.0	0.667	0.042	0.813	0.040
24 3251	64.8	15.5	6.6	2.7	4.2	0.0	6.2	0.0	0.631	0.037	0.777	0.034
25 3252	60.8	11.1	6.7	4.0	3.5	0.0	13.9	0.0	0.638	0.030	0.777	0.039
26 3253	13.7	7.1	68.7	8.1	0.9	0.0	1.5	0.0	0.634	0.035	0.760	0.041
27 3254	62.8	18.0	1.4	2.0	4.2	0.0	11.4	0.2	0.604	0.032	0.764	0.034
28 3255	62.6	13.9	6.0	5.1	3.1	0.0	9.1	0.2	0.625	0.031	0.749	0.015
29 3256	62.8	19.4	3.2	3.0	3.1	0.0	8.5	0.0	0.598	0.038	0.742	0.027
30 3257	65.8	18.5	3.8	1.6	2.2	0.0	7.9	0.2	0.640	0.037	0.760	0.020
31 3258	53.7	29.9	2.3	3.0	3.0	0.0	8.1	0.0	0.637	0.046	0.769	0.027
32 3259	64.7	11.9	0.9	1.1	2.0	0.0	18.4	1.0	0.638	0.025	0.769	0.037
33 3260	62.0	14.6	0.4	0.6	2.9	0.0	18.7	0.8	0.591	0.038	0.748	0.024
34 3261	60.7	17.9	2.8	3.5	2.1	0.0	12.6	0.4	0.607	0.030	0.779	0.033
35 3262	61.0	19.8	2.6	2.2	3.6	0.0	10.7	0.1	0.627	0.020	0.765	0.022
36 3263	58.9	19.4	3.4	3.1	2.4	0.0	12.5	0.3	0.853	0.032	0.989	0.036
37 3264	58.1	15.0	6.9	5.3	1.3	0.0	12.7	0.7	0.858	0.043	0.990	0.027
38 3265	56.4	15.4	8.8	5.7	3.7	0.0	9.8	0.2	0.826	0.053	0.979	0.026
39 3266	61.1	10.7	6.6	4.8	4.1	0.0	12.2	0.5	0.763	0.064	0.926	0.027
40 3267	67.7	4.9	7.2	6.3	2.1	0.0	11.0	0.8	0.677	0.033	0.825	0.028
41 3268	72.7	5.2	4.7	3.5	3.4	0.0	9.7	0.8	0.655	0.034	0.766	0.031
42 3269	77.0	7.3	0.6	1.0	3.3	0.0	10.0	0.8	0.601	0.036	0.710	0.023
43 3270	57.8	18.1	3.9	3.3	4.5	0.0	11.7	0.7	0.859	0.035	0.967	0.023
44 3271	62.6	16.6	5.4	4.1	3.0	0.0	7.7	0.6	0.871	0.031	0.993	0.029
45 3272	65.5	10.0	6.2	3.3	4.9	0.0	9.7	0.4	0.899	0.034	1.020	0.029
46 3273	57.7	13.7	8.3	4.0	5.3	0.0	10.8	0.2	0.874	0.056	1.020	0.028
47 3274	65.8	10.8	8.1	3.6	3.8	0.0	7.3	0.6	0.907	0.047	1.050	0.032
48 3275	73.2	14.4	2.1	0.7	3.1	0.0	6.4	0.1	0.909	0.046	1.030	0.034
49 3276	59.6	10.3	13.0	5.5	4.2	0.0	7.3	0.1	0.900	0.044	1.050	0.039
50 3277	76.6	10.1	4.6	1.2	2.9	0.0	4.2	0.4	0.939	0.041	1.050	0.036
51 3278	77.7	13.9	0.8	0.2	2.4	0.0	4.8	0.2	0.907	0.038	1.000	0.022

Maceral and Reflectance Data

KCER#	1 VIT	2 PVT	3 FUS	4 SFS	5 MIC	6 MAC	7 EX	8 RES	9 V MAX R	10 V MAX SD	11 PVT R	12 PVT SD
52 3279	56.0	10.7	13.2	4.6	2.4	0.0	11.9	1.2	0.911	0.040	1.200	0.030
53 3280	63.0	16.4	5.9	2.3	3.9	0.0	8.2	0.3	0.926	0.031	1.030	0.027
54 3281	61.1	16.5	10.2	3.2	2.8	0.0	6.2	0.0	0.924	0.034	1.020	0.023
55 3282	59.9	12.0	10.7	4.0	3.1	0.0	10.2	0.1	0.879	0.044	1.000	0.020
56 3283	63.5	14.1	13.5	2.9	0.3	0.0	5.5	0.2	1.050	0.028	1.120	0.026
57 3284	73.8	12.7	2.4	1.3	3.4	0.0	6.2	0.2	1.060	0.033	1.160	0.020
58 3285	63.6	23.6	1.2	0.5	4.1	0.0	7.0	0.0	1.050	0.035	1.150	0.014
59 3286	69.8	13.9	3.7	0.8	3.4	0.0	8.3	0.1	1.040	0.028	1.130	0.019
60 3287	71.1	7.4	6.0	2.4	3.6	0.0	9.1	0.4	0.841	0.040	0.934	0.024
61 3288	62.2	2.7	9.6	6.6	4.4	0.0	14.2	0.3	0.825	0.041	0.947	0.031
62 3289	73.1	2.5	9.2	5.3	2.0	0.0	7.5	0.4	0.813	0.035		
63 3290	51.1	0.7	14.0	13.5	6.1	0.0	14.2	0.4	0.811	0.035		
64 3291	85.9	1.0	4.2	1.4	1.9	0.0	5.3	0.3	0.773	0.031		
65 3292	75.0	11.0	2.5	1.0	2.5	0.0	7.9	0.1	0.860	0.021	0.929	0.015
66 3293	68.8	5.2	8.0	4.5	3.0	0.0	9.9	0.6	0.844	0.032	0.927	0.022
67 3294	69.4	12.3	3.9	1.7	3.8	0.0	8.6	0.3	0.856	0.036	0.931	0.018
68 3295	74.1	8.6	4.5	2.1	2.5	0.0	8.2	0.0	0.867	0.022	0.937	0.019
69 3296	86.3	0.2	2.0	0.7	5.3	0.0	5.2	0.3	0.703	0.054		
70 3297	76.6	6.6	4.2	1.5	2.9	0.0	8.0	0.2	0.748	0.037		
71 3298	79.2	2.8	5.9	2.1	3.4	0.0	6.5	0.1	0.762	0.042	0.854	0.014
72 3299	75.3	5.9	6.2	1.6	2.5	0.0	8.3	0.2	0.763	0.032	0.846	0.013
73 3300	73.4	5.1	5.3	3.0	4.0	0.0	8.9	0.3	0.767	0.030	0.853	0.019
74 3301	69.6	8.3	4.7	2.2	3.3	0.0	11.8	0.1	0.773	0.029	0.860	0.019
75 3305	67.1	5.1	13.1	4.3	1.5	0.2	8.5	0.2	0.374	0.036	0.966	0.023
76 3306	66.8	9.8	6.2	3.0	3.9	0.0	10.2	0.1	0.391	0.031	0.974	0.024
77 3307	67.3	7.1	8.3	4.5	3.9	0.0	8.9	0.0	0.391	0.031	0.971	0.019
78 3308	52.5	0.3	13.3	5.2	7.5	0.6	19.1	1.5	0.874	0.036	0.965	0.016
79 3309	79.0	5.3	1.7	1.2	2.6	0.0	9.9	0.3	0.883	0.030	0.963	0.016
80 3310	62.7	10.0	5.0	5.8	3.0	0.0	11.9	1.6	0.933	0.029	1.020	0.026
81 3311	63.1	16.7	4.2	3.1	3.3	0.0	8.9	0.7	0.944	0.027	1.040	0.032
82 3312	63.9	7.8	6.6	7.5	2.9	0.0	10.5	0.8	0.938	0.028	1.020	0.024
83 3313	58.9	3.9	9.8	11.3	3.1	0.0	10.6	2.4	0.936	0.028	1.020	0.020
84 3314	65.5	7.0	7.5	6.2	1.4	0.0	10.6	1.8	0.902	0.045	1.030	0.037
85 3315	66.3	14.5	3.9	3.9	3.0	0.0	7.4	1.0	0.916	0.036	1.010	0.031
86 3316	61.7	16.6	6.8	2.8	2.6	0.0	8.8	0.7	0.898	0.048	1.010	0.027
87 3317	50.3	1.4	14.1	12.7	5.1	0.3	12.3	3.3	0.874	0.038		
88 3318	75.9	6.5	5.5	3.0	1.1	0.0	6.2	1.8	0.864	0.028	0.939	0.015
89 3319	70.8	12.1	5.9	3.5	1.1	0.0	4.3	2.3	0.869	0.023	0.944	0.020
90 3320	68.7	8.2	7.4	2.0	3.2	0.0	10.0	0.5	0.641	0.026	0.712	0.016
91 3321	43.9	2.3	19.6	15.4	2.4	0.5	13.4	2.5	0.696	0.031	0.813	0.028
92 3322	49.4	6.7	18.1	7.2	1.8	0.1	14.3	2.4	0.691	0.027	0.779	0.014
93 3323	69.2	11.4	5.9	3.2	1.9	0.0	7.4	1.0	0.726	0.018	0.785	0.012
94 3324	70.8	13.2	2.5	1.7	1.8	0.3	7.6	2.1	0.721	0.019	0.783	0.011
95 3325	70.3	0.8	6.7	9.0	3.1	0.0	7.5	2.6	0.607	0.025		
96 3326	66.6	12.2	5.6	3.0	2.8	0.0	7.5	2.3	0.679	0.024	0.744	0.023
97 3327	76.0	7.7	3.2	2.6	2.1	0.0	6.3	2.1	0.656	0.026	0.728	0.021
98 3328	59.0	14.2	8.8	5.1	3.6	0.0	8.1	1.2	0.678	0.024	0.754	0.024
99 3329	67.0	11.9	7.3	1.5	2.4	0.0	8.7	1.2	0.674	0.028	0.759	0.026
100 3330	71.8	14.3	2.1	1.3	2.1	0.0	7.4	1.0	0.636	0.022	0.710	0.023
101 3331	61.1	13.6	6.4	3.5	2.4	0.2	10.0	2.8	0.737	0.037	0.840	0.040
102 3332	72.0	12.5	4.1	2.8	1.3	0.1	5.1	2.1	0.738	0.018	0.811	0.027

Maceral and Reflectance Data

KCER#	1 VIT	2 PVT	3 FUS	4 SFS	5 MIC	6 MAC	7 EX	8 RES	9 V MAX R	10 V MAX SD	11 PVT R	12 PVT SD	
103	3334	70.8	13.2	2.5	1.7	1.8	0.3	7.6	2.1	0.735	0.021	0.805	0.018
104	3335	79.3	4.7	3.8	1.4	2.1	0.1	6.9	1.7	0.602	0.020	0.668	0.024
105	3336	63.4	10.3	7.3	4.9	2.2	0.3	9.0	2.6	0.723	0.024	0.809	0.028
106	3337	68.8	13.3	2.6	1.9	3.9	0.0	8.6	0.9	0.745	0.026	0.837	0.030
107	3338	68.5	9.4	8.3	3.1	1.3	0.0	7.3	2.1	0.766	0.020	0.836	0.026
108	3342	76.0	7.3	3.6	2.4	2.8	0.1	5.6	2.2	0.849	0.027	0.928	0.025
109	3343	74.9	6.9	5.9	3.0	1.4	0.0	4.4	3.5	0.844	0.028	0.914	0.018
110	3344	73.2	11.4	3.8	1.7	1.1	0.1	5.8	2.9	0.843	0.023	0.914	0.017
111	3345	67.3	15.1	2.0	1.2	2.4	0.0	8.8	3.2	0.866	0.018	0.926	0.019
112	3346	76.7	8.9	3.3	1.9	2.0	0.0	5.7	1.5	0.853	0.028	0.923	0.021
113	3347	71.8	11.3	3.9	2.4	1.9	0.2	6.8	1.7	0.861	0.028	0.932	0.018
114	3348	73.8	13.3	1.9	0.5	1.9	0.0	6.5	2.1	0.865	0.025	0.993	0.020
115	3349	67.0	10.3	7.0	4.1	2.1	0.1	6.7	2.7	0.910	0.022	0.979	0.015
116	3350	63.1	11.6	5.7	4.1	4.0	0.1	8.1	3.3	0.931	0.031	1.020	0.026
117	3351	53.4	0.7	12.3	9.0	4.2	0.4	15.3	4.7	0.853	0.039		
118	3352	72.4	8.2	4.9	2.2	2.5	0.0	7.4	2.4	0.880	0.032	0.970	0.017
119	3353	62.7	17.9	5.4	2.3	2.2	0.0	6.8	1.7	0.935	0.038	1.020	0.025
120	3354	63.6	6.4	8.5	6.1	3.9	0.2	8.8	2.5	0.915	0.031	1.010	0.021
121	3355	70.1	8.9	8.2	2.4	2.1	0.0	6.0	2.3	0.800	0.024	0.865	0.017
122	3356	60.2	6.5	14.5	6.7	1.6	0.0	8.4	2.1	0.923	0.026	1.010	0.020
123	3357	66.8	14.8	5.7	1.8	1.2	0.0	7.3	1.4	0.963	0.028	1.060	0.029
124	3358	66.0	11.5	8.0	2.5	2.5	0.0	7.2	2.3	0.973	0.025	1.060	0.022
125	3359	76.3	10.4	1.3	0.4	1.7	0.0	7.0	2.9	0.821	0.022	0.885	0.013
126	3360	61.3	14.2	9.2	2.3	3.4	0.0	8.1	1.5	0.902	0.025	0.988	0.027
127	3361	62.2	12.6	8.2	4.8	4.0	0.2	6.8	1.2	0.896	0.028	0.986	0.028
128	3362	75.3	10.7	3.1	0.8	2.7	0.0	6.5	0.9	0.753	0.052	0.799	0.027
129	3363	60.2	9.5	11.9	4.5	2.7	0.2	8.8	2.2	0.772	0.030	0.877	0.037
130	3364	62.5	15.1	5.3	1.6	1.9	0.0	11.6	2.0	0.773	0.023	0.856	0.030
131	4324	70.0	13.1	2.1	1.8	2.5	0.0	9.9	0.6	0.683	0.027	0.802	0.020
132	4325	67.8	15.0	3.3	1.4	1.4	0.0	10.1	1.0	0.686	0.030	0.804	0.030
133	4326	69.8	13.7	3.6	1.4	1.8	0.0	8.4	1.3	0.682	0.036	0.812	0.030
134	4327	70.8	12.8	3.0	1.2	1.5	0.0	8.8	1.9	0.692	0.026	0.812	0.026

APPENDIX 3

Maceral and Reflectance Data (Weighted Average)

Appendix 3

Maceral and Reflectance Data (Weighted Average)

KCER #	vit	pvit	fus	sfus	mic	mac	ex	res	Vit R(max)	Pvit R(max)
3242	61.5	19.3	3.0	2.0	5.3	0.0	8.9	0.0	0.696	0.825
3245	60.4	21.0	4.1	2.9	3.8	0.0	7.8	0.0	0.675	0.811
3248-50	63.7	9.1	6.7	3.8	5.1	0.0	11.6	0.1	0.702	0.862
3251-53	44.4	11.9	31.1	4.9	3.0	0.0	4.7	0.0	0.633	0.770
3254-56	62.9	17.4	3.6	3.4	3.3	0.0	9.3	0.1	0.608	0.749
3258	53.7	29.9	2.3	3.0	3.0	0.0	8.1	0.0	0.637	0.769
3262	61.0	19.8	2.6	2.2	3.6	0.0	10.7	0.1	0.627	0.765
3263-66	58.6	15.0	6.5	4.8	2.7	0.0	11.9	0.5	0.828	0.973
3268	72.7	5.2	4.7	3.5	3.4	0.0	9.7	0.8	0.655	0.766
3270	57.8	18.1	3.9	3.3	4.5	0.0	11.7	0.7	0.859	0.967
3271-73	61.8	13.4	6.7	3.8	4.4	0.0	9.5	0.4	0.881	1.012
3274	65.8	10.8	8.1	3.6	3.9	0.0	7.3	0.6	0.907	1.050
3275-77	70.1	11.4	6.6	2.5	3.4	0.0	5.8	0.2	0.918	1.044
3279-82	59.8	13.7	10.2	3.6	3.0	0.0	9.3	0.4	0.911	1.017
3283-86	67.7	15.9	5.4	1.4	2.7	0.0	6.8	0.1	1.050	1.138
3287-91	65.8	3.0	9.1	6.8	4.2	0.0	10.7	0.4	0.814	0.933
3292-95	70.7	10.6	5.0	1.9	3.2	0.0	8.4	0.2	0.848	0.921
3296-99	77.9	4.6	5.2	1.8	3.1	0.0	7.3	0.1	0.755	0.851
3300-01	71.5	6.7	5.0	2.6	3.6	0.0	10.4	0.2	0.771	0.859
3305-08	65.3	6.9	9.0	4.0	3.9	0.1	10.5	0.3	0.886	0.970
3309-13	62.8	9.9	6.0	6.4	3.1	0.0	10.5	1.3	0.936	1.023
3314-17	61.9	11.9	7.2	5.4	2.9	0.1	9.3	1.4	0.900	1.013
3320	68.7	8.2	7.4	2.0	3.2	0.0	10.0	0.5	0.641	0.712
3325-27	72.0	8.3	4.5	3.6	2.5	0.0	6.9	2.2	0.658	0.731
3328-29	63.0	13.1	8.1	3.3	3.0	0.0	8.4	1.1	0.676	0.757
3330	71.8	14.3	2.1	1.3	2.1	0.0	7.4	1.0	0.636	0.710
3331-32	67.1	13.0	5.1	3.1	1.8	0.2	7.3	2.4	0.738	0.824
3335	79.3	4.7	3.8	1.4	2.1	0.1	6.9	1.7	0.602	0.668
3336-38	68.0	10.9	6.1	2.9	2.4	0.1	8.0	1.7	0.753	0.833
3342-45	73.0	10.0	3.4	2.1	2.1	0.1	6.4	2.9	0.852	0.922
3346-48	75.1	10.2	3.2	1.8	2.0	0.1	6.1	1.6	0.857	0.937
3349-51	62.4	9.7	7.0	4.8	3.7	0.1	8.9	3.4	0.915	1.009
3352-54	64.9	11.2	7.0	3.9	3.0	0.1	7.7	2.2	0.916	1.007
3355	70.1	8.9	8.2	2.4	2.1	0.0	6.0	2.3	0.800	0.865
3356-58	65.7	12.1	8.2	2.7	1.9	0.0	7.4	2.0	0.964	1.055
3359	76.3	10.4	1.3	0.4	1.7	0.0	7.0	2.9	0.821	0.885
3360-61	61.7	13.4	8.7	3.5	3.7	0.1	7.5	1.4	0.899	0.987
3362-64	63.3	10.6	9.3	3.4	2.6	0.1	8.8	1.9	0.836	0.931
4324-25	68.8	14.1	2.8	1.6	1.9	0.0	10.0	0.8	0.685	0.803
4326-27	70.3	13.2	3.3	1.3	1.6	0.0	8.7	1.6	0.687	0.812
3045	61.9	17.8	7.2	1.7	4.2	0.0	7.1	0.1	0.754	NA
3063	66.6	11.6	6.2	2.7	5.6	0.2	6.4	0.7	0.683	NA
3076	67.7	7.3	10.8	2.4	4.5	0.0	6.9	0.4	0.984	NA
3079	64.4	4.7	12.3	4.1	6.1	0.0	8.4	0.0	0.934	NA
3097	61.8	12.4	6.7	6.1	5.4	0.3	6.7	0.6	0.992	NA
3105	62.9	13.6	3.3	5.1	6.5	0.1	7.0	1.5	0.653	NA
3132	60.6	8.4	7.6	9.8	4.7	0.2	7.5	1.2	0.771	NA
3147	56.1	17.0	7.6	3.7	7.1	0.0	8.1	0.4	0.897	NA
3167	59.9	10.2	5.7	7.8	7.2	0.2	7.3	1.7	1.026	NA
3169	62.6	15.5	5.9	4.2	4.9	0.3	4.6	2.0	0.851	NA
3225	60.5	19.2	4.2	4.0	3.8	0.2	6.0	2.1	0.849	NA

KCER#-BASIS 1 MOIST 2 VM 3 FC 4 ASH 5 TSUL 6 C 7 H 8 N 9 O 10 BTU 11 FSI

1	3045-A/R	2.05	35.50	45.20	17.24	1.86					11860	
2	-DRY		36.24	46.15	17.60	1.90					12108	
3	-A/F		43.98	56.00		2.30					15017	
4	3063-A/R	2.88	38.90	48.10	10.11	3.02					12810	
5	-DRY		40.05	49.53	10.41	3.11					13190	
6	-A/F		44.71	55.28		3.47					14960	
7	3076-A/R	1.68	35.20	59.90	3.20	0.60					14540	
8	-DRY		35.80	60.92	3.25	0.61					14788	
9	-A/F		37.01	62.97		0.63					15346	
10	3079-A/R	1.26	34.90	51.50	12.30	0.61	72.96	5.00	0.51	8.62	13080	6.0
11	-DRY		35.35	52.16	12.45	0.62	73.89	5.06	0.52	19.91	13247	
12	-A/F		40.37	59.58		0.71	84.41	5.78	0.59	8.51	15328	
13	3097-A/R	2.33	35.80	59.90	1.95	0.60					14560	
14	-DRY		36.65	61.33	2.00	0.61					14907	
15	-A/F		37.40	62.58		0.63					15255	
16	3105-A/R	2.04	40.70	49.10	8.18	2.96					13250	
17	-DRY		41.55	50.12	8.35	3.02					13526	
18	-A/F		45.33	54.69		3.30					14961	
19	3132-A/R	1.65	38.70	51.00	8.62	3.75					13390	
20	-DRY		39.35	51.86	8.76	3.81					13615	
21	-A/F		43.13	56.84		4.18					15162	
22	3147-A/R	4.53	35.20	56.10	4.17	0.51					13600	
23	-DRY		36.87	58.76	4.37	0.53					14245	
24	-A/F		38.55	61.45		0.56					14966	
25	3167-A/R	1.99	36.10	56.40	5.54	0.72					14050	
26	-DRY		36.83	57.55	5.65	0.73					14335	
27	-A/F		39.04	60.99		0.78					15291	
28	3169-A/R	4.08	36.30	54.70	4.90	0.94					13560	
29	-DRY		37.84	57.03	5.11	0.98					14137	
30	-A/F		39.88	60.10		1.03					14992	
31	3225-A/R	2.71	37.00	55.80	4.45	1.23					14030	5.0
32	-DRY		38.03	57.35	4.57	1.26					14421	
33	-A/F		39.85	60.10		1.32					15210	
34	3239-A/R	4.91	39.50	35.50	20.05	0.62	58.47	4.75	1.26	14.85	10640	0.5
35	-DRY		41.54	37.33	21.09	0.65	61.49	5.00	1.33	31.54	11189	
36	-A/F		52.64	47.31		0.83	77.92	6.33	1.58	13.25	14511	
37	3240-A/R	10.66	48.30	35.50	5.50	0.53	66.54	4.18	1.36	21.89	11040	0.0
38	-DRY		54.06	39.74	6.13	0.59	74.48	4.68	1.52	18.73	12357	
39	-A/F		57.61	42.34		0.63	79.37	4.99	1.52	13.39	13249	
40	3241-A/R	1.70	46.40	36.60	15.31	0.89	68.06	5.76	1.32	8.66	12990	1.0
41	-DRY		47.20	37.23	15.57	0.91	69.24	5.86	1.34	22.66	13215	
42	-A/F		55.91	44.10		1.07	82.01	6.94	1.59	8.39	15924	
43	3242-A/R	3.14	42.50	50.20	4.21	2.49	77.45	5.48	1.49	8.88	13890	3.0
44	-DRY		43.88	51.83	4.35	2.57	79.96	5.66	1.54	10.27	14340	
45	-A/F		45.87	54.18		2.69	83.59	5.91	1.61	6.20	15125	
46	3243-A/R	3.54	39.80	51.00	5.66	0.68	76.54	5.38	1.53	10.21	13480	4.0
47	-DRY		41.26	52.87	5.87	0.70	79.35	5.58	1.59	12.78	13975	
48	-A/F		43.83	56.17		0.75	84.30	5.93	1.69	7.35	14941	
49	3244-A/R	3.46	40.80	51.90	3.80	1.02	78.08	5.37	1.52	10.21	13760	3.5
50	-DRY		42.26	53.76	3.94	1.06	80.88	5.56	1.57	10.93	14253	
51	-A/F		43.99	55.96		1.10	84.19	5.79	1.64	7.28	14917	
52	3245-A/R	4.54	38.60	48.70	8.22	1.31	72.45	5.01	1.48	11.53	12550	2.5
53	-DRY		40.44	51.02	8.61	1.37	75.90	5.25	1.55	15.93	13147	
54	-A/F		44.25	55.82		1.50	83.05	5.74	1.70	8.01	14534	

APPENDIX 4
Chemical Analytical Data

	KCER#-BASIS	1 MCIST	2 VM	3 FC	4 ASH	5 TSUL	6 C	7 H	8 N	9 O	10 BTU	11 FSI
55	3246-A/R	1.96	46.60	36.00	15.43	0.94	68.94	5.83	1.27	7.59	12690	1.0
56	-DRY		47.53	36.72	15.74	0.96	70.32	5.95	1.30	21.48	12944	
57	-A/F		56.41	43.58		1.14	83.45	7.06	1.54	6.82	15631	
58	3247-A/R	3.25	43.10	47.20	6.39	0.93	75.43	5.46	1.54	10.25	13530	3.5
59	-DRY		44.55	48.79	6.60	0.96	77.96	5.64	1.59	13.84	13984	
60	-A/F		47.70	52.24		1.03	83.48	6.04	1.70	7.75	15089	
61	3248-A/R	2.83	31.10	40.30	25.80	0.55	59.99	4.27	1.15	8.24	10330	0.0
62	-DRY		32.01	41.47	26.55	0.57	61.74	4.39	1.18	32.12	10631	
63	-A/F		43.58	56.47		0.77	84.05	5.98	1.61	7.58	14927	
64	3249-A/R	4.44	37.00	53.40	5.16	0.96	76.08	5.11	1.58	11.11	13260	0.0
65	-DRY		38.72	55.88	5.40	1.00	79.61	5.35	1.65	12.38	13876	
66	-A/F		40.93	59.07		1.06	84.16	5.65	1.75	7.88	14764	
67	3250-A/R	2.94	37.60	53.00	6.48	0.63	75.34	5.08	1.43	11.04	13530	0.0
68	-DRY		38.74	54.61	6.68	0.65	77.62	5.23	1.47	15.02	13940	
69	-A/F		41.51	58.51		0.70	83.18	5.61	1.58	8.94	15043	
70	3251-A/R	3.44	37.90	54.00	4.73	3.41	75.26	5.12	1.31	10.17	13550	0.0
71	-DRY		39.25	55.92	4.90	3.53	77.94	5.30	1.36	11.87	14033	
72	-A/F		41.27	58.80		3.71	81.96	5.58	1.43	7.33	14921	
73	3252-A/R	2.84	42.10	52.40	2.69	1.46	79.01	5.37	1.39	10.08	14170	0.0
74	-DRY		43.33	53.93	2.77	1.50	81.32	5.53	1.43	10.22	14584	
75	-A/F		44.56	55.47		1.55	83.64	5.68	1.47	7.66	15079	
76	3253-A/R	1.41	20.50	76.00	2.10	0.55	88.05	3.51	0.68	5.11	14460	0.0
77	-DRY		20.79	77.09	2.13	0.56	89.31	3.56	0.69	5.88	14667	
78	-A/F		21.25	78.76		0.57	91.25	3.64	0.70	3.83	15029	
79	3254-A/R	2.52	42.30	44.00	11.22	4.42	69.78	5.19	1.30	8.09	12760	0.0
80	-DRY		43.39	45.14	11.51	4.53	71.58	5.32	1.33	17.22	13090	
81	-A/F		49.04	51.01		5.12	80.89	6.02	1.51	6.46	15098	
82	3255-A/R	2.40	35.20	41.10	21.30	2.76	59.93	4.59	1.15	10.27	11080	0.0
83	-DRY		36.07	42.11	21.82	2.83	61.40	4.70	1.18	29.89	11352	
84	-A/F		46.13	53.87		3.62	78.55	6.02	1.51	10.31	14958	
85	3256-A/R	2.47	39.90	43.70	13.88	3.75	69.96	5.20	1.30	5.91	12340	0.0
86	-DRY		40.91	44.81	14.23	3.84	71.73	5.33	1.33	17.76	12653	
87	-A/F		47.70	52.24		4.48	83.63	6.22	1.55	4.11	15082	
88	3257-A/R	2.61	34.30	34.50	28.56	4.51	55.48	4.24	1.15	6.06	9850	0.0
89	-DRY		35.22	35.42	29.33	4.63	56.97	4.35	1.18	32.87	10114	
90	-A/F		49.83	50.12		6.55	80.60	6.16	1.67	5.01	14995	
91	3258-A/R	3.13	42.10	50.70	3.97	2.06	76.47	5.47	1.40	10.63	13870	0.0
92	-DRY		43.48	52.37	4.10	2.13	78.98	5.65	1.45	11.80	14326	
93	-A/F		45.34	54.60		2.22	82.36	5.89	1.51	8.02	15053	
94	3259-A/R	2.14	31.30	29.40	37.18	5.21	48.36	3.80	1.00	4.45	8600	0.0
95	-DRY		31.98	30.04	37.99	5.32	49.42	3.88	1.02	40.35	8788	
96	-A/F		51.58	48.45		8.59	79.70	6.26	1.65	3.81	15169	
97	3260-A/R	2.41	32.20	30.60	34.74	5.22	52.84	4.10	1.04	2.06	8950	0.0
98	-DRY		33.00	31.36	35.60	5.35	54.14	4.20	1.07	35.24	9171	
99	-A/F		51.23	48.69		8.31	84.07	6.52	1.65		15154	
100	3261-A/R	3.08	36.10	44.60	16.21	1.81	67.93	4.96	1.35	7.74	11880	0.0
101	-DRY		37.25	46.02	16.73	1.87	70.09	5.12	1.39	21.53	12258	
102	-A/F		44.73	55.26		2.24	84.17	6.15	1.67	5.77	15025	
103	3262-A/R	2.85	42.20	49.50	5.49	2.70	75.51	5.30	1.40	9.60	13650	0.0
104	-DRY		43.44	50.95	5.65	2.78	77.73	5.46	1.44	12.60	14050	
105	-A/F		46.04	54.00		2.95	82.38	5.78	1.53	7.36	15049	
106	3263-A/R	2.04	29.50	47.40	21.06	0.70	63.38	4.32	1.32	9.22	11350	1.5
107	-DRY		30.11	48.39	21.50	0.71	64.70	4.41	1.35	28.83	11586	
108	-A/F		38.36	61.64		0.91	82.42	5.62	1.72	9.34	15117	

	KCER#-BASIS	1 MOIST	2 VM	3 FC	4 ASH	5 TSUL	6 C	7 H	8 N	9 O	10 BTU	11 FSI
109	3264-A/R	2.04	35.00	59.00	4.03	0.65	78.73	5.24	1.80	9.55	14100	5.5
110	-DRY		35.73	60.23	4.11	0.66	80.37	5.35	1.84	11.78	14394	
111	-A/F		37.26	62.81		0.69	83.82	5.58	1.92	8.00	15083	
112	3265-A/R	1.84	35.40	61.60	1.24	0.63	83.51	5.12	1.92	7.58	14620	5.0
113	-DRY		36.06	62.75	1.26	0.64	85.08	5.22	1.96	7.11	14894	
114	-A/F		36.52	63.56		0.65	86.16	5.28	1.98	5.92	15119	
115	3266-A/R	2.09	36.70	58.20	3.01	0.59	80.34	5.21	2.05	8.80	14310	5.5
116	-DRY		37.48	59.44	3.07	0.60	82.05	5.32	2.09	9.93	14615	
117	-A/F		38.67	61.33		0.62	84.66	5.49	2.16	7.07	15136	
118	3267-A/R	1.48	27.60	31.00	39.94	2.90	44.50	3.50	1.17	7.99	8170	1.0
119	-DRY		28.01	31.47	40.54	2.94	45.17	3.55	1.19	47.15	8293	
120	-A/F		47.12	52.92		4.95	75.96	5.97	2.00	11.11	14898	
121	3268-A/R	1.72	36.90	48.10	13.33	3.37	69.53	4.91	1.91	6.95	12510	5.0
122	-DRY		37.55	48.94	13.56	3.43	70.75	5.00	1.94	18.88	12729	
123	-A/F		43.44	56.62		3.97	81.85	5.78	2.25	6.16	15029	
124	3269-A/R	1.29	47.20	45.40	6.06	3.22	74.83	5.71	2.04	8.14	14050	4.5
125	-DRY		47.82	45.99	6.14	3.26	75.81	5.78	2.07	13.08	14234	
126	-A/F		50.94	49.00		3.48	80.77	6.16	2.20	7.39	15351	
127	3271-A/R	9.51	34.60	41.90	14.02	0.45	59.48	3.63	1.38	21.04	9860	
128	-DRY		38.24	46.30	15.49	0.50	65.73	4.01	1.53	28.24	10896	
129	-A/F		45.25	54.79		0.59	77.78	4.75	1.80	15.08	13097	
130	3272-A/R	7.06	34.70	53.60	4.61	0.50	70.00	4.29	1.73	18.87	12130	
131	-DRY		37.34	57.67	4.96	0.54	75.32	4.62	1.86	17.67	13051	
132	-A/F		39.28	60.68		0.57	79.25	4.86	1.96	13.37	13803	
133	3273-A/R	5.14	32.00	56.60	6.27	0.47	69.20	4.24	1.64	18.18	12130	
134	-DRY		33.73	59.67	6.61	0.50	72.95	4.47	1.73	20.36	12787	
135	-A/F		36.12	63.89		0.53	78.11	4.79	1.85	14.72	13782	
136	3275-A/R	2.99	36.50	57.50	3.00	0.74	80.20	5.13	1.44	9.49	13960	2.0
137	-DRY		37.62	59.27	3.09	0.76	82.67	5.29	1.48	9.79	14390	
138	-A/F		38.83	61.16		0.79	85.31	5.46	1.53	6.91	14910	
139	3276-A/R	3.78	33.80	59.90	2.54	0.63	82.98	4.88	1.40	7.57	13980	5.5
140	-DRY		35.13	62.25	2.64	0.65	86.24	5.07	1.45	6.58	14529	
141	-A/F		36.08	63.94		0.67	88.58	5.21	1.49	4.05	14975	
142	3277-A/R	2.38	34.40	58.30	4.92	0.99	77.72	5.02	1.50	9.85	13960	8.5
143	-DRY		35.24	59.72	5.04	1.01	79.61	5.14	1.54	12.69	14300	
144	-A/F		37.11	62.89		1.07	83.84	5.42	1.62	8.06	15155	
145	3278-A/R	1.56	34.30	55.30	8.83	0.96	75.59	5.01	1.40	8.21	13450	8.5
146	-DRY		34.84	56.18	8.97	0.98	76.79	5.09	1.42	15.73	13663	
147	-A/F		38.28	61.71		1.07	84.35	5.59	1.56	7.42	15160	
148	3279-A/R	1.67	29.60	48.40	20.28	0.54	65.58	4.19	1.10	8.31	11650	1.5
149	-DRY		30.10	49.22	20.62	0.55	66.69	4.26	1.12	27.38	11848	
150	-A/F		37.92	62.01		0.69	84.02	5.37	1.41	8.51	15264	
151	3280-A/R	2.39	34.90	59.90	2.81	0.80	81.19	5.16	1.43	8.61	14300	1.0
152	-DRY		35.75	61.37	2.88	0.82	83.18	5.29	1.47	9.25	14650	
153	-A/F		36.81	63.19		0.84	85.64	5.44	1.51	6.56	15145	
154	3281-A/R	3.18	33.40	62.30	1.08	0.61	83.54	5.05	1.34	8.38	14480	6.0
155	-DRY		34.50	64.35	1.12	0.63	86.28	5.22	1.38	6.49	14956	
156	-A/F		34.89	65.07		0.64	87.26	5.27	1.40	5.43	15157	
157	3282-A/R	2.16	38.28	57.10	2.50	0.58	82.40	5.22	1.37	7.93	14510	8.5
158	-DRY		39.13	58.36	2.56	0.59	84.22	5.34	1.40	8.45	14830	
159	-A/F		40.15	59.89		0.61	86.43	5.48	1.44	6.05	15269	
160	3283-A/R	5.07	23.50	46.40	24.96	0.37	59.72	3.70	0.91	10.34	10070	0.5
161	-DRY		24.76	48.88	26.29	0.39	62.91	3.90	0.96	31.84	10608	
162	-A/F		33.59	66.31		0.53	85.35	5.29	1.30	7.53	14830	

KCER#-BASIS 1 MOIST 2 VM 3 FC 4 ASH 5 TSUL 6 C 7 H 8 N 9 O 10 BTU 11 FSI

217	3305-A/R	2.04	29.20	47.90	20.86	0.69	64.43	3.99	1.40	8.63	11060	1.5
218	-DRY		29.81	48.90	21.29	0.70	65.77	4.07	1.43	28.02	11290	
219	-A/F		37.87	62.13		0.89	83.57	5.18	1.82	8.55	14687	
220	3306-A/R	1.62	35.50	57.70	5.16	0.87	78.51	5.03	1.94	8.49	14000	5.5
221	-DRY		36.08	58.65	5.24	0.88	79.80	5.11	1.97	12.23	14231	
222	-A/F		38.03	61.90		0.93	84.22	5.40	2.08	7.37	15112	
223	3307-A/R	1.51	35.90	60.00	2.56	0.67	80.25	5.19	1.93	9.40	14430	6.0
224	-DRY		36.45	60.92	2.60	0.68	81.48	5.27	1.96	10.61	14651	
225	-A/F		37.42	62.55		0.70	83.65	5.41	2.01	8.22	15095	
226	3308-A/R	0.73	28.60	40.60	30.08	0.46	58.83	3.83	1.34	5.46	10230	1.0
227	-DRY		28.81	40.90	30.30	0.46	59.26	3.86	1.35	35.07	10305	
228	-A/F		41.34	58.68		0.66	85.03	5.54	1.94	6.84	15339	
229	3309-A/R	1.05	34.30	47.20	17.38	1.26	70.58	5.01	1.72	4.05	12160	6.5
230	-DRY		34.66	47.70	17.56	1.27	71.33	5.06	1.74	20.60	12289	
231	-A/F		42.05	57.86		1.54	86.53	6.14	2.11	3.68	15213	
232	3310-A/R	0.94	31.80	51.70	15.64	0.65	70.58	5.01	1.72	6.40	12510	5.0
233	-DRY		32.10	52.19	15.79	0.66	71.25	5.06	1.74	21.30	12629	
234	-A/F		38.12	61.98		0.78	84.61	6.01	2.06	6.55	15248	
235	3311-A/R	1.03	35.80	61.30	1.89	0.76	80.95	5.21	1.82	9.37	14710	6.0
236	-DRY		36.17	61.94	1.91	0.77	81.79	5.26	1.84	10.34	14863	
237	-A/F		36.88	63.14		0.78	83.38	5.37	1.87	8.59	15199	
238	3312-A/R	0.95	34.80	59.30	4.88	0.56	80.79	5.06	1.79	6.92	14210	7.5
239	-DRY		35.13	59.87	4.93	0.57	81.56	5.11	1.81	10.95	14346	
240	-A/F		36.95	62.97		0.59	85.79	5.37	1.90	6.34	15170	
241	3313-A/R	0.72	23.30	39.00	36.95	0.48	53.94	5.37	1.08	2.18	9000	1.0
242	-DRY		23.47	39.28	37.22	0.48	54.33	5.41	1.09	38.69	9065	
243	-A/F		37.38	62.57		0.77	86.54	6.62	1.73	2.34	15182	
244	3314-A/R	1.19	30.10	46.10	22.64	0.84	67.58	4.40	1.71	2.83	11230	1.0
245	-DRY		30.46	46.66	22.91	0.85	68.39	4.45	1.73	24.57	11365	
246	-A/F		39.52	60.52		1.10	88.72	5.78	2.24	2.15	15135	
247	3315-A/R	1.17	34.10	59.90	4.79	0.61	80.59	5.08	1.39	7.54	14200	5.5
248	-DRY		34.50	60.61	4.85	0.62	81.54	5.14	1.41	11.29	14368	
249	-A/F		36.26	63.70		0.65	85.70	5.40	1.48	6.77	15181	
250	3316-A/R	1.52	35.60	60.70	2.24	0.71	83.26	5.21	1.88	6.70	14660	6.0
251	-DRY		36.15	61.64	2.27	0.72	84.55	5.29	1.91	7.53	14886	
252	-A/F		36.99	63.07		0.74	86.51	5.41	1.95	5.38	15283	
253	3317-A/R	1.37	33.60	56.80	8.16	0.58	78.38	4.83	1.73	6.32	13640	2.5
254	-DRY		34.07	57.59	8.27	0.59	79.47	4.90	1.75	13.29	13829	
255	-A/F		37.14	62.78		0.64	86.64	5.34	1.91	5.47	15206	
256	3318-A/R	2.59	34.20	55.10	8.10	0.64	72.16	4.46	1.20	13.44	12980	1.0
257	-DRY		35.11	56.57	8.32	0.66	74.08	4.58	1.23	19.45	13325	
258	-A/F		38.29	61.70		0.72	80.80	4.99	1.34	12.15	14659	
259	3319-A/R	1.76	35.20	58.10	4.90	0.80	79.37	4.98	1.31	8.64	14040	5.0
260	-DRY		35.83	59.14	4.99	0.81	80.79	5.07	1.33	11.99	14292	
261	-A/F		37.71	62.25		0.86	85.03	5.34	1.40	7.37	15130	
262	3320-A/R	2.05	42.70	50.50	4.77	2.18	75.61	5.40	1.41	10.63	13630	4.0
263	-DRY		43.59	51.56	4.87	2.23	77.19	5.51	1.44	13.63	13915	
264	-A/F		45.83	54.20		2.34	81.14	5.80	1.51	9.21	14751	
265	3321-A/R	6.94	34.40	42.57	16.09	0.76	58.91	3.62	0.97	19.65	9650	
266	-DRY		36.97	45.74	17.29	0.82	63.30	3.89	1.04	30.95	10370	
267	-A/F		44.69	55.31		0.99	76.54	4.70	1.26	16.51	12767	
268	3322-A/R	7.90	35.80	48.70	7.57	0.87	64.04	4.31	0.97	22.24	11110	
269	-DRY		38.87	52.88	8.22	0.94	69.53	4.68	1.05	23.79	12063	
270	-A/F		42.35	57.61		1.03	75.76	5.10	1.15	16.96	13258	

KCER#-BASIS 1 MOIST 2 VM 3 FC 4 ASH 5 TSUL 6 C 7 H 8 N 9 O 10 BTU 11 FSI

271	3323-A/R	2.89	38.90	55.00	3.23	1.00	75.99	5.11	1.63	13.04	13570	3.5
272	-DRY		40.06	56.64	3.33	1.03	78.25	5.26	1.68	13.78	13974	
273	-A/F		41.44	58.59		1.07	80.94	5.44	1.74	10.81	14522	
274	3324-A/R	2.94	39.90	54.50	2.66	0.89	77.60	5.24	1.45	12.16	13690	3.5
275	-DRY		41.11	56.15	2.74	0.92	79.95	5.40	1.49	12.24	14105	
276	-A/F		42.27	57.73		0.94	82.20	5.55	1.54	9.77	14560	
277	3325-A/R	1.77	31.90	34.90	31.43	7.41	46.73	3.40	0.70	10.33	9190	1.0
278	-DRY		32.47	35.53	32.00	7.54	47.57	3.46	0.71	40.71	9356	
279	-A/F		47.75	52.25		11.09	69.96	5.09	1.05	12.81	14599	
280	3326-A/R	2.31	34.40	43.04	20.25	1.52	62.32	4.44	1.08	10.39	11060	2.5
281	-DRY		35.21	44.06	20.73	1.56	63.79	4.54	1.11	29.00	11322	
282	-A/F		44.42	55.58		1.96	80.48	5.73	1.39	10.43	14640	
283	3327-A/R	1.72	40.50	42.64	15.04	2.57	67.16	4.84	1.20	9.19	11890	3.0
284	-DRY		41.21	43.39	15.30	2.61	68.34	4.92	1.22	22.90	12098	
285	-A/F		48.65	51.23		3.09	80.68	5.81	1.44	8.97	14575	
286	3328-A/R	2.06	41.50	52.70	3.72	1.91	75.22	5.02	1.35	12.78	13640	3.5
287	-DRY		42.37	53.81	3.80	1.95	76.80	5.13	1.38	14.74	13927	
288	-A/F		44.05	55.93		2.03	79.83	5.33	1.43	11.38	14576	
289	3329-A/R	2.23	40.90	52.30	4.57	2.56	73.46	5.13	1.25	13.03	13630	3.0
290	-DRY		41.83	53.49	4.67	2.62	75.14	5.25	1.28	15.72	13941	
291	-A/F		43.88	56.12		2.75	78.82	5.50	1.34	11.59	14757	
292	3330-A/R	1.63	43.10	46.34	8.93	2.53	76.21	5.10	1.24	5.99	13100	3.5
293	-DRY		43.81	47.11	9.08	2.57	77.47	5.18	1.26	13.51	13317	
294	-A/F		48.19	51.81		2.83	85.21	5.70	1.39	4.87	14843	
295	3331-A/R	2.44	37.90	55.10	4.57	1.02	76.65	5.12	1.51	11.13	13630	2.5
296	-DRY		38.85	56.48	4.68	1.05	78.57	5.25	1.55	13.59	13971	
297	-A/F		40.76	59.25		1.10	82.43	5.51	1.62	9.35	14745	
298	3332-A/R	3.00	36.70	56.10	4.17	0.98	73.62	4.87	1.38	14.98	13570	3.0
299	-DRY		37.84	57.84	4.30	1.01	75.90	5.02	1.42	16.65	13990	
300	-A/F		39.53	60.43		1.06	79.31	5.25	1.49	12.91	14699	
301	3334-A/R	2.13	39.00	51.70	7.24	0.84	73.90	5.08	1.56	11.38	13240	3.5
302	-DRY		39.85	52.83	7.40	0.86	75.51	5.19	1.59	16.85	13528	
303	-A/F		43.03	57.05		0.93	81.54	5.61	1.72	10.21	14728	
304	3335-A/R	3.04	42.40	47.90	6.66	3.02	72.36	5.07	1.24	11.65	13130	3.0
305	-DRY		43.73	49.40	6.87	3.11	74.63	5.23	1.28	15.75	13542	
306	-A/F		46.95	53.05		3.34	80.13	5.61	1.37	9.53	14717	
307	3336-A/R	4.83	34.00	49.60	11.60	0.82	69.69	4.63	1.27	11.99	12220	1.5
308	-DRY		35.73	52.12	12.19	0.86	73.23	4.86	1.33	19.71	12840	
309	-A/F		40.68	59.35		0.98	83.39	5.54	1.52	8.57	14814	
310	3337-A/R	3.40	41.60	51.60	3.41	1.27	77.34	5.26	1.50	11.22	13750	3.0
311	-DRY		43.06	53.42	3.53	1.31	80.06	5.45	1.55	11.63	14234	
312	-A/F		44.64	55.37		1.36	82.99	5.64	1.61	8.39	14836	
313	3338-A/R	5.11	36.00	51.40	7.47	0.90	74.39	5.09	1.41	10.74	12960	2.5
314	-DRY		37.94	54.17	7.87	0.95	78.40	5.36	1.49	13.91	13658	
315	-A/F		41.18	58.80		1.03	85.09	5.82	1.61	6.44	14956	
316	3342-A/R	3.85	36.00	53.60	6.56	0.79	75.03	4.89	1.55	11.18	13180	1.5
317	-DRY		37.44	55.75	6.82	0.82	78.03	5.09	1.61	14.45	13708	
318	-A/F		40.18	59.83		0.88	83.75	5.46	1.73	8.18	14823	
319	3343-A/R	3.59	36.20	52.30	7.89	0.93	75.08	4.95	1.45	9.70	13030	3.5
320	-DRY		37.55	54.25	8.18	0.96	77.88	5.13	1.50	14.52	13515	
321	-A/F		40.89	59.08		1.05	84.82	5.59	1.64	6.90	14855	
322	3344-A/R	3.44	38.90	48.30	9.38	1.06	74.92	5.07	1.33	8.24	12950	2.5
323	-DRY		40.29	50.02	9.71	1.10	77.59	5.25	1.38	14.69	13411	
324	-A/F		44.62	55.40		1.22	85.94	5.82	1.53	5.51	15018	

KCER#-BASIS 1 MOIST 2 VM 3 FC 4 ASH 5 TSUL 6 C 7 H 8 N 9 O 10 BTU 11 FSI

325	3345-A/R	2.65	42.00	53.00	2.41	0.89	79.99	5.22	1.48	10.01	14200	3.5
326	-DRY		43.14	54.44	2.48	0.91	82.17	5.36	1.52	10.04	14587	
327	-A/F		44.24	55.82		0.94	84.25	5.50	1.56	7.75	15014	
328	3346-A/R	15.48	39.40	39.40	5.76	0.64	60.99	3.25	1.18	28.18	9902	0.0
329	-DRY		46.62	46.62	6.81	0.76	72.16	3.85	1.40	21.84	11716	
330	-A/F		50.03	50.03		0.81	77.44	4.13	1.50	16.12	12659	
331	3347-A/R	4.63	38.40	51.70	5.27	0.81	72.13	4.52	1.37	15.90	12700	1.5
332	-DRY		40.26	54.21	5.53	0.85	75.63	4.74	1.44	17.34	13317	
333	-A/F		42.62	57.38		0.90	80.06	5.02	1.52	12.51	14183	
334	3348-A/R	4.10	35.10	53.30	7.51	0.99	73.68	4.79	1.34	11.69	12880	2.0
335	-DRY		36.60	55.58	7.83	1.03	76.83	4.99	1.40	15.75	13431	
336	-A/F		39.71	60.30		1.12	83.36	5.42	1.52	8.59	14702	
337	3349-A/R	8.41	33.70	47.30	10.57	0.49	64.10	3.76	1.13	19.95	10620	0.0
338	-DRY		36.79	51.64	11.54	0.53	69.99	4.11	1.23	24.14	11595	
339	-A/F		41.59	58.38		0.60	79.12	4.64	1.39	14.24	13258	
340	3350-A/R	5.84	35.80	58.40	3.88	0.57	73.66	3.92	1.20	16.77	12550	1.0
341	-DRY		38.02	62.02	4.12	0.61	78.23	4.16	1.27	15.73	13328	
342	-A/F		39.65	64.69		0.63	81.59	4.34	1.33	12.11	13964	
343	3351-A/R	2.15	33.60	39.80	24.42	0.50	61.95	4.20	1.08	7.85	10950	1.0
344	-DRY		34.34	40.67	24.96	0.51	63.31	4.29	1.10	30.78	11191	
345	-A/F		45.76	54.20		0.68	84.37	5.72	1.47	7.76	15341	
346	3352-A/R	1.57	36.50	52.20	9.70	1.08	76.56	5.06	1.39	6.21	13520	8.5
347	-DRY		37.08	53.03	9.85	1.10	77.78	5.14	1.41	14.57	13736	
348	-A/F		41.14	58.83		1.22	86.28	5.70	1.57	5.23	15409	
349	3353-A/R	1.90	35.90	56.00	6.20	1.35	80.77	5.04	1.37	5.27	14000	8.0
350	-DRY		36.60	57.08	6.32	1.38	82.33	5.14	1.40	9.76	14271	
351	-A/F		39.06	60.94		1.47	87.89	5.48	1.49	3.67	15362	
352	3354-A/R	1.47	36.30	56.00	6.22	0.75	80.30	4.98	1.37	6.38	14000	6.5
353	-DRY		36.84	56.84	6.31	0.76	81.50	5.05	1.39	11.30	14209	
354	-A/F		39.32	60.67		0.81	86.99	5.39	1.48	5.32	15273	
355	3355-A/R	7.96	39.40	43.60	9.07	0.66	62.61	3.94	1.03	22.69	10430	0.0
356	-DRY		42.81	47.37	9.85	0.72	68.02	4.28	1.12	25.86	11332	
357	-A/F		47.49	52.55		0.80	75.46	4.75	1.24	17.75	12694	
358	3356-A/R	1.14	30.70	46.80	21.38	0.87	69.16	4.46	1.15	2.98	11840	2.5
359	-DRY		31.05	47.34	21.63	0.88	69.96	4.51	1.16	23.49	11977	
360	-A/F		39.62	60.40		1.12	89.26	5.76	1.48	2.37	15663	
361	3357-A/R	1.86	37.80	55.10	5.21	0.72	80.25	4.95	1.25	7.62	14200	9.0
362	-DRY		38.52	56.14	5.31	0.73	81.77	5.04	1.27	11.18	14469	
363	-A/F		40.68	59.29		0.77	86.36	5.33	1.35	6.20	15373	
364	3358-A/R	3.12	37.20	50.80	8.88	0.73	82.47	5.11	1.30	1.51	14400	8.0
365	-DRY		38.40	52.44	9.17	0.75	85.13	5.27	1.34	7.50	14864	
366	-A/F		42.27	57.73		0.83	93.72	5.81	1.48		16528	
367	3359-A/R	7.77	40.40	42.70	9.13	0.80	63.29	4.20	1.16	21.42	10510	0.0
368	-DRY		43.80	46.30	9.90	0.87	68.62	4.55	1.26	24.70	11395	
369	-A/F		48.62	51.38		0.96	76.16	5.05	1.40	16.43	12775	
370	3360-A/R	8.25	38.40	49.40	3.91	0.74	72.65	4.45	1.27	16.98	12120	0.5
371	-DRY		41.85	53.84	4.26	0.81	79.18	4.85	1.38	13.78	13210	
372	-A/F		43.72	56.24		0.84	82.71	5.07	1.45	9.94	13866	
373	3361-A/R	2.16	39.20	48.30	10.35	0.86	77.96	5.15	1.53	4.15	13830	2.5
374	-DRY		40.07	49.37	10.58	0.88	79.68	5.26	1.56	12.61	14135	
375	-A/F		44.81	55.21		0.98	89.11	5.89	1.75	2.27	15992	
376	3362-A/R	7.43	38.20	47.30	7.08	1.24	68.71	4.81	1.32	16.84	11980	1.0
377	-DRY		41.27	51.10	7.65	1.34	74.22	5.20	1.43	17.81	12942	
378	-A/F		44.68	55.33		1.45	80.37	5.63	1.54	11.01	14142	

KCER#-BASIS		1 MOIST	2 VM	3 FC	4 ASH	5 TSUL	6 C	7 H	8 N	9 O	10 BTU	11 FSI
379	3363-A/R	4.96	38.40	42.80	13.86	1.22	67.72	4.43	1.16	11.61	11880	1.0
380	-DRY		40.40	45.03	14.58	1.28	71.25	4.66	1.22	21.58	12500	
381	-A/F		47.30	52.72		1.50	83.42	5.46	1.43	8.19	14879	
382	3364-A/R	2.54	45.10	48.40	3.97	1.23	79.46	5.62	1.44	8.28	14200	4.0
383	-DRY		46.28	49.66	4.07	1.26	81.53	5.77	1.48	9.96	14570	
384	-A/F		48.24	51.77		1.32	84.99	6.01	1.54	6.14	15280	
385	4324-A/R	3.10	40.90	51.60	4.42	2.50	75.53	5.41	1.46	10.68	13830	0.0
386	-DRY		42.21	53.25	4.56	2.58	77.95	5.58	1.51	12.38	14272	
387	-A/F		44.23	55.80		2.70	81.67	5.85	1.58	8.20	15091	
388	4325-A/R	3.30	40.70	51.70	4.26	1.21	77.39	5.34	1.49	10.31	13810	0.0
389	-DRY		42.09	53.46	4.41	1.25	80.03	5.52	1.54	11.65	14281	
390	-A/F		44.03	55.93		1.31	83.72	5.78	1.61	7.58	15032	
391	4326-A/R	2.87	41.00	50.40	5.72	1.81	76.56	5.32	1.40	9.19	13640	0.0
392	-DRY		42.21	51.89	5.89	1.86	78.82	5.48	1.44	12.40	14043	
393	-A/F		44.85	55.14		1.98	83.75	5.82	1.53	6.91	15054	
394	4327-A/R	3.19	40.90	50.40	5.49	1.56	76.37	5.35	1.45	9.78	13660	0.0
395	-DRY		42.25	52.06	5.67	1.61	78.89	5.53	1.50	12.48	14110	
396	-A/F		44.79	55.19		1.71	83.63	5.86	1.59	7.22	15080	

APPENDIX 5

Chemical Analytical Data, (Weighted Average)

Appendix 5

Chemical Analytical Data (Weighted Average)

KCER #	A-R Mois	A-R Ash	A-R VM	A-R FC	A-R C	A-R H	A-R N	A-R O	A-R S	A-R BTU	FSI	MM	M-F Ash	M-F S
3242	3.14	4.21	42.5	50.2	77.5	5.48	1.49	8.88	2.49	13890	3.0	5.9	4.35	2.60
3245	4.54	8.22	38.6	48.7	72.5	5.01	1.48	11.53	1.31	12550	2.5	9.6	8.61	1.37
3248-50	4.11	6.39	36.8	52.7	75.2	5.06	1.53	10.96	0.88	13160	1.5	7.4	6.66	0.92
3251-53	2.61	3.59	31.3	62.6	80.5	4.50	1.07	8.17	2.18	13940	2.5	5.1	3.69	2.24
3254-56	2.46	15.47	39.1	43.0	66.9	5.01	1.26	7.76	3.61	12060	3.0	18.7	15.86	3.70
3258	3.18	3.97	42.1	50.7	76.5	5.47	1.40	10.63	2.06	13870	3.5	5.4	4.10	2.13
3262	2.85	5.49	42.2	49.5	75.5	5.30	1.40	9.60	2.70	13650	3.0	7.4	5.65	2.78
3263-66	2.01	6.63	34.4	57.1	77.1	5.02	1.79	8.87	0.65	13170	4.5	7.3	6.77	0.66
3268	1.72	13.33	36.9	48.1	69.5	4.91	1.91	6.96	3.37	12510	5.0	16.5	13.56	3.43
3270	1.99	4.48	36.0	57.5	79.5	5.17	1.93	8.23	0.70	14100	7.5	5.2	4.57	0.71
3271-73	7.15	8.14	33.7	51.0	66.4	4.07	1.59	19.30	0.47	11420	0.0	9.1	8.77	0.51
3274	1.31	23.00	30.0	45.7	62.6	4.17	1.46	8.14	0.55	11260	4.0	25.1	23.31	0.56
3275-77	3.01	3.59	34.8	58.6	80.2	5.01	1.45	9.01	0.80	13970	5.5	4.3	3.70	0.82
3279-82	2.32	6.96	34.1	56.6	77.9	4.89	1.31	8.29	0.63	13700	4.5	7.9	7.13	0.64
3283-86	4.43	8.08	29.6	57.9	75.5	4.63	1.33	9.93	0.55	12890	3.5	9.0	8.45	0.58
3287-91	2.79	14.17	33.8	49.2	68.4	4.57	1.25	10.48	1.11	12180	2.0	15.9	14.58	1.14
3292-95	2.26	7.05	35.7	53.9	75.3	5.16	1.35	8.95	1.08	13360	5.0	8.2	7.21	1.10
3296-99	2.65	7.09	40.1	52.5	75.7	5.32	1.36	9.71	2.30	13670	4.5	8.9	7.28	2.36
3300-01	4.32	3.36	37.2	55.9	76.2	4.93	2.12	13.49	0.64	13580	2.5	3.2	3.51	0.67
3305-08	1.55	9.96	33.7	54.8	74.3	4.76	1.77	8.47	0.72	13180	4.5	11.1	10.12	0.73
3309-13	0.93	14.17	31.8	53.1	72.2	4.74	1.63	6.76	0.65	12720	5.0	15.6	14.30	0.66
3314-17	1.34	7.29	33.9	57.5	79.1	4.98	1.68	6.26	0.68	13800	4.5	8.2	7.39	0.69
3320	2.05	4.77	42.7	50.5	75.6	5.40	1.41	10.63	2.18	13630	4.0	6.4	4.87	2.23
3325-27	1.93	18.98	37.3	41.8	62.8	4.51	1.09	9.75	2.85	11250	2.5	22.1	19.35	2.91
3328-29	2.15	4.15	41.2	52.5	74.3	5.08	1.31	12.91	2.24	13640	3.5	5.7	4.24	2.29
3330	1.63	8.93	43.1	46.3	76.2	5.10	1.24	5.99	2.53	13100	3.5	11.0	9.08	2.57
3331-32	2.75	4.35	37.3	55.7	75.0	4.98	1.44	13.25	1.00	13600	3.0	5.2	4.47	1.03
3335	3.04	6.66	42.4	47.9	72.4	5.07	1.24	11.65	3.02	13130	3.0	8.8	6.87	3.11
3336-38	4.44	6.44	37.9	51.3	75.0	5.10	1.43	11.06	1.03	13170	2.5	7.5	6.74	1.08
3342-45	3.40	6.12	38.1	52.4	76.4	5.02	1.48	8.40	0.89	13390	2.5	7.1	6.34	0.92
3346-48	10.97	5.95	38.4	44.7	65.8	3.81	1.25	22.45	0.74	11070	1.0	6.8	6.68	0.83
3349-51	5.77	8.33	35.1	53.4	70.0	3.93	1.17	16.01	0.54	11930	1.0	9.2	8.84	0.57
3352-54	1.66	6.86	36.3	55.3	79.8	5.02	1.37	5.91	1.05	13910	7.5	7.9	6.98	1.07
3355	7.96	9.07	39.4	43.6	62.6	3.94	1.03	22.69	0.66	10430	0.0	10.1	9.85	0.72
3356-58	2.47	8.86	36.8	51.9	80.3	4.99	1.27	3.79	0.77	14070	8.0	9.9	9.08	0.79
3359	7.77	9.13	40.4	42.7	63.3	4.20	1.16	21.42	0.80	10510	0.0	10.3	9.90	0.87
3360-61	5.31	7.02	38.8	48.9	75.2	4.79	1.40	10.79	0.80	12960	1.5	8.0	7.41	0.84
3362-64	5.02	11.10	39.4	44.5	69.7	4.68	1.23	12.03	1.23	12260	1.5	12.7	11.69	1.30
4324-25	3.21	4.34	40.8	51.7	76.5	5.37	1.48	10.48	1.82	13820	4.0	5.7	4.48	1.88
4326-27	3.04	5.60	41.0	50.4	76.6	5.34	1.43	9.49	1.68	13650	4.0	6.9	5.78	1.73
3045	2.05	17.24	35.5	45.2	NA	NA	NA	NA	1.86	11860	NA	3.2	17.60	1.90
3063	2.88	10.11	38.9	48.1	NA	NA	NA	NA	3.02	12810	NA	3.8	10.41	3.11
3076	1.68	3.20	35.2	59.9	NA	NA	NA	NA	0.60	14540	7.0	2.1	3.25	0.61
3079	1.26	12.30	34.9	51.5	NA	NA	NA	NA	0.61	13080	6.0	13.6	12.46	0.62
3097	2.33	1.95	35.8	59.9	NA	NA	NA	NA	0.60	14560	8.0	2.4	2.00	0.61
3105	2.04	8.18	40.7	49.1	NA	NA	NA	NA	2.96	13250	5.5	10.5	8.35	3.02
3132	1.65	8.62	38.7	51.0	NA	NA	NA	NA	3.75	13390	6.0	11.4	8.76	3.71
3147	4.53	4.17	35.2	56.1	NA	NA	NA	NA	0.51	13600	5.5	4.8	4.37	0.53
3167	1.99	5.54	36.1	56.4	NA	NA	NA	NA	0.72	14050	8.5	6.3	5.65	0.73
3169	4.08	4.90	36.3	54.7	NA	NA	NA	NA	0.94	13560	5.0	5.8	5.11	0.98
3225	2.71	4.45	37.0	55.8	NA	NA	NA	NA	1.23	14030	5.0	5.4	4.57	1.26

APPENDIX 6

Bench Thickness Versus Ash and Sulfur

Appendix 6. Bench Thicknesses vs. Ash and Sulfur

roof: shale 3279-82
 floor: underclay

3283-86
 roof: shale w/siderite
 floor: underclay

3287-91
 roof: sandstone
 floor: underclay

roof: shale w/siderite 3292-95
 floor: underclay

roof: silty shale 3296-99
 floor: underclay

roof: shale 3300-01
 floor: underclay

3336-38
 roof: shale & siltstone
 floor: siltstone

8242-45
 roof: shale
 floor: underclay

3346-48
 roof: shale
 floor: underclay

4326-27

roof: shale
floor: underclay