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GEOLOGICAL SURVEY

# Chemical and Physical Characterization of Mine Samples from Lakhra Coal Field, South Sind, Pakistan

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

1/ U.S. Geological Survey
2/ Geological Survey of Pakistan

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## ABSTRACT

Thirty-nine coal samples were collected from operating coal mines in the Lakhra (37 samples) and Meting-Jhimpir (2) coal fields of the South Sind region, Pakistan. The samples represent 29 different coal mines, were obtained from operating faces, and were collected and analyzed in accordance with the standards established by the American Society for Testing and Materials.

Statistical appraisal of the analytical results indicates that the bulk of the coal currently being mined in the South Sind region has an apparent rank of subbituminous C with high sulfur (4 percent) and medium ash (15 percent) contents. The generalized chemical and physical characteristics on the as-received basis are as follows: moisture, volatile matter, and fixed carbon are each about 28 percent; and heat value is about 7100 Btu/lb.

The study is a beginning in valid characterization of the Early Tertiary coals of southern Pakistan.

# INTRODUCTION

## Background

The coal samples described herein were collected and analyzed as part of the Coal Resource Exploration and Assessment Program (COALREAP) that is Component 2a of the Energy Planning and Development Project. Component 2a is being conducted by the Geological Survey of Pakistan (GSP) with assistance from the U.S. Geological Survey (USGS) under financing of the Government of Pakistan and the U.S. Agency for International Development (USAID).

## Field Work

Coal quality studies in the Lakhra coal field were initiated in July 1985, with a mine sampling program. F.O. Simon of the USGS and Rafiq Ahmed Khan of the GSP, with the assistance of other geologists from GSP and the Water and Power Development Authority of Pakistan (WAPDA), sampled 27 mines in the Lakhra field and two mines in the adjoining Meting-Jhimpir coal field. The samples were collected from active mining faces in operating coal mines in accordance with the specifications for collection of samples listed in Standard D388-84 of the Standard Classification of Coals by Rank of the American Society for Testing and Materials (ASTM). The samples are, therefore, called "bed samples" or "face samples" as discussed in Standard D388, Section 7. Sampling (ASTM, 1986). The samples were collected, bagged, transported, stored, and handled in the approved manners to provide credible analytical results.

## Analytical Work

Upon arrival at the coal analytical laboratory in the United States, the samples were split to create equally representative samples. One sample split was immediately entered into the analytical process to produce the determinations presented in this report. Another sample split was sent to the USGS laboratory for determination of major-, minor-, and trace-element contents.

The analytical work reported herein was done in the laboratories of Geochemical Testing Incorporated in Somerset, Pennsylvania, under the leadership of F.E. Walker (who was in charge of the U.S. Bureau of Mines coal laboratories in Pittsburgh, Pennsylvania, prior to the demise of that world-famed facility).

## Acknowledgments

The assistance of Ishaq Ghaznavi, Sabahat Noor, Mukarram Khan, Mukhtar, and Saleem Khan during collection and handling of these samples is heartily appreciated.

The cooperation of the owners, managers, and miners of the mines that were visited was invaluable and their assistance is much appreciated.

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## COAL IN PAKISTAN

Coal is known in 23 different coal fields, areas, and occurrences in Pakistan (fig. 1). Some of the known coal fields have been exploited for more than 100 years, and some of the fields expected to be increasingly important in Pakistan's energy future are still in the early stages of exploration. Total recoverable reserves of Pakistan are estimated at approximately 800 million tons (table 1). The estimate is conservative but cannot be significantly improved without additional definitive information.

The annual coal production of Pakistan is now estimated to be 2 million tons or more. Production in 1947 was about 350 thousand tons. The reason for the increase rests with increased demand for coal by the brick-making industry, which uses an estimated 80 to 90 percent of annual coal production at present. This demand is expected to increase at an annual rate of 2 to 5 percent as the economic development of the country continues. Only 15 MW of the total electrical generating capacity of the country is created using coal. The total electricity generating capacity of Pakistan is about 5,000 MW and there are predictions that 9,000 MW will be needed in the near future. If coal alone supplied even one-quarter of the energy for such an increase in capacity, the annual coal production of Pakistan would have to increase by a factor of 2 or 3 (5 to 6 million tons) annually.

The coal in Pakistan is largely lignite A to subbituminous C in rank according to ASTM standards (1986), though small quantities reach a rank of high-volatile A bituminous. The coals characteristically have medium- to high-ash and high-sulfur contents. Beneficiation studies to date have not produced economically acceptable results. Combustion in fluidized beds is a relatively new technology that promises to allow use of high-ash and high-sulfur coals with, perhaps, fewer technologic or environmental problems. The range of quality characteristics of Pakistan's coal has not been established and much remains to be learned. Effective utilization of coal is almost completely dependent on the physical and chemical properties of the coal. This report is intended to be the first of similar studies that will provide the credible data base needed for increased efficient and economic use of the coals of Pakistan.

### South Sind Coal Area

The samples whose analyses are reported herein are from the Lakhra and Meting-Jhimpir coal fields, which are parts of the South Sind Coal Area. This large coal region is included in the Hyderabad Division of Sind Province. At this time, it is not known how much of the Hyderabad Division is underlain by potentially coal-bearing rocks. The Division includes almost 90 thousand square kilometers, and if one-quarter is underlain by rocks that might contain coal, the area and potential coal resources are large. Table 2 summarizes the available information about the parts of the South Sind Area known to contain coal at this time.

Two rock units are known to contain coal in the area - the Ranikot Group of Paleocene age and the Sohnari Member of the Laki Formation of Eocene age. The resource potential of the Ranikot Group is large because the unit is known to be present, and to contain coal, over very large areas. The Sohnari Member

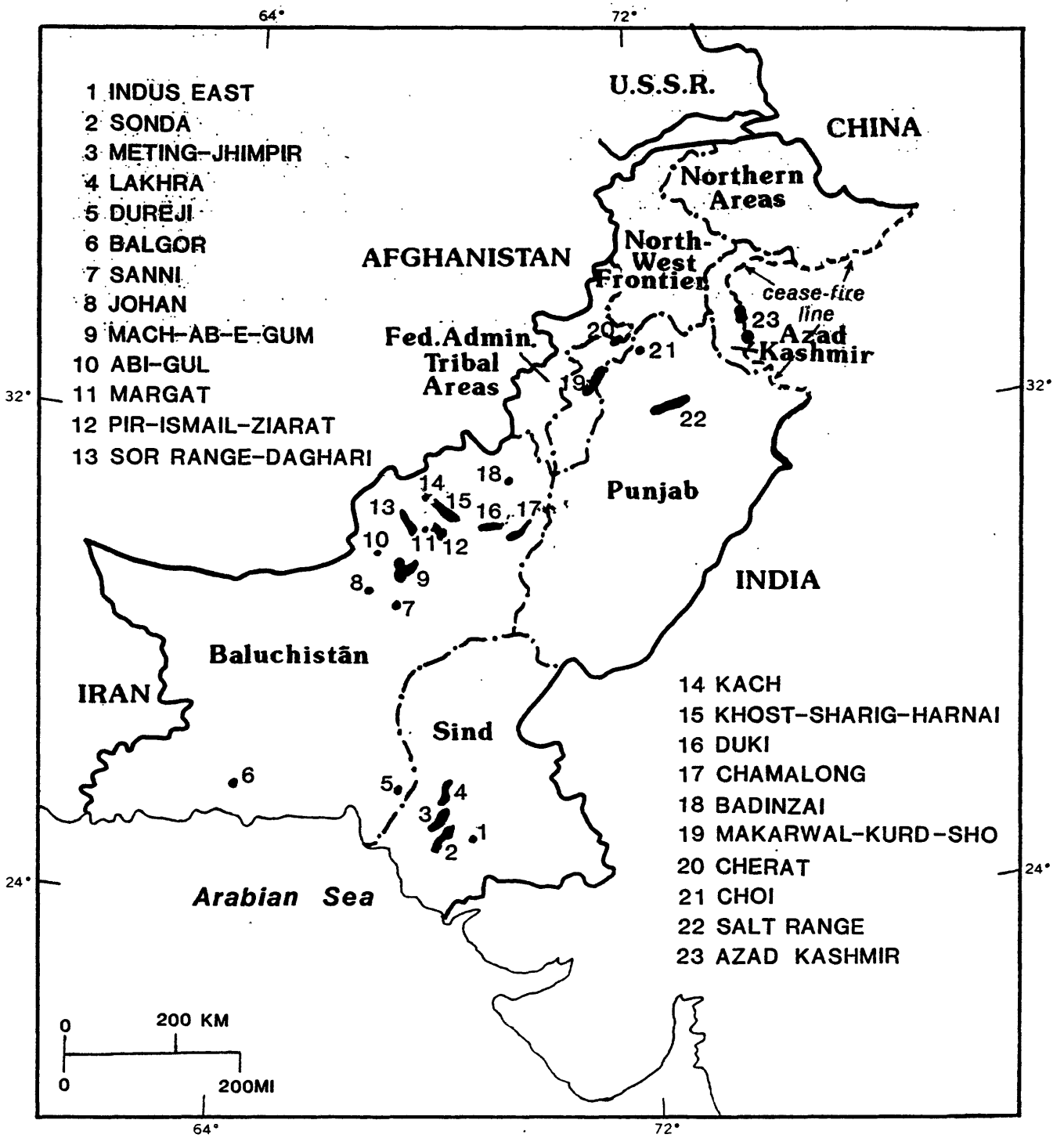


Figure 1. Location of Pakistan coalfields and occurrences.

Table 1.--Summary information on known coal fields

| Province and coal field | Area (sq. km) | Average mined thickness (m) | Demonstrated recoverable reserves ($10^6$ tons) | Inferred recoverable reserves ($10^6$ tons) | Total recoverable reserves ($10^6$ tons) | Coal rank[1/] (ASTM) | Average reported annual production ($10^3$ tons) |
|---|---|---|---|---|---|---|---|
| Sind | | | | | | | |
| Lakhra | 200 | 1.5 | 100 | 200 | 300 | ligA-subC | 300 |
| Meting-Jhimpir | 90 | .5 | 8 | 17 | 25 | ligA-subC | 40 |
| Sonda | 650 | --- | 124 | 156 | 280 | ligA-subB | --- |
| Punjab (and NWFP) | | | | | | | |
| Makarwal | 75 | 1.5 | 7 | 12 | 19[2/] | hvCb-hvBb | 225 |
| Salt Range | 260 | .75 | 17 | 58 | 75 | hvCb | 225 |
| Baluchistan | | | | | | | |
| Sor Range-Daghari | 50 | 1.25 | 18 | 16 | 34 | subB-subA | 460 |
| Khost-Sharig-Harnai | 200 | .75 | 24 | 23 | 47 | hvBb-hvAb | 100 |
| Mach | 45 | .75 | 9 | 6 | 15 | subC-subB | 125 |
| Pir-Ismail-Ziarat | 20 | .5 | 6 | 5 | 11 | hvCb | 115 |
| Duki | 100 | .5 | 8 | 5 | 13 | subC-subA | 250 |
| Totals | 1,690 | --- | 321 | 498 | 819 | --- | 1,840 |

[1/] LigA = lignite A, subC = subbituminous C, subB = subbituminous B, subA = subbituminous A, hvCb = high volatile C bituminous, hvBb = high volatile B bituminous, hvAb = high volatile A bituminous (American Society for Testing and Materials, 1982).

[2/] Includes Kurd-Sho area of NWFP.

Table 2. South Sind Coal Area

(MT = million metric tons, m = meter, leaders (---) = no data, others as indicated)

| | Lakhra | Northwest Lakhra | Meting-Jhimpir | Sonda | Indus East |
|---|---|---|---|---|---|
| Estimated demonstrated recoverable reserves | 100 MT | --- | 8 MT | 124 MT | --- |
| Depth of deepest reported coal | 460 m | --- | 500 m | 260 m | 550 m |
| Depth of present mines | <130 m | --- | 150 m | --- | --- |
| Average annual production | 0.3 MT | --- | 0.4 MT | --- | --- |
| Coal Quality Range: | | | | | |
| Moisture (percent) | 13-39 | --- | 23-37 | 9-40 | --- |
| Ash (percent) | 7-25 | --- | 8-17 | 5-39 | --- |
| Sulfur (percent) | 2-6.5 | --- | 3-5 | 0.4-5.6 | --- |
| Heat value - KC/kg | 2600-4990 | --- | 3470-4290 | 3600-5700 | --- |
| - Btu/lb | 4680-8980 | --- | 6250-7720 | 6480-10260 | --- |
| Rank | ligA-subC | --- | ligA-subC | ligA-subC | --- |
| | Potential Utilization | | | | |
| Electricity | yes | --- | yes | yes | --- |
| Brick-making | yes | --- | yes | yes | --- |
| Cement manufacture | ? | --- | ? | ? | --- |
| Process and direct heat | yes | --- | yes | yes | --- |
| Briquettes | yes | --- | ? | ? | --- |
| Other conversions | ? | --- | ? | ? | --- |

is known to contain coal only in the Meting-Jhimpir coal field, though there are ambiguous indications that coal may be present in the Sohnari or equivalent age units in other parts of the area also.

The Ranikot Group is reportedly almost 1,000 meters thick in an oil exploration drill hole on the Lakhra anticline but is not as thick in most parts of the area. The variation in thickness is caused by differences in the original depositional thickness, erosion prior to the deposition of the overlying Sohnari Member, and erosion now and in the recent past.

The Sohnari Member is commonly only a few tens of meters thick, but it is not present everywhere. The regional distribution and geologic history of the Sohnari are poorly understood, and a regional study of the area would help understand the distribution of Eocene age coal in Sind.

The Ranikot Group is known to contain coal at depths of as much as 550 meters beneath the surface in the South Sind area. In the area where the Ranikot is being actively mined at present, the mined coals are seldom more than 100 meters deep. The Sohnari is within 100 meters of the surface in most of the area where it is now mined.

The perceived coal resource potential of the area is based on scant and very poorly distributed information. Much information has been developed for mine planning in one small part of the area; the other part is sparsely explored and its total resource potential cannot be evaluated to the necessary degree of assurance for utilization planning.

The area lies across the primary transportation artery of Pakistan, which extends northeast from Karachi along the Indus River and eventually to Lahore. Not only are the roads, railroads, people, irrigation systems, main industries, and light industries concentrated along this major artery, which is a wide belt in the Five Rivers Area of eastern Punjab, but major parts of the national electrical grid are also concentrated there (see Survey of Pakistan, 1985). The coal-bearing parts of the South Sind region might be able to supply the necessary thermal energy to produce most of the future electricity needed by the country.

## Lakhra Coal Field

The Lakhra coal field in the southern part of Sind Province lies along the crest of a north-trending anticline that is about 65 kilometers long and about 16 kilometers wide. The currently exploited Lakhra field comprises an area of about 200 square kilometers in which the Ranikot group contains many coal beds, several of which are fairly persistent. The beds currently mined are as thick as 3.35 meters and average about 1.5 meters thick. In most of the field, the rocks dip at less than 6° so that the only major mining problems caused by structure are the offsets of the coal beds by movement along north-trending normal faults.

The field has been mined since about 1959 (though initial mining attempts occurred as much as one hundred years previously) and a large number of small, naturally ventilated, unmechanized, relatively shallow mines have operated in the central part of the field. The 37 samples obtained for this quality characterization study were collected in operating mines, most operated by private companies.

Samples collected and analyzed previously according to ASTM standards were reported by Landis and others (1973). A large number of other samples have been collected and analyzed in the past but non-standard collection and sample-handling methods render most of those analytical results uncomparable and uninterpretable. The results obtained during recent feasibility studies in a small segment of the Lakhra field by the John T. Boyd Company should be very reliable but the sample-collection area is small. Extension of the results of that small-area study to larger parts of the field might be unwarranted.

## Meting-Jhimpir Coal Field

The coal of the Meting-Jhimpir field occurs in the Sohnari Member in the lowest part of the Laki Formation. Generally only one thin minable bed is present. Seldom more than 1 meter thick, the bed averages about 0.5 meter in the mining area. Only about 40 thousand tons are produced in the field annually. Only two mines were sampled during this effort and those two samples are added to the 37 samples from the Lakhra field as part of this study.

## SAMPLES

Each of the analyzed samples has acquired three different number designations during the collection and analysis sequence. Table 3 lists the 39 samples and the pertinent U.S. Geological Survey (USGS) laboratory number, the field collection number, and the Geochemical Testing (G.T.) laboratory number. Henceforth in this report all samples will be discussed according to the USGS laboratory number.

### Sample Sources

Thirty-seven of the 39 samples were collected from operating mines; the other two samples were collected in a mine that had been idle for 2 months prior to sampling. A total of 29 different mines were sampled (table 4).

This sample suite is the most comprehensive ever collected in the Lakhra coal field (or any other coal field in Pakistan). However, the results must still be considered as preliminary with respect to a complete understanding of the quality of the coal in the Lakhra field. For example, only one location was sampled within each of the 29 mines, whereas section 7.1 of the Standard Classification of Coals by Rank, D388-84 (ASTM, 1986), states that to classify a coal bed requires a minimum of "... three and preferably five or more face samples taken in different and uniformly distributed localities, either within the same mine or closely adjacent mines representing a continuous and compact area not greater than approximately four square miles in regions of geological uniformity." More information points (sample localities) would be necessary to satisfy the cited standard.

The derived statistical appraisal of the analytical results presented in this report must be viewed as a beginning to understanding, not the end.

Table 3.--USGS laboratory numbers and corresponding field and Geochemical Testing (G.T.) laboratory numbers for 39 samples of coal from Pakistan.

| USGS LAB NO. | FIELD NO. | G.T. NO. |
|---|---|---|
| W233048 | 85LK001A | U12570 |
| W233049 | 85LK001C | U12571 |
| W233050 | 85LK002A | U12572 |
| W233051 | 85LK003 | U12573 |
| W233052 | 85LK004A | U12574 |
| W233053 | 85LK004B | U12575 |
| W233054 | 85LK005 | U12576 |
| W233055 | 85LK006A | U12579 |
| W233056 | 85LK006B | U12580 |
| W233057 | 85LK007 | U12581 |
| W233058 | 85LK008A | U12582 |
| W233059 | 85LK008B | U12583 |
| W233060 | 85LK009A | U12584 |
| W233061 | 85LK009B | U12585 |
| W233062 | 85LK010 | U12586 |
| W233063 | 85LK011 | U12587 |
| W233064 | 85LK012A | U12588 |
| W233065 | 85LK012B | U12589 |
| W233047 | 85LK012D | U12590 |
| W233066 | 85LK013 | U12591 |
| W233210 | 85LK014 | U12623 |
| W233211 | 85LK015 | U12624 |
| W233212 | 85LK016A | U12625 |
| W233213 | 85LK016B | U12626 |
| W233214 | 85LK017A | U12627 |
| W233215 | 85LK017B | U12628 |
| W233216 | 85LK018 | U12629 |
| W233217 | 85LK019 | U12630 |
| W233218 | 85LK020 | U12631 |
| W233219 | 85LK021 | U12632 |
| W233220 | 85LK022 | U12633 |

Table 3.--USGS laboratory numbers and corresponding field and geochemical Testing (G.T.) laboratory numbers for 39 samples of coal from Pakistan--Continued

| USGS LAB NO. | FIELD NO. | G.T. NO. |
|---|---|---|
| W233221 | 85LK023 | U12634 |
| W233222 | 85LK024 | U12635 |
| W233223 | 85LK025 | U12636 |
| W233224 | 85LK026A | U12637 |
| W233225 | 85LK027A | U12638 |
| W233226 | 85LK027B | U12639 |
| W233208 | 85MT001 | U12621 |
| W233209 | 85MT002 | U12622 |

Table 4.--Source and character of samples

| USGS lab No. | Source of sample | Lithology | Thickness ft (m) |
|---|---|---|---|
| W233048 | Gul Mine No.11 (Habibullah)<br>Lower bench; parting [0.1(0.04)] not sampled | Coal | 1.8 (0.53) |
| W233049 | ----do----------<br>Upper bench | Coal | 5.0 (1.5) |
| W233050 | Indus Mine No. 2A<br>Face channel; total bed | Coal | 8.8 (2.7) |
| W233051 | Mumtaz Mine No. 44 (Habibullah)<br>Face channel; lower part of 10.0(3.0) bed | Coal | 9.6 (2.9) |
| W233052 | National Mine No. 44<br>Lower bench | Coal | 8.9 (2.7) |
| W233053 | ----do----------<br>Parting; upper bench [0.5(0.15)] not sampled | Parting | 0.3 (0.09) |
| W233054 | Faiz Mine No. 11<br>Face channel; total bed | Coal | 9.1 (2.8) |
| W233055 | Delux Mine No. 1A<br>Lower bench; no parting | Coal | 2.9 (0.89) |
| W233056 | ----do----------<br>Upper bench; uppermost 0.6(0.18) of bed not sampled | Coal | 4.9 (1.51) |
| W233057 | Baluchistan Mine No. 13<br>Face channel; total bed | Coal | 3.3 (1.0) |
| W233058 | PMDC Mine No. 2<br>Lower bench; no parting | Coal | 4.3 (1.3) |
| W233059 | ----do----------<br>Upper bench; uppermost 0.4(0.12) of bed not sampled | Coal | 5.8 (1.8) |
| W233060 | M. Amin Bros. Mine No. 5/MC-10<br>Lower bench; no parting | Coal | 2.4 (0.74) |
| W233061 | ----do----------<br>Upper bench; uppermost 0.6(0.18) of bed not sampled | Coal | 5.3 (1.6) |
| W233062 | Amin Mine No. 5-A<br>Face channel; lower part of 5.5(1.71) bed | Coal | 4.5 (1.4) |

Table 4.--Source and character of samples--Continued

| USGS lab No. | Source of sample | Lithology | Thickness ft (m) |
|---|---|---|---|
| W233063 | Sind Mine No.5<br>Face channel; total bed | Coal | 4.5 (1.4) |
| W233064 | Ch M. Iqbal Mine No. 9<br>Lower bench; no parting | Coal | 4.6 (1.4) |
| W233065 | ----do----------<br>Upper bench; clay band [0.4(0.12] on top not sampled | Coal | 5.9 (1.8) |
| W233047 | ----do----------<br>Nominal roof at sample location | Shaley coal | 0.8 (0.24) |
| W233066 | Inam Mine No. 28 (Habibullah)<br>Face channel; total bed | Coal | 5.8 (1.8) |
| W233210 | Iqbal 4C-413 Mine (Habibullah)<br>Face channel; lower part of 4.5(1.34) bed | Coal | 4.4 (1.3) |
| W233211 | Khalid-B-2 Mine (Habibullah)<br>Face channel; total bed | Coal | 3.9 (1.2) |
| W233212 | Baluchistan No. 6 Mine<br>Lower bench; no parting | Coal | 2.7 (0.83) |
| W233213 | ----do----------<br>Upper bench; uppermost 2.1(0.64) of bed not sampled | Coal | 3.6 (1.1) |
| W233214 | Ghapfar No. 26 Mine (Habibullah)<br>Lower bench; no parting | Coal | 1.8 (0.53) |
| W233215 | ----do----------<br>Upper bench; uppermost 0.4(0.12) of bed not sampled | Coal | 4.8 (1.5) |
| W233216 | Indus No. 6 Mine<br>Face channel; lower part of 4.8(1.5) bed | Coal | 4.1 (1.3) |
| W233217 | Hamza No 37 Mine (Habibullah)<br>Face channel; total bed | Coal | 4.9 (1.5) |
| W233218 | Tauseef No 22. Mine (Habibullah)<br>Face channel; lower part of 3.5(1.05) bed | Coal | 3.3 (1.0) |
| W233219 | Amin Bros. No. 3-MC/10 Mine<br>Face channel; total bed | Coal | 3.9 (1.2) |
| W233220 | Indus No. 1 Mine<br>Face channel; total bed | Coal | 6.0 (1.8) |

Table 4.--Source and character of samples--Continued

| USGS lab No. | Source of sample | Lithology | Thickness ft (m) |
|---|---|---|---|
| W233221 | National Mine No. 1<br>Face channel; lower part of 6.0(1.85) bed | Coal | 5.8 (1.8) |
| W233222 | Baluchistan No. 14 Mine<br>Face channel; lower part of 3.4(1.04) bed | Coal | 3.2 (0.99) |
| W233223 | PMDC Mine No. 1<br>Face channel; lower part of 5.2(1.64) bed | Coal | 5.1 (1.6) |
| W233224 | PMDC Mine No. 3<br>Face channel; total bed | Coal | 3.0 (0.92) |
| W233225 | PMDC Mine BF-11 Shaft (idle)<br>Lower bench; no parting. | Coal | 6.4 (2.0) |
| W233226 | ----do----------<br>Upper bench; uppermost 1.1(0.33) of bed not sampled | Coal | 1.8 (0.56) |
| W233208 | Amin Bros. No. 22-C Mine<br>Face channel; total bed | Coal | 1.8 (0.55) |
| W233209 | Lalazar Mine (National)<br>Face channel; total bed | Coal | 2.6 (0.80) |

## Sampling Methods

As required by the Standard Classification of Coals by Rank, D388-84 (ASTM, 1986), samples to be used to classify coals should be collected in accordance with specified methodology (Holmes, 1911; Schopf, 1960).

Standards for collection of low rank coals that will be classified on the "moist" basis "... that is, inclusive of its natural compliment of inherent or bed moisture, ..." require that the samples be taken "... in a manner most likely to preserve inherent moisture for purposes of analysis." (D388-84, ASTM, 1986). Obviously, the manner in which samples are packed, shipped, and stored prior to analysis is extremely important in the total process. The elapsed time between collection and analysis is also important, especially for the low-rank coals (Hobbs and others, 1983).

Twenty of the samples (table 4) are face channel samples that represent all or most of the coal bed at the sampled point. Presumably, the samples did not include any megascopically visible non-coal material more than about 1 centimeter in thickness. However, lighting in many mines commonly does not allow discrimination of units as thin as 1 centimeter, and the samples reported upon herein may include non-coal partings as thick as 3 centimeters. This estimate is based solely on the fact that the thinnest parting reported in the descriptions of the samples is 4 centimeters thick.

## SUMMARY OF ANALYTICAL RESULTS

Table 5 presents a statistical appraisal of the results of the chemical and physical testing done on the 39 samples collected for this report. The arithmetic mean, standard deviation, observed range, geometric mean, and geometric deviation are given for the results of the proximate and ultimate analyses and for the heat value, forms of sulfur, apparent specific gravity, and Hardgrove grindability.

Statistical appraisal of coal-analyses data commonly yields several values. Study of the frequency distribution of the data-mass can yield a "range", or spread of values. The range is thus an expression of what may be expected as the difference between the smallest and greatest value of a measured physical or chemical property of a material. However, grouping by frequency distribution alone is seldom adequate, and description of groups of data by numbers that represent the typical values of the individual groups of data is required. These measures of the central tendency or averages take several forms.

The arithmetic mean is by far the most commonly used measure of the central tendency because it is easily derived and understood and is fairly reliable. Much less commonly used is the geometric mean because it is not so easily derived nor commonly understood. However, extreme high and low values do not affect the geometric mean as much as they affect the arithmetic mean. In general, the geometric mean will equal or be less than the arithmetic mean.

While the arithmetic and geometric means may satisfy most central-tendency requirements, a measure of probable departure from the mean is sometimes desirable. The standard deviation is a commonly used measure of dispersion. In a normal distribution, about 68.3 percent of the observations

Table 5.--Statistical appraisal of 39 coal samples, on the as-received basis, values in weight percent, except heat value, apparent specific gravity, and Hardgrove Grindability Index

| | Arithmetic mean | Standard deviation | Observed range | | Geometric mean | Geometric deviation |
|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | | |
| | | | | Proximate and ultimate analyses | | |
| Moisture | 28.2 | 2.9 | 22.4 | 34.5 | 28.1 | 1.1 |
| Volatile matter | 28.4 | 2.8 | 21.8 | 33.0 | 28.3 | 1.1 |
| Fixed carbon | 27.2 | 3.1 | 18.8 | 35.7 | 27.5 | 1.1 |
| Ash | 15.7 | 5.6 | 6.7 | 32.4 | 14.8 | 1.4 |
| Hydrogen | 6.3 | .4 | 5.4 | 6.9 | 6.2 | 1.1 |
| Carbon | 39.6 | 4.8 | 26.3 | 50.2 | 39.3 | 1.1 |
| Nitrogen | .75 | .1 | .54 | .97 | .74 | 1.1 |
| Oxygen | 33.5 | 2.7 | 26.5 | 38.9 | 33.3 | 1.1 |
| Sulfur | 4.3 | 1.3 | 2.5 | 9.0 | 4.1 | 1.3 |
| Heat value (Btu/lb) | 7100 | 875 | 4680 | 8980 | 7050 | 1.1 |
| Sulfate sulfur | .42 | .32 | .10 | 1.53 | .33 | 2.0 |
| Pyritic sulfur | 2.7 | 1.0 | 1.6 | 5.9 | 2.6 | 1.4 |
| Organic sulfur | 1.1 | .5 | .1 | 2.6 | 1.0 | 1.7 |
| Apparent Specific Gravity | 1.4 | .1 | 1.2 | 1.7 | 1.4 | 1.1 |
| Hardgrove Grindability Index | 70 | 656 | 80 | 70 | | 1.1 |

lie within the range of values between the arithmetic mean plus or minus the standard deviation, and about 95 percent of the observations lie within the range of values between the arithmetic mean plus or minus 1.96 times the standard deviation (Belarmino and others, 1976, p. 67). If, however, the distribution is not normal, a logarithmic analysis results in the most meaningful measure of the central tendency and the possible dispersion of observed values. The geometric deviation is the antilogarithm of the standard deviation of the logarithms of the observed values. About two-thirds of the observed values should lie within the range of values between the geometric mean divided by the geometric deviation and the geometric mean multiplied by the geometric deviation. About 95 percent of the observed values should lie with the range of values between the geometric mean divided by the square of the geometric deviation and the geometric mean multiplied by the square of the geometric deviation (Connor and others, 1976).

For example, the arithmetic mean moisture value for the 39 samples appraised herein is 28.2 percent. Assuming a normal distribution, applying the standard deviation of 2.9 percent, about 95 percent of observed values should lie within the range between 22.5 and 33.9 percent. According to logarithmic analysis, the geometric mean moisture value for the 39 samples appraised herein is 28.1 percent, and applying the geometric deviation of 1.1, about 95 percent of observed values should be within the range between 23.2 and 34.0 percent.

An extremely voluminous literature exists on the evaluation of the meaning, significance, and usability of analytical results such as presented in this report. Among many such reports available, those of Rees (1966) and Speight (1983) are excellent examples. The annual Book of ASTM Standards (for example, ASTM, 1986) is invaluable for an understanding of what the derived and measured values represent and for interpretation of these analytical results.

## STANDARD COAL ANALYSES

Tables 6 and 6A present the results of the proximate and ultimate analyses of the 39 samples discussed in this report plus determinations of the heat content, air-dried loss, forms of sulfur, free-swelling index, and ash-fusion temperatures. Each of these quality characteristics will be briefly described and evaluated in following sections of this report in the order in which they are presented in table 5. The analytical results as reported by the laboratory are presented in appendix B.

### Proximate Analysis

The moisture, volatile matter, fixed carbon, and ash in coal are derived by application of standardized analytical procedures (D3172) to samples as described in American Society for Testing and Materials Volume 05.05 Gaseous Fuels; Coal and coke (annual volumes).

#### Moisture

In all coals, but especially in those of low rank, determination of moisture content is an extremely critical part of the analytical sequence. Commercial evaluation of coal for utilization and valuation is commonly done

Table 6.--Proximate and ultimate analyses and heat contents for 39 coal samples from Pakistan.

[Results listed by USGS laboratory sample numbers, each with entries on three bases: first line, as received; second, moisture-free; and third, moisture- and ash-free. Samples analyzed by a commercial testing laboratory using ASTM standards. All figures are percent unless otherwise indicated.]

| | PROXIMATE ANALYSIS | | | | ULTIMATE ANALYSIS | | | | | HEAT OF COMBUSTION | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER (USGS) | MOISTURE | VOLATILE MATTER | FIXED CARBON | ASH | HYDROGEN | CARBON | NITROGEN | OXYGEN | SULFUR | KCAL/KG | BTU/LB |
| W233048 | 28.4 | 28.3 | 31.5 | 11.8 | 6.4 | 44.2 | 0.8 | 32.4 | 4.4 | 4,340 | 7,810 |
| | --- | 39.5 | 44.0 | 16.5 | 4.6 | 61.8 | 1.1 | 9.9 | 6.2 | 6,060 | 10,910 |
| | --- | 47.3 | 52.7 | --- | 5.5 | 73.9 | 1.3 | 11.9 | 7.4 | 7,250 | 13,050 |
| W233049 | 30.2 | 24.8 | 25.8 | 19.2 | 6.1 | 35.5 | .7 | 35.2 | 3.3 | 3,470 | 6,250 |
| | --- | 35.5 | 37.0 | 27.5 | 4.0 | 50.9 | 1.0 | 12.0 | 4.7 | 4,970 | 8,950 |
| | --- | 49.0 | 51.0 | --- | 5.5 | 70.2 | 1.4 | 16.5 | 6.4 | 6,860 | 12,340 |
| W233050 | 33.3 | 25.7 | 27.0 | 13.9 | 6.6 | 37.7 | .8 | 37.4 | 3.5 | 3,710 | 6,680 |
| | --- | 38.5 | 40.6 | 20.9 | 4.3 | 56.6 | 1.1 | 11.7 | 5.3 | 5,570 | 10,030 |
| | --- | 48.7 | 51.3 | --- | 5.5 | 71.6 | 1.4 | 14.8 | 6.7 | 7,040 | 12,680 |
| W233051 | 26.0 | 25.9 | 22.3 | 25.7 | 5.6 | 32.3 | .6 | 31.7 | 4.0 | 3,200 | 5,770 |
| | --- | 35.1 | 30.1 | 34.8 | 3.6 | 43.7 | .9 | 11.6 | 5.4 | 4,330 | 7,800 |
| | --- | 53.8 | 46.2 | --- | 5.6 | 67.0 | 1.3 | 17.9 | 8.2 | 6,640 | 11,950 |
| W233052 | 29.9 | 26.2 | 25.8 | 18.1 | 6.3 | 36.5 | .6 | 34.7 | 3.7 | 3,600 | 6,490 |
| | --- | 37.3 | 36.8 | 25.8 | 4.3 | 52.0 | .9 | 11.6 | 5.3 | 5,140 | 9,250 |
| | --- | 50.3 | 49.7 | --- | 5.8 | 70.2 | 1.2 | 15.6 | 7.2 | 6,930 | 12,470 |
| W233053 | 27.0 | 21.8 | 18.8 | 32.4 | 5.5 | 26.3 | .5 | 32.8 | 2.5 | 2,600 | 4,680 |
| | --- | 29.8 | 25.7 | 44.4 | 3.4 | 36.0 | .7 | 12.0 | 3.4 | 3,560 | 6,410 |
| | --- | 53.7 | 46.3 | --- | 6.2 | 64.8 | 1.3 | 21.6 | 6.1 | 6,400 | 11,530 |
| W233054 | 31.7 | 25.4 | 26.8 | 16.0 | 6.3 | 35.8 | .7 | 36.4 | 4.7 | 3,600 | 6,480 |
| | --- | 37.3 | 39.3 | 23.5 | 4.1 | 52.4 | 1.1 | 12.0 | 7.0 | 5,270 | 9,490 |
| | --- | 48.7 | 51.3 | --- | 5.3 | 68.5 | 1.4 | 15.7 | 9.1 | 6,890 | 12,400 |
| W233055 | 27.3 | 28.4 | 26.1 | 18.1 | 6.1 | 38.8 | .7 | 32.9 | 3.3 | 3,890 | 7,000 |
| | --- | 39.1 | 35.9 | 25.0 | 4.2 | 53.5 | 1.0 | 11.8 | 4.6 | 5,350 | 9,630 |
| | --- | 52.1 | 47.9 | --- | 5.6 | 71.3 | 1.3 | 15.8 | 6.1 | 7,130 | 12,840 |
| W233056 | 25.7 | 24.9 | 22.7 | 26.6 | 5.7 | 32.7 | .6 | 30.7 | 3.7 | 3,210 | 5,780 |
| | --- | 33.6 | 30.6 | 35.8 | 3.8 | 44.1 | .9 | 10.5 | 5.0 | 4,330 | 7,790 |
| | --- | 52.4 | 47.6 | --- | 5.9 | 68.7 | 1.4 | 16.3 | 7.7 | 6,740 | 12,140 |
| W233057 | 30.8 | 24.4 | 28.0 | 16.8 | 6.2 | 35.7 | .7 | 34.9 | 5.6 | 3,570 | 6,420 |
| | --- | 35.3 | 40.4 | 24.3 | 4.1 | 51.7 | 1.0 | 10.8 | 8.2 | 5,160 | 9,290 |
| | --- | 46.6 | 53.4 | --- | 5.4 | 68.2 | 1.3 | 14.3 | 10.8 | 6,810 | 12,270 |
| W233058 | 31.3 | 27.1 | 29.1 | 12.4 | 6.6 | 40.0 | .7 | 35.8 | 4.5 | 3,960 | 7,130 |
| | --- | 39.5 | 42.4 | 18.0 | 4.6 | 58.2 | 1.0 | 11.6 | 6.6 | 5,770 | 10,380 |
| | --- | 48.2 | 51.8 | --- | 5.6 | 71.0 | 1.2 | 14.1 | 8.1 | 7,030 | 12,660 |

Table 6.--Proximate and ultimate analyses and heat contents for 39 coal samples from Pakistan.--continued

| SAMPLE NUMBER (USGS) | PROXIMATE ANALYSIS | | | | ULTIMATE ANALYSIS | | | | | HEAT OF COMBUSTION | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOISTURE | VOLATILE MATTER | FIXED CARBON | ASH | HYDROGEN | CARBON | NITROGEN | OXYGEN | SULFUR | KCAL/KG | BTU/LB |
| W233059 | 30.1 | 26.2 | 28.5 | 15.2 | 6.4 | 38.1 | 0.7 | 36.7 | 2.9 | 3,800 | 6,840 |
| | --- | 37.5 | 40.7 | 21.8 | 4.4 | 54.5 | 1.0 | 14.2 | 4.1 | 5,440 | 9,780 |
| | --- | 47.9 | 52.1 | --- | 5.7 | 69.6 | 1.3 | 18.1 | 5.3 | 6,950 | 12,500 |
| W233060 | 30.6 | 28.3 | 30.4 | 10.7 | 6.6 | 41.5 | .7 | 36.3 | 4.1 | 4,270 | 7,690 |
| | --- | 40.8 | 43.8 | 15.5 | 4.6 | 59.8 | 1.0 | 13.2 | 5.9 | 6,150 | 11,080 |
| | --- | 48.2 | 51.8 | --- | 5.4 | 70.7 | 1.2 | 15.6 | 7.0 | 7,280 | 13,100 |
| W233061 | 30.5 | 28.1 | 28.1 | 13.3 | 6.5 | 40.4 | .8 | 35.5 | 3.6 | 4,000 | 7,210 |
| | --- | 40.5 | 40.4 | 19.1 | 4.5 | 58.1 | 1.1 | 12.1 | 5.2 | 5,760 | 10,370 |
| | --- | 50.1 | 49.9 | --- | 5.6 | 71.8 | 1.4 | 14.9 | 6.4 | 7,120 | 12,810 |
| W233062 | 27.4 | 31.9 | 29.4 | 11.2 | 6.5 | 43.1 | .8 | 33.6 | 4.8 | 4,360 | 7,840 |
| | --- | 44.0 | 40.6 | 15.5 | 4.8 | 59.4 | 1.1 | 12.7 | 6.6 | 6,010 | 10,810 |
| | --- | 52.0 | 48.0 | --- | 5.6 | 70.3 | 1.3 | 15.0 | 7.8 | 7,110 | 12,790 |
| W233063 | 27.8 | 31.5 | 25.1 | 15.6 | 6.3 | 40.2 | .8 | 33.2 | 3.9 | 3,950 | 7,120 |
| | --- | 43.6 | 34.8 | 21.6 | 4.4 | 55.7 | 1.1 | 11.8 | 5.3 | 5,480 | 9,860 |
| | --- | 55.6 | 44.4 | --- | 5.6 | 71.1 | 1.4 | 15.1 | 6.8 | 6,990 | 12,580 |
| W233064 | 30.2 | 30.0 | 27.7 | 12.1 | 6.4 | 40.9 | .7 | 35.8 | 4.0 | 4,080 | 7,340 |
| | --- | 43.0 | 39.7 | 17.3 | 4.4 | 58.6 | 1.0 | 12.8 | 5.8 | 5,840 | 10,500 |
| | --- | 52.0 | 48.0 | --- | 5.3 | 70.9 | 1.2 | 15.5 | 7.0 | 7,060 | 12,710 |
| W233065 | 30.2 | 27.0 | 27.3 | 15.4 | 6.4 | 37.7 | .7 | 35.4 | 4.4 | 3,770 | 6,790 |
| | --- | 38.7 | 39.2 | 22.1 | 4.3 | 54.1 | 1.0 | 12.3 | 6.2 | 5,400 | 9,720 |
| | --- | 49.7 | 50.3 | --- | 5.5 | 69.4 | 1.2 | 15.8 | 8.0 | 6,940 | 12,490 |
| W233047 | 29.5 | 22.4 | 23.1 | 24.9 | 5.8 | 29.7 | .6 | 33.6 | 5.4 | 2,950 | 5,310 |
| | --- | 31.9 | 32.7 | 35.4 | 3.6 | 42.1 | .8 | 10.4 | 7.6 | 4,180 | 7,530 |
| | --- | 49.3 | 50.7 | --- | 5.5 | 65.2 | 1.3 | 16.2 | 11.8 | 6,480 | 11,660 |
| W233066 | 32.1 | 27.1 | 29.1 | 11.6 | 6.5 | 39.8 | .7 | 37.0 | 4.3 | 3,970 | 7,140 |
| | --- | 40.0 | 42.9 | 17.1 | 4.3 | 58.5 | 1.1 | 12.5 | 6.4 | 5,840 | 10,510 |
| | --- | 48.2 | 51.8 | --- | 5.2 | 70.6 | 1.3 | 15.1 | 7.7 | 7,040 | 12,680 |
| W233210 | 26.1 | 31.5 | 33.4 | 9.0 | 6.5 | 47.0 | .9 | 33.0 | 3.6 | 4,620 | 8,310 |
| | --- | 42.6 | 45.2 | 12.2 | 4.9 | 63.7 | 1.2 | 13.3 | 4.8 | 6,250 | 11,240 |
| | --- | 48.5 | 51.5 | --- | 5.5 | 72.5 | 1.4 | 15.1 | 5.5 | 7,110 | 12,810 |
| W233211 | 28.5 | 31.8 | 30.7 | 9.1 | 6.6 | 45.8 | .9 | 34.0 | 3.6 | 4,560 | 8,210 |
| | --- | 44.5 | 42.9 | 12.7 | 4.8 | 64.0 | 1.3 | 12.2 | 5.1 | 6,380 | 11,480 |
| | --- | 50.9 | 49.1 | --- | 5.5 | 73.3 | 1.5 | 13.9 | 5.8 | 7,300 | 13,140 |
| W233212 | 27.3 | 29.6 | 24.9 | 18.2 | 6.1 | 39.6 | .7 | 31.9 | 3.4 | 3,930 | 7,080 |
| | --- | 40.7 | 34.3 | 25.1 | 4.3 | 54.4 | .9 | 10.6 | 4.7 | 5,410 | 9,740 |
| | --- | 54.3 | 45.7 | --- | 5.7 | 72.7 | 1.2 | 14.1 | 6.3 | 7,220 | 13,000 |

Table 6.--Proximate and ultimate analyses and heat contents for 39 coal samples from Pakistan.--continued

| SAMPLE NUMBER (USGS) | PROXIMATE ANALYSIS | | | | ULTIMATE ANALYSIS | | | | | HEAT OF COMBUSTION | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOISTURE | VOLATILE MATTER | FIXED CARBON | ASH | HYDROGEN | CARBON | NITROGEN | OXYGEN | SULFUR | KCAL/KG | BTU/LB |
| W233213 | 34.5 | 28.3 | 25.7 | 11.5 | 6.9 | 38.7 | 0.7 | 38.9 | 3.3 | 3,840 | 6,910 |
| | --- | 43.2 | 39.2 | 17.5 | 4.7 | 59.1 | 1.1 | 12.6 | 5.1 | 5,860 | 10,550 |
| | --- | 52.4 | 47.6 | --- | 5.7 | 71.6 | 1.3 | 15.2 | 6.2 | 7,110 | 12,790 |
| W233214 | 24.7 | 28.8 | 29.5 | 17.1 | 6.0 | 40.7 | .7 | 29.7 | 5.8 | 4,140 | 7,460 |
| | --- | 38.2 | 39.2 | 22.6 | 4.3 | 54.1 | 1.0 | 10.3 | 7.7 | 5,500 | 9,900 |
| | --- | 49.4 | 50.6 | --- | 5.6 | 69.9 | 1.3 | 13.3 | 10.0 | 7,110 | 12,800 |
| W233215 | 27.6 | 31.6 | 29.5 | 11.3 | 6.5 | 44.1 | .8 | 33.2 | 4.0 | 4,400 | 7,920 |
| | --- | 43.6 | 40.7 | 15.7 | 4.7 | 61.0 | 1.2 | 12.0 | 5.5 | 6,080 | 10,940 |
| | --- | 51.7 | 48.3 | --- | 5.6 | 72.3 | 1.4 | 14.2 | 6.5 | 7,210 | 12,970 |
| W233216 | 24.8 | 28.0 | 27.8 | 19.3 | 5.9 | 38.3 | .7 | 29.4 | 6.3 | 3,910 | 7,040 |
| | --- | 37.3 | 37.1 | 25.7 | 4.2 | 51.0 | 1.0 | 9.8 | 8.4 | 5,200 | 9,360 |
| | --- | 50.1 | 49.9 | --- | 5.6 | 68.6 | 1.3 | 13.1 | 11.4 | 7,000 | 12,600 |
| W233217 | 25.1 | 32.5 | 35.7 | 6.7 | 6.5 | 50.2 | .9 | 32.1 | 3.5 | 4,990 | 8,980 |
| | --- | 43.4 | 47.7 | 8.9 | 5.0 | 67.0 | 1.3 | 13.1 | 4.7 | 6,660 | 11,990 |
| | --- | 47.6 | 52.4 | --- | 5.5 | 73.6 | 1.4 | 14.4 | 5.1 | 7,320 | 13,170 |
| W233218 | 22.4 | 29.1 | 26.9 | 21.6 | 5.6 | 38.0 | .7 | 26.5 | 7.6 | 3,870 | 6,960 |
| | --- | 37.4 | 34.7 | 27.9 | 4.0 | 48.9 | .9 | 8.6 | 9.8 | 4,980 | 8,960 |
| | --- | 51.9 | 48.1 | --- | 5.5 | 67.8 | 1.2 | 11.9 | 13.6 | 6,900 | 12,420 |
| W233219 | 26.4 | 33.0 | 28.9 | 11.7 | 6.3 | 45.2 | .9 | 31.9 | 4.0 | 4,480 | 8,070 |
| | --- | 44.8 | 39.3 | 15.9 | 4.6 | 61.5 | 1.2 | 11.4 | 5.4 | 6,100 | 10,970 |
| | --- | 53.3 | 46.7 | --- | 5.5 | 73.1 | 1.4 | 13.5 | 6.5 | 7,250 | 13,050 |
| W233220 | 25.0 | 30.2 | 27.2 | 17.5 | 6.0 | 41.7 | .8 | 30.2 | 3.8 | 4,160 | 7,490 |
| | --- | 40.3 | 36.3 | 23.4 | 4.3 | 55.6 | 1.0 | 10.7 | 5.1 | 5,550 | 9,990 |
| | --- | 52.6 | 47.4 | --- | 5.6 | 72.6 | 1.3 | 13.9 | 6.6 | 7,240 | 13,040 |
| W233221 | 24.3 | 30.5 | 25.6 | 19.6 | 5.7 | 38.2 | .9 | 31.2 | 4.3 | 3,730 | 6,710 |
| | --- | 40.3 | 33.8 | 25.9 | 3.9 | 50.5 | 1.2 | 12.7 | 5.7 | 4,920 | 8,860 |
| | --- | 54.4 | 45.6 | --- | 5.3 | 68.1 | 1.7 | 17.2 | 7.7 | 6,640 | 11,960 |
| W233222 | 25.8 | 30.9 | 31.9 | 11.4 | 6.4 | 45.8 | .7 | 32.3 | 3.4 | 4,610 | 8,300 |
| | --- | 41.7 | 42.9 | 15.4 | 4.8 | 61.6 | .9 | 12.7 | 4.6 | 6,210 | 11,180 |
| | --- | 49.3 | 50.7 | --- | 5.6 | 72.9 | 1.1 | 15.0 | 5.4 | 7,340 | 13,220 |
| W233223 | 25.9 | 29.1 | 27.9 | 17.1 | 6.1 | 41.3 | 1.0 | 31.2 | 3.3 | 4,080 | 7,340 |
| | --- | 39.3 | 37.6 | 23.1 | 4.4 | 55.8 | 1.3 | 11.0 | 4.5 | 5,500 | 9,900 |
| | --- | 51.1 | 48.9 | --- | 5.7 | 72.5 | 1.7 | 14.3 | 5.8 | 7,150 | 12,870 |
| W233224 | 27.3 | 30.9 | 31.1 | 10.7 | 6.4 | 44.7 | .7 | 33.2 | 4.3 | 4,430 | 7,980 |
| | --- | 42.5 | 42.7 | 14.8 | 4.6 | 61.5 | .9 | 12.3 | 5.9 | 6,090 | 10,970 |
| | --- | 49.9 | 50.1 | --- | 5.4 | 72.2 | 1.1 | 14.4 | 6.9 | 7,150 | 12,860 |

Table 6.--Proximate and ultimate analyses and heat contents for 39 coal samples from Pakistan. --continued

| SAMPLE NUMBER (USGS) | PROXIMATE ANALYSIS | | | | ULTIMATE ANALYSIS | | | | | HEAT OF COMBUSTION | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOISTURE | VOLATILE MATTER | FIXED CARBON | ASH | HYDROGEN | CARBON | NITROGEN | OXYGEN | SULFUR | KCAL/KG | BTU/LB |
| W233225 | 26.9 | 31.5 | 28.3 | 13.2 | 6.3 | 40.9 | 0.9 | 32.7 | 5.9 | 4,180 | 7,520 |
| | --- | 43.2 | 38.7 | 18.1 | 4.6 | 55.9 | 1.2 | 12.1 | 8.0 | 5,710 | 10,280 |
| | --- | 52.7 | 47.3 | --- | 5.6 | 68.3 | 1.5 | 14.8 | 9.8 | 6,980 | 12,560 |
| W233226 | 24.0 | 26.6 | 25.7 | 23.7 | 5.4 | 32.2 | .7 | 28.9 | 9.0 | 3,280 | 5,910 |
| | --- | 35.0 | 33.8 | 31.2 | 3.6 | 42.4 | 1.0 | 10.0 | 11.8 | 4,320 | 7,780 |
| | --- | 50.9 | 49.1 | --- | 5.3 | 61.6 | 1.4 | 14.5 | 17.2 | 6,280 | 11,310 |
| W233208 | 30.2 | 30.4 | 28.2 | 11.2 | 6.8 | 42.6 | .8 | 34.6 | 4.0 | 4,290 | 7,720 |
| | --- | 43.6 | 40.4 | 16.0 | 4.9 | 61.1 | 1.2 | 11.1 | 5.7 | 6,150 | 11,070 |
| | --- | 51.9 | 48.1 | --- | 5.8 | 72.8 | 1.4 | 13.2 | 6.8 | 7,320 | 13,180 |
| W233209 | 32.8 | 29.0 | 28.2 | 10.0 | 6.9 | 41.5 | .7 | 37.4 | 3.5 | 4,140 | 7,460 |
| | --- | 43.1 | 42.0 | 14.9 | 4.9 | 61.7 | 1.1 | 12.3 | 5.2 | 6,170 | 11,100 |
| | --- | 50.6 | 49.4 | --- | 5.7 | 72.5 | 1.2 | 14.5 | 6.1 | 7,240 | 13,030 |

Table 6A.--Air-dried losses, forms of sulfur, free-swelling indexes, and ash-fusion temperatures for 39 coal samples from Pakistan.

[Results listed by USGS laboratory sample numbers, each with entries on three bases: first line, as received; second, moisture-free; and third, moisture- and ash-free. Samples analyzed by a commercial testing laboratory using ASTM standards. All figures are percent unless otherwise indicated.]

| SAMPLE NUMBER (USGS) | AIR-DRIED LOSS | FORMS OF SULFUR | | | FREE-SWELLING INDEX | ASH-FUSION TEMPERATURE, C | | |
|---|---|---|---|---|---|---|---|---|
| | | SULFATE | PYRITIC | ORGANIC | | INITIAL DEFORMATION | SOFTENING | FLUID |
| W233048 | 17.0 | 0.27 | 3.05 | 1.11 | 0.0 | 1,140 | 1,175 | 1,380 |
| | --- | .38 | 4.26 | 1.55 | | | | |
| | --- | .45 | 5.10 | 1.86 | | | | |
| W233049 | 16.2 | .30 | 2.23 | .73 | .0 | 1,240 | 1,400 | 1,445 |
| | --- | .43 | 3.20 | 1.05 | | | | |
| | --- | .59 | 4.41 | 1.44 | | | | |
| W233050 | 21.0 | .31 | 2.08 | 1.16 | .0 | 1,160 | 1,215 | 1,410 |
| | --- | .47 | 3.12 | 1.74 | | | | |
| | --- | .59 | 3.95 | 2.20 | | | | |
| W233051 | 16.8 | .85 | 2.25 | .87 | .0 | 1,300 | 1,400 | 1,500 |
| | --- | 1.15 | 3.04 | 1.18 | | | | |
| | --- | 1.76 | 4.66 | 1.80 | | | | |
| W233052 | 18.8 | .36 | 2.01 | 1.35 | .0 | 1,270 | 1,315 | 1,415 |
| | --- | .51 | 2.87 | 1.92 | | | | |
| | --- | .69 | 3.86 | 2.60 | | | | |
| W233053 | 21.2 | .21 | 1.74 | .51 | .0 | 1,505 | 1,515 | 1,5406 |
| | --- | .29 | 2.38 | .70 | | | | |
| | --- | .52 | 4.29 | 1.26 | | | | |
| W233054 | 19.7 | .74 | 2.76 | 1.25 | .0 | 1,210 | 1,230 | 1,295 |
| | --- | 1.08 | 4.04 | 1.83 | | | | |
| | --- | 1.42 | 5.28 | 2.39 | | | | |
| W233055 | 19.5 | .17 | 2.21 | .94 | .0 | 1,270 | 1,395 | 1,410 |
| | --- | .23 | 3.04 | 1.29 | | | | |
| | --- | .31 | 4.05 | 1.72 | | | | |
| W233056 | 17.1 | .35 | 2.66 | .68 | .0 | 1,420 | 1,470 | 1,540 |
| | --- | .47 | 3.58 | .92 | | | | |
| | --- | .73 | 5.58 | 1.43 | | | | |
| W233057 | 19.2 | .58 | 4.37 | 0.69 | .0 | 1,125 | 1,165 | 1,360 |
| | --- | .84 | 6.32 | 1.00 | | | | |
| | --- | 1.11 | 8.35 | 1.32 | | | | |
| W233058 | 19.8 | .42 | 2.91 | 1.22 | .0 | 1,150 | 1,205 | 1,420 |
| | --- | .61 | 4.24 | 1.78 | | | | |
| | --- | .75 | 5.17 | 2.17 | | | | |

Table 6A.--Air-dried losses, forms of sulfur, free-swelling indexes, and ash-fussion temperatures for 39 coal samples from Pakistan.--continued

| SAMPLE NUMBER (USGS) | AIR-DRIED LOSS | FORMS OF SULFUR | | | FREE-SWELLING INDEX | ASH-FUSION TEMPERATURE, C | | |
|---|---|---|---|---|---|---|---|---|
| | | SULFATE | PYRITIC | ORGANIC | | INITIAL DEFORMATION | SOFTENING | FLUID |
| W233059 | 17.3 | 0.26 | 1.83 | 0.81 | 0.0 | 1,250 | 1,295 | 1,395 |
| | --- | .37 | 2.62 | 1.16 | | | | |
| | --- | .48 | 3.35 | 1.48 | | | | |
| W233060 | 22.8 | .14 | 1.88 | 2.10 | .0 | 1,215 | 1,255 | 1,395 |
| | --- | .20 | 2.71 | 3.02 | | | | |
| | --- | .24 | 3.20 | 3.58 | | | | |
| W233061 | 16.7 | .19 | 2.59 | .80 | .0 | 1,230 | 1,260 | 1,395 |
| | --- | .27 | 3.73 | 1.15 | | | | |
| | --- | .34 | 4.61 | 1.42 | | | | |
| W233062 | 17.8 | .87 | 3.05 | .85 | .0 | 1,170 | 1,200 | 1,430 |
| | --- | 1.20 | 4.20 | 1.17 | | | | |
| | --- | 1.42 | 4.97 | 1.39 | | | | |
| W233063 | 16.6 | 1.53 | 1.99 | .34 | .0 | 1,270 | 1,300 | 1,400 |
| | --- | 2.12 | 2.76 | .47 | | | | |
| | --- | 2.70 | 3.52 | .60 | | | | |
| W233064 | 20.4 | .26 | 2.53 | 1.26 | .0 | 1,225 | 1,255 | 1,415 |
| | --- | .37 | 3.62 | 1.80 | | | | |
| | --- | .45 | 4.38 | 2.18 | | | | |
| W233065 | 20.3 | .33 | 3.08 | .95 | .0 | 1,210 | 1,245 | 1,415 |
| | --- | .47 | 4.41 | 1.36 | | | | |
| | --- | .61 | 5.67 | 1.75 | | | | |
| W233047 | 23.2 | .27 | 4.97 | .12 | .0 | 1,190 | 1,245 | 1,470 |
| | --- | .38 | 7.05 | .17 | | | | |
| | --- | .59 | 10.92 | .26 | | | | |
| W233066 | 21.2 | .52 | 2.99 | .83 | .0 | 1,150 | 1,170 | 1,415 |
| | --- | .77 | 4.40 | 1.22 | | | | |
| | --- | .92 | 5.31 | 1.47 | | | | |
| W233210 | 19.4 | .53 | 1.69 | 1.34 | .0 | 1,115 | 1,125 | 1,225 |
| | --- | .72 | 2.29 | 1.81 | | | | |
| | --- | .82 | 2.60 | 2.07 | | | | |
| W233211 | 22.7 | .12 | 2.81 | .70 | .0 | 1,095 | 1,115 | 1,300 |
| | --- | .17 | 3.93 | .98 | | | | |
| | --- | .19 | 4.50 | 1.12 | | | | |
| W233212 | 23.7 | .53 | 1.88 | 1.01 | .0 | 1,295 | 1,330 | 1,390 |
| | --- | .73 | 2.59 | 1.39 | | | | |
| | --- | .97 | 3.45 | 1.85 | | | | |

Table 6A.--Air-dried losses, forms of sulfur, free-swelling indexes, and ash-fussion temperatures for 39 coal samples from Pakistan.--continued

| SAMPLE NUMBER (USGS) | AIR-DRIED LOSS | FORMS OF SULFUR | | | FREE-SWELLING INDEX | ASH-FUSION TEMPERATURE, C | | |
|---|---|---|---|---|---|---|---|---|
| | | SULFATE | PYRITIC | ORGANIC | | INITIAL DEFORMATION | SOFTENING | FLUID |
| W233213 | 31.7 | 0.17 | 2.01 | 1.16 | 0.0 | 1,115 | 1,125 | 1,315 |
| | --- | .26 | 3.07 | 1.77 | | | | |
| | --- | .31 | 3.72 | 2.15 | | | | |
| W233214 | 18.3 | .40 | 3.88 | 1.53 | .0 | 1,180 | 1,205 | 1,370 |
| | --- | .53 | 5.15 | 2.03 | | | | |
| | --- | .69 | 6.66 | 2.63 | | | | |
| W233215 | 22.1 | .52 | 2.29 | 1.17 | .0 | 1,195 | 1,215 | 1,465 |
| | --- | .72 | 3.16 | 1.62 | | | | |
| | --- | .85 | 3.75 | 1.92 | | | | |
| W233216 | 18.6 | .25 | 4.23 | 1.86 | .0 | 1,180 | 1,215 | 1,425 |
| | --- | .33 | 5.63 | 2.48 | | | | |
| | --- | .45 | 7.57 | 3.33 | | | | |
| W233217 | 19.2 | .23 | 1.86 | 1.40 | .0 | 1,070 | 1,080 | 1,310 |
| | --- | .31 | 2.48 | 1.87 | | | | |
| | --- | .34 | 2.73 | 2.05 | | | | |
| W233218 | 16.5 | .79 | 4.88 | 1.92 | .0 | 1,200 | 1,215 | 1,350 |
| | --- | 1.02 | 6.29 | 2.47 | | | | |
| | --- | 1.41 | 8.71 | 3.43 | | | | |
| W233219 | 21.8 | .13 | 2.80 | 1.06 | .0 | 1,305 | 1,340 | 1,405 |
| | --- | .18 | 3.81 | 1.44 | | | | |
| | --- | .21 | 4.53 | 1.71 | | | | |
| W233220 | 18.2 | .18 | 2.41 | 1.21 | .0 | 1,190 | 1,240 | 1,370 |
| | --- | .24 | 3.21 | 1.61 | | | | |
| | --- | .31 | 4.19 | 2.11 | | | | |
| W233221 | 19.7 | 1.13 | 1.58 | 1.62 | .0 | 1,190 | 1,225 | 1,360 |
| | --- | 1.49 | 2.09 | 2.14 | | | | |
| | --- | 2.01 | 2.82 | 2.89 | | | | |
| W233222 | 20.7 | .15 | 2.57 | .68 | .0 | 1,150 | 1,170 | 1,410 |
| | --- | .20 | 3.46 | .92 | | | | |
| | --- | .24 | 4.09 | 1.08 | | | | |
| W233223 | 16.7 | .20 | 2.39 | .74 | .0 | 1,225 | 1,250 | 1,445 |
| | --- | .27 | 3.22 | 1.00 | | | | |
| | --- | .35 | 4.19 | 1.30 | | | | |
| W233224 | 21.9 | .24 | 2.84 | 1.22 | .0 | 1,080 | 1,095 | 1,180 |
| | --- | .33 | 3.90 | 1.68 | | | | |
| | --- | .39 | 4.58 | 1.97 | | | | |

Table 6A.--Air-dried losses, forms of sulfur, free-swelling indexes, and ash-fussion temperatures for 39 coal samples from Pakistan.--continued

| SAMPLE NUMBER | AIR-DRIED LOSS | FORMS OF SULFUR | | | FREE-SWELLING INDEX | ASH-FUSION TEMPERATURE, C | | |
|---|---|---|---|---|---|---|---|---|
| | | SULFATE | PYRITIC | ORGANIC | | INITIAL DEFORMATION | SOFTENING | FLUID |
| W233225 | 22.6 | 0.53 | 2.69 | 2.64 | 0.0 | 1,195 | 1,225 | 1,395 |
| | --- | .72 | 3.68 | 3.61 | | | | |
| | --- | .89 | 4.49 | 4.41 | | | | |
| W233226 | 20.4 | .99 | 5.94 | 2.06 | .0 | 1,140 | 1,170 | 1,370 |
| | --- | 1.30 | 7.81 | 2.71 | | | | |
| | --- | 1.89 | 11.36 | 3.94 | | | | |
| W233208 | 24.2 | .10 | 2.90 | 1.00 | .0 | 1,070 | 1,095 | 1,150 |
| | --- | .14 | 4.16 | 1.43 | | | | |
| | --- | .17 | 4.95 | 1.71 | | | | |
| W233209 | 27.4 | .10 | 2.09 | 1.31 | .0 | 1,075 | 1,095 | 1,125 |
| | --- | .15 | 3.11 | 1.95 | | | | |
| | --- | .17 | 3.65 | 2.29 | | | | |

on a moist basis; for example, the rank of low-rank coals is established by the moist, mineral-matter-free heat value.

Moisture in coal is commonly present in two forms. Inherent moisture is defined (ASTM, D121-1986) as "... moisture that exists as an integral part of the coal seam in its natural state, including water in pores but not that present in macroscopically visible fractures. Inherent moisture is considered to be equivalent to bed moisture, but may not be equated to the moisture remaining in a coal sample after air drying, as is the practice in some other countries." Free moisture (sometimes referred to as surface moisture) is defined (ASTM, D121-1986) as "... that portion of total moisture in coal ... that is in excess of inherent moisture ... . It is not to be equated with the weight loss upon air-drying."

Total moisture is defined as "... that moisture determined as the loss in weight in an air atmosphere under rigidly controlled conditions of temperature, time and air flow as established in Test Method D3302." (ASTM, 1986). Test Method D3173 can be, and commonly is, used in conjunction with Test Method D3302 to determine total moisture. The "Air dry loss" and "residual moisture" reported by analytical laboratories are references to their test methods and, as previously stated, are not to be equated with either free moisture or inherent moisture.

In actual practice, the results of test methods are mathematically converted according to standardized formulas and reported in a variety of conventional bases, both of which are presented in D3180-84 (ASTM, 1986). Ordinarily, standard coal analyses are presented in three related bases: 1) the as-received basis, "... analytical data calculated to the moisture condition of the sample as it arrived at the laboratory and before any processing or conditioning."; 2) the dry basis, "... data calculated to a theoretical base of no moisture associated with the sample."; and 3) the dry, ash-free basis, "... data calculated to a theoretical base of no moisture or ash associated with the sample." (D3180-84, ASTM, 1986).

All three bases are normally derived from "as-determined" data that represent the numerical values obtained at the particular moisture level in the sample at the time of analysis. In addition to the inherent moisture content of the coal, the "as-determined" moisture value may include free moisture that is related to climate, oxidation and weathering, conditions during packing, and storing and shipping sample containers, all of which tend to make the calculated "as-received" moisture value not representative of the true, in-place, moisture content of the undisturbed coal immediately prior to mining.

In an attempt to determine more exactly the true moisture content of the coal prior to mining, and to allow valid comparison of the reported moisture content of different samples of coals (particularly low-rank coals), the standard test method for equilibrium moisture of coal at 96 to 97 percent relative humidity and 30° C (D1412, ASTM, 1986) has been applied to seven of the samples analyzed for this report.

Table 7 presents a comparison of statistical appraisals of the seven samples according to the "as-received" and "equilibrium moisture" bases. As is shown, the equilibrium moisture determination validates the representational character of the samples, the "as-determined" analytical character, and the "as-received" analytical values previously reported.

Table 7.--Statistical appraisal of seven[1/] samples on as-received and equilibrium moisture bases, values in weight percent except heat value

[As-received value/Equilibrium moisture value]

| | Arithmetic mean | Standard deviation | Observed range | | Geometric mean | Geometric deviation |
|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | | |
| | | | Proximate and ultimate analyses | | | |
| Moisture | 27.0/26.9 | 2.4/1.1 | 24.0/25.6 | 31.7/28.9 | 26.9/26.8 | 1.1/1.0 |
| Volatile matter | 27.8/27.9 | 2.9/3.0 | 24.9/24.7 | 31.9/32.4 | 27.7/27.8 | 1.1/1.1 |
| Fixed carbon | 25.9/26.0 | 2.7/3.0 | 22.3/22.2 | 29.4/29.9 | 25.8/25.9 | 1.1/1.1 |
| Ash | 19.2/19.2 | 6.2/5.9 | 11.2/11.4 | 26.6/26.3 | 18.4/18.4 | 1.4/1.4 |
| Hydrogen | 6.0/ 6.0 | 0.4/0.4 | 5.4/ 5.5 | 6.5/ 6.4 | 6.0/ 6.0 | 1.1/1.1 |
| Carbon | 36.6/36.7 | 4.4/4.8 | 32.2/31.5 | 43.1/43.8 | 36.3/36.4 | 1.1/1.1 |
| Nitrogen | 0.74/0.74 | 0.09/0.09 | 0.64/0.64 | 0.91/0.90 | 0.74/0.74 | 1.1/1.1 |
| Oxygen | 32.4/32.3 | 2.4/1.3 | 28.9/30.2 | 36.4/34.2 | 32.3/32.3 | 1.1/1.0 |
| Sulfur | 5.1/ 5.1 | 1.9/1.9 | 3.3/ 3.3 | 9.0/ 8.8 | 4.8/ 4.8 | 1.4/1.4 |
| Heat value (Btu/lb) | 6610/6640 | 860/920 | 5770/5720 | 7840/7980 | 6570/6580 | 1.1/1.1 |
| Sulfate sulfur | 0.65/ 0.64 | 0.3/ 0.3 | 0.17/ 0.17 | 0.99/0.97 | 0.57/0.56 | 1.9/1.9 |
| Pyritic sulfur | 3.1/ 3.1 | 1.3/ 1.2 | 2.2/ 2.2 | 5.9/ 5.8 | 2.9/ 2.9 | 1.4/1.4 |
| Organic sulfur | 1.3/ 1.3 | 0.7/ 0.7 | 0.7/ 0.7 | 2.6/ 2.6 | 1.2/ 1.2 | 1.7/1.6 |

[1/] USGS numbers W233051, 054, 055, 056, 062, 225, and 226. See Appendix C.

Moisture determination is critical to all other coal analytical bases including the ultimate analysis discussed subsequently. A non-representative moisture determination affects the calculation relative to all other content determinations. Consequently, if the moisture determination is non-representative, all other determinations are also non-representative. In high-rank coals the amount of moisture in the coal (by weight percentage) is relatively small and may approach zero. In low-rank coals moisture may be in excess of 35 percent and the importance of moisture in determining the characterization of a coal is immensely greater than in high-rank coals.

In utilization of coals, moisture is almost always a detrimental constituent. In contrast to high-rank coals, high-moisture coals oxidize and weather faster, lose or gain free moisture easier, are more susceptible to spontaneous combustion, are less efficient to transport because of the water content, have less heat value, tend to be tough and more difficult to crush and grind, will not make high-heat-value slurries, and require different than conventional design in boilers for burning. Consequently, reliable characterization of the moisture content is absolutely imperative for informed planning for usage.

## Volatile Matter

The volatile-matter content of a sample is defined as "... the percentage of gaseous products, exclusive of moisture vapor, in the analysis sample [the sample being analyzed] which are released under the specific conditions of the test. ... Volatile matter is determined by establishing the loss in weight resulting from heating a coal sample under rigidly controlled conditions. The measured weight loss, corrected for moisture as determined in Method D3173, establishes the volatile matter content." (D3175-82, ASTM, 1986).

The volatile-matter content is of importance because it may be used to establish the rank of coals, to indicate coke yield resulting from carbonization processes, to provide the basis for buying or selling for particular uses, or to assist in attempts to predict burning characteristics. (D3175-82, ASTM, 1986).

## Fixed Carbon

The reported fixed carbon of a coal sample is a calculated value. "It is the resultant of the summation of percentage moisture, ash, and volatile matter subtracted from 100." (D3172-73, ASTM, 1986). In higher rank coals the fixed-carbon percentage can be used to establish the rank of coals. (D388-84, ASTM, 1986).

## Ash

Ash is the "... inorganic residue remaining after ignition of combustible substances, determined by definite prescribed methods ... ash may not be identical, in composition or quantity, with the inorganic substances present in the material before ignition." (D121-85, ASTM, 1986). "Incineration causes an expulsion of all water, the loss of carbon dioxide from carbonates, the conversion of iron pyrites into ferric oxide, and other chemical reactions." (D3174-82, ASTM, 1986). Consequently, a reported analytical result on the "ash-free" basis is not comparable to a reported analytical result on the

"mineral-matter-free" basis. Also, the chemical character and quantity of ash produced during combustion of coal will vary depending on the incineration conditions.

For the above reasons, it is difficult to precisely predict the burning characteristics of coals during utilization solely on the basis of the ash weight percentage determined by standard test methods. Many other analytical determinations and test methods attempt to predict the burning characteristics of different coals; for example, determination of the swelling characteristics of the sampled coals (see Free-swelling index) and determinations of the temperatures at which certain physical changes in the coal occur (see Ash-fusion temperature).

## Ultimate Analysis

During the procedure termed "ultimate analysis", the hydrogen, carbon, nitrogen, oxygen, and sulfur contents of the coal are determined. The ash content will ordinarily have already been determined for the proximate analysis and also forms part of the ultimate analysis. Sometimes, only sulfur is determined, and the complete ultimate analysis is not made. The hydrogen and carbon are determined as found in the gaseous products of the complete combustion of the sample; nitrogen, sulfur, and ash are determined on the sample as a whole; and the oxygen content is calculated by difference. The ultimate analysis is intended, along with the proximate analysis, to permit cursory valuation of coals for use as fuels or as ingredients to other carbonaceous processes (D3176-84, ASTM, 1986).

### Hydrogen and Carbon

Both hydrogen and carbon are determined in one operation applying standard test method D3178-84 (ASTM, 1986). "This test method yields the total percentages of carbon and hydrogen in the coal as analyzed and the results include not only the carbon and hydrogen in the organic matter, but also the carbon present in mineral carbonates and the hydrogen present in the free moisture accompanying the sample as well as hydrogen present as water of hydration of silicates." (D3178-84, ASTM, 1986). The "Carbon and hydrogen values are used to calculate the amount of oxygen (air) required in combustion processes, and in the calculations of efficiency of combustion processes. ... Carbon and hydrogen determinations are used in material balances on coal conversion processes; also one or the other is frequently used in correlations of chemical and physical properties, such as yields of products in liquefaction, reactivity in gasification, and the density and porosity of coal." (D3178-84, ASTM, 1986).

### Nitrogen

Total nitrogen in coal samples is determined in accordance with test method D3179-84 (ASTM, 1986). Determination of the nitrogen content is necessary when oxygen content is derived by difference and is important for evaluation of the potential formation of nitrogen oxides as a source of atmospheric pollution.

### Oxygen

The oxygen content of a coal sample is derived by subtracting from 100 the summation of the determined hydrogen, carbon, nitrogen, sulfur, and ash contents of that sample.

### Sulfur

Total sulfur is determined as part of the ultimate analysis in accordance with test method D3177-84 (ASTM, 1986). Sulfur and ash are the primary deleterious constituents considered when coals are classified by grade. Coals with 1 percent or less sulfur are classed as low-sulfur, coals with more than 1 percent and less than 3 percent sulfur are classed as medium-sulfur, and coals with 3 percent or more sulfur are classed as high-sulfur (Wood and others, 1983). (See later discussion under "Forms of Sulfur").

### Ash

Ash, defined as "The inorganic residue remaining after complete incineration of coal." (Wood and others, 1983), is part of both the proximate and ultimate analyses of coals (see discussion under Proximate Analysis). In classification of coals by grade, coals with less than 8 percent ash are classed as low-ash, coals with 8 to 15 percent ash are classed as medium-ash, and coals with more than 15 percent ash are classed as high-ash (Wood and others, 1983).

As briefly discussed previously, both the absolute quantity and the type of inorganic material represented by the ash are extremely important in determining the behavior of coals during combustion and conversion processes.

## Other Analyses

A variety of other tests of physical and chemical characteristics of coal can be performed. Some determinations, such as heat value, are routinely made. Others, such as forms of sulfur, are not as commonly done. Still others, such as equilibrium-moisture determinations, and ash-fusion temperatures, should be part of a routine but are sometimes not performed until problems in marketing or utilization arise.

### Heat Value

The major use for coal is in combustion, and the test for heat value (calorific value) is commonly the most significant analytical procedure of all. Knowledge of the heat value is critical for a variety of purposes such as classification of coals by rank, estimation of energy resources, evaluation of utilization potential and methods, and estimation of economic value.

Direct measurement of heat value is the commonest method of determination. However, heat value can be calculated from proximate and ultimate analyses by a wide variety of formulas. Many (most?) of the proposed formulas for calculation of heat value are at least partially empirical and are only valid for particular coals from particular areas. A few formulas are of broad enough applicability to be used as substitutes for direct measurement when direct measurements are not available (Speight, 1983). However, even

these particular formulas yield deviations from measured values of as much as 4 or 5 percent in the case of low-rank coals (Selvig and Gibson, 1945).

## Forms of sulfur

Determination of the sulfur content of coals is often accompanied in modern practice by determination of the amount of the total sulfur that is present in the forms of sulfate sulfur, pyritic sulfur, and organic sulfur. Distinction between the three sulfur forms has major economic significance. The standard test method for forms of sulfur in coal (D2492-84, ASTM, 1986) was used in the determinations reported herein. Sulfate sulfur and pyritic sulfur are direct determinations, organic sulfur is derived by difference between their sum and the total sulfur.

Sulfate sulfur is low in fresh coal and higher in oxidized or weathered coal. "The sulfates (mainly calcium and iron) rarely exceed 0.1 percent except in highly weathered or oxidized samples of coal..." (Speight, 1983, p. 145). The sulfate-sulfur content of the samples discussed here is relatively high - with a geometric mean of 0.33 (table 6A). Most of the coal beds presently being mined in the Lakhra field are within the zone of weathering and contain secondary deposits of gypsum. This accounts for the high sulfate-sulfur content of many of the samples. However, some of the sulfate may also be present as iron-sulfate minerals. Ordinarily, weathering and oxidation reduce the heat value of low-rank coal and this fact may indicate that deeper coals in South Sind, below the weathering zone, may have higher heat values than the coal presently being mined.

The bulk of sulfur in coal is in the pyritic form as a mineral, and in the organic form as a complex with the organic material. For both technologic and economic reasons, organic sulfur is usually deemed "not removable" from coal at the present time. Pyritic sulfur may or may not be removable, depending on the size of the pyrite mineral grains. Coarse grains are easily removed by conventional coal preparation processes, largely gravimetric. Disseminated, very fine grains are usually considered impossible to remove. Petrographic studies are a necessary first step in determining whether pyritic sulfur is removable, and washability studies are commonly required to determine how much pyrite might be removed.

Organic-sulfur content is derived by the difference between the total-sulfur content and the sum of the measured sulfate-and pyritic-sulfur contents. Much basic and applied research applicable to, and directed at, removing the organic sulfur from coal has been done and several promising processes have been proposed. However, many pilot studies and full-scale tests remain to be done before technical and economic feasibility is accepted.

## Free-swelling Index

This determination "... is a measure of the increase in volume of a coal when it is heated without restriction under specific heating conditions." (Rees, 1966, p. 48). As such, it is used in an attempt to predict caking, coking, and agglomerating properties and the related behavior during combustion. "In general terms, a coal exhibiting a free swelling index of 2 or less will most likely not be a good coking coal." (Speight, 1983, p. 179). All analyses of coal reported herein have a free-swelling index of 0 (appendix B).

## Apparent Specific Gravity

Specific gravity of porous materials such as coal is difficult to determine using conventional methods. The analytical results are therefore designated "apparent" rather than "true". Many factors affect the apparent specific gravity, though the amount and type of non-organic material in the sample is obviously very important. For estimation of coal resources, a specific gravity of 1.3 is assumed for coal of subbituminous rank. The geometric mean for the apparent specific gravity of the coal analyses presented herein is 1.4.

## Hardgrove Grindability Index

The grindability, or ease of pulverization, is of importance in evaluating utilization of coals. Because a range of properties, such as hardness and toughness, are involved, meaningful determination is difficult. The standard test for grindability of coal by the Hardgrove-machine method (D409-85, ASTM, 1986) yields an empirical result that is comparative to standard coals. In general, the higher the number, the easier a coal is to pulverize. Coals of lignitic and subbituminous rank commonly have lower grindability indexes, in the range of 40 to 60, than coals of bituminous rank. The mean index of 70 determined for the coals reported herein is higher than expected but cannot be evaluated without further analysis.

## Ash-fusion Temperatures

This test is intended to supply information on the fusion characteristics of the ash of coal. "Ash fusibility values are frequently specified in coal contracts because they are thought to furnish information regarding the clinker tendencies of the ash of the coal." (Rees, 1966, p. 44). Rees warns that "Ash fusibility data are too often over-interpreted. ... the test should be considered an empirical one and the data, at best, only qualitative." (Rees, 1966, p. 44).

The standard test method for fusibility of coal and coke ash (D1858-68, ASTM, 1986) "... covers the observation of the temperatures at which triangular pyramids (cones) prepared from coal and coke ash attain and pass through certain defined stages of fusing and flow when heated at a specified rate in controlled, mildly reducing, and where desired, oxidizing atmospheres." In practice, four temperature points are determined: the initial deformation (ID) temperature, at which the initial rounding of the apex of the pyramid takes place; the softening temperature (ST), at which the cone has fused so that the height is equal to the width of the base; the hemispherical temperature (HT), at which the cone has fused so that the height is one-half the width of the base; and the fluid temperature (FT), at which the cone has been reduced to a nearly flat layer. In the reported analytical results in appendix B, the HT is reported after the FT but should have been presented in the above-described sequence.

The four temperature points are determined in both mildly reducing and oxidizing atmospheres to provide more data relative to possible usage conditions. The means of the laboratory determinations are as follows:

| Temperature point | Arithmetic mean | Standard deviation | Geometric mean | Geometric deviation |
|---|---|---|---|---|
| | | Mildly Reducing Atmosphere | | |
| ID | 2190 | 160 | 2180 | 1.1 |
| ST | 2260 | 180 | 2250 | 1.1 |
| HT | 2320 | 180 | 2310 | 1.1 |
| FT | 2520 | 160 | 2510 | 1.1 |
| | | Oxidizing Atmosphere | | |
| ID | 2520 | 110 | 2520 | 1.0 |
| ST | 2580 | 100 | 2580 | 1.0 |
| HT | 2610 | 100 | 2610 | 1.0 |
| FT | 2660 | 90 | 2660 | 1.0 |

Two samples contained 26.61 and 32.41 percent ash and had high (more than 2,800° F) temperature points in several determinations.

## CONCLUSIONS

Statistical appraisal of the 39 samples results in the following generalized chemical and physical characterization on the as-received basis:

| | | |
|---|---|---|
| Moisture - | 28 | percent |
| Volatile matter - | 28 | percent |
| Fixed carbon - | 28 | percent |
| Ash - | 15 | percent |
| Hydrogen - | 6 | percent |
| Carbon - | 39 | percent |
| Nitrogen - | 0.7 | percent |
| Oxygen - | 33 | percent |
| Sulfur - | 4 | percent |
| Heat value - | 7,100 | Btu/lb |
| Sulfate sulfur - | 0.3 | percent |
| Pyritic sulfur - | 2.6 | percent |
| Organic sulfur - | 1.0 | percent |
| Hardgrove Grindability Index - | 70 | |

A coal with the listed chemical and physical characteristics would be classified as subbituminous C in rank according to the Standard Classification of Coals by Rank (D388-84, ASTM, 1986). However, the number of samples from each mine is not sufficient for definitive rank classification, and, in addition, Standard D388 specifically does not allow use of samples of weathered or oxidized coal for classification by rank (see previous discussion of "Forms of sulfur"). Consequently, valid rank classification remains to be established by further sampling and analytical studies.

However, standard D388 does allow designation of "apparent rank" for samples that do not meet the standards of bed sampling. "Apparent ranks" for the 39 samples reported herein are: one (1) subbituminous B, fifteen (15) lignite A, and twenty-three (23) subbituminous C. At this time, it appears valid to conclude that the "apparent rank" of coal presently mined in the Lakhra field ranges from lignite A to subbituminous B, and that the bulk of the coal presently being mined in the field has an "apparent rank" of subbituminous C.

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# APPENDIX A

## Description of Samples

Gul Mine No. 11 (Habibullah)

Location: lat 25°41'45" N., long 68°09'43" E.
Surface elevation: 350 ft (107 m)
Depth to top of sample: 82 ft (25 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 10, 1985.

Section sample

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| | Coal (USGS No. W233049) | 5.0 | (1.5) |
| * | Clayey coal parting | 0.1 | (0.04) |
| | Coal (USGS No. W233048) | 1.8 | (0.53) |
| * | Floor rock (not observed) | --- | --- |
| | Total bed thickness | 6.9 | (2.1) |
| | Total thickness sampled | 6.8 | (2.0) |

* Not analyzed.

Indus Mine No. 2A

Location: lat 25°43'07" N., long 68°09'08" E.
Surface elevation: 420 ft (128 m)
Depth to top of sample: 256 ft (78 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghanznavi and Rafiq A. Khan, GSP, August 11, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Sandy shale (roof) | --- | --- |
| * | Claystone | 0.6 | (0.18) |
| | Coal (USGS No. W233050) | 8.8 | (2.7) |
| * | Shale (floor) | --- | --- |
| | Total bed thickness | 8.8 | (2.7) |
| | Total thickness sampled | 8.8 | (2.7) |

* Not analyzed.

## Faiz Mine No. 11

Location: lat 25°44'16" N., long 68°08'26" E.
Surface elevation: 405 ft (123 m)
Depth to top of sample: 165 ft (50 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 12, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous claystone (roof) | --- | --- |
| | Coal (USGS No. W233054) | 9.1 | (2.8) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 9.1 | (2.8) |
| | Total thickness sampled | 9.1 | (2.8) |

* Not analyzed.

## Delux Mine No. 1 A

Location: lat 25°11'38" N., long 68°11'26" E.
Surface elevation: 405 ft (123 m)
Depth to top of sample: 247 ft (75 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 13, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| * | Coal (not sampled) | 0.6 | (0.18) |
| | Coal (USGS No. W233056) | 4.9 | (1.51) |
| | Coal (USGS No. W233055) | 2.9 | (0.89) |
| * | Carbonaceous claystone (floor) | --- | --- |
| | Total bed thickness | 8.5 | (2.6) |
| | Total thickness sampled | 7.8 | (2.4) |

* Not analyzed.

## Mumtaz Mine No. 44 (Habibullah)

Location: lat 25°40'14" N., long 68°08'53" E.
Surface elevation: 310 ft (95 m)
Depth to top of sample: 88 ft (27 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 11, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Shale (roof) | --- | --- |
| * | Coal (not sampled) | 0.4 | (0.12) |
| | Coal (USGS No. W233051) | 9.6 | (2.9) |
| * | Shale (floor) | --- | ---- |
| | Total bed thickness | 10.0 | (3.0) |
| | Total thickness sampled | 9.6 | (2.9) |

* Not analyzed.

## National Mine No.4A

Location: lat 25°43'55" N., long 68°08'52" E.
Surface elevation: 405 ft (123 m)
Depth to top of sample: 225 ft (69 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 12, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| * | Coal (not sampled) | 0.5 | (0.15) |
| | Carbonaceous clay parting (USGS No. W233053) | 0.3 | ( .09) |
| | Coal (USGS No. W233052) | 8.9 | (2.7) |
| * | Carbonaceous siltstone (floor) | --- | --- |
| | Total bed thickness | 9.7 | (3.0) |
| | Total thickness sampled | 9.2 | (2.8) |

* Not analyzed.

## Baluchistan Mine No. 13

Location: lat 25°40'24" N., long 68°11'00" E.
Surface elevation: 390 ft (119 m)
Depth to top of sample: 118 ft (36 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Ishaq Ghaznavi and Rafiq A. Khan, GSP, August 13, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| | Coal (USGS No. W233057) | 3.3 | (1.0) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 3.3 | (1.0) |
| | Total thickness sampled | 3.3 | (1.0) |

* Not analyzed.

## PMDC Mine No. 2

Location: lat 25°42'38" N., long 68°10'00" E.
Surface elevation: 410 ft (125 m)
Depth to top of sample: 195 ft (60 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 14, 1985.

Section Sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | -- |
| * | Coal (not sampled) | 0.4 | (0.12) |
| | Coal (USGS No. W233059) | 5.8 | (1.8) |
| | Coal (USGS No. W233058) | 4.3 | (1.3) |
| * | Shale (floor) | --- | --- |
| | Total bed thickness | 10.5 | (3.2) |
| | Total thickness sampled | 10.1 | (3.1) |

* Not analyzed.

M. Amin Bros. Mine No. 5/MC-10

Location: lat 25°40'55" N., long 68°07'45" E.
Surface elevation: 360 ft (110 m)
Depth to top of sample: 165 ft (50 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 14, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| * | Coal (not sampled) | 0.6 | (0.18) |
| | Coal (USGS No. W233061) | 5.3 | (1.6) |
| | Coal (USGS No. W233060) | 2.4 | (0.74) |
| * | Shale (floor) | --- | --- |
| | Total bed thickness | 8.3 | (2.5) |
| | Total thickness sampled | (7.7) | (2.3) |

* Not analyzed.

Amin Mine No. 5-A

Location: lat 25°38'04" N., long 68°09'06" E.
Surface elevation: 295 ft (90 m)
Depth to top of sample: 115 ft (35 m)

Bench channel sample, Lailian bed, collected by Ishaq Ghaznavi, GSP, August 14, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| * | Coal (not sampled) | 1.0 | (0.31) |
| | Coal (USGS No. W233062) | 4.5 | (1.4) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 5.5 | (1.7) |
| | Total thickness sampled | 4.5 | (1.4) |

* Not analyzed.

## Sind Mine No. 5

Location: lat 25°37'08" N., long 68°09'20" E.
Surface elevation: 295 ft (90 m)
Depth to top of sample: 115 ft (35 m)

Face channel sample, Lailian bed, collected by Ishaq Ghaznavi, GSP, August 14, 1985.

Section sample

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Shale (roof) | --- | --- |
| | Coal (USGS No. W233063) | 4.5 | (1.4) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 4.5 | (1.4) |
| | Total thickness sample | 4.5 | (1.4) |

* Not analyzed.

## Ch. M. Iqbal Mine No. 9

Location: lat 25°44'01" N., long 68°08'45" E.
Surface elevation: 408 ft (124 m)
Depth to top of sample: 165 ft (50 m)

Three bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan and Mukarram Khan, GSP, August 15, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| | Carbonaceous shale (roof) (USGS No. W233047) (Analysis indicates shaley coal) | 0.8 | (0.24) |
| * | Clay band above coal | 0.4 | (0.12) |
| * | Coal (not sampled) | 0.08 | (0.02) |
| | Coal (USGS No. W233065) | 5.9 | (1.8) |
| | Coal (USGS No. W233064) | 4.6 | (1.4) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 10.6 | (3.2) |
| | Total thickness sampled (excluding roof) | 10.5 | (3.2) |

* Not analyzed.

## Inam Mine No. 28 (Habibullah)

Location: lat 25°42'16" N., long 68°08'27" E.
Surface elevation: 395 ft (120 m)
Depth to top of coal bed: 155 ft (47 m)

Face channel sample, Lailian bed, collected by Ishaq Ghaznavi and Sabahat Noor, GSP August 15, 1985.

Section sample

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| | Coal (USGS No. W233066) | 5.8 | (1.8) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 5.8 | (1.8) |
| | Total thickness sampled | 5.8 | (1.8) |

* Not analyzed.

## Iqbal 4C-413 Mine (Habibullah)

Location: lat 25°40'45" N., long 68°07'38" E.
Surface elevation: 405 ft (123 m)
Depth to top of sample: 127 ft (39 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan and Sabahat Noor, GSP, August 18, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| * | Coal (not sampled) | 0.1 | (0.04) |
| | Coal (USGS No. W233210) | 4.4 | (1.3) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 4.5 | (1.3) |
| | Total thickness sampled | 4.4 | (1.3) |

* Not analyzed.

## Khalid - B- 2 Mine (Habibullah)

Location: lat 25°40'55" N., long 68°10'05" E.
Surface elevation: 390 ft (119 m)
Depth to top of sample: 75 ft (23 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan and Sabahat Noor, GSP, August 18, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| | Coal (USGS No. W233211) | 3.9 | (1.2) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 3.9 | (1.2) |
| | Total thickness sampled | 3.9 | (1.2) |

* Not analyzed.

## Baluchistan No. 6 Mine

Location: lat 25°41'30" N., long 68°10'30 E.
Surface elevation: 380 ft (116 m)
Depth to top of sample: 172 ft (52 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 20, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Sandstone (roof) | --- | --- |
| * | Coal (not sampled) | 2.1 | (0.64) |
| | Coal (USGS No. W233213) | 3.6 | (1.1) |
| | Coal (USGS No. W233212) | 2.7 | (0.83) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 8.4 | (2.6) |
| | Total thickness sampled | 6.3 | (1.9) |

* Not analyzed.

## Ghapfar No. 26 Mine (Habibullah)

Location: lat 25°42'20" N., long 68°09'02" E.
Surface elevation: 360 ft (110 m)
Depth to top of sample: 157 ft (48 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 22, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceus shale (roof) | --- | --- |
| * | Coal (not sampled) | 0.4 | (0.12) |
| | Coal (USGS No. W233215) | 4.8 | (1.5) |
| | Coal (USGS No. W233214) | 1.8 | (0.53) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 7.0 | (2.1) |
| | Total sample thickness | 6.6 | (2.0) |

* Not analyzed.

## Indus No. 6 Mine

Location: lat 25°43'12" N., long 68°08'20" E.
Surfaces elevation: 415 ft (127 m)
Depth to top of sample: 222.3 ft (67.8 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 22, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous claystone (roof) | --- | --- |
| * | Coal (not sampled) | 0.7 | (0.20) |
| | Coal (USGS No. W233216) | 4.1 | (1.3) |
| * | Shale (floor) | --- | --- |
| | Total bed thickness | 4.8 | (1.5) |
| | Total thickness sampled | 4.1 | (1.3) |

* Not analyzed.

## Hamza No. 37 Mine (Habibullah)

Location: lat 25°40'45" N., long 68°08'35" E.
Surface elevation: 390 ft (119 m)
Depth to top of sample: 90 ft (27 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 24, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| | Coal (USGS No. W233217) | 4.9 | (1.5) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 4.9 | (1.5) |
| | Total thickness sampled | 4.9 | (1.5) |

* Not analyzed.

## Tauseef No. 22 Mine (Habibullah)

Location: lat 25°40'45" N., long 68°09'01" E.
Surface elevation: 342 ft (104 m)
Depth to top of sample: 142 ft (43 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 24, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Sandstone (roof) | --- | --- |
| * | Coal (not sampled) | 0.2 | (0.05) |
| | Coal (USGS No. W233218) | 3.3 | (1.0) |
| * | Claystone (floor) | --- | --- |
| | Total bed thickness | 3.5 | (1.1) |
| | Total thickness sampled | 3.3 | (1.0) |

* Not analyzed.

## Amin Bros. No. 3-MC/10 Mine

Location: lat 25°40'45" N., long 68°07'47" E.
Surface elevation: 353 ft (108 m)
Depth to top of sample: 186 ft (57 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 24, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| | Coal (USGS No. W233219) | 3.9 | (1.2) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 3.9 | (1.2) |
| | Total thickness sampled | 3.9 | (1.2) |

* Not analyzed.

## Indus No. 1 Mine

Location: lat 25°42'46" N., long 68°09'00" E.
Surface elevation: 400 ft (122 m)
Depth to top of sample: 183 ft (56 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 25, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| | Coal (USGS No. W233220) | 6.0 | (1.8) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 6.0 | (1.8) |
| | Total thickness sampled | 6.0 | (1.8) |

* Not analyzed.

National Mine No. 1

Location: lat 25°43'55" N., long 68°08'45" E.
Surface elevation: 415 ft (127 m)
Depth to top of sample: 183 ft (56 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 27, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Carbonacous shale (roof) | --- | --- |
| * | Coal (not sampled) | 0.2 | (0.05) |
| | Coal (USGS No. W233221) | 5.8 | (1.8) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 6.0 | (1.8) |
| | Total thickness sampled | 5.8 | (1.8) |

* Not analyzed.

Baluchistan No. 14 Mine

Location: lat 25°40'50" N., long 68°11'05" E.
Surface elevation: 370 ft (113 m)
Depth to top of sample: 140 ft (43 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 27, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| * | Coal (not sampled) | 0.2 | (0.05) |
| | Coal (USGS No. W233222) | 3.2 | (0.99) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 3.4 | (1.0) |
| | Total thickness sampled | 3.2 | (0.99) |

* Not analyzed.

PMDC Mine No. 1

Location: lat 25°42'10" N., long 68°10'20" E.
Surface elevation: 400 ft (122 m)
Depth to top of sample: 235 ft (72 m)

Bench channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 28, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| * | Coal (not sampled) | 0.1 | (0.04) |
| | Coal (USGS No. W233223) | 5.1 | (1.6) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 5.2 | (1.6) |
| | Total thickness sampled | 5.1 | (1.6) |

* Not analyzed.

PMDC Mine No. 3

Location: lat 25°42'37" N., long 68°09'24" E.
Surface elevation: 380 ft (116 m)
Depth to top of sample: 210 ft (64 m)

Face channel sample, Lailian bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan, GSP, August 28, 1985.

Section sampled

| | Description | Thickness ft | (m) |
|---|---|---|---|
| * | Fossiliferous claystone (roof) | --- | --- |
| | Coal (USGS No. W233224) | 3.0 | (0.92) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 3.0 | ( .92) |
| | Total thickness sampled | 3.0 | ( .92) |

* Not analyzed.

PMDC BT. 11 Shaft (idle)

Location: lat 25°45'12" N., long 68°05'07" E.
Surface elevation: 400 ft (122 m)
Depth to top of sample: 208 ft (63 m)

Two bench channel samples, Lailian bed, collected by Fred O. Simon, USGS, August 30, 1985. Mine idle for two months prior to sampling.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Claystone (roof) | --- | --- |
| * | Coal (not sampled) | 1.1 | (0.33) |
| | Coal (USGS No. W233226) | 1.8 | (0.56) |
| | Coal (USGS No. W233225) | 6.4 | (2.0) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | (9.3) | (2.9) |
| | Total thickness sampled | (8.2) | (2.6) |

* Not analyzed.

Amin Bros. No 22-C Mine

Location: lat 25°05'40" N., long 68°08'09" E.
Surface elevation: 179 ft (55 m)
Depth to top of sample: 95 ft (29 m)

Face channel sample, unnamed bed, collected by Fred O. Simon, USGS, and Rafiq A. Khan and Mukhtar, GSP, August 16, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Shale (roof) | --- | --- |
| | Coal (USGS No. W233208) | 1.8 | (0.55) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 1.8 | (0.55) |
| | Total thickness sampled | 1.8 | (0.55) |

* Not analyzed.

## Lalazar Mine (National)

Location: lat 25°03'48" N., long 68°06'24" E.
Surface elevation: 210 ft (64 m)
Depth to top of sample: Not measured

Face channel sample, unnamed bed, collected by Fred O. Simon, USGS, and Sabahat Noor, and Saleem Khan, GSP, August 16, 1985.

Section sampled

| | Description | Thickness ft | Thickness (m) |
|---|---|---|---|
| * | Carbonaceous shale (roof) | --- | --- |
| | Coal (USGS No. W233209) | 2.6 | (0.80) |
| * | Carbonaceous shale (floor) | --- | --- |
| | Total bed thickness | 2.6 | (0.80) |
| | Total thickness sampled | 2.6 | (0.80) |

* Not analyzed.

# APPENDIX B

## Analytical Laboratory Report

# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 3  State: PK  Field ID: 85LK001A1/3-3/

Lab No. U12570 **********

AIR DRY LOSS 16.99  RESIDUAL MOISTURE 13.78

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 28.42 | | |
| Ash ..... | 11.78 | 16.46 | |
| Volatile Matter ..... | 28.29 | 39.52 | 47.31 |
| Fixed Carbon ..... | 31.51 | 44.02 | 52.69 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.42 | 4.52 | 5.41 |
| Carbon ..... | 44.21 | 61.76 | 73.93 |
| Nitrogen ..... | 0.78 | 1.09 | 1.30 |
| Sulfur ..... | 4.43 | 6.19 | 7.41 |
| Oxygen ..... | 32.38 | 9.98 | 11.95 |
| Ash ..... | 11.78 | 16.46 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7806 | 10906 | 13055 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.27 | 0.38 | 0.45 |
| Pyritic sulfur ..... | 3.05 | 4.26 | 5.10 |
| Organic sulfur ..... | 1.11 | 1.55 | 1.86 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.29

HARDGROVE GRINDABILITY INDEX 72

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2080 F | 2480 F |
| Softening Temp. | 2150 F | 2640 F |
| Fluid Temp. | 2520 F | 2720 F |
| Hemispherical Temp. | 2180 F | 2670 F |

Forrest E. Walker
Director of Technical Services

# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 9  State: PK  Field ID: 85LK011C1/9-9/ 001C

Lab No. U12571 **********

AIR DRY LOSS 16.18  RESIDUAL MOISTURE 16.74

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 30.22 | | |
| Ash ..... | 19.17 | 27.47 | |
| Volatile Matter ..... | 24.78 | 35.52 | 48.97 |
| Fixed Carbon ..... | 25.83 | 37.01 | 51.03 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.12 | 3.93 | 5.42 |
| Carbon ..... | 35.51 | 50.89 | 70.16 |
| Nitrogen ..... | 0.72 | 1.03 | 1.42 |
| Sulfur ..... | 3.26 | 4.67 | 6.44 |
| Oxygen ..... | 35.22 | 12.01 | 16.56 |
| Ash ..... | 19.17 | 27.47 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6247 | 8952 | 12343 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.30 | 0.44 | 0.61 |
| Pyritic sulfur ..... | 2.23 | 3.19 | 4.40 |
| Organic sulfur ..... | 0.73 | 1.04 | 1.43 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.43

HARDGROVE GRINDABILITY INDEX 74

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2260 F | 2670 F |
| Softening Temp. | 2550 F | 2700 F |
| Fluid Temp. | 2630 F | 2730 F |
| Hemispherical Temp. | 2580 F | 2710 F |

Forrest E. Walker
Director of Technical Services

# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 3  State: PK  Field ID: 85LK002A1/3-3/

Lab No. U12572 **********

AIR DRY LOSS 21.03  RESIDUAL MOISTURE 15.60

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 33.35 | | |
| Ash ..... | 13.94 | 20.92 | |
| Volatile Matter ..... | 25.66 | 38.50 | 48.69 |
| Fixed Carbon ..... | 27.05 | 40.58 | 51.31 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.58 | 4.27 | 5.40 |
| Carbon ..... | 37.75 | 56.64 | 71.63 |
| Nitrogen ..... | 0.76 | 1.15 | 1.45 |
| Sulfur ..... | 3.55 | 5.33 | 6.74 |
| Oxygen ..... | 37.42 | 11.69 | 14.78 |
| Ash ..... | 13.94 | 20.92 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6683 | 10027 | 12680 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.31 | 0.47 | 0.59 |
| Pyritic sulfur ..... | 2.08 | 3.12 | 3.95 |
| Organic sulfur ..... | 1.16 | 1.74 | 2.20 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.44

HARDGROVE GRINDABILITY INDEX 69

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2120 F | 2400 F |
| Softening Temp. | 2220 F | 2440 F |
| Fluid Temp. | 2570 F | 2700 F |
| Hemispherical Temp. | 2340 F | 2500 F |

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0031/2-2/2

Lab No. U12573 **********

AIR DRY LOSS 16.81  RESIDUAL MOISTURE 11.08

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 26.02 | | |
| Ash ..... | 25.74 | 34.79 | |
| Volatile Matter ..... | 25.95 | 35.07 | 53.78 |
| Fixed Carbon ..... | 22.29 | 30.14 | 46.22 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.58 | 3.60 | 5.52 |
| Carbon ..... | 32.33 | 43.70 | 67.01 |
| Nitrogen ..... | 0.64 | 0.86 | 1.32 |
| Sulfur ..... | 3.97 | 5.36 | 8.22 |
| Oxygen ..... | 31.74 | 11.69 | 17.93 |
| Ash ..... | 25.74 | 34.79 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 5767 | 7795 | 11954 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.85 | 1.15 | 1.76 |
| Pyritic sulfur ..... | 2.25 | 3.04 | 4.66 |
| Organic sulfur ..... | 0.87 | 1.17 | 1.80 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.58

HARDGROVE GRINDABILITY INDEX 73

EQUILIBRIUM MOISTURE 26.47%

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2370 F | 2630 F |
| Softening Temp. | 2550 F | 2670 F |
| Fluid Temp. | 2730 F | 2780 F |
| Hemispherical Temp. | 2615 F | 2700 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 8SLK004A1/2-2/

Lab No. U12574 **********

AIR DRY LOSS 18.83  RESIDUAL MOISTURE 13.60

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 29.87 | | |
| Ash ..... | 18.11 | 25.83 | |
| Volatile Matter ..... | 26.19 | 37.35 | 50.36 |
| Fixed Carbon ..... | 25.83 | 36.82 | 49.64 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.34 | 4.28 | 5.77 |
| Carbon ..... | 36.50 | 52.05 | 70.18 |
| Nitrogen ..... | 0.65 | 0.93 | 1.25 |
| Sulfur ..... | 3.72 | 5.30 | 7.15 |
| Oxygen ..... | 34.68 | 11.61 | 15.65 |
| Ash ..... | 18.11 | 25.83 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6487 | 9250 | 12471 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.36 | 0.51 | 0.69 |
| Pyritic sulfur ..... | 2.01 | 2.86 | 3.86 |
| Organic sulfur ..... | 1.35 | 1.93 | 2.60 |

FREE SWELLING INDEX 0.0

HARDGROVE GRINDABILITY INDEX 70

APPARENT SPECIFIC GRAVITY 1.47

ASH FUSION TEMPERATURES

| | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2320 F | 2470 F |
| Softening Temp. | 2400 F | 2490 F |
| Fluid Temp. | 2580 F | 2600 F |
| Hemispherical Temp. | 2470 F | 2530 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK004B1/1

Lab No. U12575 **********

AIR DRY LOSS 21.18  RESIDUAL MOISTURE 7.43

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 27.04 | | |
| Ash ..... | 32.41 | 44.41 | |
| Volatile Matter ..... | 21.77 | 29.83 | 53.67 |
| Fixed Carbon ..... | 18.78 | 25.76 | 46.33 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.52 | 3.41 | 6.13 |
| Carbon ..... | 26.29 | 36.03 | 64.82 |
| Nitrogen ..... | 0.54 | 0.74 | 1.33 |
| Sulfur ..... | 2.46 | 3.37 | 6.06 |
| Oxygen ..... | 32.78 | 12.04 | 21.66 |
| Ash ..... | 32.41 | 44.41 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 4675 | 6408 | 11528 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.21 | 0.29 | 0.52 |
| Pyritic sulfur ..... | 1.74 | 2.38 | 4.28 |
| Organic sulfur ..... | 0.51 | 0.70 | 1.26 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.62

HARDGROVE GRINDABILITY INDEX 73

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2740 F | 2800+ F |
| Softening Temp. | 2760 F | 2800+ F |
| Fluid Temp. | 2800+ F | 2800+ F |
| Hemispherical Temp. | 2800 F | 2800+ F |

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COAL, WATER, AND MATERIALS ANALYSIS

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0051/3-3/3

Lab No. U12576 **********

AIR DRY LOSS 19.73  RESIDUAL MOISTURE 14.95

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 31.73 | | |
| Ash ..... | 16.02 | 23.47 | |
| Volatile Matter ..... | 25.45 | 37.27 | 48.70 |
| Fixed Carbon ..... | 26.80 | 39.26 | 51.30 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.31 | 4.04 | 5.28 |
| Carbon ..... | 35.80 | 52.44 | 68.52 |
| Nitrogen ..... | 0.72 | 1.05 | 1.37 |
| Sulfur ..... | 4.75 | 6.96 | 9.09 |
| Oxygen ..... | 36.40 | 12.04 | 15.74 |
| Ash ..... | 16.02 | 23.47 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6479 | 9490 | 12400 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.74 | 1.09 | 1.42 |
| Pyritic sulfur ..... | 2.76 | 4.05 | 5.29 |
| Organic sulfur ..... | 1.25 | 1.82 | 2.38 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.48

HARDGROVE GRINDABILITY INDEX 74

EQUILIBRIUM MOISTURE 28.89%

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2210 F | 2450 F |
| Softening Temp. | 2250 F | 2490 F |
| Fluid Temp. | 2360 F | 2650 F |
| Hemispherical Temp. | 2290 F | 2620 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK006A1/1

Lab No. U12579 **********

AIR DRY LOSS 19.49  RESIDUAL MOISTURE 9.75

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 27.34 | | |
| Ash ..... | 18.15 | 24.98 | |
| Volatile Matter ..... | 28.40 | 39.08 | 52.10 |
| Fixed Carbon ..... | 26.11 | 35.94 | 47.90 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.07 | 4.15 | 5.53 |
| Carbon ..... | 38.84 | 53.46 | 71.26 |
| Nitrogen ..... | 0.72 | 0.98 | 1.31 |
| Sulfur ..... | 3.32 | 4.57 | 6.09 |
| Oxygen ..... | 32.90 | 11.86 | 15.81 |
| Ash ..... | 18.15 | 24.98 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6997 | 9630 | 12837 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.17 | 0.24 | 0.32 |
| Pyritic sulfur ..... | 2.21 | 3.04 | 4.05 |
| Organic sulfur ..... | 0.94 | 1.29 | 1.72 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.33

HARDGROVE GRINDABILITY INDEX 68

EQUILIBRIUM MOISTURE 26.94%

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2320 F | 2640 F |
| Softening Temp. | 2540 F | 2710 F |
| Fluid Temp. | 2570 F | 2780 F |
| Hemispherical Temp. | 2550 F | 2730 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK006B1/2-2/

Lab No. U12580 **********

AIR DRY LOSS 17.14  RESIDUAL MOISTURE 10.39

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 25.75 | | |
| Ash ..... | 26.61 | 35.84 | |
| Volatile Matter ..... | 24.94 | 33.58 | 52.34 |
| Fixed Carbon ..... | 22.70 | 30.58 | 47.66 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 5.66 | 3.74 | 5.83 |
| Carbon ..... | 32.73 | 44.08 | 68.70 |
| Nitrogen ..... | 0.65 | 0.87 | 1.36 |
| Sulfur ..... | 3.69 | 4.97 | 7.75 |
| Oxygen ..... | 30.66 | 10.50 | 16.36 |
| Ash ..... | 26.61 | 35.84 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 5783 | 7789 | 12140 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.35 | 0.47 | 0.73 |
| Pyritic sulfur ..... | 2.66 | 3.58 | 5.58 |
| Organic sulfur ..... | 0.68 | 0.92 | 1.44 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.54

HARDGROVE GRINDABILITY INDEX 79

EQUILIBRIUM MOISTURE 26.61%

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2590 F | 2770 F |
| Softening Temp. | 2680 F | 2800+F |
| Fluid Temp. | 2800 F | 2800+F |
| Hemispherical Temp. | 2730 F | 2800+F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0071/2.2/2

Lab No. U12581 **********

AIR DRY LOSS 19.21  RESIDUAL MOISTURE 14.40

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.84 | | |
| Ash ..... | 16.80 | 24.29 | |
| Volatile Matter ..... | 24.40 | 35.27 | 46.59 |
| Fixed Carbon ..... | 27.96 | 40.44 | 53.41 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.23 | 4.02 | 5.31 |
| Carbon ..... | 35.73 | 51.67 | 68.25 |
| Nitrogen ..... | 0.69 | 1.00 | 1.32 |
| Sulfur ..... | 5.64 | 8.15 | 10.77 |
| Oxygen ..... | 34.91 | 10.87 | 14.35 |
| Ash ..... | 16.80 | 24.29 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6423 | 9287 | 12267 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.58 | 0.84 | 1.11 |
| Pyritic sulfur ..... | 4.37 | 6.32 | 8.35 |
| Organic sulfur ..... | 0.69 | 0.99 | 1.31 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.48

HARDGROVE GRINDABILITY INDEX 71

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2060 F | 2520 F |
| Softening Temp. | 2130 F | 2690 F |
| Fluid Temp. | 2480 F | 2730 F |
| Hemispherical Temp. | 2170 F | 2710 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK008A1/2-2/

Lab No. U12582 **********

AIR DRY LOSS 19.84  RESIDUAL MOISTURE 14.31

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 31.31 | | |
| Ash ..... | 12.39 | 18.04 | |
| Volatile Matter ..... | 27.15 | 39.52 | 48.22 |
| Fixed Carbon ..... | 29.15 | 42.44 | 51.78 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.61 | 4.52 | 5.51 |
| Carbon ..... | 39.99 | 58.22 | 71.03 |
| Nitrogen ..... | 0.67 | 0.98 | 1.20 |
| Sulfur ..... | 4.55 | 6.62 | 8.08 |
| Oxygen ..... | 35.79 | 11.62 | 14.18 |
| Ash ..... | 12.39 | 18.04 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7129 | 10378 | 12662 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.42 | 0.61 | 0.74 |
| Pyritic sulfur ..... | 2.91 | 4.23 | 5.16 |
| Organic sulfur ..... | 1.22 | 1.78 | 2.18 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.50

HARDGROVE GRINDABILITY INDEX 72

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atmosphere) |
|---|---|---|
| Initial Deformation | 2100 F | 2530 F |
| Softening Temp. | 2200 F | 2620 F |
| Fluid Temp. | 2590 F | 2740 F |
| Hemispherical Temp. | 2410 F | 2690 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK008B1/2-2/

Lab No. U12583 **********

AIR DRY LOSS 17.26  RESIDUAL MOISTURE 15.55

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.12 | | |
| Ash ..... | 15.20 | 21.75 | |
| Volatile Matter ..... | 26.21 | 37.51 | 47.93 |
| Fixed Carbon ..... | 28.47 | 40.74 | 52.07 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.44 | 4.39 | 5.61 |
| Carbon ..... | 38.06 | 54.46 | 69.59 |
| Nitrogen ..... | 0.71 | 1.02 | 1.30 |
| Sulfur ..... | 2.90 | 4.16 | 5.32 |
| Oxygen ..... | 36.69 | 14.22 | 18.18 |
| Ash ..... | 15.20 | 21.75 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6837 | 9783 | 12502 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.26 | 0.38 | 0.49 |
| Pyritic sulfur ..... | 1.83 | 2.63 | 3.36 |
| Organic sulfur ..... | 0.81 | 1.15 | 1.47 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.45

HARDGROVE GRINDABILITY INDEX 66

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2290 F | 2500 F |
| Softening Temp. | 2360 F | 2560 F |
| Fluid Temp. | 2540 F | 2690 F |
| Hemispherical Temp. | 2430 F | 2590 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK009A1/1

Lab No. U12584 **********

AIR DRY LOSS 22.76  RESIDUAL MOISTURE 10.11

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 30.57 | | |
| Ash ..... | 10.73 | 15.45 | |
| Volatile Matter ..... | 28.31 | 40.77 | 48.22 |
| Fixed Carbon ..... | 30.39 | 43.78 | 51.78 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.59 | 4.57 | 5.41 |
| Carbon ..... | 41.52 | 59.80 | 70.73 |
| Nitrogen ..... | 0.71 | 1.02 | 1.21 |
| Sulfur ..... | 4.12 | 5.94 | 7.03 |
| Oxygen ..... | 36.33 | 13.22 | 15.62 |
| Ash ..... | 10.73 | 15.45 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7692 | 11079 | 13104 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.14 | 0.20 | 0.24 |
| Pyritic sulfur ..... | 1.88 | 2.71 | 3.21 |
| Organic sulfur ..... | 2.10 | 3.03 | 3.58 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.21

HARDGROVE GRINDABILITY INDEX 59

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2220 F | 2510 F |
| Softening Temp. | 2290 F | 2530 F |
| Fluid Temp. | 2540 F | 2630 F |
| Hemispherical Temp. | 2350 F | 2550 F |

Forrest E. Walker
Director of Technical Services

# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK009B1/2-2/

Lab No. U12585 **********

AIR DRY LOSS 16.69  RESIDUAL MOISTURE 16.56

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.49 | | |
| Ash ..... | 13.27 | 19.09 | |
| Volatile Matter ..... | 28.15 | 40.50 | 50.05 |
| Fixed Carbon ..... | 28.09 | 40.41 | 49.95 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.51 | 4.46 | 5.51 |
| Carbon ..... | 40.39 | 58.11 | 71.82 |
| Nitrogen ..... | 0.76 | 1.10 | 1.36 |
| Sulfur ..... | 3.58 | 5.15 | 6.36 |
| Oxygen ..... | 35.49 | 12.09 | 14.95 |
| Ash ..... | 13.27 | 19.09 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7205 | 10365 | 12810 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.19 | 0.28 | 0.35 |
| Pyritic sulfur ..... | 2.59 | 3.72 | 4.60 |
| Organic sulfur ..... | 0.80 | 1.15 | 1.41 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.43

HARDGROVE GRINDABILITY INDEX 67

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2250 F | 2510 F |
| Softening Temp. | 2300 F | 2550 F |
| Fluid Temp. | 2540 F | 2660 F |
| Hemispherical Temp. | 2350 F | 2570 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0101/2-2/2

Lab No. U12586 **********

AIR DRY LOSS 17.77  RESIDUAL MOISTURE 11.77

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 27.45 | | |
| Ash ..... | 11.24 | 15.49 | |
| Volatile Matter ..... | 31.89 | 43.95 | 52.01 |
| Fixed Carbon ..... | 29.42 | 40.56 | 47.99 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.51 | 4.74 | 5.61 |
| Carbon ..... | 43.10 | 59.41 | 70.30 |
| Nitrogen ..... | 0.80 | 1.10 | 1.30 |
| Sulfur ..... | 4.77 | 6.57 | 7.77 |
| Oxygen ..... | 33.58 | 12.69 | 15.02 |
| Ash ..... | 11.24 | 15.49 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7842 | 10809 | 12790 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.87 | 1.20 | 1.42 |
| Pyritic sulfur ..... | 3.05 | 4.20 | 4.97 |
| Organic sulfur ..... | 0.85 | 1.17 | 1.38 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.34

HARDGROVE GRINDABILITY INDEX 66

EQUILIBRIUM MOISTURE 26.21%

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2140 F | 2530 F |
| Softening Temp. | 2190 F | 2570 F |
| Fluid Temp. | 2610 F | 2650 F |
| Hemispherical Temp. | 2280 F | 2600 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0111/3-3/3

Lab No. U12587 **********

AIR DRY LOSS 16.57  RESIDUAL MOISTURE 13.44

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 27.78 | | |
| Ash ..... | 15.63 | 21.64 | |
| Volatile Matter ..... | 31.47 | 43.58 | 55.62 |
| Fixed Carbon ..... | 25.12 | 34.78 | 44.38 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.27 | 4.38 | 5.59 |
| Carbon ..... | 40.24 | 55.72 | 71.11 |
| Nitrogen ..... | 0.78 | 1.08 | 1.38 |
| Sulfur ..... | 3.86 | 5.35 | 6.83 |
| Oxygen ..... | 33.22 | 11.83 | 15.09 |
| Ash ..... | 15.63 | 21.64 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7118 | 9856 | 12579 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 1.53 | 2.12 | 2.71 |
| Pyritic sulfur ..... | 1.99 | 2.76 | 3.52 |
| Organic sulfur ..... | 0.34 | 0.47 | 0.60 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.44

HARDGROVE GRINDABILITY INDEX 65

ASH FUSION TEMPERATURES (Reducing atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2320 F | 2440 F |
| Softening Temp. | 2370 F | 2480 F |
| Fluid Temp. | 2550 F | 2570 F |
| Hemispherical Temp. | 2400 F | 2520 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK012A1/2-2/

Lab No. U12588 **********

AIR DRY LOSS 20.36  RESIDUAL MOISTURE 12.29

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.16 | | |
| Ash ..... | 12.10 | 17.33 | |
| Volatile Matter ..... | 30.01 | 42.97 | 51.98 |
| Fixed Carbon ..... | 27.73 | 39.70 | 48.02 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.43 | 4.37 | 5.29 |
| Carbon ..... | 40.95 | 58.64 | 70.93 |
| Nitrogen ..... | 0.71 | 1.01 | 1.22 |
| Sulfur ..... | 4.05 | 5.80 | 7.02 |
| Oxygen ..... | 35.76 | 12.85 | 15.54 |
| Ash ..... | 12.10 | 17.33 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7336 | 10505 | 12707 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.26 | 0.38 | 0.46 |
| Pyritic sulfur ..... | 2.53 | 3.62 | 4.38 |
| Organic sulfur ..... | 1.26 | 1.80 | 2.18 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.39

HARDGROVE GRINDABILITY INDEX 67

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2240 F | 2500 F |
| Softening Temp. | 2290 F | 2590 F |
| Fluid Temp. | 2580 F | 2700 F |
| Hemispherical Temp. | 2350 F | 2640 F |

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COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No. 2  State: PK  Field ID: 85LK012B1/2-2/

Lab No. U12589 **********

AIR DRY LOSS 20.29  RESIDUAL MOISTURE 12.46

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.22 | | |
| Ash ..... | 15.44 | 22.13 | |
| Volatile Matter ..... | 27.01 | 38.71 | 49.71 |
| Fixed Carbon ..... | 27.33 | 39.16 | 50.29 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.37 | 4.28 | 5.50 |
| Carbon ..... | 37.73 | 54.06 | 69.42 |
| Nitrogen ..... | 0.67 | 0.96 | 1.23 |
| Sulfur ..... | 4.36 | 6.25 | 8.03 |
| Oxygen ..... | 35.43 | 12.32 | 15.82 |
| Ash ..... | 15.44 | 22.13 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6785 | 9723 | 12486 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.33 | 0.48 | 0.62 |
| Pyritic sulfur ..... | 3.08 | 4.42 | 5.68 |
| Organic sulfur ..... | 0.95 | 1.35 | 1.73 |

FSSE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.50

HARDGROVE GRINDABILITY INDEX 68

ASH FUSION TEMPERATURES (Reducing Atmosphere) (Oxidizing Atms.)

| | | |
|---|---|---|
| Initial Deformation | 2210 F | 2500 F |
| Softening Temp. | 2270 F | 2590 F |
| Fluid Temp. | 2580 F | 2680 F |
| Hemospherical Temp. | 2330 F | 2620 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: BSLK012D1/1

Lab No. U12590 **********

AIR DRY LOSS 23.23  RESIDUAL MOISTURE 8.22

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 29.54 | | |
| Ash ..... | 24.94 | 35.40 | |
| Volatile Matter ..... | 22.45 | 31.86 | 49.32 |
| Fixed Carbon ..... | 23.07 | 32.74 | 50.68 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.80 | 3.54 | 5.48 |
| Carbon ..... | 29.69 | 42.14 | 65.23 |
| Nitrogen ..... | 0.59 | 0.84 | 1.30 |
| Sulfur ..... | 5.36 | 7.61 | 11.78 |
| Oxygen ..... | 33.62 | 10.47 | 16.21 |
| Ash ..... | 24.94 | 35.40 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 5307 | 7533 | 11660 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.27 | 0.38 | 0.59 |
| Pyritic sulfur ..... | 4.97 | 7.05 | 10.91 |
| Organic sulfur ..... | 0.12 | 0.18 | 0.28 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.55

HARDGROVE GRINDABILITY INDEX 80

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2170 F | 2650 F |
| Softening Temp. | 2270 F | 2680 F |
| Fluid Temp. | 2680 F | 2740 F |
| Hemispherical Temp. | 2330 F | 2700 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 09/30/85

USGS Lab No.  State: PK  Field ID: 85LK0131/3-3/3

Lab No. U12591 **********

AIR DRY LOSS 21.21  RESIDUAL MOISTURE 13.80

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 32.08 | | |
| Ash ..... | 11.63 | 17.12 | |
| Volatile Matter ..... | 27.14 | 39.95 | 48.21 |
| Fixed Carbon ..... | 29.15 | 42.93 | 51.79 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.51 | 4.30 | 5.19 |
| Carbon ..... | 39.76 | 58.54 | 70.64 |
| Nitrogen ..... | 0.73 | 1.08 | 1.30 |
| Sulfur ..... | 4.34 | 6.39 | 7.71 |
| Oxygen ..... | 37.03 | 12.57 | 15.16 |
| Ash ..... | 11.63 | 17.12 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7138 | 10510 | 12682 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.52 | 0.76 | 0.92 |
| Pyritic sulfur ..... | 2.99 | 4.41 | 5.32 |
| Organic sulfur ..... | 0.83 | 1.22 | 1.47 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY 1.48

HARDGROVE GRINDABILITY INDEX 72

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2100 F | 2670 F |
| Softening Temp. | 2140 F | 2700 F |
| Fluid Temp. | 2580 F | 2760 F |
| Hemispherical Temp. | 2180 F | 2740 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK014

Lab No. U12623 **********

AIR DRY LOSS 19.44  RESIDUAL MOISTURE 8.27

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 26.10 | | |
| Ash ..... | 9.01 | 12.19 | |
| Volatile Matter ..... | 31.49 | 42.62 | 48.54 |
| Fixed Carbon ..... | 33.40 | 45.19 | 51.46 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.49 | 4.82 | 5.49 |
| Carbon ..... | 47.04 | 63.66 | 72.50 |
| Nitrogen ..... | 0.88 | 1.19 | 1.36 |
| Sulfur ..... | 3.56 | 4.82 | 5.49 |
| Oxygen ..... | 33.02 | 13.32 | 15.16 |
| Ash ..... | 9.01 | 12.19 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 8310 | 11245 | 12806 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.53 | 0.72 | 0.82 |
| Pyritic sulfur ..... | 1.69 | 2.29 | 2.61 |
| Organic sulfur ..... | 1.34 | 1.81 | 2.06 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.35

HARDGROVE GRINDABILITY INDEX 57

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2040 F | 2450 F |
| Softening Temp. | 2060 F | 2550 F |
| Fluid Temp. | 2240 F | 2640 F |
| Hemispherical Temp. | 2100 F | 2580 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK015

Lab No. U12624 **********

AIR DRY LOSS 22.66  RESIDUAL MOISTURE 7.49

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 28.46 | | |
| Ash ..... | 9.06 | 12.66 | |
| Volatile Matter ..... | 31.81 | 44.47 | 50.92 |
| Fixed Carbon ..... | 30.67 | 42.87 | 49.08 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.57 | 4.73 | 5.42 |
| Carbon ..... | 45.82 | 64.04 | 73.32 |
| Nitrogen ..... | 0.91 | 1.27 | 1.45 |
| Sulfur ..... | 3.63 | 5.08 | 5.82 |
| Oxygen ..... | 34.01 | 12.22 | 13.99 |
| Ash ..... | 9.06 | 12.66 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 8210 | 11476 | 13139 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.12 | 0.17 | 0.19 |
| Pyritic sulfur ..... | 2.81 | 3.92 | 4.49 |
| Organic sulfur ..... | 0.70 | 0.99 | 1.14 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.37

HARDGROVE GRINDABILITY INDEX 73

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2000 F | 2470 F |
| Softening Temp. | 2040 F | 2580 F |
| Fluid Temp. | 2370 F | 2680 F |
| Hemispherical Temp. | 2180 F | 2610 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK016A

Lab No. U12625 **********

AIR DRY LOSS 23.71  RESIDUAL MOISTURE 4.70

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 27.29 | | |
| Ash ..... | 18.23 | 25.07 | |
| Volatile Matter ..... | 29.57 | 40.66 | 54.26 |
| Fixed Carbon ..... | 24.91 | 34.27 | 45.74 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.14 | 4.25 | 5.67 |
| Carbon ..... | 39.59 | 54.45 | 72.67 |
| Nitrogen ..... | 0.68 | 0.94 | 1.25 |
| Sulfur ..... | 3.42 | 4.70 | 6.27 |
| Oxygen ..... | 31.94 | 10.59 | 14.14 |
| Ash ..... | 18.23 | 25.07 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7080 | 9738 | 12996 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.53 | 0.73 | 0.97 |
| Pyritic sulfur ..... | 1.88 | 2.59 | 3.46 |
| Organic sulfur ..... | 1.01 | 1.38 | 1.84 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.50

HARDGROVE GRINDABILITY INDEX 71

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2360 F | 2480 F |
| Softening Temp. | 2430 F | 2530 F |
| Fluid Temp. | 2530 F | 2610 F |
| Hemispherical Temp. | 2470 F | 2560 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK016B

Lab No. U12626 **********

AIR DRY LOSS 31.67  RESIDUAL MOISTURE 4.16

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 34.51 | | |
| Ash ..... | 11.48 | 17.53 | |
| Volatile Matter ..... | 28.31 | 43.23 | 52.42 |
| Fixed Carbon ..... | 25.70 | 39.24 | 47.58 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.90 | 4.63 | 5.61 |
| Carbon ..... | 38.68 | 59.07 | 71.62 |
| Nitrogen ..... | 0.69 | 1.05 | 1.27 |
| Sulfur ..... | 3.34 | 5.10 | 6.18 |
| Oxygen ..... | 38.91 | 12.62 | 15.32 |
| Ash ..... | 11.48 | 17.53 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6909 | 10550 | 12792 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.17 | 0.27 | 0.33 |
| Pyritic sulfur ..... | 2.01 | 3.07 | 3.72 |
| Organic sulfur ..... | 1.16 | 1.76 | 2.13 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.55

HARDGROVE GRINDABILITY INDEX 76

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2040 F | 2730 F |
| Softening Temp. | 2060 F | 2740 F |
| Fluid Temp. | 2400 F | 2750 F |
| Hemispherical Temp. | 2150 F | 2745 F |

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Somerset, Pennsylvania 15501

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK017A

Lab No. U12627 **********

AIR DRY LOSS 18.34  RESIDUAL MOISTURE 7.75

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 24.67 | | |
| Ash ..... | 17.06 | 22.64 | |
| Volatile Matter ..... | 28.76 | 38.17 | 49.34 |
| Fixed Carbon ..... | 29.51 | 39.19 | 50.66 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.00 | 4.29 | 5.55 |
| Carbon ..... | 40.74 | 54.08 | 69.91 |
| Nitrogen ..... | 0.73 | 0.96 | 1.24 |
| Sulfur ..... | 5.81 | 7.72 | 9.98 |
| Oxygen ..... | 29.66 | 10.31 | 13.32 |
| Ash ..... | 17.06 | 22.64 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7458 | 9901 | 12799 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.40 | 0.53 | 0.69 |
| Pyritic sulfur ..... | 3.88 | 5.16 | 6.67 |
| Organic sulfur ..... | 1.53 | 2.03 | 2.62 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.48

HARDGROVE GRINDABILITY INDEX 78

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2160 F | 2460 F |
| Softening Temp. | 2200 F | 2540 F |
| Fluid Temp. | 2500 F | 2590 F |
| Hemispherical Temp. | 2240 F | 2560 F |

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COAL, WATER, AND MATERIALS ANALYSIS

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK0178

Lab No. U12628 **********

AIR DRY LOSS 22.15  RESIDUAL MOISTURE 6.98

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 27.59 | | |
| Ash ..... | 11.35 | 15.67 | |
| Volatile Matter ..... | 31.57 | 43.59 | 51.69 |
| Fixed Carbon ..... | 29.49 | 40.74 | 48.31 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.47 | 4.67 | 5.54 |
| Carbon ..... | 44.14 | 60.96 | 72.29 |
| Nitrogen ..... | 0.84 | 1.17 | 1.39 |
| Sulfur ..... | 3.98 | 5.49 | 6.51 |
| Oxygen ..... | 33.22 | 12.04 | 14.27 |
| Ash ..... | 11.35 | 15.67 | |
| | 100.00 | 100.00 | 100.00 |
| **HEATING VALUE (BTU/LB)** | 7922 | 10940 | 12973 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.52 | 0.71 | 0.84 |
| Pyritic sulfur ..... | 2.29 | 3.16 | 3.75 |
| Organic sulfur ..... | 1.17 | 1.62 | 1.92 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.39

HARDGROVE GRINDABILITY INDEX 74

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2180 F | 2490 F |
| Softening Temp. | 2220 F | 2520 F |
| Fluid Temp. | 2670 F | 2570 F |
| Hemispherical Temp. | 2260 F | 2550 F |

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK018

Lab No. U12629 **********

AIR DRY LOSS 18.56  RESIDUAL MOISTURE 7.73

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 24.85 | | |
| Ash ..... | 19.30 | 25.68 | |
| Volatile Matter ..... | 28.00 | 37.26 | 50.14 |
| Fixed Carbon ..... | 27.85 | 37.06 | 49.86 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.89 | 4.14 | 5.57 |
| Carbon ..... | 38.31 | 50.97 | 68.59 |
| Nitrogen ..... | 0.74 | 0.99 | 1.33 |
| Sulfur ..... | 6.34 | 8.44 | 11.36 |
| Oxygen ..... | 29.42 | 9.78 | 13.15 |
| Ash ..... | 19.30 | 25.68 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7035 | 9361 | 12596 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.25 | 0.33 | 0.44 |
| Pyritic sulfur ..... | 4.23 | 5.63 | 7.58 |
| Organic sulfur ..... | 1.86 | 2.48 | 3.34 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.49

HARDGROVE GRINDABILITY INDEX 68

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2160 F | 2430 F |
| Softening Temp. | 2220 F | 2540 F |
| Fluid Temp. | 2600 F | 2580 F |
| Hemispherical Temp. | 2260 F | 2560 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK019

Lab No. U12630 **********

AIR DRY LOSS 19.24  RESIDUAL MOISTURE 7.24

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 25.09 | | |
| Ash ..... | 6.70 | 8.95 | |
| Volatile Matter ..... | 32.50 | 43.39 | 47.65 |
| Fixed Carbon ..... | 35.71 | 47.66 | 52.35 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.54 | 4.98 | 5.47 |
| Carbon ..... | 50.17 | 66.97 | 73.55 |
| Nitrogen ..... | 0.95 | 1.27 | 1.39 |
| Sulfur ..... | 3.49 | 4.66 | 5.12 |
| Oxygen ..... | 32.15 | 13.17 | 14.47 |
| Ash ..... | 6.70 | 8.95 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 8983 | 11991 | 13169 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.23 | 0.31 | 0.34 |
| Pyritic sulfur ..... | 1.86 | 2.49 | 2.73 |
| Organic sulfur ..... | 1.40 | 1.86 | 2.05 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.36

HARDGROVE GRINDABILITY INDEX 66

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 1960 F | 2530 F |
| Softening Temp. | 1980 F | 2600 F |
| Fluid Temp. | 2390 F | 2650 F |
| Hemispherical Temp. | 2130 F | 2620 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK020

Lab No. U12631 **********

AIR DRY LOSS 16.54  RESIDUAL MOISTURE 6.97

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 22.36 | | |
| Ash ..... | 21.63 | 27.86 | |
| Volatile Matter ..... | 29.07 | 37.44 | 51.90 |
| Fixed Carbon ..... | 26.94 | 34.70 | 48.10 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.57 | 3.95 | 5.48 |
| Carbon ..... | 38.00 | 48.95 | 67.85 |
| Nitrogen ..... | 0.69 | 0.89 | 1.23 |
| Sulfur ..... | 7.59 | 9.77 | 13.54 |
| Oxygen ..... | 26.52 | 8.58 | 11.90 |
| Ash ..... | 21.63 | 27.86 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6957 | 8960 | 12420 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.79 | 1.02 | 1.41 |
| Pyritic sulfur ..... | 4.80 | 6.28 | 8.71 |
| Organic sulfur ..... | 1.92 | 2.47 | 3.42 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.51

HARDGROVE GRINDABILITY INDEX 68

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2190 F | 2490 F |
| Softening Temp. | 2220 F | 2560 F |
| Fluid Temp. | 2460 F | 2660 F |
| Hemispherical Temp. | 2430 F | 2610 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK021

Lab No. U12632 **********

AIR DRY LOSS 21.82  RESIDUAL MOISTURE 5.92

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 26.45 | | |
| Ash ..... | 11.72 | 15.93 | |
| Volatile Matter ..... | 32.96 | 44.81 | 53.30 |
| Fixed Carbon ..... | 28.87 | 39.26 | 46.70 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.33 | 4.58 | 5.45 |
| Carbon ..... | 45.20 | 61.45 | 73.09 |
| Nitrogen ..... | 0.88 | 1.20 | 1.43 |
| Sulfur ..... | 3.99 | 5.43 | 6.46 |
| Oxygen ..... | 31.88 | 11.41 | 13.57 |
| Ash ..... | 11.72 | 15.93 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 8071 | 10974 | 13053 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.13 | 0.18 | 0.21 |
| Pyritic sulfur ..... | 2.80 | 3.80 | 4.52 |
| Organic sulfur ..... | 1.06 | 1.45 | 1.73 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.39

HARDGROVE GRINDABILITY INDEX 74

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2380 F | 2420 F |
| Softening Temp. | 2440 F | 2450 F |
| Fluid Temp. | 2560 F | 2470 F |
| Hemispherical Temp. | 2460 F | 2460 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK022

Lab No. U12633 **********

AIR DRY LOSS 18.22  RESIDUAL MOISTURE 8.33

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 25.03 | | |
| Ash ..... | 17.52 | 23.37 | |
| Volatile Matter ..... | 30.21 | 40.30 | 52.59 |
| Fixed Carbon ..... | 27.24 | 36.33 | 47.41 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 5.98 | 4.24 | 5.53 |
| Carbon ..... | 41.70 | 55.62 | 72.58 |
| Nitrogen ..... | 0.76 | 1.02 | 1.33 |
| Sulfur ..... | 3.80 | 5.07 | 6.62 |
| Oxygen ..... | 30.24 | 10.68 | 13.94 |
| Ash ..... | 17.52 | 23.37 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7489 | 9990 | 13036 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.18 | 0.25 | 0.33 |
| Pyritic sulfur ..... | 2.41 | 3.22 | 4.20 |
| Organic sulfur ..... | 1.21 | 1.60 | 2.09 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.43

HARDGROVE GRINDABILITY INDEX 69

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2170 F | 2340 F |
| Softening Temp. | 2260 F | 2370 F |
| Fluid Temp. | 2500 F | 2410 F |
| Hemispherical Temp. | 2290 F | 2390 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK023

Lab No. U12634 **********

AIR DRY LOSS 19.68  RESIDUAL MOISTURE 5.74

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 24.29 | | |
| Ash ..... | 19.59 | 25.88 | |
| Volatile Matter ..... | 30.51 | 40.30 | 54.37 |
| Fixed Carbon ..... | 25.61 | 33.82 | 45.63 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 5.67 | 3.90 | 5.26 |
| Carbon ..... | 38.24 | 50.50 | 68.13 |
| Nitrogen ..... | 0.94 | 1.24 | 1.67 |
| Sulfur ..... | 4.33 | 5.72 | 7.72 |
| Oxygen ..... | 31.23 | 12.76 | 17.22 |
| Ash ..... | 19.59 | 25.88 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 6711 | 8865 | 11960 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 1.13 | 1.50 | 2.02 |
| Pyritic sulfur ..... | 1.58 | 2.09 | 2.82 |
| Organic sulfur ..... | 1.62 | 2.13 | 2.88 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.56

HARDGROVE GRINDABILITY INDEX 69

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2170 F | 2340 F |
| Softening Temp. | 2240 F | 2360 F |
| Fluid Temp. | 2480 F | 2410 F |
| Hemispherical Temp. | 2270 F | 2380 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK024

Lab No. U12635 **********

AIR DRY LOSS 20.66  RESIDUAL MOISTURE 6.43

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 25.77 | | |
| Ash ..... | 11.44 | 15.41 | |
| Volatile Matter ..... | 30.93 | 41.66 | 49.25 |
| Fixed Carbon ..... | 31.86 | 42.93 | 50.75 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.41 | 4.76 | 5.63 |
| Carbon ..... | 45.76 | 61.65 | 72.89 |
| Nitrogen ..... | 0.69 | 0.93 | 1.10 |
| Sulfur ..... | 3.40 | 4.57 | 5.40 |
| Oxygen ..... | 32.30 | 12.68 | 14.98 |
| Ash ..... | 11.44 | 15.41 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 8299 | 11180 | 13217 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.15 | 0.20 | 0.24 |
| Pyritic sulfur ..... | 2.57 | 3.46 | 4.09 |
| Organic sulfur ..... | 0.68 | 0.91 | 1.07 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.38

HARDGROVE GRINDABILITY INDEX 63

| ASH FUSION TEMPERATURES (Reducing Atmosphere) | | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2100 F | 2540 F |
| Softening Temp. | 2140 F | 2580 F |
| Fluid Temp. | 2570 F | 2620 F |
| Hemispherical Temp. | 2180 F | 2600 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK025

Lab No. U12636 **********

AIR DRY LOSS 16.66  RESIDUAL MOISTURE 11.07

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 25.89 | | |
| Ash ..... | 17.09 | 23.05 | |
| Volatile Matter ..... | 29.15 | 39.33 | 51.11 |
| Fixed Carbon ..... | 27.87 | 37.62 | 48.89 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.13 | 4.36 | 5.67 |
| Carbon ..... | 41.32 | 55.76 | 72.47 |
| Nitrogen ..... | 0.97 | 1.31 | 1.70 |
| Sulfur ..... | 3.33 | 4.49 | 5.84 |
| Oxygen ..... | 31.16 | 11.03 | 14.32 |
| Ash ..... | 17.09 | 23.05 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7339 | 9903 | 12870 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.20 | 0.27 | 0.35 |
| Pyritic sulfur ..... | 2.39 | 3.23 | 4.20 |
| Organic sulfur ..... | 0.74 | 0.99 | 1.29 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.44

HARDGROVE GRINDABILITY INDEX 77

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2240 F | 2430 F |
| Softening Temp. | 2280 F | 2530 F |
| Fluid Temp. | 2630 F | 2570 F |
| Hemispherical Temp. | 2320 F | 2550 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK026A

Lab No. U12637 **********

AIR DRY LOSS 21.95  RESIDUAL MOISTURE 6.82

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| **PROXIMATE ANALYSIS** | | | |
| Moisture ..... | 27.27 | | |
| Ash ..... | 10.73 | 14.76 | |
| Volatile Matter ..... | 30.93 | 42.53 | 49.89 |
| Fixed Carbon ..... | 31.07 | 42.71 | 50.11 |
| | 100.00 | 100.00 | 100.00 |
| **ULTIMATE ANALYSIS** | | | |
| Hydrogen ..... | 6.39 | 4.59 | 5.38 |
| Carbon ..... | 44.74 | 61.52 | 72.17 |
| Nitrogen ..... | 0.67 | 0.93 | 1.09 |
| Sulfur ..... | 4.30 | 5.91 | 6.93 |
| Oxygen ..... | 33.17 | 12.29 | 14.43 |
| Ash ..... | 10.73 | 14.76 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7976 | 10967 | 12866 |
| **FORMS OF SULFUR** | | | |
| Sulfate sulfur ..... | 0.24 | 0.33 | 0.39 |
| Pyritic sulfur ..... | 2.84 | 3.90 | 4.58 |
| Organic sulfur ..... | 1.22 | 1.68 | 1.96 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.41

HARDGROVE GRINDABILITY INDEX 62

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 1980 F | 2470 F |
| Softening Temp. | 2000 F | 2590 F |
| Fluid Temp. | 2160 F | 2690 F |
| Hemispherical temp. | 2030 F | 2680 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: BSLK027A

Lab No. U12638 **********

AIR DRY LOSS .22.57  RESIDUAL MOISTURE 5.58

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 26.89 | | |
| Ash ..... | 13.24 | 18.11 | |
| Volatile Matter ..... | 31.55 | 43.16 | 52.70 |
| Fixed Carbon ..... | 28.32 | 38.73 | 47.30 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.35 | 4.57 | 5.58 |
| Carbon ..... | 40.89 | 55.92 | 68.28 |
| Nitrogen ..... | 0.91 | 1.25 | 1.53 |
| Sulfur ..... | 5.86 | 8.02 | 9.79 |
| Oxygen ..... | 32.75 | 12.13 | 14.82 |
| Ash ..... | 13.24 | 18.11 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7517 | 10282 | 12555 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.53 | 0.72 | 0.88 |
| Pyritic sulfur ..... | 2.69 | 3.68 | 4.49 |
| Organic sulfur ..... | 2.64 | 3.62 | 4.42 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.32

HARDGROVE GRINDABILITY INDEX 67

EQUILIBRIUM MOISTURE = 27.34%

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2180 F | 2510 F |
| Softening Temp. | 2240 F | 2560 F |
| Fluid Temp. | 2540 F | 2610 F |
| Hemispherical Temp. | 2300 F | 2570 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85LK027B

Lab No. U12639 **********

AIR DRY LOSS 20.45  RESIDUAL MOISTURE 4.45

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 23.99 | | |
| Ash ..... | 23.74 | 31.23 | |
| Volatile Matter ..... | 26.59 | 34.99 | 50.88 |
| Fixed Carbon ..... | 25.68 | 33.78 | 49.12 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 5.42 | 3.61 | 5.25 |
| Carbon ..... | 32.21 | 42.38 | 61.62 |
| Nitrogen ..... | 0.74 | 0.98 | 1.42 |
| Sulfur ..... | 8.99 | 11.83 | 17.20 |
| Oxygen ..... | 28.90 | 9.97 | 14.51 |
| Ash ..... | 23.74 | 31.23 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 5911 | 7776 | 11307 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.99 | 1.31 | 1.90 |
| Pyritic sulfur ..... | 5.94 | 7.81 | 11.36 |
| Organic sulfur ..... | 2.06 | 2.71 | 3.94 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.68

HARDGROVE GRINDABILITY INDEX 76

EQUILIBRIUM MOISTURE = 25.57%

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 2080 F | 2560 F |
| Softening Temp. | 2140 F | 2590 F |
| Fluid Temp. | 2500 F | 2620 F |
| Hemispherical Temp. | 2130 F | 2600 F |

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## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85MT001

Lab No. U12621 **********

AIR DRY LOSS 24.20  RESIDUAL MOISTURE 7.98

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 30.25 | | |
| Ash ..... | 11.16 | 15.99 | |
| Volatile Matter ..... | 30.38 | 43.56 | 51.85 |
| Fixed Carbon ..... | 28.21 | 40.45 | 48.15 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.77 | 4.86 | 5.79 |
| Carbon ..... | 42.64 | 61.13 | 72.77 |
| Nitrogen ..... | 0.81 | 1.17 | 1.39 |
| Sulfur ..... | 4.00 | 5.74 | 6.83 |
| Oxygen ..... | 34.62 | 11.11 | 13.22 |
| Ash ..... | 11.16 | 15.99 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7723 | 11072 | 13180 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.10 | 0.15 | 0.18 |
| Pyritic sulfur ..... | 2.90 | 4.15 | 4.94 |
| Organic sulfur ..... | 1.00 | 1.44 | 1.71 |

FREE SWELLING INDEX 0.0
APPARENT SPECIFIC GRAVITY = 1.38
HARDGROVE GRINDABILITY INDEX 56

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 1960 F | 2480 F |
| Softening Temp. | 2000 F | 2590 F |
| Fluid Temp. | 2100 F | 2640 F |
| Hemispherical Temp. | 2030 F | 2610 F |

Forrest E. Walker

Forrest E. Walker
Director of Technical Services

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# GEOCHEMICAL TESTING

COAL, WATER, AND MATERIALS ANALYSIS

R.D. 2, BOX 124

Somerset, Pennsylvania 15501

Phone: (814) 445-6666 or 443-1671


## COAL ANALYSIS REPORT

Client: United States Geological Survey  Date of report: 10/21/85

USGS Lab No.  State: PK  Field ID: 85MT002

Lab No. U12622 **********

AIR DRY LOSS 27.42  RESIDUAL MOISTURE 7.42

| | As-received | Dry | Dry ash-free |
|---|---|---|---|
| PROXIMATE ANALYSIS | | | |
| Moisture ..... | 32.80 | | |
| Ash ..... | 9.98 | 14.85 | |
| Volatile Matter ..... | 28.98 | 43.12 | 50.64 |
| Fixed Carbon ..... | 28.24 | 42.03 | 49.36 |
| | 100.00 | 100.00 | 100.00 |
| ULTIMATE ANALYSIS | | | |
| Hydrogen ..... | 6.92 | 4.84 | 5.68 |
| Carbon ..... | 41.46 | 61.69 | 72.45 |
| Nitrogen ..... | 0.71 | 1.06 | 1.24 |
| Sulfur ..... | 3.50 | 5.21 | 6.12 |
| Oxygen ..... | 37.43 | 12.35 | 14.51 |
| Ash ..... | 9.98 | 14.85 | |
| | 100.00 | 100.00 | 100.00 |
| HEATING VALUE (BTU/LB) | 7458 | 11097 | 13032 |
| FORMS OF SULFUR | | | |
| Sulfate sulfur ..... | 0.10 | 0.15 | 0.18 |
| Pyritic sulfur ..... | 2.09 | 3.11 | 3.65 |
| Organic sulfur ..... | 1.31 | 1.95 | 2.29 |

FREE SWELLING INDEX 0.0

APPARENT SPECIFIC GRAVITY = 1.36

HARDGROVE GRINDABILITY INDEX 75

| ASH FUSION TEMPERATURES | (Reducing Atmosphere) | (Oxidizing Atms.) |
|---|---|---|
| Initial Deformation | 1970 F | 2400 F |
| Softening Temp. | 2000 F | 2490 F |
| Fluid Temp. | 2060 F | 2630 F |
| Hemispherical Temp. | 2020 F | 2520 F |

Forrest E. Walker

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Director of Technical Services

# APPENDIX C

## Analyses on Equilibrium Moisture Basis

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12638 | PK | | |

W233225

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 26.89 | 27.34 | 0.00 | 0.00 |
| % ASH | 13.24 | 13.15 | 18.11 | 0.00 |
| % VOLATILE | 31.55 | 31.36 | 43.15 | 52.70 |
| % FIXED CARBON | 28.32 | 28.15 | 38.74 | 47.30 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 6.35 | 6.38 | 4.57 | 5.58 |
| % CARBON | 40.89 | 40.64 | 55.93 | 68.30 |
| % NITROGEN | 0.91 | 0.90 | 1.24 | 1.52 |
| % SULFUR | 5.86 | 5.82 | 8.02 | 9.79 |
| % OXYGEN | 32.75 | 33.10 | 12.13 | 14.81 |
| % ASH | 13.24 | 13.16 | 18.11 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.53 | 0.53 | 0.72 | 0.89 |
| % PRYTIC S | 2.69 | 2.67 | 3.68 | 4.49 |
| % ORGANIC S | 2.64 | 2.62 | 3.61 | 4.41 |
| HEAT VALUE(BTU/LB) | 7520 | 7470 | 10280 | 12550 |

BTU/LB USING PARR FORMULA IS 8692

RANK BY PARR FORMULA IS SUBBITUMINOUS C COAL

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12639<br>W233226 | PK | | |

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 23.99 | 25.57 | 0.00 | 0.00 |
| % ASH | 23.74 | 23.25 | 31.23 | 0.00 |
| % VOLATILE | 26.59 | 26.04 | 34.98 | 50.87 |
| % FIXED CARBON | 25.68 | 25.15 | 33.79 | 49.13 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 5.42 | 5.54 | 3.60 | 5.23 |
| % CARBON | 32.21 | 31.54 | 42.38 | 61.62 |
| % NITROGEN | 0.74 | 0.72 | 0.97 | 1.42 |
| % SULFUR | 8.99 | 8.80 | 11.83 | 17.20 |
| % OXYGEN | 28.90 | 30.15 | 9.99 | 14.53 |
| % ASH | 23.74 | 23.25 | 31.23 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.99 | 0.97 | 1.30 | 1.89 |
| % PRYTIC S | 5.94 | 5.82 | 7.81 | 11.36 |
| % ORGANIC S | 2.06 | 2.02 | 2.71 | 3.94 |
| HEAT VALUE(BTU/LB) | 5910 | 5790 | 7780 | 11310 |

BTU/LB USING PARR FORMULA IS 7632

RANK BY PARR FORMULA IS LIGNITE A

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12573 (G.T.)<br>W23305 1 (USGS) | PK | | |

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 26.02 | 26.47 | 0.00 | 0.00 |
| % ASH | 25.74 | 25.58 | 34.79 | 0.00 |
| % VOLATILE | 25.95 | 25.79 | 35.08 | 53.79 |
| % FIXED CARBON | 22.29 | 22.15 | 30.13 | 46.21 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 5.58 | 5.61 | 3.61 | 5.53 |
| % CARBON | 32.33 | 32.13 | 43.70 | 67.02 |
| % NITROGEN | 0.64 | 0.64 | 0.87 | 1.33 |
| % SULFUR | 3.97 | 3.95 | 5.37 | 8.23 |
| % OXYGEN | 31.74 | 32.09 | 11.67 | 17.89 |
| % ASH | 25.74 | 25.58 | 34.79 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.85 | 0.84 | 1.15 | 1.76 |
| % PRYTIC S | 2.25 | 2.24 | 3.04 | 4.66 |
| % ORGANIC S | 0.87 | 0.86 | 1.18 | 1.80 |
| HEAT VALUE(BTU/LB) | 5770 | 5730 | 7800 | 11958 |

BTU/LB USING PARR FORMULA IS 7882

RANK BY PARR FORMULA IS LIGNITE A

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12576<br>W23054 | PK | | |

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 31.73 | 28.89 | 0.00 | 0.00 |
| % ASH | 16.02 | 16.69 | 23.47 | 0.00 |
| % VOLATILE | 25.45 | 26.51 | 37.28 | 48.71 |
| % FIXED CARBON | 26.80 | 27.91 | 39.26 | 51.29 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 6.31 | 6.11 | 4.04 | 5.28 |
| % CARBON | 35.80 | 37.29 | 52.44 | 68.52 |
| % NITROGEN | 0.72 | 0.75 | 1.05 | 1.38 |
| % SULFUR | 4.75 | 4.95 | 6.96 | 9.09 |
| % OXYGEN | 36.40 | 34.22 | 12.04 | 15.73 |
| % ASH | 16.02 | 16.69 | 23.47 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.74 | 0.77 | 1.08 | 1.42 |
| % PRYTIC S | 2.76 | 2.87 | 4.04 | 5.28 |
| % ORGANIC S | 1.25 | 1.30 | 1.83 | 2.39 |
| HEAT VALUE(BTU/LB) | 6480 | 6750 | 9490 | 12400 |

BTU/LB USING PARR FORMULA IS 8201

RANK BY PARR FORMULA IS LIGNITE A

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12579<br>W23305 | PK | | |

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 27.34 | 26.94 | 0.00 | 0.00 |
| % ASH | 18.15 | 18.25 | 24.98 | 0.00 |
| % VOLATILE | 28.40 | 28.56 | 39.09 | 52.10 |
| % FIXED CARBON | 26.11 | 26.25 | 35.93 | 47.90 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 6.07 | 6.04 | 4.14 | 5.52 |
| % CARBON | 38.84 | 39.05 | 53.45 | 71.25 |
| % NITROGEN | 0.72 | 0.72 | 0.99 | 1.32 |
| % SULFUR | 3.32 | 3.34 | 4.57 | 6.09 |
| % OXYGEN | 32.90 | 32.59 | 11.86 | 15.81 |
| % ASH | 18.15 | 18.25 | 24.98 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.17 | 0.17 | 0.23 | 0.31 |
| % PRYTIC S | 2.21 | 2.22 | 3.04 | 4.05 |
| % ORGANIC S | 0.94 | 0.95 | 1.29 | 1.72 |
| HEAT VALUE(BTU/LB) | 7000 | 7030 | 9630 | 12840 |

BTU/LB USING PARR FORMULA IS 8753

RANK BY PARR FORMULA IS SUBBITUMINOUS C COAL

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12580 | PK | | |

W233056

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 25.75 | 26.61 | 0.00 | 0.00 |
| % ASH | 26.61 | 26.30 | 35.84 | 0.00 |
| % VOLATILE | 24.94 | 24.65 | 33.59 | 52.35 |
| % FIXED CARBON | 22.70 | 22.44 | 30.57 | 47.65 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 5.66 | 5.72 | 3.74 | 5.83 |
| % CARBON | 32.73 | 32.35 | 44.08 | 68.70 |
| % NITROGEN | 0.65 | 0.64 | 0.88 | 1.36 |
| % SULFUR | 3.69 | 3.65 | 4.97 | 7.75 |
| % OXYGEN | 30.66 | 31.33 | 10.49 | 16.35 |
| % ASH | 26.61 | 26.30 | 35.84 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.35 | 0.35 | 0.47 | 0.73 |
| % PRYTIC S | 2.66 | 2.63 | 3.58 | 5.58 |
| % ORGANIC S | 0.68 | 0.67 | 0.92 | 1.43 |
| HEAT VALUE(BTU/LB) | 5780 | 5720 | 7790 | 12140 |

BTU/LB USING PARR FORMULA IS 7950

RANK BY PARR FORMULA IS LIGNITE A

# COAL ANALYSIS RECALCULATED ON AN EQUILIBRIUM MOISTURE BASIS BY USGS

| SAMPLE NUMBER | STATE | COAL BED NAME | FIELD NUMBER |
|---|---|---|---|
| U12566 | PK | | |

W233062

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## PROXIMATE ANALYSIS

| | AS-RECEIVED BASIS | AS-RECEIVED TO EQUILIBRIUM MOISTURE | DRY BASIS | DRY ASH-FREE |
|---|---|---|---|---|
| % MOISTURE | 27.45 | 26.21 | 0.00 | 0.00 |
| % ASH | 11.24 | 11.43 | 15.49 | 0.00 |
| % VOLATILE | 31.89 | 32.44 | 43.96 | 52.01 |
| % FIXED CARBON | 29.42 | 29.92 | 40.55 | 47.99 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## ULTIMATE ANALYSIS

| | | | | |
|---|---|---|---|---|
| % HYDROGEN | 6.51 | 6.43 | 4.74 | 5.61 |
| % CARBON | 43.10 | 43.84 | 59.41 | 70.30 |
| % NITROGEN | 0.80 | 0.81 | 1.10 | 1.30 |
| % SULFUR | 4.77 | 4.85 | 6.57 | 7.78 |
| % OXYGEN | 33.58 | 32.64 | 12.68 | 15.01 |
| % ASH | 11.24 | 11.43 | 15.49 | 0.00 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 |

## FORMS OF SULFUR

| | | | | |
|---|---|---|---|---|
| % SULFATE S | 0.87 | 0.88 | 1.20 | 1.42 |
| % PRYTIC S | 3.05 | 3.10 | 4.20 | 4.97 |
| % ORGANIC S | 0.85 | 0.86 | 1.17 | 1.39 |
| HEAT VALUE(BTU/LB) | 7840 | 7980 | 10810 | 12790 |

BTU/LB USING PARR FORMULA IS 9098

RANK BY PARR FORMULA IS SUBBITUMINOUS C COAL