DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

CHEMICAL AND PHYSICAL CHARACTERISTICS OF COAL AND CARBONACEOUS SHALE SAMPLES FROM THE SALT RANGE COAL FIELD, PUNJAB PROVINCE, PAKISTAN

by

P. D. Warwick[1]

and

T. Shakoor[2], S. Javed[2], S. T. A. Mashhadi[2],
H. Hussain[2], M. Anwar[2], and M. I. Ghaznavi[2]

OPEN-FILE REPORT 90-524

Report prepared jointly by the Geological Survey of Pakistan and the U.S. Geological Survey under the auspices of the U.S. Agency for International Development

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
Reston, Virginia

[2]Geological Survey of Pakistan
Lahore

1990

CONTENTS

ILLUSTRATIONS

TABLES

CHEMICAL AND PHYSICAL CHARACTERISTICS OF COAL AND CARBONACEOUS SHALE SAMPLES FROM THE SALT RANGE COAL FIELD, PUNJAB PROVINCE, PAKISTAN

by

P. D. Warwick, U.S. Geological Survey; T. Shakoor, S. Javed, S. T. A. Mashhadi, H. Hussain, M. Anwar, and M. I. Ghaznavi, Geological Survey of Pakistan

ABSTRACT

Sixty coal and carbonaceous shale samples collected from the Paleocene Patala Formation in the Salt Range coal field, Punjab Province, Pakistan, were analyzed to examine the relationships between coal bed chemical and physical characteristics and depositional environments. Results of proximate and ultimate analyses, reported on an as-received basis, indicate that coal beds have an average ash yield of 24.23 percent, average sulfur content of 5.32 percent, average pyritic sulfur content of 4.07 percent, and average calorific value of 8943 Btu (4972 kcal/kg). Thirty-five coal samples, analyzed on a whole-coal, dry basis for selected trace elements and oxides, have anomalously high average concentrations of Ti, at 0.36 percent; Zr, at 382 ppm; and Se, at 11.4 ppm, compared to world-wide averages for these elements in coal.

Some positive correlation coefficients, significant at a 0.01 level, are those between total sulfur and As, pyritic sulfur and As, total sulfur and sample location, organic sulfur and Se,

calorific value (Btu) and sample location, and coal bed thickness and Se. Calorific values for the samples, calculated on a moist, mineral-matter free basis, indicate that the apparent rank of the coal is high volatile C bituminous.

Variations observed in the chemical and physical characteristics of the coal beds may be related to depositional environments. Total ash yields and concentrations of Se and organic sulfur increase toward more landward depositional environments and may be related to an increase of fluvial influence on peat deposition. Variations in pyritic sulfur concentrations may be related to post-peat pyrite filled burrows commonly observed in the upper part of the coal bed. The thickest coal beds that have the lowest ash content, and highest calorific values, formed from peats deposited in back barrier, tidal flat environments of the central and western parts of the coal field. The reasons for correlations between Se and coal bed thickness and Se and ash content are not clear and may be a product of averaging.

ACKNOWLEDGEMENTS

This work would not have been possible without the generous cooperation of the many mining companies in the Salt Range area, who allowed us to collect the samples analyzed for this report.

INTRODUCTION

This work is part of a Coal Resources Exploration and Assessment Program (COALREAP) that is being conducted by the Geological Survey of Pakistan (GSP) with assistance from the U.S. Geological Survey (USGS) under financing from the Government of Pakistan and the U.S. Agency for International Development (USAID). The 60 samples for this study were collected between 1985 and 1988 by geologists of GSP and USGS from the Paleocene Patala Formation in the Salt Range area of Punjab Province, Pakistan (figs. 1 and 2).

The Salt Range is an east-northeasterly trending mountain range in the northern part of Pakistan (figs. 1 and 2). The southern margin of the Salt Range is an escarpment which rises abruptly from the Punjab Plains, which are covered by alluvium. Coal mining, exploratory drilling, and related activities in the Salt Range have been concentrated in beds that crop out along the escarpment and limestone capped plateaus of the Eastern and Central Salt Range. No Tertiary coal beds are present in the Western Salt Range.

Previous reports that contain drilling records, measured sections, coal analytical data, descriptions of depositional environments, or estimates of coal resources for the Salt Range coal field include Ahmad and others, 1986; Alam and others, 1987; Gee, 1938, 1945, 1949; Ghaznavi, 1988; Khan, 1949; LaTouche, 1894; Landis and others, 1971; Powell Duffryn Technical Services, 1949; Shah, 1980; Wardlaw and others, 1990; Warwick and Hussain,

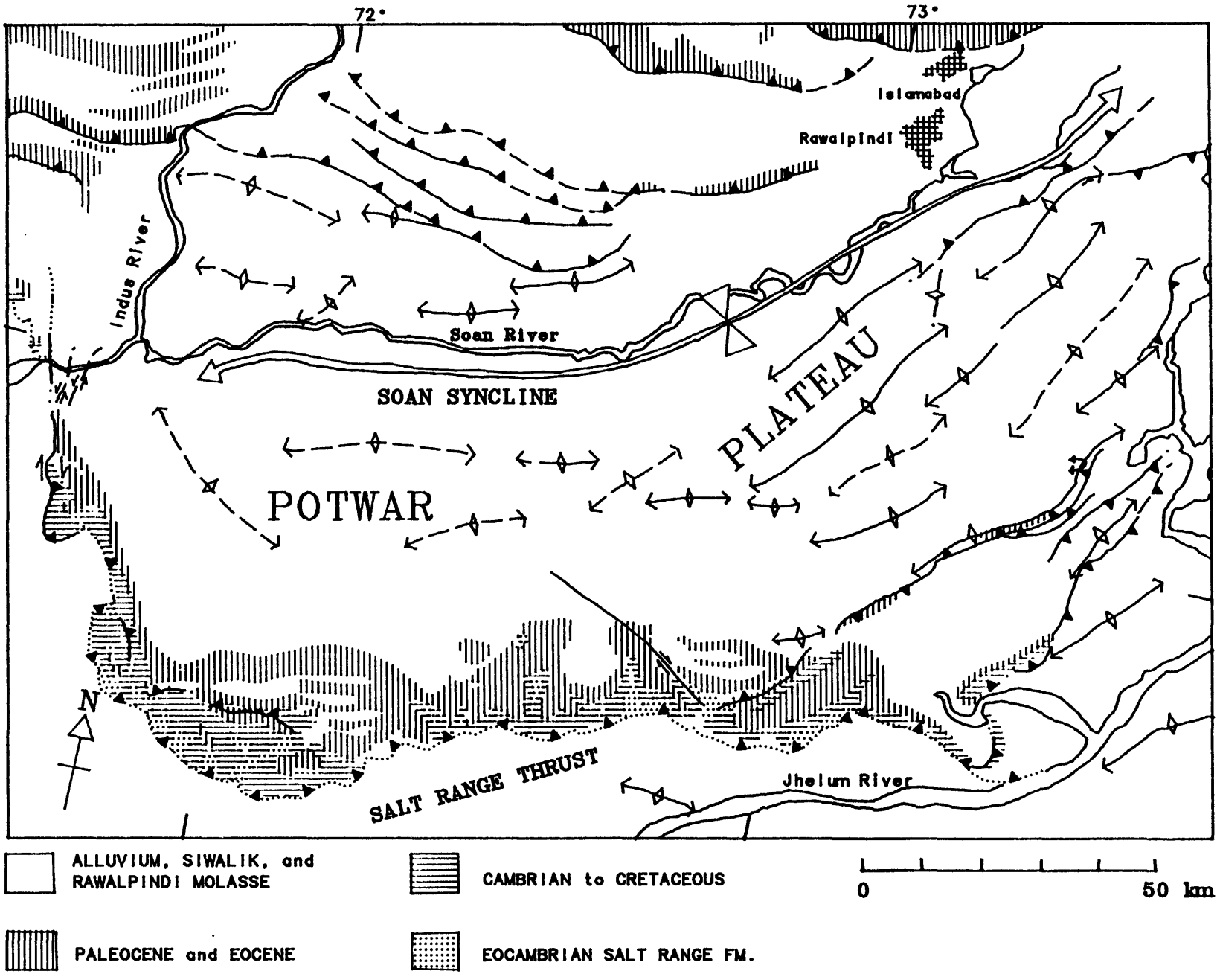


Figure 1. Generalized geology of the Salt Range – Potwar Plateau area. (After Baker and others, 1988.)

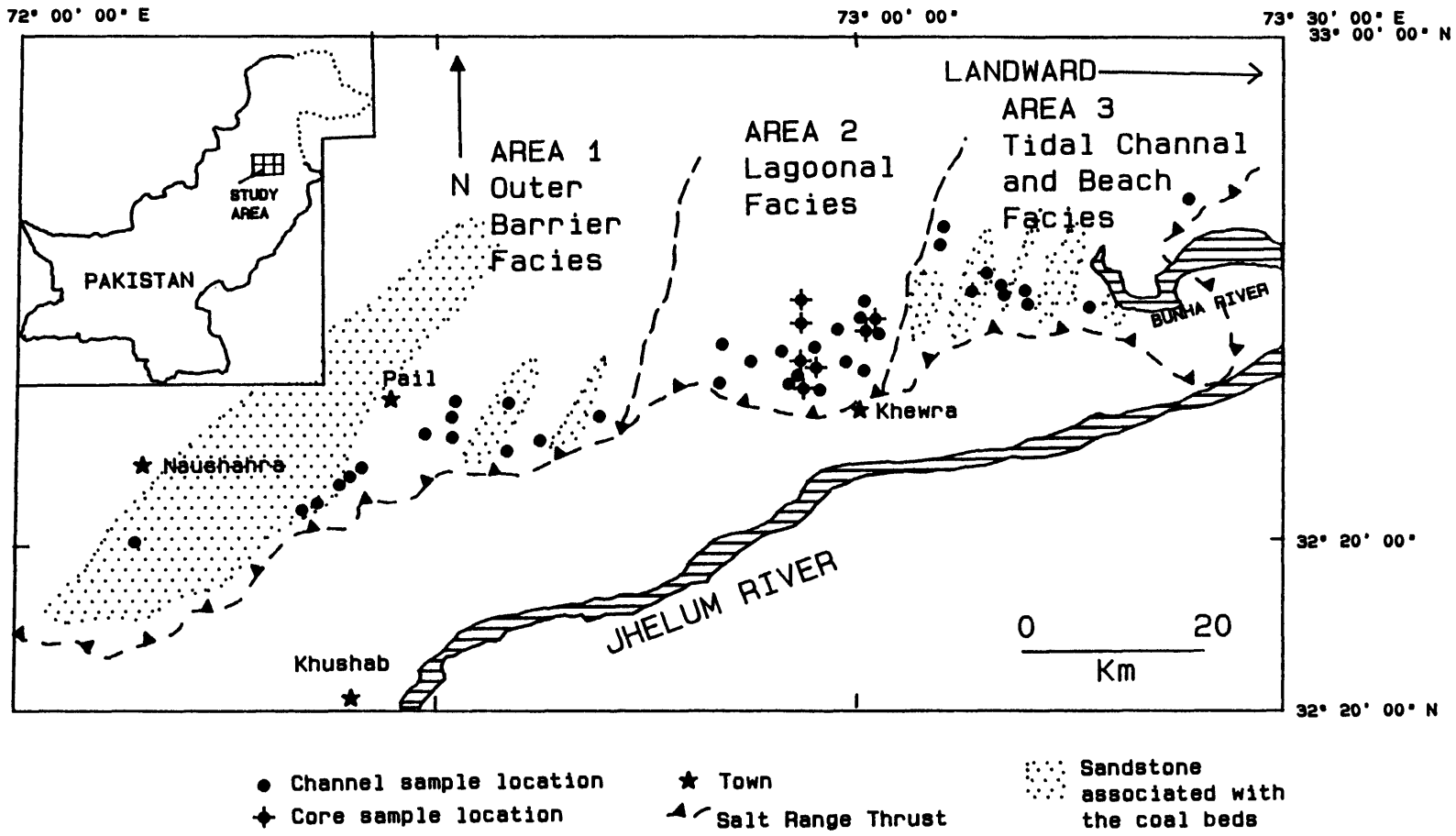


Figure 2. Map showing sample locations, geography, and generalized sandstone distribution in the Petala Formation (sandstone data from Warwick and Shakoor, 1988b).

1990; Warwick and Shakoor, 1988a,b; Warwick and Javed, 1990; Warwick and others, 1990; Wells, 1984; and Wynne, 1878.

The coal-bearing Patala Formation (ranges from 5-90 m thick) is composed of dark gray, fossiliferous shale interbedded with white quartzose sandstone, siltstone, marl, and limestone. Coal and carbonaceous shale deposits generally occur as a single bed (<1 m thick) that is commonly split by dark gray shale or thin (<0.25 m thick) bands of quartzose sandstone. These laterally discontinuous coal and carbonaceous shale beds overlie and are laterally associated with northeasterly trending, elongate, quartzose sandstone bodies (ranges from 1-20 m thick, fig. 2) and are interpreted to have been deposited in back-barrier and near-marine environments (Alam and others, 1987; Warwick and Shakoor, 1988a,b).

METHODS

Seventeen of the samples described in this report were collected as core during a drilling program conducted by the Geological Survey of Pakistan in the Eastern Salt Range. Eleven of these samples were shale and carbonaceous shale (sediments that comprise the majority of the coal-bearing Patala Formation) that were collected from drill hole DSM-17 (fig. 2; Appendix I). Forty-three samples were collected as whole bed or bench channel samples from active working faces of 35 underground coal mines in all parts of the Salt Range coal field (Appendix I). Coal and carbonaceous shale channel samples were collected following ASTM

(1986) procedures. Roof and floor rock, and partings greater than 1 cm thick were not included in the coal and carbonaceous shale channel and core samples.

The proximate and ultimate analytical data reported here was done in the laboratories of Geochemical Testing Incorporated in Somerset, Pennsylvania, and Dickinson Laboratories Incorporated of El Paso, Texas using ASTM (1986) methods. Randomly selected coal and carbonaceous shale samples were analyzed for major-, minor-, and trace-element contents by USGS laboratories in Reston, Virginia using methods described in Golightly and Simon (1989).

Correlation coefficients were calculated among trace element, proximate, ultimate, location, and coal bed thickness data. Few samples have a complete set of analytical data; therefore, the number of samples used in each correlation will vary. Sample locations (Areas 1, 2, and 3 on fig. 2) were assigned to the western, central, and eastern parts of the Salt Range coal field.

RESULTS

Figures 1 and 2 show the location of the Salt Range coal field and the sample locations. Appendix I lists sample location coordinates and background information. Appendix II and III lists data obtained from proximate, ultimate, forms-of-sulfur, free-swelling-index, Hardgrove-Grindability-index, and ash-fusion-temperature analyses. Appendix IV lists major-, minor-

Table 1. Averaged selected analytical results of tests on coal samples by sample location shown on figure 2 (N = number of samples; ave. = average; s.d. = standard deviation; all values as received or whole coal basis except thickness).

	AREA 1 (west)			AREA 2 (central)			AREA 3 (east)			All AREAS (1+2+3)		
	N	ave.	s.d.	N	ave.	s.d.	N	ave.	s.d.	N	ave.	s.d.
Coal bed Thickness (m)	18	0.42	0.22	13	0.6	0.3	6	0.43	0.15	37	0.49	0.25
Moisture (%)	19	9.11	2.93	17	9.15	1.43	8	8.23	2.8	44	8.97	2.4
Ash Yield (%)	19	21.8	8.72	17	22.61	8.79	8	33.42	9.68	44	24.23	9.76
Volatile Matter (%)	19	34.62	4.7	17	33.75	4.46	8	29.26	3.68	44	33.31	4.77
Fixed Carbon (%)	19	34.47	4.95	17	34.48	4.29	8	29.09	5.25	44	33.5	5.1
Carbon (%)	19	50.37	7.45	17	50.07	6.35	8	41.15	7.51	44	48.58	7.74
Hydrogen (%)	19	4.96	0.54	17	4.92	0.58	8	4.39	0.59	44	4.84	0.59
Nitrogen (%)	19	0.98	0.16	17	0.86	0.13	8	0.63	0.14	44	0.87	0.19
Total Sulfur (%)	19	6.42	2.88	17	4.09	1.35	8	5.35	2.55	44	5.32	2.52
Pyritic Sulfur (%)	19	5.41	2.59	17	2.91	1.43	8	3.42	2.82	44	4.08	2.50
Organic Sulfur (%)	19	0.86	0.86	17	1.04	0.44	8	1.76	0.91	44	1.1	0.61
Sulfate Sulfur (%)	19	0.14	0.07	17	0.13	0.13	8	0.17	0.12	44	0.14	0.1
Oxygen (%)	19	15.44	3.04	17	17.44	2.59	8	15.05	3.75	44	16.14	3.12
Calorific Value (Btu/lb)	19	9355	1385	17	9151	1225	8	7521	1407	44	8943	1467
Al (%)	3	1.04	0.24	6	2.57	1.64	2	4.3	3.11	11	2.47	1.9
Ca (%)	3	0.19	0.05	6	0.18	0.05	2	0.18	0.04	11	0.18	0.04
Fe (%)	3	4.83	2.37	6	2.3	1.11	2	3.4	0.28	11	3.19	1.74
K (%)	3	0.06	0.03	6	0.14	0.13	2	0.23	0.18	11	0.13	0.12
Mg (%)	3	0.06	0.02	6	0.08	0.05	2	0.07	0.05	11	0.07	0.04
Na (%)	3	0.03	0.02	6	0.05	0.02	2	0.06	0.03	11	0.05	0.02
Si (%)	3	1.83	0.45	6	7.08	7.31	2	13.0	2.83	11	6.73	6.53
Ti (%)	3	0.15	0.01	6	0.33	0.19	2	0.78	0.45	11	0.36	0.3
Ag (PPM)	3	0.11	0.07	6	0.09	0.07	2	0.08	0.02	11	0.09	0.06
As (PPM)	19	18.2	17.14	12	9.56	6.19	4	15.97	15.28	35	14.31	14.31
B (PPM)	3	100.33	29.5	6	121.17	45.51	2	110.0	0	11	113.45	36.05
Ba (PPM)	3	18.23	14.42	6	22.12	14.19	2	38.5	36.06	11	24.04	18.07
Be (PPM)	3	4.9	1.21	6	4.0	1.92	2	1.9	0.56	11	3.86	1.81
Br (PPM)	3	1.57	0.81	6	6.88	4.17	2	5.6	1.98	11	5.2	3.86
Cd (PPM)	3	0.13	0.05	6	0.13	0.07	2	0.08	0.01	11	0.12	0.06
Ce (PPM)	19	38.99	34.11	12	21.41	14.67	4	34.55	23.83	35	32.45	28.34
Cl (PPM)	3	100.0	0	6	103.33	8.16	2	100.0	0	11	101.81	6.03
Co (PPM)	19	6.58	5.86	12	6.61	4.87	4	7.32	8.51	35	6.68	5.68
Cr (PPM)	19	37.26	27.67	12	31.88	22.23	4	47.72	25.96	35	36.61	25.44
Cs (PPM)	19	0.54	0.51	12	0.42	0.35	4	0.69	0.6	35	0.52	0.46
Cu (PPM)	3	12.27	7.80	6	15.05	6.38	2	15.0	5.66	11	14.28	6.12
Eu (PPM)	19	0.90	0.62	12	0.56	0.38	4	0.71	0.48	35	0.76	0.54
F (PPM)	3	33.33	11.55	6	26.67	12.11	2	20.0	0	11	27.27	11.04
Ga (PPM)	1	10.0	0	6	11.58	5.89	2	13.9	17.11	9	11.92	7.73
Ge (PPM)	3	15.33	8.5	6	14.77	9.11	2	3.05	0.49	11	12.79	8.9
Hf (PPM)	19	2.53	2.04	12	2.7	1.98	4	5.2	2.03	35	2.89	2.13
Hg (PPM)	3	0.14	0.01	6	0.02	0.02	2	0.03	0.03	11	0.02	0.02
La (PPM)	19	20.06	17.38	12	12.07	8.93	4	19.3	12.75	35	17.23	14.64

Table 1. Averaged selected analytical results of tests on coal samples by sample location shown on figure 2 (continued).

	AREA 1 (west)			AREA 2 (central)			AREA 3 (east)			All AREAS (1+2+3)		
	N	ave.	s.d.	N	ave.	s.d.	N	ave.	s.d.	N	ave.	s.d.
Li (PPM)	3	11.53	6.71	6	47.17	31.02	2	66.0	62.22	11	40.87	35.85
Lu (PPM)	19	0.31	0.16	12	0.24	0.15	4	0.28	0.16	35	0.28	0.15
Mn (PPM)	3	23.0	9.54	6	33.0	19.22	2	31.5	6.36	11	30.00	15.09
Mo (PPM)	1	2.4	0	6	8.05	2.4	2	13.7	10.32	9	8.68	5.33
Nb (PPM)	3	5.0	1.9	6	11.47	9.64	2	29.5	6.36	11	12.98	11.24
Nd (PPM)	3	16.0	4.36	6	16.03	5.27	2	26.0	18.38	11	17.83	8.23
Ni (PPM)	3	13.57	6.83	6	22.47	13.83	2	26.0	7.07	11	20.68	11.52
P (PPM)	3	131.03	215.62	6	177.62	140.04	2	103.0	9.9	11	151.34	141.84
Pb (PPM)	3	11.5	6.95	6	14.67	7.17	2	13.8	5.94	11	13.64	6.4
Pr (PPM)	3	11.53	7.99	6	4.18	5.35	2	2.9	0.28	11	5.95	6.34
Rb (PPM)	19	41.82	15.18	12	31.21	21.03	4	22.7	14.83	35	35.99	18.23
Sb (PPM)	19	0.35	0.18	12	0.31	0.09	4	0.65	0.3	35	0.37	0.2
Sc (PPM)	19	7.42	5.87	12	5.87	4.08	4	7.15	4.43	35	6.85	5.09
Se (PPM)	19	9.28	2.78	12	11.77	3.48	4	21.0	6.73	35	11.48	5.04
Sm (PPM)	19	4.52	3.35	12	2.76	1.87	4	3.77	2.56	35	3.83	2.89
Sn (PPM)	1	3.5	0	6	4.6	2.03	2	6.05	4.88	9	4.8	2.48
Sr (PPM)	3	186.67	60.28	6	142.17	103.85	2	131.0	55.15	11	152.27	83.24
Ta (PPM)	3	0.4	0.08	6	0.93	0.52	2	1.95	0.92	11	0.71	0.71
Tb (PPM)	19	0.64	0.37	12	0.44	0.30	4	0.51	0.33	35	0.55	0.34
Th (PPM)	19	5.89	3.93	12	7.12	3.13	4	12.85	6.58	35	7.11	4.46
U (PPM)	3	1.89	1.07	6	2.6	1.4	2	9.4	6.5	11	3.64	3.69
V (PPM)	3	33.0	16.09	6	46.5	24.94	2	76.0	33.94	11	48.18	26.53
W (PPM)	3	0.53	0.06	6	1.36	0.5	2	2.0	0.99	11	1.25	0.71
Y (PPM)	3	16.33	6.11	6	15.62	4.13	2	19.0	4.24	11	16.43	4.42
Yb (PPM)	19	2.31	1.21	12	1.57	0.99	4	2.06	1.12	35	2.02	1.15
Zn (PPM)	3	67.33	37.81	6	70.83	85.92	2	61.0	43.84	11	68.09	64.68
Zr (PPM)	3	33.0	2.0	6	579.0	1235.46	2	315.0	106.07	11	382.0	908.31

Table 2. Averaged selected analytical results of tests on carbonaceous shale samples listed by percent ash content as received basis (N = number of samples; ave. = average; s.d. = standard deviation; all values as received or whole coal basis except thickness). Tests for minor- and trace-elements for samples containing greater than 75 % ash, as-received basis, were not run.

	50 - 75 % ASH			> 75 % ASH		
	N	ave.	s.d.	N	ave.	s.d.
Coal bed Thickness (m)	1	0.46	0	11	1.34	0.37
Moisture (%)	5	6.57	2.09	11	6.01	2.77
Ash Yield (%)	5	60.29	8.05	11	83.56	3.79
Volatile Matter (%)	5	20.04	2.81	11	9.80	3.36
Fixed Carbon (%)	5	13.08	7.98	11	0.61	1.71
Carbon (%)	5	19.02	10.00	11	2.06	2.51
Hydrogen (%)	5	2.66	0.68	11	1.55	0.32
Nitrogen (%)	5	0.28	0.17	11	0.05	0.05
Total Sulfur (%)	5	3.37	3.28	11	2.02	1.14
Pyritic Sulfur (%)	5	2.86	3.35	11	1.84	1.03
Organic Sulfur (%)	5	0.33	0.29	11	0.1	0.16
Sulfate Sulfur (%)	5	0.18	0.12	11	0.08	0.05
Oxygen (%)	5	14.38	4.83	11	10.73	3.01
Calorific Value (Btu/lb)	5	3323	2085	11	178	516
Al (%)	4	7.65	2.65			
Ca (%)	4	0.22	0.06			
Fe (%)	4	3.8	3.61			
K (%)	4	0.33	0.12			
Mg (%)	4	0.15	0.09			
Na (%)	5	0.08	0.03			
Si (%)	4	16.5	2.08			
Ti (%)	4	1.55	0.29			
Ag (PPM)	4	0.44	0.57			
As (PPM)	5	14.2	10.99			
B (PPM)	4	129.25	35.76			
Ba (PPM)	4	78.5	16.54			
Be (PPM)	4	3.9	2.47			
Br (PPM)	4	4.02	1.44			
Cd (PPM)	4	0.12	0.01			
Ce (PPM)	4	43.25	9.6			
Cl (PPM)	4	100.0	0			
Co (PPM)	4	7.5	6.57			
Cr (PPM)	4	75.25	12.89			
Cs (PPM)	4	0.78	0.34			
Cu (PPM)	4	22.75	6.18			
Eu (PPM)	4	0.66	0.06			
F (PPM)	4	45.00	37.86			
Ga (PPM)	4	25.25	8.96			
Ge (PPM)	4	4.27	1.68			

Table 2. Averaged selected analytical results of tests on carbonaceous shale samples listed by percent ash content, as-received basis (continued).

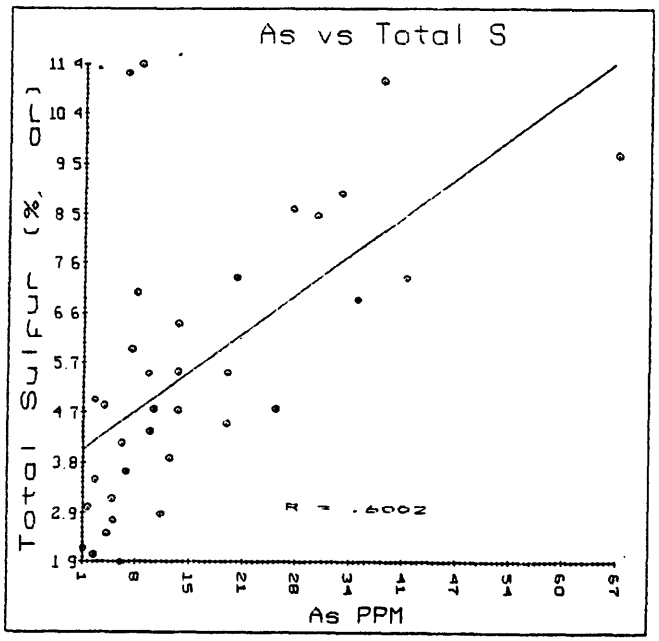
	50 - 75 % ASH		
	N	ave.	s.d.
Hf (PPM)	4	8.82	2.82
Hg (PPM)	5	0.04	0.04
La (PPM)	4	27.75	6.07
Li (PPM)	4	122.0	75.26
Lu (PPM)	4	0.41	0.06
Mn (PPM)	4	64.0	27.17
Mo (PPM)	4	8.47	7.69
Nb (PPM)	4	49.25	28.19
Nd (PPM)	4	27.0	15.47
Ni (PPM)	4	41.75	24.98
P (PPM)	4	87.25	11.24
Pb (PPM)	5	19.65	9.89
Pr (PPM)	4	6.3	2.69
Rb (PPM)	4	19.5	6.45
Sb (PPM)	4	1.82	2.52
Sc (PPM)	4	9.12	1.7
Se (PPM)	5	16.2	8.56
Sm (PPM)	4	3.5	0.42
Sn (PPM)	4	10.2	3.66
Sr (PPM)	5	182.5	15.0
Ta (PPM)	4	3.6	0.76
Tb (PPM)	4	0.48	0.01
Th (PPM)	5	19.0	2.16
U (PPM)	4	6.25	1.75
V (PPM)	4	115.25	29.07
W (PPM)	4	3.37	0.52
Y (PPM)	4	28.0	12.19
Yb (PPM)	4	2.55	0.31
Zn (PPM)	4	26.5	7.85
Zr (PPM)	4	457.5	309.56

and trace-element composition for 39 coal and carbonaceous samples. Average results of selected analytical data are listed on Tables 1 and 2.

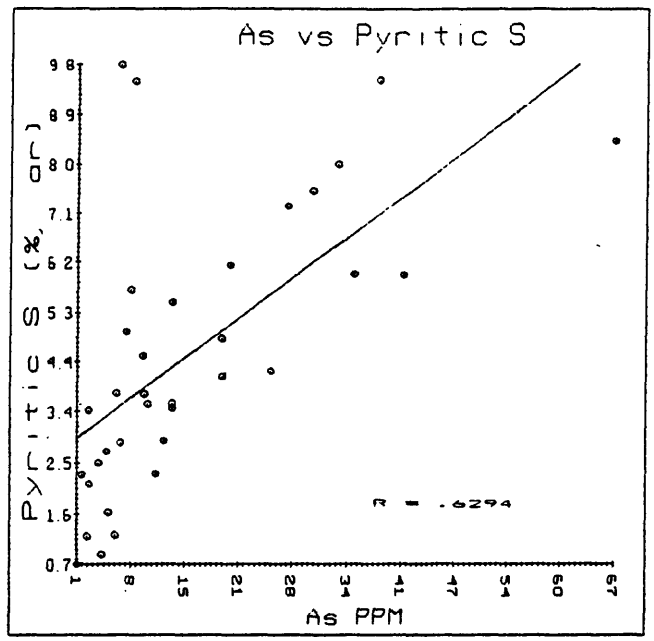
The three sample areas shown on figure 2 roughly correspond to depositional facies of the coal-bearing strata described in Wardlaw and others, 1990; Warwick and Hussain, 1990; Warwick and Shakoor 1988a,b. The coal beds in the western area are interbedded with deposits of a northerly trending barrier-bar complex, the coal beds in the central part of the coal field are associated with lagoonal and tidal flat deposits, and coal beds in the eastern part of the coal field are associated with upper shore face and tidal channel deposits.

Coal and carbonaceous shale bed thicknesses from 37 sample locations averaged 0.49 m (Table 1). Results of proximate and ultimate analyses, reported on an as-received basis, indicate that 44 samples with less than 50 percent ash yield (USGS definition of coal) have an average ash yield of 24.23 percent, average sulfur content of 5.32 percent, average pyritic sulfur content of 4.07 percent, and average calorific value of 8943 Btu (4972 kcal/kg). Averaged results for 35 coal samples, analyzed on a whole-coal, dry basis for selected trace elements are listed on Table 1.

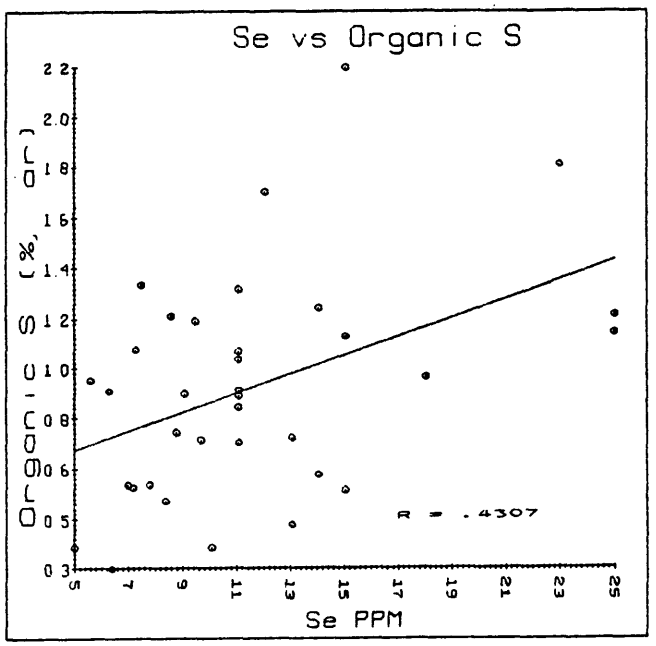
Positive correlations, significant at a 0.01 level, exist between total sulfur and As, pyritic sulfur and As, total sulfur and location, organic sulfur and Se, calorific value (Btu) and location, and coal bed thickness and Se (figs. 3 and 4). In



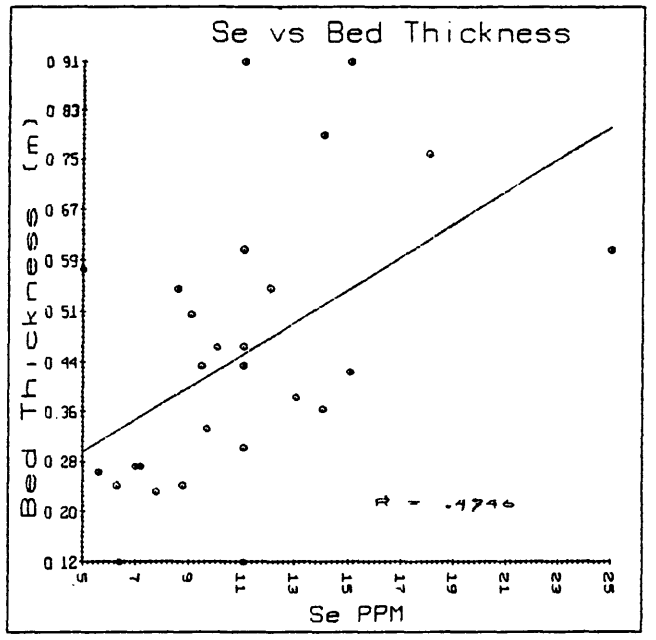
A.



B.

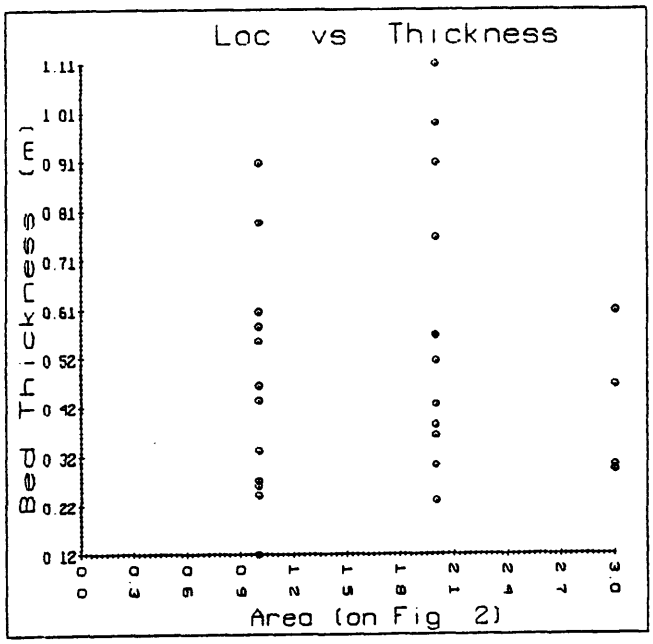


C.

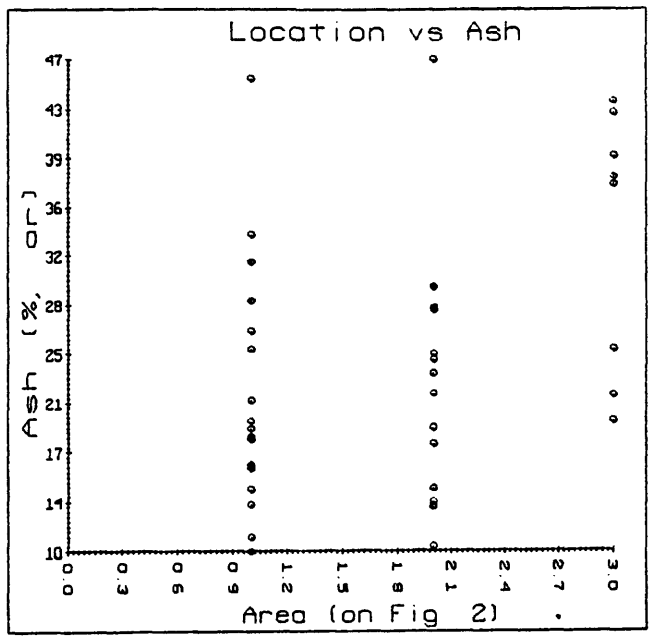


D.

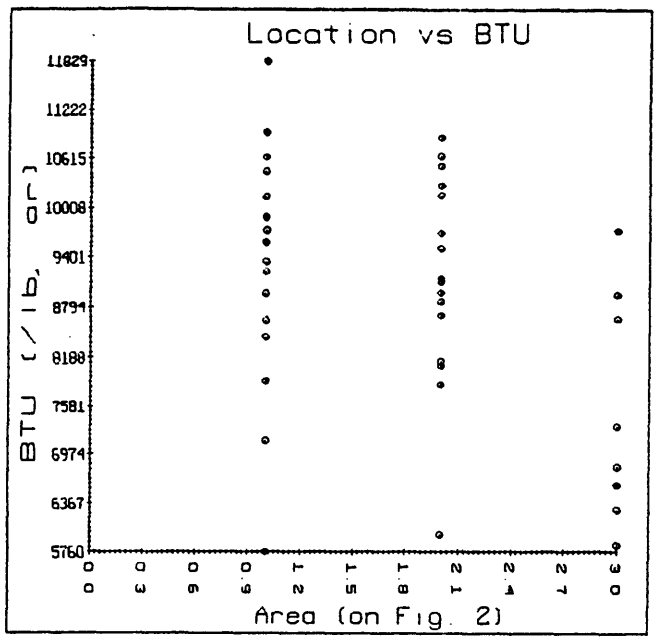
Figure 3. Plots of some positive correlations (0.01 level) found among analytical data; A) As and total S; B) As and pyritic S; C) Se and organic S; D) Se and coal bed thickness. All values reported in percentage as received (% ar), in parts per million (PPM), or in meters (m). R = correlation coefficient.



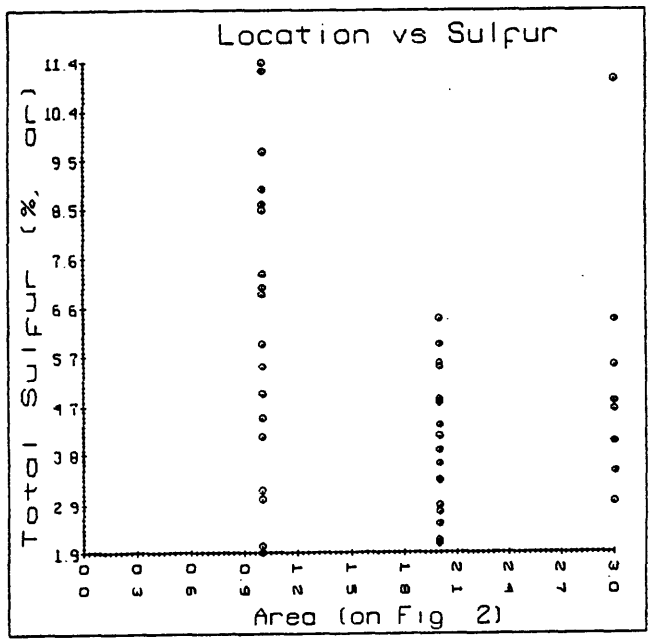
A.



B.



C.



D.

Figure 4. Plots of sample location and coal bed A) thickness, B) ash yield, C) BTU, and D) total S. All values reported in percentage, as received (% ar) for samples with less than 50% ash yield. Locations refer to Areas 1-3 on figure 2.

general, the thickest coal beds with the lowest total sulfur content are in the central part of the coal field. Organic sulfur and Se contents are greatest in the eastern part of the coal field; pyritic sulfur content is greatest in the western part of the coal field. Total ash yields increase towards the east. Calorific values for the samples, calculated to a moist, mineral-matter free basis, indicate that the apparent rank of the coal is high volatile C bituminous.

Results of proximate and ultimate analyses, reported on an as-received basis, for 5 carbonaceous shale samples, with greater than 50 percent and less than 75 percent ash yield (summarized on Table 2), have an average ash yield of 60.29 percent, average sulfur content of 3.37 percent, average pyritic sulfur content of 2.86 percent, and average calorific value of 3323 Btu (1847 kcal/kg). Results for analyses of selected minor- and trace-elements, analyzed on a whole-rock, dry basis, are summarized on Table 2.

Results of proximate and ultimate analyses, reported on an as-received basis, for 11 shale samples, with greater than 75 percent ash yield (summarized on Table 2), have an average ash yield of 83.57 percent, an average sulfur content of 2.02 percent, an average pyritic sulfur content of 1.84 percent, and average calorific value of 982 Btu (547 kcal/kg). No tests for minor- and trace-element concentrations were run for samples having greater than 75 percent ash yield.

DISCUSSION

Variations in the chemical and physical characteristics of the Salt Range coal beds may be related to depositional environments of the coal-bearing strata. Increased ash concentrations in an easterly or landward direction probably indicate less stable, more fluvially influenced environments of peat deposition than elsewhere. Organic sulfur and Se content increases in a landward direction. This indicates that Se and organic sulfur probably formed in similar geochemical environments (their correlation coefficient is significant at 0.4307). Se and coal bed thickness have a significant correlation coefficient at 0.4946, but the reason for this correlation is not clear and may be an artifact of averaging. For example, the thicker coal beds generally contain less ash and are located in the central and western part of the field, not in the eastern part where coal bed thickness is less and ash and Se content is greatest. The increase of organic sulfur eastward may indicate that the eastern peats were deposited in fresher-water environments than in the other parts of the field, and that they were inundated by marine waters that contributed to organic sulfur concentrations. Similar depositional environments have been proposed for increases in organic sulfur content in Appalachian coal beds by Davies and Raymond (1983).

Total sulfur values are greatest in the western part of the coal field and may be related to post-peat pyrite-filled burrows observed commonly in the upper part of the coal bed near the

barrier-bar complex. The thickest coal beds with the lowest ash content and highest calorific values formed from peats deposited in back barrier, tidal flat environments of the central and western parts of the coal field.

No significant correlations were found between total sulfur and bed thickness, and ash yield and bed thickness.

Concentrations of Ti, at 0.36 percent; Zr, at 382 ppm; and Se, at 11.4 ppm, are high compared to world-wide averages for these elements in coal (Stach and others, 1982; Ward, 1984, written communication, Finkelman, 1989). Four carbonaceous shale samples, analyzed on a whole-rock, dry basis for selected trace elements, have average concentrations of Ti, at 1.55 percent; Zr, at 457 ppm; and Se, at 9.1 ppm. The high percentages of Ti and Zr in the coal samples may be related to the ash yield of the samples. Zr and Si have a positive correlation coefficient of 0.7994 and Ti and ash yield have a positive correlation coefficient of 0.6970.

CONCLUSIONS

In general, the thickest coal beds with the lowest total sulfur content are in the central part of the Salt Range coal field. Organic sulfur and Se contents are greatest in the eastern part of the coal field; pyritic sulfur content is greatest in the western part of the coal field. Total ash yields increase towards the east. Calorific values for coal samples, calculated on a moist, mineral-matter free basis, indicate that

the apparent rank of the coal is high volatile C bituminous.

Some of the variations observed in the chemical and physical characteristics of the Salt Range coal beds may be related to different depositional environments of the coal-bearing strata. Ash yield and organic sulfur content are greatest in the eastern part of the coal field where fluvial and lacustrine environments may have contributed to the character of the coal beds. Coal bed thickness is greatest and total sulfur content is least in lagoonal environments of the central part of the coal field. Total and pyritic sulfur content is greatest in the western part of the coal field and may be related an abundance of post-peat pyrite filled burrows commonly observed in the upper part of the coal bed. Concentrations of Ti, Zr, and Se are high compared to world-wide averages for these elements in coal and may be related to the high ash yield of the samples.

REFERENCES

Ahmad, W., Gauhar, S. H., Siddiqi, R. A., 1986, Coal resources of Pakistan: Records of the Geological Survey of Pakistan, vol. 73, 55 p.

Alam, G. S., Bhatti, N. A., Mashhadi, S. T. A., Shakoor, T., Javed, S., and Anwar, M., 1987, Coal deposits of the Dalwal Plateau, District Chakwal, eastern Salt Range, Punjab, Pakistan: Geological Survey of Pakistan Information Release 325, 33 p.

American Society for Testing and Materials, 1986, Annual book of ASTM Standards: vol. .05.05, Gaseous Fuels; Coal and Coke: ASTM, Philadelphia, Pennsylvania, 565 p.

Baker, D. M., Lillie, R. J., Yeats, R. S., Johnson, G. D., Yousuf, M., and Zamin, A. S. H., 1988, Development of the Himalayan frontal thrust zone: Salt Range Pakistan: Geology, v. 16, p. 3-7.

Davies, T. D., and Raymond, R., Jr., 1983, Sulfur as a reflection of depositional environments in peats and coals, in Raymond, R., Jr., and Andrejko, M. J., eds., Proceedings of workshop on Mineral Matter in Peat, Its Occurrence, Form, and Distribution, September 26-30, 1983, Los Alamos National Laboratory, Los Alamos, New Mexico, p. 123-140.

Gee, E. R., 1938, The economic geology of the northern Punjab, with notes on adjoining portions of the North-West Frontier Province: India Mining Geology and Metallic Institute Transaction, vol. 33, pt. 3, p. 263-350.

Gee, E. R., 1945, Coal: Records of the Geological Survey of India, vol. 76, n. 16, 147 p.

Gee, E. R., 1949, The mineral resources of north western India: Records of the Geological Survey of Pakistan, vol. 1, pt. 1, 25 p.

Ghaznavi, M. I., 1988, The petrographic properties of the coals of Pakistan: (M. S. Thesis), Carbondale, Southern Illinois University, 175 p.

Golightly, D. W. and Simon, F. O., eds. 1989, Methods for sampling and inorganic analysis of coal: U.S. Geological Survey Bulletin 1823, 72 p.

Khan, N. M., 1949, A survey of coal resources of Pakistan: Geological Survey of Pakistan Records, vol. 2, pt. 2, p. 1-11.

LaTouche, B. A., 1894, Report on the Bhaganwala coal field, Salt Range, Punjab: Geological Survey of India Records, vol. 27, p. 16-33.

Landis, E. R., Reinemund, J. A., Cone, G. C., Schick, D. P., Kebblish, W., 1971, Analyses of Pakistan coals: U. S. Geological Survey Project Report, (IR) PK-58, 71 p.

Powell Duffryn Technical Services, Ltd., 1949, Report on the production and utilization of coal in Pakistan: Second report to the Government of Pakistan, 136 p., 13 pl.

Shah, S. M. I., 1980, Stratigraphy and economic geology of central Salt Range: Records of the Geological Survey of Pakistan, vol. 52, 104 p.

Stach, E., Mackowsky M.-TH., Teichmuller M., Taylor G. H., Chandra D. and Teichmuller R. 1982, Stach's textbook of coal petrology: Gebruder Borntraeger, Stuttgart, 535 p.

Ward, C. R. (ed.), 1984, Coal geology and coal technology: Blackwell Scientific Publications, Melbourne, 345 p.

Wardlaw, B. R., Martin, W. E., and Haydri, I. H., 1990, Preliminary lithofacies analysis of the Lockhart, Patala, and Nammal Formations (Paleocene - Eocene) of the Salt Range: Geological Survey of Pakistan Project Report (IR) PK-90, 40 manuscript pages (in press).

Warwick, P. D., and Husain, Farhat, 1990, Coal fields of Punjab and North-West Frontier Provinces, and Azad Kashmir, Pakistan: in Kazmi, A. H., ed., Proceedings of a workshop on the Significance of Coal Resources of Pakistan, February 8-9, Karachi, Pakistan: Geological Survey of Pakistan, Quetta, 18 manuscript pages (in press).

Warwick, P. D., and Javed, S., 1990, Quality and character of Pakistan coal: in Kazmi, A. H., ed., Proceedings of a workshop on the Significance of Coal Resources of Pakistan, February 8-9, Karachi, Pakistan: Geological Survey of Pakistan, Quetta, 17 manuscript pages (in press).

Warwick, P. D., and Shakoor, T., 1988a, Controls on the distribution and lithofacies of marginal-marine Paleocene formations of the Salt Range, Pakistan: Geological Society of America, Abstracts with Programs, vol. 20, no. 7, p. A90.

Warwick, P. D., and Shakoor, T., 1988b, Preliminary report on the coal characteristics in the Salt Range area of north-central Pakistan: U.S. Geological Survey Open File Report 88-637, 333 p. (Also Geological Survey of Pakistan Project Report (IR) PK-83.)

Warwick, P. D., Shakoor, T., Javed, S., Mashhadi, S. T. A., and Ghaznavi, M. I., 1990, Chemical and physical characteristics of coal beds from the Salt Range coal field, Punjab Province, Pakistan: USGS research on energy resources - 1990 Program and Abstracts, Sixth V. E. McKelvey Forum on Mineral and Energy Resources, U.S. Geological Survey Circular 1060, p. 86.

Wells, N. A., 1984, Marine and continental sedimentation in the early Cenozoic Kohat Basin and adjacent northwestern Indo-Pakistan: Ph.D. dissertation, University of Michigan, Ann Arbor, Michigan, 465 p.

Wynne, A. B., 1878, Geology of the Salt Range in the Punjab: Memoirs of the Geological Survey of India, vol. 14, 313 p.

APPENDIX I. COAL AND CARBONACEOUS SHALE
SAMPLE BACKGROUND DATA

Dashed line indicates no data or not applicable.

SAMPLE NUMBER	LONGITUDE	LATITUDE	DISTRICT	DATE COLLECTED	COLLECTOR	MINE NAME
85-SDT-001	725500 E	323930 N	KHUSHAB	--------	GHAZNAVI	----------
85-SKA-003	723940 E	323358 N	JEHLUM	--------	GHAZNAVI	----------
85-SPR-002	723100 E	323700 N	KHUSHAB	--------	GHAZNAVI	----------
85MIG104	730140 E	324255 N	JEHLUM	--------	GHAZNAVI	RAKH DIWAN
85MIG105	730012 E	324010 N	JEHLUM	--------	GHAZNAVI	KARANGAL
85MIG109	725225 E	324050 N	JEHLUM	--------	GHAZNAVI	CHITTI DAND
85MIG111	725030 E	324130 N	JEHLUM	--------	GHAZNAVI	DALWAL
85MIG116	722115 E	323258 N	KUSHAB	--------	GHAZNAVI	ARARA
86-TGM-1	725830 E	324253 N	JEHLUM	--------	GHAZNAVI	AFTAB COAL COMPANY
86-TGM-2	731010 E	324445 N	JEHLUM	--------	GHAZNAVI	SIDHANDI
86-TGM-3	730930 E	324555 N	JEHLUM	--------	GHAZNAVI	MUNAWAR
86-TGM-4	731225 E	324430 N	JEHLUM	--------	GHAZNAVI	NAWAZ
86-TGM-7	730036 E	324410 N	JEHLUM	--------	GHAZNAVI	NAZAZ NO 33
86-TGM-8	730550 E	324800 N	JEHLUM	--------	GHAZNAVI	HASAIN
86-TGM-9	730005 E	324355 N	JEHLUM	--------	GHAZNAVI	NAWAZ
ARA-DD-6	731155 E	324345 N	JEHLUM	01/18/88	WARWICK & SHAKOOR	DHOLA DHER NO. 6
ARA-MC-5	730815 E	324450 N	JEHLUM	01/19/88	WARWICK & SHAKOOR	MUNAWER CORP. NO.5
ARA-MN-19	731625 E	324340 N	JHELUM	12/12/87	WARWICK & SHAKOOR	MEHR NAZER & CO.
ARA-TC-6	731030 E	324440 N	JEHLUM	01/24/88	WARWICK & SHAKOOR	TARIQ COAL CO. MINE NO. 6
ARR-HM-RT-A	722055 E	323250 N	KHUSHAB	03/26/88	WARWICK & SHAKOOR	HAYAL-UL-MIR COAL CO.
ARR-HM-RT-B	722055 E	323250 N	KHUSHAB	03/26/88	WARWICK & SHAKOOR	HAYAT-UL-MIR COAL CO.
ARR-JV-7	722330 E	323310 N	KHUSHAB	03/23/88	WARWICK & SHAKOOR	JHELUM VALLEY COAL CO.
CB-KC-3A	722510 E	323425 N	KHUSHAB	03/22/88	WARWICK & SHAKOOR	KATHA COLLIERIES NO. 3
CB-KC-3B	722510 E	323425 N	KHUSHAB	03/22/88	WARWICK & SHAKOOR	KATHA COLLIERIES NO. 3
CD-DL-4	725030 E	323940 N	JEHLUM	04/21/88	WARWICK & SHAKOOR	CHITTIDAND COLLIERY NO. 4
CGAS-HCC-3	730625 E	324850 N	JEHLUM	02/10/88	WARWICK & SHAKOOR	HUSSAIN COAL CO.
DANDOT-CA-2	725510 E	324100 N	JEHLUM	10/07/88	WARWICK & SHAKOOR	CAPTAIN ABID MINE NO. 2
DANDOT-KC-6	725603 E	323933 N	JEHLUM	01/26/88	HUSSAIN & JAVED	----------
DANDOT-PJ-M1	725717 E	323905 N	JEHLUM	01/26/88	HUSSAIN & JAVED	DANDOT MAIN INCLINE, PUNJMIN
DANDOT-PJ-PG-1	725919 E	324030 N	JEHLUM	01/28/88	HUSSAIN & JAVED	PUNJMIN-PG
DANDOT-SP-6	725636 E	324033 N	JEHLUM	01/11/88	HUSSAIN & JAVED	SUPER PUNJAB COAL CO. MINE NO.6
DSD-13-2	725615 E	324352 N	JEHLUM	02/18/88	MASHHADI	----------
DSD-14-3	725607 E	323955 N	JEHLUM	03/14/88	MASHHADI	----------
DSD-15-4	725624 E	324012 N	JEHLUM	03/31/88	MASHHADI	----------
DSD-16-5	725722 E	324000 N	JEHLUM	04/14/88	MASHHADI	----------
DSM-18-6	730147 E	324325 N	JEHLUM	06/14/88	MASHHADI	----------
JT-MDM-5B	732340 E	325010 N	JEHLUM	02/06/88	WARWICK & SHAKOOR	MALIK DOST MOHAMAD & CO.
KK-GH-8A	724225 E	323725 N	JEHLUM	02/21/88	WARWICK & SHAKOOR	GULZAR & CO. HASNAIN COLLIERY MINE NO. 8
KK-GH-8B	724225 E	323725 N	JEHLUM	02/21/88	WARWICK & SHAKOOR	GULZAR & CO. HASNAIN COLLIERY MINE NO. 8
KW-CYS-1	720850 E	323025 N	KHUSHAB	03/29/88	WARWICK & SHAKOOR	CHAUDRY YOUNES SHAFIQ & CO.
M-SAL-1	723325 E	323925 N	JEHLUM	03/08/88	WARWICK & SHAKOOR	S.A. LATIF & CO.
MN-1	730105 E	324308 N	JEHLUM	06/02/88	MASHHADI & JAVED	----------
MN-10	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-11	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-2	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-3	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-4	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-5	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-6	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-7	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-8	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
MN-9	730105 E	324308 N	JEHLUM	06/03/88	MASHHADI & JAVED	----------
NW-JV-1	723725 E	323645 N	JEHLUM	02/22/88	WARWICK & SHAKOOR	JAVED & CO.
NW-MAM-2	723515 E	323805 N	JEHLUM	03/02/88	WARWICK & SHAKOOR	MALIK ATA MOHAMMED & CO. NO. 2
P-KB-6B	722845 E	323640 N	KHUSHAB	03/09/88	WARWICK & SHAKOOR	KARAM BUTSH & CO. NO. 6B
P-KC-12	723535 E	323530 N	KHUSHAB	03/06/88	WARWICK & SHAKOOR	KHYBER COAL CO. NO. 12
PJ-PCP-1	723100 E	323745 N	KHUSHAB	03/03/88	WARWICK & SHAKOOR	PUNJMIN PCP NO. 1
PJ-PCP-2A	723120 E	323815 N	KHUSHAB	03/03/88	WARWICK & SHAKOOR	PUNJMIN PCP-2
PJ-PCP-2B	723120 E	323815 N	KHUSHAB	03/03/88	WARWICK & SHAKOOR	PUNJMIN PCP-2
TSD-7-1	725605 E	324307 N	JEHLUM	02/03/88	ANWAR & MASHHADI	----------

APPENDIX I. SAMPLE BACKGROUND DATA
(continued)
Dashed line indicates no data or not applicable.

SAMPLE NUMBER	SAMPLE INTERVAL THICKNESS (m)	DEPTH TO TOP OF COAL BED (m)	DRILL HOLE NUMBER	ROOF ROCK TYPE	FLOOR ROCK TYPE
85-SDT-001	0.76	------	------	--------	--------
85-SKA-003	0.91	------	------	--------	--------
85-SPR-002	0.79	------	------	--------	--------
85MIG104	----	------	------	--------	--------
85MIG105	----	------	------	--------	--------
85MIG109	----	------	------	--------	--------
85MIG111	----	------	------	--------	--------
85MIG116	----	------	------	--------	--------
86-TGM-1	0.36	------	------	--------	--------
86-TGM-2	----	------	------	--------	--------
86-TGM-3	----	------	------	--------	--------
86-TGM-4	----	------	------	--------	--------
86-TGM-7	----	------	------	--------	--------
86-TGM-8	----	------	------	--------	--------
86-TGM-9	----	------	------	--------	--------
ARA-DD-6	0.61	------	------	SHALE	SHALE
ARA-MC-5	0.46	------	------	SILTSTONE	SANDSTONE
ARA-MM-19	0.29	------	------	CARBONACEOUS SHALE	--------
ARA-TC-6	0.30	------	------	SHALE	CARBONACEOUS SHALE
ARR-HM-RT-A	0.43	------	------	SANDSTONE/SHALE	SHALE
ARR-HM-RT-B	0.12	------	------	SILTSTONE/SHALE	SHALE
ARR-JV-7	0.55	------	------	SANDSTONE/SHALE	SILTSTONE
CB-KC-3A	0.12	------	------	SHALE	SHALE
CB-KC-3B	0.27	------	------	SILTSTONE/SHALE	SHALE
CD-DL-4	0.38	------	------	SHALE	SHALE
CGAS-HCC-3	0.30	------	------	SHALE	SHALE
DANDOT-CA-2	0.36	------	------	CARBONACEOUS SHALE	CARBBONACEOUS SHALE
DANDOT-KC-6	0.99	------	------	CARBONACEOUS SHALE	SHALE
DANDOT-PJ-M1	0.91	------	------	SHALE	SHALE
DANDOT-PJ-PG-1	1.11	------	------	SILTSTONE	SHALE
DANDOT-SP-6	0.56	------	------	SHALE	SHALE
DSD-13-2	0.30	118.51	DSD-13	SHALE	SHALE
DSD-14-3	0.91	117.35	DSD-14	SHALE	SHALE
DSD-15-4	0.42	98.14	DSD-15	CARBONACEOUS SHALE	SHALE
DSD-16-5	0.51	96.62	DSD-16	SHALE	CARBONACEOUS SHALE
DSM-18-6	0.82	82.60	DSM-18	SHALE	SHALE
JT-MDM-5B	0.61	------	------	SHALE	SANDSTONE/SILTSTONE
KK-GH-8A	0.61	------	------	SHALE/SANDSTONE	SHALE
KK-GH-8B	0.27	------	------	SHALE	SHALE
KW-CYS-1	0.55	------	------	SHALE	SILTSTONE
M-SAL-1	0.24	------	------	SHALE	SHALE
MN-1	0.46	66.55	DSM-17	MARL	LOST
MN-10	1.52	82.85	DSM-17	LOST	SHALE
MN-11	0.46	84.37	DSM-17	SHALE	SANDSTONE - PERMIAN
MN-2	1.37	68.09	DSM-17	LOST	LOST
MN-3	1.52	70.10	DSM-17	LOST	SHALE
MN-4	1.37	71.62	DSM-17	SHALE	LOST
MN-5	1.40	73.22	DSM-17	LOST	LOST
MN-6	1.61	74.90	DSM-17	LOST	LOST
MN-7	1.66	77.72	DSM-17	LOST	SHALE
MN-8	1.52	79.38	DSM-17	SHALE	SHALE
MN-9	1.52	80.90	DSM-17	SHALE	LOST
NW-JV-1	0.43	------	------	SHALE/SANDSTONE	CARB SHALE
NW-MAM-2	0.26	------	------	SHALE	SHALE
P-KB-6B	0.46	------	------	SHALE	SHALE W/SS
P-KC-12	0.46	------	------	SHALE	SHALE
PJ-PCP-1	0.33	142.34	------	SHALE	SANDSTONE/SHALE
PJ-PCP-2A	0.58	------	------	SILTSTONE	SHALE
PJ-PCP-2B	0.24	------	------	SHALE	SILTSTONE
TSD-7-1	0.23	95.70	TSD-7	SHALE	SHALE

Appendix II. Proximate and ultimate analyses and calorific value determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

[All analyses except calorific value in percent. For each sample number, the analyses are reported to four bases: first, equilibrium moisture basis; second, as-received basis; third, moisture-free basis; and fourth, moisture- and ash-free basis. Dashed line indicates not analyzed. All analyses by commercial testing laboratories following ASTM (1986) standards.]

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
85-SDT-001	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	11.44	13.84	35.36	39.36	57.19	5.47	0.95	----	2.71	19.84	10,279	5,715
	-----	15.63	39.93	44.44	64.58	4.73	1.07	----	3.05	10.94	11,607	6,453
	-----	-----	47.33	52.67	76.54	5.61	1.27	----	3.62	12.96	13,757	7,649
85-SKA-003	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	14.46	13.63	32.06	39.85	52.71	5.37	0.95	----	7.02	20.32	9,574	5,323
	-----	15.93	37.48	46.59	61.63	4.39	1.10	----	8.21	8.74	11,192	6,223
	-----	-----	44.58	55.42	73.31	5.22	1.31	----	9.77	10.39	13,313	7,402
85-SPR-002	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	9.23	18.48	35.03	37.26	51.66	4.90	1.01	----	8.62	15.33	9,880	5,493
	-----	20.36	38.59	41.05	56.92	4.26	1.11	----	9.49	7.86	10,885	6,052
	-----	-----	48.46	51.54	71.47	5.35	1.39	----	11.92	9.87	13,668	7,599
85MIG104	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	7.11	13.51	40.86	38.52	58.60	5.41	0.88	----	4.88	16.72	10,865	6,041
	-----	14.54	43.98	41.48	63.08	4.97	0.94	----	5.26	11.21	11,696	6,503
	-----	-----	51.46	48.54	73.82	5.82	1.10	----	6.16	13.10	13,687	7,610
85MIG105	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	10.14	28.02	29.32	32.52	44.50	4.55	0.81	----	2.47	19.65	7,852	4,366
	-----	31.18	32.63	36.19	49.52	3.80	0.90	----	2.47	11.86	8,738	4,858
	-----	-----	47.42	52.58	71.96	5.52	1.31	----	3.98	17.23	12,698	7,060
85MIG109	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	10.06	10.53	36.66	42.75	58.18	5.34	0.85	----	4.80	20.30	10,520	5,849
	-----	11.71	40.76	47.53	64.69	4.69	0.94	----	5.33	12.64	11,696	6,503
	-----	-----	46.16	53.84	73.27	5.31	1.06	----	6.04	14.32	13,247	7,365
85MIG111	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	4.79	55.98	22.68	16.55	25.52	3.18	0.43	----	2.85	12.04	4,650	2,585
	-----	58.80	23.83	17.37	26.81	2.78	0.45	----	2.99	8.17	4,884	2,715
	-----	-----	57.84	42.16	65.07	6.75	1.09	----	7.26	19.83	11,854	6,590

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
85MIG116	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	5.32	11.25	46.72	36.71	63.33	5.96	1.16	----	2.96	15.34	11,829	6,577
	-----	11.89	49.35	38.76	66.88	5.67	1.23	----	3.12	11.21	12,494	6,947
	-----	-----	56.01	43.99	75.90	6.43	1.40	----	3.54	12.73	14,179	7,883
86-TGM-1	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	9.01	29.67	30.62	30.70	44.04	4.60	0.71	----	3.63	17.35	8,080	4,492
	-----	32.61	33.65	33.74	48.40	3.95	0.78	----	3.99	10.27	8,880	4,937
	-----	-----	49.93	50.07	71.82	5.86	1.16	----	5.92	15.24	13,177	7,326
86-TGM-2	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	5.45	43.55	26.89	24.11	34.64	3.64	0.45	----	4.82	12.90	6,282	3,493
	-----	46.06	28.44	25.50	36.63	3.20	0.47	----	5.10	8.54	6,645	3,695
	-----	-----	52.72	47.28	67.91	5.93	0.87	----	9.45	15.84	12,319	6,849
86-TGM-3	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	5.28	56.89	22.04	15.79	24.34	3.13	0.34	----	1.65	13.65	4,239	2,357
	-----	60.06	23.26	16.68	25.70	2.68	0.36	----	1.74	9.46	4,475	2,488
	-----	-----	58.23	41.77	64.34	6.71	0.90	----	4.36	23.69	11,204	6,229
86-TGM-4	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	10.01	37.30	24.85	27.84	36.80	3.93	0.44	----	5.51	16.02	6,585	3,661
	-----	41.45	27.62	30.93	40.89	3.12	0.49	----	6.12	7.93	7,317	4,068
	-----	-----	47.17	52.83	69.84	5.33	0.84	----	10.45	13.54	12,497	6,948
86-TGM-7	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	7.31	51.22	20.36	21.11	28.06	3.15	0.42	----	2.13	15.02	5,123	2,848
	-----	55.26	21.96	22.78	30.27	2.51	0.46	----	2.29	9.21	5,527	3,073
	-----	-----	49.08	50.92	67.66	5.61	1.03	----	5.12	20.58	12,353	6,868
86-TGM-8	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	5.58	66.99	15.53	11.90	12.48	2.13	0.18	----	9.12	9.10	2,605	1,448
	-----	70.95	16.45	12.60	13.22	1.60	0.19	----	9.66	4.38	2,759	1,534
	-----	-----	56.63	43.37	45.51	5.51	0.65	----	33.26	15.07	9,498	5,281
86-TGM-9	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	-----
	7.51	46.70	21.49	24.30	34.37	3.32	0.45	----	2.16	13.00	5,977	3,323
	-----	50.50	23.24	26.26	37.16	2.68	0.48	----	2.34	6.84	6,462	3,593
	-----	-----	46.94	53.06	75.06	5.41	0.97	----	4.73	13.83	13,053	7,257
ARA-DD-6	11.74	41.04	26.02	21.20	31.34	4.17	0.52	0.01	4.49	18.43	5,618	3,124
	8.16	42.71	27.08	22.05	32.61	3.89	0.54	0.01	4.67	15.57	5,846	3,250
	-----	46.50	29.48	24.02	35.51	3.24	0.59	0.01	5.09	9.06	6,365	3,539
	-----	-----	55.11	44.89	-----	----	----	----	9.51	-----	11,898	6,615

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
ARA-MC-5	5.79	39.45	28.99	25.77	39.48	4.02	0.64	0.01	2.89	13.51	7,320	4,070
	5.70	39.49	29.02	25.79	39.52	4.02	0.64	0.01	2.89	13.43	7,327	4,074
	-----	41.87	30.77	27.36	41.90	3.58	0.67	0.01	3.07	8.90	7,770	4,320
	-----	-----	52.94	47.06	-----	----	----	----	5.28	-----	13,368	7,433
ARA-MN-19	13.53	19.93	32.46	34.08	48.16	5.18	0.68	0.01	4.08	21.96	8,712	4,844
	14.15	19.78	32.23	33.84	47.82	5.22	0.68	0.01	4.05	22.44	8,649	4,809
	-----	23.04	37.54	39.42	55.70	4.24	0.79	0.01	4.71	11.51	10,075	5,602
	-----	-----	48.78	51.22	-----	----	----	----	6.13	-----	13,091	7,279
ARA-TC-6	9.28	24.66	33.25	32.81	47.16	4.98	0.75	0.01	6.28	16.16	8,806	4,896
	7.89	25.04	33.76	33.31	47.88	4.88	0.77	0.01	6.38	15.04	8,941	4,971
	-----	27.18	36.65	36.17	51.99	4.34	0.83	0.01	6.92	8.73	9,707	5,367
	-----	-----	50.34	49.66	-----	----	----	----	9.51	-----	13,330	7,411
ARR-HM-RT-A	8.82	19.11	36.89	35.18	51.13	4.84	0.92	0.02	11.12	12.86	9,667	5,375
	8.15	19.25	37.16	35.44	51.51	4.79	0.92	0.02	11.20	12.31	9,738	5,414
	-----	20.96	40.46	38.58	56.08	4.22	1.00	0.02	12.19	5.53	10,602	5,895
	-----	-----	51.19	48.81	-----	----	----	----	15.42	-----	13,414	7,458
ARR-HM-RT-B	6.74	26.59	35.45	31.22	47.86	4.86	0.87	0.02	5.95	13.85	8,986	4,996
	6.97	26.53	35.36	31.14	47.75	4.87	0.86	0.02	5.94	14.03	8,964	4,984
	-----	28.52	38.01	33.47	51.32	4.40	0.93	0.02	6.38	8.43	9,635	5,357
	-----	-----	53.18	46.82	-----	----	----	----	8.93	-----	13,479	7,494
ARR-JV-7	9.15	19.91	35.19	35.75	52.45	5.01	0.95	0.05	5.02	16.61	9,631	5,355
	9.67	19.80	34.98	35.55	52.15	5.04	0.94	0.05	4.99	17.03	9,576	5,324
	-----	21.92	38.73	39.35	57.74	4.39	1.05	0.05	5.52	9.33	10,601	5,894
	-----	-----	49.60	50.04	-----	----	----	----	7.07	-----	13,577	7,549
CB-KC-3A	5.45	31.74	35.64	27.17	47.06	4.81	0.94	0.02	4.18	11.25	8,664	4,817
	5.84	31.61	35.49	27.06	46.86	4.83	0.94	0.02	4.16	11.58	8,628	4,797
	-----	33.57	37.69	28.74	49.77	4.44	1.00	0.02	4.42	6.78	9,163	5,095
	-----	-----	56.74	43.26	-----	----	----	----	6.65	-----	13,794	7,669
CB-KC-3B	9.48	16.28	37.03	36.85	55.34	5.36	1.14	0.02	5.48	16.38	10,112	5,622
	9.58	16.33	37.13	36.96	55.50	5.34	1.15	0.02	5.50	16.16	10,141	5,638
	-----	18.06	41.07	40.87	61.38	4.72	1.27	0.02	6.08	8.47	11,215	6,235
	-----	-----	50.12	49.88	-----	----	----	----	7.42	-----	13,687	7,610

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
CD-DL-4	9.64	19.45	33.91	37.00	49.40	5.06	0.95	0.02	2.86	22.26	9,584	5,329
	10.42	19.28	33.61	36.69	48.98	5.11	0.94	0.02	2.83	22.84	9,501	5,282
	-----	21.53	37.52	40.95	54.67	4.41	1.05	0.02	3.16	15.16	10,606	5,897
	-----	-----	47.82	52.18	-----	----	----	----	4.03	-----	13,516	7,515
CGAS-HCC-3	8.71	37.39	25.67	28.23	36.17	4.72	0.66	0.02	10.91	10.13	6,738	3,746
	7.59	37.85	25.98	28.58	36.61	4.64	0.67	0.02	11.04	9.17	6,821	3,792
	-----	40.96	28.12	30.92	39.62	4.10	0.73	0.02	11.95	2.62	7,381	4,104
	-----	-----	47.62	52.38	-----	----	----	----	20.24	-----	12,501	6,951
DANDOT-CA-2	8.66	24.02	34.26	33.06	48.80	5.06	0.85	0.01	3.26	18.00	8,969	4,987
	7.30	24.37	34.77	33.56	49.53	4.97	0.87	0.01	3.31	16.94	9,102	5,061
	-----	26.29	37.51	36.20	53.43	4.48	0.94	0.01	3.57	11.28	9,819	5,459
	-----	-----	50.90	49.10	-----	----	----	----	4.84	-----	13,322	7,407
DANDOT-KC-6	9.41	21.95	35.35	33.29	50.12	5.13	0.92	0.01	4.19	17.68	9,205	5,118
	10.04	21.80	35.10	33.06	49.77	5.17	0.92	0.01	4.16	18.17	9,141	5,082
	-----	24.23	39.02	36.75	55.32	4.50	1.02	0.01	4.62	10.30	10,161	5,649
	-----	-----	51.49	48.51	-----	----	----	----	6.10	-----	13,410	7,456
DANDOT-PJ-M1	10.93	13.53	38.22	37.32	57.17	5.64	1.00	0.01	2.09	20.56	10,221	5,683
	11.49	13.45	37.98	37.08	56.81	5.68	0.99	0.01	2.08	20.98	10,157	5,647
	-----	15.19	42.91	41.90	64.19	4.96	1.12	0.01	2.35	12.18	11,475	6,380
	-----	-----	50.59	49.41	-----	----	----	----	2.77	-----	13,531	7,523
DANDOT-PJ-PG-1	9.58	23.99	32.98	33.45	47.96	4.92	0.87	0.02	5.48	16.76	8,847	4,919
	8.31	24.33	33.44	33.92	48.63	4.83	0.89	0.02	5.56	15.74	8,971	4,989
	-----	26.53	36.48	36.99	53.04	4.25	0.97	0.02	6.06	9.13	9,785	5,440
	-----	-----	49.65	50.35	-----	----	----	----	8.25	-----	13,319	7,405
DANDOT-SP-6	10.13	17.87	33.63	38.37	52.51	5.18	0.95	0.02	5.85	17.62	9,576	5,324
	9.05	18.08	34.03	38.84	53.14	5.11	0.96	0.02	5.92	16.77	9,691	9,691
	-----	19.88	37.42	42.70	58.43	4.50	1.06	0.02	6.51	9.60	10,655	5,924
	-----	-----	46.71	53.29	-----	----	----	----	8.13	-----	13,299	7,394
DSD-13-2	6.06	29.95	33.73	30.26	47.20	4.76	0.86	0.02	3.90	13.31	8,749	4,864
	6.67	29.75	33.51	30.07	46.90	4.80	0.85	0.02	3.88	13.80	8,692	4,833
	-----	31.88	35.90	32.22	50.25	4.34	0.91	0.02	4.15	8.45	9,313	5,178
	-----	-----	52.71	47.29	-----	----	----	----	6.10	-----	13,672	7,602
DSD-14-3	8.34	23.37	34.37	33.92	49.49	4.93	0.81	0.02	5.50	15.88	9,145	5,085
	8.70	23.28	34.23	33.79	49.30	4.95	0.81	0.02	5.48	16.16	9,109	5,065
	-----	25.49	37.49	37.02	53.99	4.36	0.89	0.02	6.00	9.25	9,977	5,547
	-----	-----	50.32	49.68	-----	----	----	----	8.05	-----	13,390	7,445

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
DSD-15-4	8.90	28.50	30.20	32.40	45.86	4.31	0.84	0.02	4.42	16.05	8,215	4,567
	9.76	28.23	29.92	32.09	45.42	4.38	0.83	0.02	4.38	16.74	8,137	4,524
	-----	31.28	33.15	35.57	50.34	3.64	0.92	0.02	4.85	8.95	9,017	5,013
	-----	-----	48.25	51.75	-----	----	----	----	7.06	-----	13,122	7,296
DSD-16-5	8.00	25.16	33.33	33.51	49.44	4.24	0.87	0.02	6.53	13.74	9,001	5,005
	9.42	24.77	32.81	33.00	48.67	4.35	0.85	0.02	6.43	14.91	8,862	4,927
	-----	27.34	36.23	36.43	53.74	3.64	0.94	0.02	7.09	7.23	9,783	5,439
	-----	-----	49.86	50.14	-----	----	----	----	9.76	-----	13,465	7,486
DSM-18-6	4.90	78.27	11.07	5.76	9.26	1.64	0.20	0.01	4.41	6.21	1,723	958
	5.04	78.15	11.05	5.76	9.24	1.66	0.20	0.01	4.41	6.33	1,720	956
	-----	82.30	11.64	6.06	9.74	1.15	0.21	0.01	4.64	1.95	1,812	1,007
	-----	-----	65.73	34.27	-----	----	----	----	26.21	-----	10,234	5,690
JT-MDM-5B	6.33	21.77	34.49	37.41	53.62	4.89	0.83	0.02	3.49	15.38	9,778	5,437
	6.91	21.64	34.27	37.18	53.29	4.93	0.83	0.02	3.47	15.82	9,718	5,403
	-----	23.24	36.82	39.94	57.25	4.47	0.89	0.02	3.72	10.41	10,439	5,804
	-----	-----	47.97	52.03	-----	----	----	----	4.85	-----	13,600	7,561
KK-GH-8A	11.40	10.11	39.38	39.11	59.95	5.90	1.05	0.13	2.03	20.83	10,848	6,031
	10.67	10.19	39.70	39.44	60.45	5.86	1.05	0.13	2.04	20.28	10,938	6,082
	-----	11.41	44.45	44.14	67.67	5.22	1.18	0.14	2.29	12.09	12,244	6,808
	-----	-----	50.17	49.83	-----	----	----	----	2.58	-----	13,821	7,684
KK-GH-8B	9.68	28.29	33.00	29.03	45.47	5.06	0.87	0.10	1.88	18.33	8,310	4,620
	8.32	28.72	33.50	29.46	46.16	4.97	0.88	0.10	1.91	17.26	8,435	4,690
	-----	31.32	36.54	32.14	50.34	4.40	0.96	0.11	2.09	10.78	9,201	5,116
	-----	-----	53.21	46.79	-----	----	----	----	3.04	-----	13,398	7,449
KW-CYS-1	14.21	25.97	28.93	30.89	38.80	4.52	0.66	0.02	11.74	18.29	7,364	4,094
	16.87	25.16	28.03	29.94	37.60	4.73	0.64	0.02	11.37	20.48	7,136	3,968
	-----	30.27	33.72	36.01	45.23	3.42	0.77	0.02	13.68	6.61	8,584	4,773
	-----	-----	48.36	51.64	-----	----	----	----	19.62	-----	12,309	6,844
M-SAL-1	7.71	16.42	37.52	38.35	55.69	5.11	1.24	0.05	8.44	13.05	10,549	5,865
	7.06	16.54	37.78	38.62	56.08	5.06	1.24	0.05	8.50	12.53	10,624	5,907
	-----	17.80	40.65	41.55	60.34	4.60	1.34	0.05	9.15	6.72	11,431	6,356
	-----	-----	49.45	50.55	-----	----	----	----	11.13	-----	13,905	7,731

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
MN-1	9.58	70.64	19.73	0.05	4.71	1.70	0.03	0.01	1.09	21.82	------	-----
	9.91	70.38	19.66	0.05	4.69	1.73	0.03	0.01	1.09	22.07	------	-----
	-----	78.13	21.82	0.05	5.21	0.69	0.03	0.01	1.21	14.72	------	-----
	-----	-----	99.76	0.24	-----	----	----	----	5.51	-----	------	-----
MN-10	2.80	81.23	15.81	0.16	1.63	1.51	0.04	0.02	3.37	12.20	------	-----
	1.86	82.01	15.96	0.17	1.64	1.42	0.04	0.02	3.41	11.46	------	-----
	-----	83.57	16.26	0.17	1.67	1.23	0.04	0.02	3.47	10.00	------	-----
	-----	-----	98.96	1.04	----	----	----	----	21.12	-----	------	-----
MN-11	3.22	83.65	12.79	0.34	1.10	1.49	0.03	0.01	1.80	11.92	------	-----
	1.73	84.94	12.98	0.35	1.12	1.34	0.03	0.01	1.83	10.73	------	-----
	-----	86.44	13.21	0.35	1.14	1.17	0.03	0.01	1.86	9.35	------	-----
	-----	-----	97.40	2.60	----	----	----	----	13.73	-----	------	-----
MN-2	9.78	77.86	12.33	0.03	1.77	2.05	0.04	0.01	0.94	17.33	------	-----
	8.98	78.55	12.44	0.03	1.79	1.97	0.04	0.01	0.95	16.69	------	-----
	-----	86.30	13.66	0.04	1.97	1.06	0.04	0.01	1.04	9.58	------	-----
	-----	-----	99.70	0.30	----	----	----	----	7.59	-----	------	-----
MN-3	7.20	85.26	7.40	0.14	0.77	1.73	0.04	0.02	0.72	11.46	------	-----
	6.12	86.26	7.49	0.13	0.78	1.62	0.04	0.02	0.72	10.56	------	-----
	-----	91.88	7.98	0.14	0.83	0.99	0.04	0.02	0.77	5.47	------	-----
	-----	-----	98.23	1.77	----	----	----	----	9.49	-----	------	-----
MN-4	6.08	83.94	9.91	0.07	1.69	1.64	0.04	0.01	2.48	10.20	58	32
	5.16	84.76	10.01	0.07	1.70	1.54	0.04	0.01	2.51	9.44	58	32
	-----	89.37	10.55	0.08	1.80	1.02	0.04	0.01	2.65	5.11	61	34
	-----	-----	99.23	0.77	----	----	----	----	24.88	-----	576	315
MN-5	7.60	81.99	10.37	0.04	3.27	1.69	0.08	0.02	1.76	11.19	244	135
	7.59	82.00	10.37	0.04	3.27	1.69	0.08	0.02	1.76	11.18	244	135
	-----	88.73	11.22	0.05	3.54	0.91	0.08	0.02	1.91	4.81	264	146
	-----	-----	99.54	0.46	----	----	----	----	16.94	-----	2,341	1,302
MN-6	10.93	81.16	7.82	0.09	1.09	1.98	0.01	0.01	1.27	14.48	------	-----
	10.88	81.21	7.83	0.08	1.10	1.97	0.01	0.01	1.27	14.43	------	-----
	-----	91.12	8.78	0.10	1.23	0.85	0.01	0.01	1.43	5.35	------	-----
	-----	-----	98.93	1.07	----	----	----	----	16.11	-----	------	-----

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
MN-7	8.77	81.92	9.26	0.05	1.33	1.84	0.04	0.01	2.27	12.59	------	-----
	7.85	82.75	9.36	0.04	1.34	1.75	0.04	0.01	2.30	11.81	------	-----
	-----	89.80	10.15	0.05	1.46	0.94	0.04	0.01	2.49	5.26	------	-----
	-----	-----	99.49	0.51	----	----	----	----	24.42	-----	------	-----
MN-8	3.81	89.50	6.68	0.01	0.49	1.05	0.01	0.02	2.34	6.59	------	-----
	5.03	88.37	6.59	0.01	0.48	1.18	0.01	0.02	2.31	7.63	------	-----
	-----	93.05	6.94	0.01	0.51	0.65	0.01	0.02	2.44	3.32	------	-----
	-----	-----	99.85	0.15	----	----	----	----	35.03	-----	------	-----
MN-9	2.43	93.60	3.92	0.05	0.26	0.51	0.03	0.02	0.80	4.78	------	-----
	5.92	90.25	3.78	0.05	0.25	0.90	0.03	0.02	0.77	7.78	------	-----
	-----	95.93	4.02	0.05	0.27	0.25	0.03	0.02	0.82	2.68	------	-----
	-----	-----	98.77	1.23	----	----	----	----	20.20	-----	------	-----
NW-JV-1	7.48	44.82	26.11	21.23	30.74	3.61	0.63	0.02	7.23	12.95	5,703	3,171
	6.92	45.27	26.38	21.43	31.05	3.54	0.63	0.02	7.30	12.19	5,760	3,203
	-----	48.63	28.34	23.03	33.36	2.97	0.68	0.02	7.85	6.49	6,189	3,441
	-----	-----	55.16	44.84	-----	----	----	----	15.28	-----	12,048	6,699
NW-MAM-2	10.48	18.43	32.89	38.20	51.13	5.05	1.05	0.02	9.54	14.78	9,608	5,342
	9.46	18.64	33.27	38.63	51.71	4.98	1.07	0.02	9.65	13.93	9,717	5,403
	-----	20.59	36.75	42.66	57.12	4.33	1.18	0.02	10.66	6.10	10,733	5,967
	-----	-----	46.27	53.73	-----	----	----	----	13.42	-----	13,515	7,514
P-KB-6B	9.05	21.56	32.23	37.16	51.09	4.76	0.97	0.03	7.39	14.20	9,443	5,250
	10.05	21.32	31.87	36.76	50.53	4.83	0.96	0.03	7.31	15.02	9,339	5,192
	-----	23.70	35.44	40.86	56.18	4.12	1.06	0.03	8.13	6.78	10,383	5,773
	-----	-----	46.44	53.56	-----	----	----	----	10.65	-----	13,608	7,566
P-KC-12	11.15	14.96	34.58	39.31	54.99	5.32	1.05	0.02	4.58	19.08	10,010	5,566
	12.09	14.80	34.21	38.90	54.41	5.38	1.04	0.02	4.53	19.82	9,904	5,507
	-----	16.84	38.92	44.24	61.89	4.58	1.18	0.02	5.16	10.33	11,266	6,264
	-----	-----	46.80	53.20	-----	----	----	----	6.20	-----	13,547	7,532
PJ-PCP-1	8.10	16.46	38.00	37.44	54.39	5.08	1.17	0.02	8.88	14.00	10,418	5,792
	7.78	16.52	38.13	37.57	54.58	5.06	1.18	0.02	8.91	13.73	10,454	5,812
	-----	17.91	41.35	40.74	59.18	4.54	1.27	0.02	9.66	7.42	11,336	6,303
	-----	-----	50.37	49.63	-----	----	----	----	11.77	-----	13,809	7,678

Appendix II (continued). Proximate and ultimate analyses and calorific values determinations for 60 coal samples from Punjab, Pakistan.

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS						CALORIFIC VALUE	
SAMPLE NUMBER	MOISTURE	ASH	VOLATILE MATTER	FIXED CARBON	CARBON	HYDROGEN	NITROGEN	CHLORINE	SULFUR	OXYGEN	BTU/LB	KCAL/KG
PJ-PCP-2A	7.70	34.10	27.24	30.96	44.02	4.11	0.89	0.04	3.16	13.68	8,001	4,449
	8.95	33.64	26.87	30.54	43.43	4.20	0.88	0.04	3.12	14.69	7,893	4,388
	-----	36.94	29.51	33.55	47.70	3.52	0.97	0.04	3.42	7.41	8,669	4,820
	-----	-----	46.81	53.19	-----	----	----	----	5.43	-----	13,748	7,644
PJ-PCP-2B	6.77	26.21	33.69	33.33	49.05	4.63	1.05	0.02	6.82	12.22	9,122	5,072
	5.75	26.49	34.05	33.71	49.59	4.56	1.06	0.02	6.89	11.39	9,221	5,127
	-----	28.11	36.13	35.76	52.61	4.15	1.13	0.02	7.31	6.67	9,784	5,440
	-----	-----	50.26	49.74	-----	----	----	----	10.17	-----	13,610	7,567
TSD-7-1	7.53	15.07	40.84	36.56	58.09	5.48	1.09	0.04	4.90	15.33	10,830	6,021
	9.11	14.81	40.14	35.94	57.10	5.58	1.07	0.04	4.82	16.58	10,645	5,917
	-----	16.30	44.16	39.54	62.82	5.02	1.18	0.04	5.30	9.34	11,712	6,512
	-----	-----	52.76	47.24	-----	----	----	----	6.33	-----	13,992	7,780

Appendix III. Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

[All analyses except free-swelling- and Hardgrove-Grindability-indices, and ash-fusion temperatures in percent. For each sample number, the analyses are reported to four bases: first, equilibrium moisture basis; second, as-received basis; third, moisture-free basis; and fourth, moisture- and ash-free basis. All analyses by commercial testing laboratories following ASTM (1986) standards. Dashed line = not analyzed.]

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GRINDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
85-SDT-001	-----	----	----						
	1.67	0.05	0.99	0.5	46	2160	2200	2500	2270
	1.89	0.05	1.11						
	2.24	0.06	1.32						
85-SKA-003	-----	----	----						
	5.67	0.20	1.15	0.5	53	2120	2160	2520	2190
	6.63	0.23	1.35						
	7.89	0.27	1.61						
85-SPR-002	-----	----	----						
	7.21	0.15	1.26	1.0	50	2120	2160	2370	2190
	7.94	0.16	1.39						
	9.97	0.20	1.75						
85MIG104	-----	----	----						
	2.54	0.16	2.18	0.5	----	2040	2100	----	2200
	2.73	0.18	2.35						
	3.19	0.21	2.76						
85MIG105	-----	----	----						
	0.90	0.47	1.10	0.0	----	2800+	2800+	----	2800+
	1.01	0.53	1.20						
	1.47	0.77	1.74						
85MIG109	-----	----	----						
	3.59	0.45	0.76	0.0	----	1960	2030	----	2070
	3.99	0.50	0.84						
	4.52	0.57	0.95						
85MIG111	-----	----	----						
	2.44	0.18	0.23	0.0	----	2800+	2800+	----	2800+
	2.56	0.19	0.24						
	6.21	0.46	0.59						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
85MIG116	-----	----	----						
	2.33	0.11	0.52	0.5	----	1980	2060	----	2190
	2.46	0.12	0.54						
	2.79	0.14	0.61						
86-TGM-1	-----	----	----						
	2.89	0.12	0.62	0.0	----	2600	2700	----	2730
	3.17	0.13	0.69						
	4.70	0.19	1.03						
86-TGM-2	-----	----	----						
	3.59	0.07	1.16	0.0	----	2610	2790	----	2800+
	3.80	0.08	1.22						
	7.04	0.15	2.26						
86-TGM-3	-----	----	----						
	0.95	0.09	0.61	0.0	----	2800+	2800+	----	2800+
	1.00	0.10	0.64						
	2.50	0.25	1.61						
86-TGM-4	-----	----	----						
	3.51	0.20	1.80	0.0	----	2720	2800+	----	2800+
	3.90	0.22	2.00						
	6.66	0.38	3.41						
86-TGM-7	-----	----	----						
	1.28	0.20	0.65	0.0	----	2600	2660	----	2720
	1.38	0.22	0.69						
	3.08	0.49	1.55						
86-TGM-8	-----	----	----						
	8.76	0.36	0.00	0.0	----	2370	2430	----	2510
	9.28	0.38	0.00						
	31.95	1.31	0.00						
86-TGM-9	-----	----	----						
	0.72	0.09	1.35	0.0	----	2800+	2800+	----	2800+
	0.77	0.10	1.47						
	1.56	0.20	2.97						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
ARA-DD-6	2.96	0.41	1.12						
	3.08	0.42	1.17	0.0	70	2410	2530	2700	2700
	3.35	0.46	1.28		(4.28)				
	6.27	0.86	2.38						
ARA-MC-5	1.26	0.06	1.57						
	1.26	0.06	1.57	0.0	47	2650	2700	2700	2700
	1.34	0.06	1.67		(2.18)				
	2.30	0.11	2.87						
ARA-MN-19	0.05	0.11	3.92						
	0.05	0.11	3.89	0.0	51	2450	2560	2580	2700
	0.05	0.13	4.53		(7.52)				
	0.07	0.17	5.89						
ARA-TC-6	4.15	0.23	1.90						
	4.21	0.23	1.94	0.0	46	2100	2180	2220	2460
	4.57	0.25	2.10		(3.80)				
	6.28	0.34	2.89						
ARR-HM-RT-A	9.47	0.18	1.20						
	9.81	0.18	1.21	0.0	49	2000	2090	2100	2200
	10.69	0.19	1.31		(2.39)				
	13.52	0.25	1.65						
ARR-HM-RT-B	4.93	0.14	0.88						
	4.92	0.14	0.88	0.0	47	2000	2270	2350	2380
	5.29	0.15	0.94		(2.09)				
	7.40	0.21	1.32						
ARR-JV-7	3.50	0.28	1.24						
	3.48	0.28	1.23	0.0	54	2500	2510	2520	2580
	3.85	0.31	1.36		(2.40)				
	4.93	0.39	1.75						
CB-KC-3A	3.80	0.11	0.27						
	3.79	0.11	0.26	0.0	36	2140	2410	2470	2500
	4.02	0.11	0.29		(1.79)				
	6.05	0.17	0.43						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
CB-KC-3B	4.77	0.14	0.57						
	4.79	0.14	0.57	0.0	47	1960	2040	2120	2380
	5.29	0.15	0.64		(2.92)				
	6.46	0.19	0.77						
CD-DL-4	2.37	0.05	0.44						
	2.35	0.05	0.43	0.0	50	2120	2480	2530	2610
	2.63	0.05	0.48		(2.86)				
	3.35	0.07	0.61						
CGAS-HCC-3	9.42	0.18	1.31						
	9.53	0.18	1.33	0.0	61	2030	2270	2370	2410
	10.32	0.19	1.44		(2.09)				
	17.47	0.33	2.44						
DANDOT-CA-2	1.44	0.07	1.75						
	1.47	0.07	1.77	0.0	51	2700	2700	2700	2700
	1.58	0.07	1.92		(3.82)				
	2.14	0.10	2.60						
DANDOT-KC-6	2.98	0.08	1.13						
	2.96	0.07	1.13	0.0	51	2340	2440	2460	2510
	3.29	0.08	1.25		(3.71)				
	4.34	0.11	1.65						
DANDOT-PJ-M1	0.95	0.07	1.07						
	0.95	0.07	1.06	0.0	71	2170	2420	2540	2630
	1.07	0.07	1.21		(5.56)				
	1.26	0.09	1.42						
DANDOT-PJ-	4.03	0.12	1.33						
PG-1	4.09	0.13	1.34	0.0	53	2100	2280	2350	2410
	4.46	0.14	1.46		(4.84)				
	6.06	0.19	2.00						
DANDOT-SP-6	4.56	0.21	1.08						
	4.61	0.21	1.10	0.0	53	2000	2230	2330	2480
	5.07	0.23	1.21		(4.33)				
	6.33	0.29	1.51						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
DSD-13-2	2.94	0.04	0.92						
	2.92	0.04	0.92	0.0	----	2490	2590	2650	2700
	3.13	0.04	0.98						
	4.60	0.06	1.44						
DSD-14-3	4.49	0.07	0.94						
	4.47	0.07	0.94	0.0	47	2060	2380	2460	2500
	4.90	0.08	1.02		(1.82)				
	6.58	0.11	1.36						
DSD-15-4	3.81	0.05	0.56						
	3.77	0.05	0.56	0.0	53	2370	2450	2500	2600
	4.18	0.05	0.62		(2.12)				
	6.08	0.07	0.91						
DSD-16-5	5.54	0.05	0.94						
	5.45	0.05	0.93	0.0	53	1950	2100	2270	2350
	6.02	0.05	1.02		(2.17)				
	8.29	0.07	1.40						
DSM-18-6	3.97	0.08	0.36						
	3.96	0.08	0.37	0.0	81	2330	2670	2700	2700
	4.18	0.08	0.38		(1.08)				
	23.59	0.46	2.16						
JT-MDM-5B	2.18	0.07	1.24						
	2.17	0.07	1.23	0.0	47	2700	2700	2700	2700
	2.33	0.07	1.32		(2.25)				
	3.04	0.09	1.72						
KK-GH-8A	1.23	0.06	0.74						
	1.24	0.06	0.74	0.0	49	2130	2170	2190	2380
	1.38	0.07	0.84		(2.51)				
	1.56	0.08	0.94						
KK-GH-8B	1.24	0.07	0.57						
	1.26	0.07	0.58	0.0	41	2610	2700	2700	2700
	1.38	0.08	0.63		(1.26)				
	2.01	0.12	0.91						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
KW-CYS-1	9.81	0.16	1.77						
	9.51	0.16	1.70	0.0	65	2010	2050	2060	2360
	11.44	0.19	2.05		(4.25)				
	16.40	0.27	2.95						
M-SAL-1	7.44	0.07	0.93						
	7.49	0.07	0.94	0.0	45	2050	2060	2070	2150
	8.06	0.07	1.02		(1.38)				
	9.81	0.09	1.23						
MN-1	0.89	0.05	0.15						
	0.89	0.05	0.15	0.0	111	2060	2100	2110	2170
	0.99	0.05	0.17		(3.81)				
	4.52	0.24	0.75						
MN-10	3.12	0.16	0.09						
	3.15	0.16	0.10	0.0	59	2590	2700	2700	2700
	3.21	0.16	0.10		(0.87)				
	19.52	0.98	0.62						
MN-11	1.72	0.08	0.00						
	1.74	0.08	0.01	0.0	63	2630	2700	2700	2700
	1.77	0.08	0.01		(0.69)				
	13.07	0.59	0.07						
MN-2	0.87	0.04	0.03						
	0.88	0.04	0.03	0.0	69	2140	2210	2300	2560
	0.97	0.04	0.03		(3.82)				
	7.06	0.30	0.23						
MN-3	0.67	0.04	0.01						
	0.68	0.04	0.00	0.0	64	2330	2360	2500	2570
	0.72	0.04	0.01		(2.71)				
	8.86	0.51	0.12						
MN-4	2.34	0.07	0.07						
	2.36	0.07	0.08	0.0	75	2310	2370	2550	2610
	2.49	0.07	0.09		(2.08)				
	23.44	0.67	0.77						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
MN-5	1.65	0.05	0.06						
	1.65	0.05	0.06	0.0	110	2180	2310	2450	2660
	1.79	0.05	0.07		(2.57)				
	15.85	0.46	0.63						
MN-6	1.23	0.03	0.01						
	1.23	0.03	0.01	0.0	91	2080	2260	2350	2530
	1.38	0.03	0.02		(5.61)				
	15.51	0.36	0.24						
MN-7	1.78	0.03	0.46						
	1.80	0.03	0.47	0.0	78	2160	2220	2340	2560
	1.95	0.03	0.51		(3.28)				
	19.15	0.30	4.97						
MN-8	2.14	0.18	0.02						
	2.11	0.18	0.02	0.0	89	2630	2700	2700	2700
	2.22	0.19	0.03		(1.03)				
	31.98	2.76	0.29						
MN-9	0.71	0.08	0.01						
	0.69	0.08	0.00	0.0	----	2700	2700	2700	2700
	0.73	0.08	0.01						
	17.98	1.97	0.25						
NW-JV-1	5.89	0.26	1.08						
	5.95	0.26	1.09	0.0	51	2390	2460	2510	2640
	6.39	0.28	1.18		(1.61)				
	12.45	0.55	2.28						
NW-MAM-2	8.31	0.26	0.97						
	8.41	0.26	0.98	0.0	50	2020	2050	2060	2120
	9.28	0.29	1.09		(2.41)				
	11.96	0.36	1.37						
P-KB-6B	6.20	0.12	1.07						
	6.13	0.12	1.06	0.0	53	1980	1990	2000	2380
	6.82	0.13	1.18		(2.33)				
	8.94	0.17	1.54						

Appendix III (continued). Forms-of-sulfur, free-swelling- and Hardgrove-Grindability-index, and ash-fusion-temperature determinations for 60 coal and carbonaceous shale samples from Punjab, Pakistan.

SAMPLE NUMBER	FORMS OF SULFUR			FREE SWELLING INDEX	HARDGROVE GIRNDABILITY INDEX (AT % MOISTURE)	ASH FUSION TEMPERATURE, °F			
	PYRITIC	SULFATE	ORGANIC			INITIAL DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
P-KC-12	4.13	0.10	0.35						
	4.09	0.10	0.34	0.0	49	1950	2200	2340	2550
	4.65	0.11	0.40		(2.44)				
	5.60	0.14	0.46						
PJ-PCP-1	7.98	0.16	0.74						
	8.00	0.16	0.75	0.0	44	2040	2060	2070	2120
	8.68	0.17	0.81		(1.95)				
	10.57	0.21	0.99						
PJ-PCP-2A	2.78	0.04	0.34						
	2.74	0.04	0.34	0.0	58	2640	2690	2700	2700
	3.01	0.04	0.37		(1.88)				
	4.77	0.06	0.60						
PJ-PCP-2B	5.90	0.15	0.77						
	5.96	0.15	0.78	0.0	44	1930	2030	2150	2350
	6.33	0.16	0.82		(1.39)				
	8.80	0.23	1.14						
TSD-7-1	4.26	0.05	0.59						
	4.19	0.05	0.58	0.0	----	1960	1990	2050	2280
	4.61	0.05	0.64						
	5.51	0.06	0.76						

Table IV. Major-, minor-, and trace-element composition of selected coal and carbonaceous shale samples from Punjab, Pakistan, reported on a whole-coal basis.

[Values in percent or parts-per-million. 22 elements are from determinations on whole-coal: all other elements calculated from analyses of ash. L means less than the value shown; H, interference for an element which cannot be resolved by any routine method; G, greater than; S, after element title indicates determinations by automatic plate reading computer assisted, emission spectrographic analyses. For elements by emission spectrographic analysis, the standard deviation of any answer should be taken as plus 50% and minus 35%. Sample number is field number. Analytical procedures after Golightly and Simon, 1989.]

SAMPLE NUMBER	Si (%)	Al (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Fe (%)	Ti (%)
85-SDT-001	3.0	1.6	0.28	0.12	0.029	0.079	2.1	0.44
85-SKA-003	1.4	.83	.21	.073	.010	.044	5.5	.13
85-SPR-002	2.3	1.0	.13	.058	.042	.10	6.8	.16
85MIG104	2.4	2.0	.18	.056	.046	.13	2.6	.16
85MIG105	7.4	4.5	.14	.16	.069	.37	1.5	.43
85MIG109	1.2	1.1	.16	.033	.073	.015	3.8	.050
85MIG111	14	9.5	.24	.27	.13	.48	3.1	1.3
85MIG116	1.8	1.3	.23	.039	.040	.053	2.2	.15
86-TGM-1	7.5	4.8	.16	.085	.038	.20	3.1	.56
86-TGM-2	11	6.5	.21	.11	.077	.36	3.6	1.1
86-TGM-3	16	9.3	.18	.12	.071	.35	1.4	1.6
86-TGM-4	15	2.1	.15	.044	.040	.10	3.2	.46
86-TGM-7	19	3.8	.17	.064	.054	.19	1.6	2.3
86-TGM-8	17	8.0	.31	.14	.063	.30	9.1	1.0
86-TGM-9	21	1.4	.19	.039	.049	.034	.72	.32

SAMPLE NUMBER	Ag-S PPM	As PPM	B-S PPM	Ba-S PPM	Be-S PPM	Br PPM	Cd PPM	Ce PPM	Cl PPM	Co PPM	Cr PPM	Cs PPM
85-SDT-001	0.097	5.2	110	20	4.8	1.2	0.11	28	100L	7.6	39	0.24
85-SKA-003	.12	7.9	100	5.7	3.5	1.2	.070	14	100L	5.2	14	.30L
85-SPR-002	.17	27	130	34	5.6	1.0	.13	18	100L	3.3	20	.47
85MIG104	.044	4.0	89	17	1.6	3.5	.057	2.5	100L	0.44	3.7	.08
85MIG105	.45	4.4	190	42	5.7	7.3	.21	13	100L	3.3	17	.50
85MIG109	.053	13	68	2.7	5.1	7.0	.23	1.3	120	1.6	2.2	.03L
85MIG111	.16	13	140	100	3.3	2.8	.12	45	100L	16	72	1.0
85MIG116	.034	2.0	71	15	5.6	2.5	.18	3.8	100L	.10	4.0	.03
86-TGM-1	.082	6.7	160	35	5.3	9.3	.063	13	100L	2.2	23	.20
86-TGM-2	.095	10	110	64	2.3	4.2	.091	31	100L	4.0	55	.77
86-TGM-3	.11	8.4	130	83	1.9	3.4	.12L	45	100L	3.5	78	1.1
86-TGM-4	.072	13	110	13L	1.5	7.0	.080L	5.2	100L	3.6	9.9	.13
86-TGM-7	1.3	5.4	170	65	7.5	6.1	.11	30	100L	1.3	60	.34
86-TGM-8	.18	30	77	66	2.9	3.8	.14L	53	100L	9.2	91	.69
86-TGM-9	.23L	1.4	110	16L	1.5	13	.098L	5.1	100L	.58	9.7	.10L

Table IV. (continued) Major-, minor-, and trace-element composition of coal and carbonaceous shale samples from Punjab, Pakistan, reported on a whole-coal basis.

SAMPLE NUMBER	Cu PPM	Eu PPM	F PPM	Ga-S PPM	Ge-S PPM	Hf PPM	Hg PPM	La PPM	Li PPM	Lu PPM
85-SDT-001	18	0.82	50	13	13	3.0	0.005L	11	24	0.35
85-SKA-003	9.8	.40	40	H	15	.73	.005L	6.4	6.0	.23
85-SPR-002	6.0	.53	40	H	24	1.1	.005L	8.6	9.6	.26
85MIG104	8.3	.05	30	7.3	6.3	0.14	0.005L	1.5	30	.02
85MIG105	10	.26	20L	15	22	1.2	.005L	7.7	75	.12
85MIG109	15	.06	20L	7.8	25	.06	.030	.44	32	.02
85MIG111	24	.67	20L	35	6.4	6.8	.10	30	220	.38
85MIG116	21	.12	20L	10	7.0	.17	.030	1.9	19	.04
86-TGM-1	13	.24	20L	21	20	1.6	.070	7.6	97	.12
86-TGM-2	19	.50	20L	26	3.4	5.1	.010	20	110	.22
86-TGM-3	15	.67	100	30	2.7L	7.9	.020	29	140	.35
86-TGM-4	11	.14	20L	1.8	2.7	3.6	.060	2.2	22	.10
86-TGM-7	22	.58	20L	15	4.8	13	.010	19	51	.48
86-TGM-8	30	.74	40	21	3.2L	7.6	.030	33	77	.43
86-TGM-9	26	.15	20L	5.4	2.3L	6.5	.010	2.1	25	.15

SAMPLE NUMBER	Mn PPM	Mo-S PPM	Nb-S PPM	Nd-S PPM	Ni-S PPM	P PPM	Pb PPM	Pr-S PPM	Rb PPM	Sb PPM
85-SDT-001	32	10	6.9	20	41	8.7L	15	15L	60L	0.42
85-SKA-003	22	H	4.5	11	17	4.4L	15	18L	60L	.25
85-SPR-002	33	H	7.1	18	18	8.7L	16	14L	50L	.28
85MIG104	26	11	5.4	10	11	310L	5.6	1.2	5.7L	.29
85MIG105	36	5.7	8.4	17	23	140L	8.4	2.0L	12L	.26
85MIG109	15	9.4	3.1	9.2	34	380L	17	1.5	4.5L	.33
85MIG111	42	4.9	30	50	69	92	28	3.9L	29L	.76
85MIG116	14	2.4	3.4	19	5.7	380L	3.5	2.6	3.5L	.14
86-TGM-1	20	5.3	16	22	22	140L	16	2.1L	13L	.29
86-TGM-2	36	6.4	34	39	31	96L	18	3.1	12	.51
86-TGM-3	44	4.2	41	19L	32	74	14	6.5	18	.49
86-TGM-4	27	21	25	13	21	110L	9.6	2.7L	8.8L	1.1
86-TGM-7	70	4.8	91	17L	12	83L	8.6	10	16L	.45
86-TGM-8	100	20	35	22L	54	100	28	4.8L	15	5.6
86-TGM-9	69	6.9	29	18	3.8	87L	26	3.3L	9.3L	.15

Table IV. (continued) Major-, minor-, and trace-element composition of coal and carbonaceous shale samples from Punjab, Pakistan, reported on a whole-coal basis.

SAMPLE NUMBER	Sc PPM	Se PPM	Sm PPM	Sn-S PPM	Sr-S PPM	Ta PPM	Tb PPM	Th PPM	U PPM	V-S PPM
85-SDT-001	6.9	18	3.7	7.6	350	1.2	0.57	6.4	2.7	57
85-SKA-003	3.3	15	1.7	H	130	.31	.31	2.4	.76	18
85-SPR-002	4.8	14	2.5	H	180	.45	.40	3.5	2.0	31
85MIG104	.65	15	.22	3.7	90	.40	.029	3.5	1.5	24
85MIG105	2.9	7.2	1.3	3.0	130	1.2	.22	7.5	4.7	45
85MIG109	.69	13	.25	4.7	80	.17	.045	3.4	.88	35
85MIG111	10	28	3.6	13	190	3.3	.48	21	5.1	140
85MIG116	1.0	8.3	.53	3.5	250	.45	.090	5.6	2.9	50
86-TGM-1	3.1	14	1.3	6.3	120	1.5	.19	13	3.6	91
86-TGM-2	7.1	25	2.7	9.5	170	2.6	.34	19	4.8	100
86-TGM-3	11	13	3.6	9.5	170	3.7	.49	19	5.1	140
86-TGM-4	1.3	23	.69	2.6	92	1.3	.13	4.4	14	52
86-TGM-7	7.2	7.8	2.9	5.3	170	4.6	.48	16	6.0	97
86-TGM-8	8.3	16	3.9	13	200	2.8	.48	20	8.8	84
86-TGM-9	1.2	7.4	.71	2.3	83	1.1	.14	4.5	2.2	27

SAMPLE NUMBER	W PPM	Y-S PPM	Yb PPM	Zn PPM	Zr-S PPM
85-SDT-001	1.7	14	1.8	110	95
85-SKA-003	.49	11	1.1	38	35
85-SPR-002	.60	15	1.6	54	31
85MIG104	.86	8.7	.08	30	41
85MIG105	2.0	16	.73	24	84
85MIG109	.81	16	.14	230	34
85MIG111	3.6	21	2.3	28	220
85MIG116	.49	23	.25	110	33
86-TGM-1	1.7	18	.71	21	120
86-TGM-2	2.7	22	1.5	30	240
86-TGM-3	3.6	25	2.4	21	390
86-TGM-4	1.3	16	.85	92	390
85-TGM-7	3.7	46	3.0	37	910
85-TGM-8	2.6	20	2.5	20	310
85-TGM-9	1.1	21	.93	10	3,110

Table IV. (continued) Major-, minor-, and trace-element composition of coal and carbonaceous shale samples from Punjab, Pakistan, reported on a whole-coal basis.

SAMPLE NUMBER	As PPM	Ce PPM	Co PPM	Cr PPM	Cs PPM	Eu PPM	Hf PPM	La PPM	Lu PMM	Rb PPM	Sb PPM	Sc PPM	Se PPM	Sm PPM	Tb PPM	Th PPM	Yb PPM
ARR-HM-RT-A	6.6	35	2.7	17	.10L	.76	.8	16	.18	30L	.26	4.2	9.4	4.1	.45	2.1	1.3
ARR-HM-RT-B	7.3	66	4.8	64	.81	1.4	3.9	33	.39	40L	.31	17	11	7.3	.91	11	3
ARR-JV-7	2.8	28	2.8	27	.10L	.61	3.2	16	.2	31L	.2	4.3	8.5	3.4	.43	4.2	1.7
CB-KC-3A	6.2	100	5.1	57	1.3	2.1	4.6	53	.62	60L	.42	15	6.3	11	1.4	12	4.4
CB-KC-3B	19	31	3.2	29	.32	.86	1.4	16	.25	41L	.41	7.2	7.1	4.4	.65	4.9	2.3
CD-DL-4	11	31	10	40	.49	1	3.1	19	.37	60L	.5	8.4	13	4.8	.81	6.8	2.6
CGAS-HCC-3	38	63	20	69	1.5	1.2	4	33	.34	40L	.44	12	11	6.3	.77	11	2.5
DSD-13-2	12	48	12	69	1.2	1	5.5	29	.46	40L	.35	13	11	5.2	.81	12	2.7
DSD-14-3	9.4	35	15	53	.76	.83	2.7	21	.3	40L	.29	9.8	11	4.1	.66	7.7	2.3
DSD-15-4	9.6	25	7.4	63	.68	.63	4	18	.27	50L	.33	9.3	15	3.2	.52	9.3	2.2
DSD-16-5	13	34	9.3	37	.58	.82	3.2	18	.31	40L	.2	8	9	4.2	.58	7.3	2.2
JT-MDM-5B	2.9	39	1.7	57	.38	1	8.1	22	.48	30L	.55	8.2	25	5.4	.8	17	3.4
KK-GH-8A	2.7	21	5	20	.28	.48	1.2	1	.07L	80L	.15	3.5	11	2.5	.3	3.2	.79
KK-GH-8B	6.1	140	12	110	1.6	2.6	3.5	69	.6	40L	.33	21	6.9	14	1.5	13	4.9
KW-CYS-1	8.3	36	9.3	23	.54	1.1	1.4	19	.28	30L	.41	3.5	12	3.6	.54	3.6	1.8
M-SAL-1	30	19	12	29	.35	.79	1	8.1	.44	50L	.48	6.3	6.2	3.3	.68	3	2.7
NW-JV-1	41	72	26	96	1.8	1.4	5.3	39	.43	40L	.93	18	11	7.1	.93	14	3.4
NW-MAM-2	67	40	9.3	32	.29	1.1	1.4	19	.28	40L	.66	5.3	5.5	5.1	.75	3.4	2.5
P-KB-6B	20	11	2.5	23	.1L	.32	3.9	6	.23	40L	.25	2.6	11	1.4	.31	3.2	1.6
P-KC-12	19	14	3.4	23	.4	.49	1.2	8.3	.22	40L	.35	3.9	10	2.2	.38	3.5	1.6
PJ-PCP-1	33	17	2.9	24	.37	.65	.69	7.9	.24	40L	.32	4.9	9.6	2.8	.55	2.7	2.3
PJ-PCP-2A	5	32	4.4	48	.35	.56	7.9	21	.34	40L	.25	5.2	4.9	3.5	.59	8.2	2.9
PJ-PCP-2B	35	43	11	48	.86	1.2	4.2	22	.52	40L	.32	10	8.7	5.5	.93	8.5	3.7
TSD-7-1	25	21	10	26	.21	.92	1.4	9.5	.37	40L	.28	6.5	7.7	4.2	.72	4	2.5