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Geochemical Data on Selected Coal Beds, Raton Coal Field, Colfax County, New Mexico

By

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Introduction

This report presents analytical data on 16 coal samples and 10 shale samples from underground and open-pit mines, outcrops, and a core hole in the Raton coal field, Colfax County, New Mexico (fig. 1). The samples were collected from coal beds in rocks of the Vermejo Formation of Late Cretaceous age and the Raton Formation of Late Cretaceous and Paleocene age (fig. 2). Proximate, ultimate, Btu, and forms-of-sulfur analyses are given on 10 selected coal samples; major and minor oxides and trace-element compositions of these and 6 additional coal samples, and of shale beds related to the York Canyon mine and the outcrop of Vermejo Park were also determined.

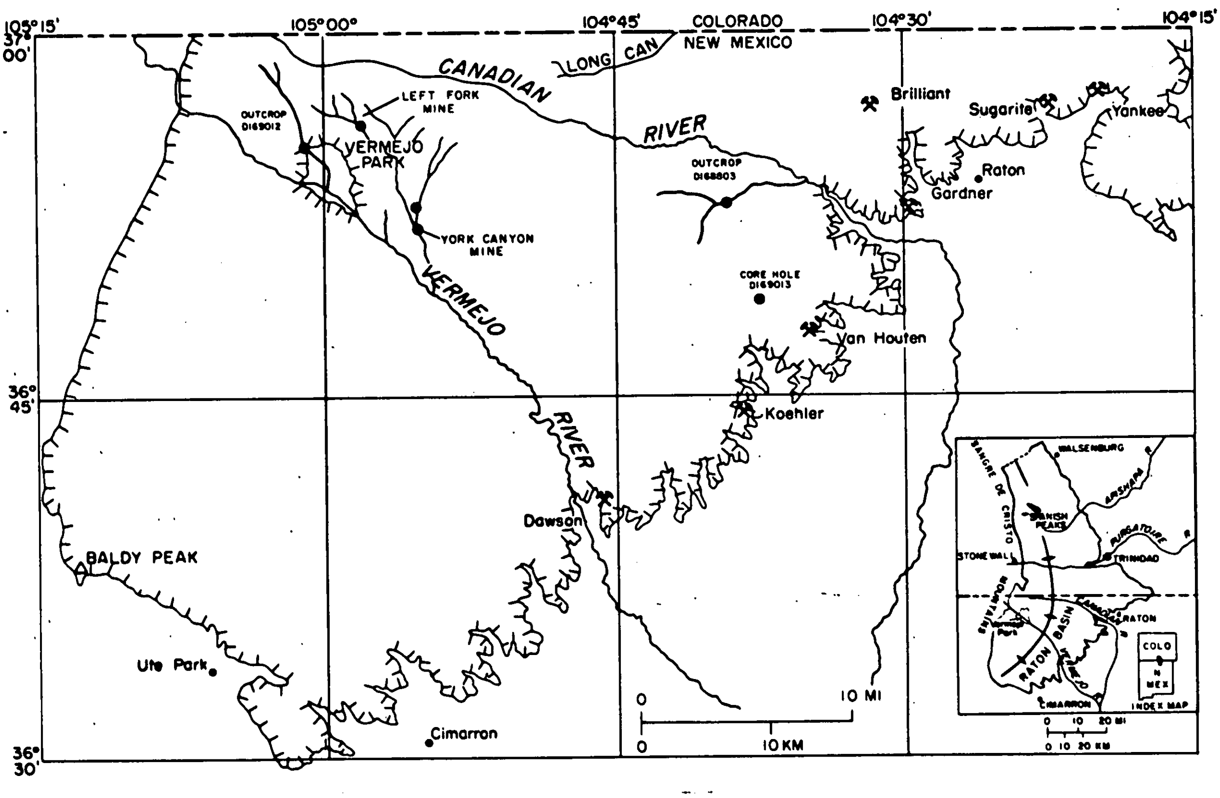

Figure 1.--Map showing sample localities in the Raton coal field (hachured outline), Colfax County, New Mexico. Abandoned coal mines are shown by crossed picks.

AGE		FORMATION	GENERAL DESCRIPTION	APPROXIMATE THICKNESS IN FEET
TERTIARY	PALEOCENE	POISON CANYON FORMATION	Sandstone, coarse to conglomeratic, beds 5 to more than 50 feet thick, interbeds of soft yellow-weathering clayey sandstone; thickens to west at expense of underlying rocks	500+
TERTIARY	PALEOCENE	RATON FORMATION	Sandstone, very fine grained to fine grained with interbeds of claystone, siltstone, and coal; commercial coal beds in upper part. Lower few feet conglomeratic; intertongues with Poison Canyon to the west. Generally sharp erosional contact with underlying Vermejo Formation	0-2000
CRETACEOUS	LATE CRETACEOUS	VERMEJO FORMATION	Sandstone, very fine grained to medium grained, interbedded with mudstone, carbonaceous shale, and coal; extensive thick coals top and bottom	0-380
CRETACEOUS	LATE CRETACEOUS	TRINIDAD SANDSTONE	Sandstone, very fine grained to medium grained, contains casts of *Ophiomorpha* sp.	0-130
CRETACEOUS	LATE CRETACEOUS	PIERRE SHALE	Black shale, limestone concretions, silty in upper part, grades up to sandstone	2500+

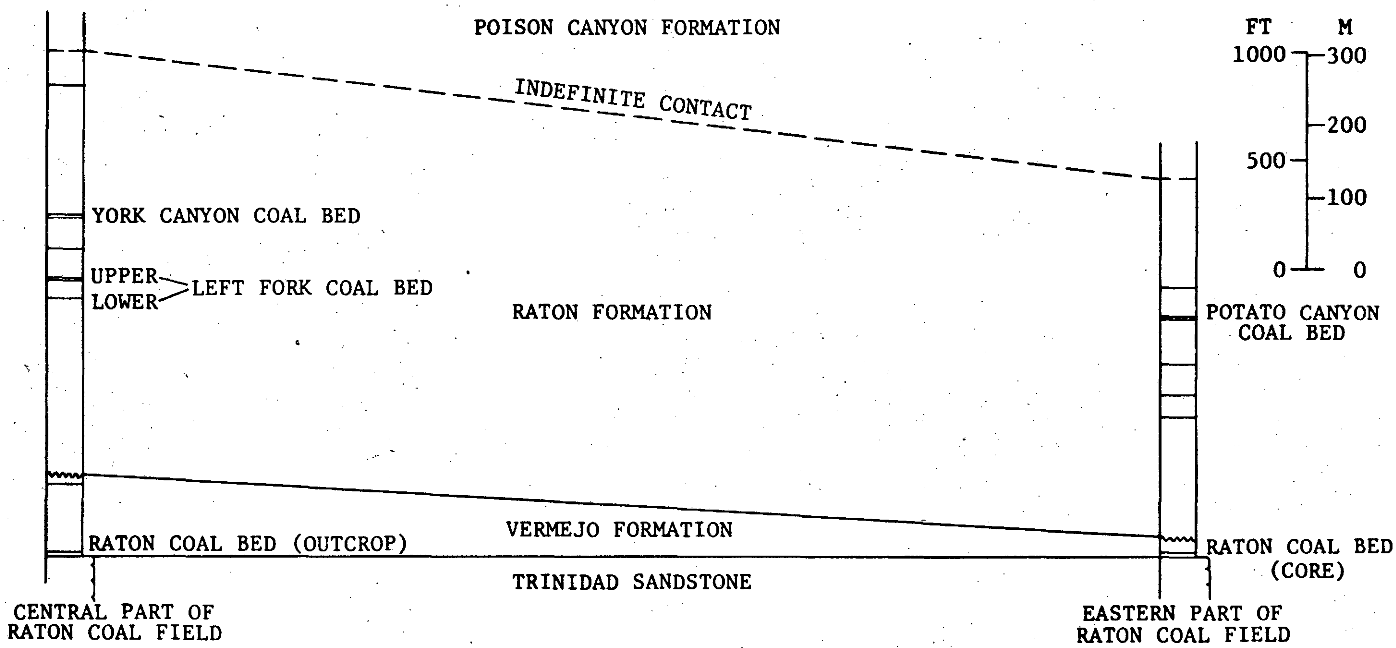

Figure 2.--Generalized stratigraphic description of rocks in the Raton coal field, with sections showing approximate levels of coal beds in the central and eastern parts of the field. Positions of coal beds in the eastern part are courtesy of Kaiser Steel Corporation.

Sample distribution

Three coal beds in the Raton Formation were sampled. Several samples from the York Canyon coal bed were taken from Kaiser Steel's York Canyon underground (Sample Nos. D169000, 001 and D176216, 217) and surface (Sample Nos. D169004, 005, 006, 007, and 008) mines. Samples of the middling (D169002) and washed (D169003) coal from the wash plant were also analyzed. The Upper Left Fork coal bed (D169801, 802) was sampled in Kaiser Steel's development entries in the Left Fork of York Canyon. The Potato Canyon coal bed (D168803), in the eastern part of the field, was sampled at a test entry at Potato Canyon near the road to the York Canyon mine.

Two samples of the Raton coal bed of the Vermejo Formation were taken: an outcrop of the bed (D169012) was sampled near the Bartlett mine at the northwest entrance to Vermejo Park; and a core sample of the Raton bed (D169013), from a deep hole in the eastern part of the field, about 12 mi (20 km) southwest of Raton, was furnished by Kaiser Steel Corporation.

The cooperation of Kaiser Steel in granting access to the sample sites and supplying the core of the Raton bed is gratefully acknowledged. We also thank the New Mexico Bureau of Mines and Mineral Resources for permission to include data on D176216 and D176217.

Analytical data

Analytical data for the 16 selected coal samples and the 10 rock samples from the Raton coal field are tabulated in tables 1-5. Statistical summaries of these data for the 16 coal samples are listed in tables 6-8. For comparison, statistical summaries for 295 Rocky Mountain province coal samples are listed in tables 6a-8a.

Using the analytical data, comparison between individual coals in the same and in different formations is possible. The whole-coal data (tables 3, 4), as summarized below, show that the core sample of the Raton coal bed (D169013) contains considerably more of certain elements than the outcrop sample of the same bed (D169012), which is about 22 miles (35 km) away (fig. 1):

		D169013	D169012
Whole coal:			
(ppm)	Pb	61.6	6.5
	Li	37.3	6.5
	P	140	71
	Se	1.6	.7
	Th	15.5	3.0 L
	U	4.1	1.5
	Cu	14.5	8.1
	Mo	3	1.5
	Nb	10	3
Percent ash:		31.6	16.2
Ppm in ash:	Pb	195	40
	Li	118	40

The analyses of the ash of these samples (table 2) show appreciable differences of about the same magnitude as noted above; lead values for D169013 are about five times those of D169012, and Li values are about three times higher.

Differences in composition between the Raton coal bed of the Vermejo Formation and the composition of coal beds in the Raton Formation are that the coal in the Raton bed has lower volatile-matter and fixed-carbon values; generally higher ash content; lower hydrogen, oxygen, nitrogen, and Btu values; and somewhat higher S contents (table 1). Other elemental analyses display the following pertinent differences: (1) U and Th contents in the whole-coal analyses of the Raton bed core sample (D169013) are generally two to five times higher than in other coal samples. (2) The Cu content of the ash of samples of the Raton coal bed are one-half to one-fourth those of the Raton Formation coal beds (table 2). (3) The average value for P in the whole coal (table 4) is about one-fourth to one-third that of the Raton Formation coal beds.

Table 6 summarizes the ultimate, proximate, Btu, and forms-of-sulfur determinations for 10 selected samples from the Raton coal field on the as-received basis. This table shows that average (arithmetic mean) ash content of the coal samples from the Raton field is 11.4 percent; nitrogen, 1.7 percent; sulfur, 0.5 percent; Btu/lb, 13,100. For comparison, the average value in 86 Rocky Mountain province coal samples (table 6a) is 9.1 percent ash, 1.2 percent nitrogen, 0.6 percent sulfur, and 10,480 Btu/lb. The coals typical of the Raton coal field are higher in Btu and lower in sulfur content than representative coals of the Rocky Mountain province.

Average concentrations of oxides in the laboratory ash of the 16 Raton field coal samples are shown in table 7. A comparison of these values with those determined for the laboratory ash of 295 Rocky Mountain province coal samples (table 7a) shows that P_2O_5 concentration is higher by more than 50 percent in the ash of Raton field coals, while Na_2O, MnO, and SO_3 concentrations are lower by more than 50 percent. The average values for the other nine oxides reported in the ash are about the same in both sets of samples.

Data for 37 elements calculated to, or reported on, a whole-coal basis are summarized for the Raton field coal samples on table 8 and for the 295 Rocky Mountain province coal samples on table 8a. For comparative purposes, the average element concentrations in shale (Turekian and Wedepohl, 1961, table 2) are listed on both tables. A comparison of the average amounts of elements in Raton field coal with those in the average shale shows that the concentrations of Al, Fe, Ti, F, Hg, Li, B, Co, Sc, V, and Zr are less by more than a factor of five in the coal; Mg, Na, K, An, Cr, and Ni are less by more than a factor of ten. The concentrations of the other 20 elements reported on the table are similar to those of the average shale.

A comparison of the average composition of coal in the Raton field to that of Rocky Mountain coal (tables 8 and 8a) shows that Na, As, Cd, B, Mo, and Nb concentrations in Raton field coal are less by a factor of two or more than those in Rocky Mountain coal. Copper values are about 50 percent higher, and Sr about two times higher than those of the Rocky Mountain coal. The average concentrations of the other 29 elements in the Raton field coal samples do not differ significantly from their average amounts in Rocky Mountain coal.

Statistical methods

The estimate of the most probable concentration, as used in this report, is the geometric mean, GM, which is the antilog of the mean of the logarithms of concentration. The measure of scatter about the mode is the geometric deviation, GD, which is the antilog of the standard deviation of the logarithms of concentration. These statistics are used because of the common tendency for trace-element concentration in natural materials to exhibit positively skewed frequency distributions. The distributions can be normalized by analyzing and summarizing trace-element data on a logarithmic basis.

If the underlying frequency distributions are, in fact, lognormal, the geometric mean is the best estimate of the mode, and the estimated range of the central two-thirds of the observed distribution has a lower limit equal to GM/GD and an upper limit equal to GM·GD. The estimated range of the central 95 percent of the observed distribution has a lower limit equal to $GM/(GD)^2$ and an upper limit equal to $GM\cdot(GD)^2$ (Connor and others, 1976).

Although the geometric mean is generally an adequate estimate of the most common concentration, it is a biased estimate of elemental abundance. In tables 6-8 and 6a-8a, the estimates of arithmetic means (abundance) are Sichel's $\underline{t}$ statistic (Miesch, 1967).

A common problem in statistical summaries of trace-element data arises when the element concentration in one or more of the samples lies below the limit of analytical detection, resulting in a censored distribution. Procedures developed by Cohen (1959) are used here to compute unbiased estimates of the geometric mean, geometric deviation, and arithmetic mean for cases in which the concentration data are censored.

Acknowledgments

The analytical results for this paper were compiled with the assistance of Scott D. Woodruff and Ricky T. Hildebrand, U.S. Geological Survey. The proximate, ultimate, Btu, and forms-of-sulfur analyses of the coal samples in table 1 were made by the Coal Analysis Section of the U.S. Bureau of Mines, Pittsburgh, Pa., under the direction of Forrest E. Walker, chemist-in-charge. The major- and minor-oxide and trace-element analyses in tables 2, 3, 4, and 5 were made by A. J. Bartel, J. W. Brown, G. T. Burrow, E. J. Fennelly, J. Gardner, P. Guest, J. C. Hamilton, R. J. Knight, R. E. McGregor, V. M. Merritt, H. T. Millard, Jr., D. R. Norton, V. E. Shaw, G. D. Shipley, J. A. Thomas, J. S. Wahlberg, and T. L. Yager of the U.S. Geological Survey, under the direction of Claude Huffman, Jr., chemist-in-charge.

References cited

Cohen, A. C., 1959, Simplified estimators for the normal distribution when samples are singly censored or truncated: Technometrics, v. 1, no. 3, p. 217-237.

Connor, J. J., Keith, J. R., and Anderson, B. M., 1976, Trace-metal variation in soils and sagebrush in the Powder River Basin, Wyoming and Montana: U.S. Geol. Survey Jour. Research, v. 4, no. 1, p. 49-59.

Miesch, A. T., 1967, Methods of computation for estimating geochemical abundance: U.S. Geol. Survey Prof. Paper 574-B, 15 p.

Pillmore, C. L., 1969, Geology and coal deposits of the Raton coal field, Colfax County, New Mexico: Mtn. Geologist, v. 6, no. 3, p. 125-142.

Turekian, K. K., and Wedepohl, K. H., 1961, Distribution of the elements in some major units of the Earth's crust: Geol. Soc. America Bull., v. 72, p. 175-192.

Description of 10 analyzed samples on table 1

Samples D168801 and D168802

Underground mine face channel samples (D168801) and (D168802), Left Fork coal bed, Raton Formation, Paleocene age; sample D168801 is 108 inches thick, a 6-inch parting is excluded; sample D168802 is 84 inches thick, a basal split and parting are excluded, Left Fork prospect, Colfax County, New Mexico, lat. 36°56'21" N, long. 105°58' W.

Sample D168803

Outcrop channel sample, Potato Canyon bed, 72 inches thick, partings excluded, Raton Formation, Paleocene age, Potato Canyon prospect, Colfax County, New Mexico, lat. 36°52'27" N, long. 104°40'36" W.

Samples D169000 and D169001

Face bench samples, lower (D169000) and main (D169001) benches of the York Canyon bed, 27 and 48 inches thick, respectively, Raton Formation, Paleocene age, York Canyon mine, long wall panel, 7th right, Colfax County, New Mexico, lat. 36°52'13" N, long. 104°53'37" W.

Samples D169004 and D169005

Face bench samples, main (D169004) and upper (D169005) benches of the York Canyon bed, 106 and 16 inches thick, respectively, Raton Formation, Paleocene age, Kaiser Steel strip mine (south end), Colfax County, New Mexico, lat. 36°52'13" N, long. 104°55'14" W.

Sample D169006

Face bench sample, main bench of the York Canyon bed, 87 inches thick, Raton Formation, Paleocene age, Kaiser Steel strip mine (north end), Colfax County, New Mexico, lat. 36°52'38" N, long. 104°55'17" W.

Sample D169013

Core sample, 60 inches thick, Raton bed, Vermejo Formation, Early Cretaceous age, depth 1,189-1,194 feet, lat. 36°48'55" N, long. 104°37'13" W.

Sample D176216

Underground mine face channel sample, York Canyon bed, lower bench 60 inches thick (composited with D176217 for this analysis), partings excluded, Raton Formation, Paleocene age, York Canyon mine, Colfax County, New Mexico, lat. 36°53' N, long. 104°54'46" W. (Collected by George S. Austin, New Mexico Bureau of Mines and Mineral Resources.)

Table 1.—Proximate, ultimate, Btu, and forms-of-sulfur analyses of 10 samples from selected sites in the Raton coal field, New Mexico

[All analyses except Btu are in percent. Original moisture content may be slightly more than shown, because samples were collected and transported in plastic bags to avoid metal contamination. Form of analyses: 1, as received; 2, moisture free; 3, moisture and ash free. A. D. Loss is air-dried loss]

SAMPLE	FORM OF ANALYSIS	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS				
		MOISTURE	VOL.MTR.	FIXED C	ASH	HYDROGEN	CARBON	NITROGEN	OXYGEN	SULFUR
D168801	1	1.5	36.6	54.4	7.5	5.2	76.7	1.7	8.4	0.5
	2	-	37.2	55.1	7.7	5.1	77.9	1.8	7.0	.5
	3	-	40.3	59.7	-	5.6	84.3	1.9	7.7	.5
D168802	1	2.1	36.7	50.8	10.4	5.3	71.6	1.8	10.4	.5
	2	-	37.5	51.9	10.6	5.1	73.1	1.8	8.9	.5
	3	-	41.9	58.1	-	5.8	81.7	2.0	10.0	.5
D168803	1	1.5	35.1	53.6	9.8	5.0	74.8	1.6	8.3	.5
	2	-	35.6	54.4	10.0	4.9	75.9	1.7	7.0	.5
	3	-	39.5	60.5	-	5.4	84.3	1.8	7.9	.6
D169000	1	2.2	33.3	45.3	19.2	4.7	65.7	1.5	8.4	.5
	2	-	34.0	46.4	19.6	4.5	67.2	1.6	6.6	.5
	3	-	42.3	57.7	-	5.6	83.6	2.0	8.2	.6
D169001	1	1.9	36.1	54.0	8.0	5.2	75.9	1.7	8.8	.4
	2	-	36.8	55.1	8.1	5.1	77.3	1.8	7.2	.5
	3	-	40.0	60.0	-	5.5	84.1	1.9	8.0	.5
D169004	1	1.4	38.2	51.9	8.5	5.2	75.9	1.7	8.3	.4
	2	-	38.7	52.7	8.6	5.1	77.0	1.8	7.1	.4
	3	-	42.4	57.6	-	5.6	84.3	1.9	7.7	.5
D169005	1	1.3	42.3	50.6	5.8	6.0	77.8	2.0	7.8	.6
	2	-	42.8	51.3	5.9	5.9	78.8	2.0	6.8	.6
	3	-	45.5	54.5	-	6.3	83.8	2.1	7.1	.7
D169006	1	1.8	37.1	53.4	7.7	5.4	76.4	1.7	8.4	.4
	2	-	37.8	54.4	7.8	5.3	77.8	1.8	6.9	.4
	3	-	41.0	59.0	-	5.7	84.4	1.9	7.5	.5
D169013	1	2.5	31.2	43.5	22.8	4.7	61.8	1.2	8.9	.6
	2	-	32.0	44.6	23.4	4.6	63.4	1.3	6.7	.6
	3	-	41.7	58.3	-	6.0	82.7	1.7	8.8	.8
D176216*	1	1.7	34.2	49.6	14.5	5.0	70.2	1.6	8.2	.5
	2	-	34.8	50.4	14.8	4.9	71.4	1.6	6.7	.6
	3	-	40.8	59.2	-	5.7	83.8	1.9	7.9	.7

Table 1.--Proximate, ultimate, Btu, and forms-of-sulfur analyses of 10 samples from selected sites in the Raton coal field, New Mexico--Continued

SAMPLE	FORM OF ANALYSIS	BTU	A.D.LOSS	FORMS OF SULFUR SULFATE	FORMS OF SULFUR PYRITIC	FORMS OF SULFUR ORGANIC
D168801	1	13740	.00	0.01	0.05	0.40
	2	13950	-	.01	.05	.41
	3	15110	-	.01	.05	.44
D168802	1	12830	.00	.00	.04	.44
	2	13110	-	.00	.04	.45
	3	14660	-	.00	.05	.50
D168803	1	13410	.00	.02	.04	.43
	2	13610	-	.02	.04	.44
	3	15110	-	.02	.05	.48
D169000	1	11810	.40	.01	.07	.42
	2	12070	-	.01	.07	.43
	3	15020	-	.01	.09	.53
D169001	1	13550	.50	.01	.07	.37
	2	13810	-	.01	.07	.38
	3	15030	-	.01	.08	.41
D169004	1	13620	.00	.00	.06	.38
	2	13810	-	.00	.06	.39
	3	15110	-	.00	.07	.42
D169005	1	14230	.00	.00	.05	.56
	2	14410	-	.00	.05	.57
	3	15320	-	.00	.05	.60
D169006	1	13660	.20	.00	.11	.30
	2	13910	-	.00	.11	.30
	3	15090	-	.00	.12	.33
D169013	1	11620	.50	.00	.08	.49
	2	11910	-	.00	.08	.50
	3	15550	-	.00	.11	.65
D176216*	1	12520	.55	.01	.02	.52
	2	12740	-	.01	.02	.53
	3	14950	-	.01	.02	.62

Description of 6 additional coal samples not on table 1 but included on tables 2, 3, and 4

Samples D169007 and D169008

Upper bench samples, 18 inches second bench (D169007), and 14 inches top bench (D169008) of the York Canyon bed, Raton Formation, Paleocene age, Kaiser Steel strip mine (north end), Colfax County, New Mexico, lat. 36°52'38" N, long. 104°55'17" W.

Sample D169012

Outcrop face channel sample, Raton bed, 60 inches thick, Vermejo Formation, Late Cretaceous age, tributary to Spring Canyon, Vermejo Park, Colfax County, New Mexico, lat. 36°55'30" N, long. 105°01'10" W.

Sample D169002

Tipple sample (middling coal), York Canyon mine wash plant, York Canyon bed, Raton Formation, Paleocene age, Colfax County, New Mexico, lat. 36°52'13" N, long. 104°53'37" W.

Sample D169003

Tipple sample (clean-coal pile), York Canyon mine wash plant, York Canyon bed, Raton Formation, Paleocene age, Colfax County, New Mexico, lat. 36°52'13" N, long. 104°53'37" W.

Sample D176217

Underground mine face channel sample, York Canyon bed, upper bench 69 inches thick, Raton Formation, Paleocene age, York Canyon mine, Colfax County, New Mexico, lat. 36°53' N, long. 104°54'46" W. (Collected by George S. Austin, New Mexico Bureau of Mines and Mineral Resources.)

Table 2.--Major and minor oxide and trace-element composition of the laboratory ash of 16 coal samples from selected sites in the Raton coal field, New Mexico

[Values are in either percent or parts per million. The coals were ashed at 525°C. L after a value means less than the value shown, N means not detected. S after the element title means that the values listed were determined by semiquantitative spectrographic analysis. The spectrographic results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as mid-points of those brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of the spectrographic data is approximately one bracket at 68 percent, or two brackets at 95 percent confidence]

SAMPLE	ASH %	SIO2 %	AL2O3 %	CAO %	MGO %	NA2O %	K2O %	FE2O3 %	MNO %	TIO2 %
D168801	6.4	48.	28.	3 8	1.83	0.70	0.34	7.7	0.020L	1.3
D168802	9.8	48.	28.	3 4	1.91	.67	.46	7.5	.020L	1.3
D168803	11.7	48.	27.	3.2	1.10	.26	.66	6.5	.020L	1.0
D169000	18.6	57.	27.	1.8	1.39	.81	1.2	4.6	.020L	1.0
D169001	8.3	33.	22.	16.	1.81	.95	.075	8.0	.030	1.2
D169002	38.2	50.	20.	11.	1.44	.49	1.2	3.0	.020L	.91
D169003	9.1	42.	25.	7.8	1.96	.95	.41	6.9	.020L	1.2
D169004	10.0	39.	23.	13.	2.01	.58	.27	5.3	.020L	1.2
D169005	6.3	40.	27.	5.8	2.16	.49	.30	11.	.020	.81
D169006	10.0	32.	21.	17.	2.49	1.24	.19	6.2	.028	.86
D169007	11.4	41.	25.	12.	2.41	.36	.16	5.0	.020L	1.2
D169008	6.2	44.	26.	6.6	1.58	.51	.42	11.	.020L	.86
D169012	16.2	60.	17.	4.3	1.08	.49	2.3	4.3	.024	.73
D169013	31.6	60.	30.	.36	.53	.54	.33	2.8	.020L	.88
D176216	9.5	37.	21.	13.	1.99	1.53	.52	5.5	.015	1.3
D176217	20.6	47.	22.	6.8	1.44	.57	1.3	4.3	.017	.90

SAMPLE	P2O5 %	SO3 %	CL %	CD PPM	CU PPM	LI PPM	PB PPM	ZN PPM	B PPM-S	BA PPM-S
D168801	1.5	3 0	0.10 L	1.0L	196.	78.	35.	43.	150	7000
D168802	1.7	2.6	.10 L	1.0L	146.	80.	45.	46.	150	5000
D168803	.45	.10 L	.10 L	1.0L	130.	78.	55.	86	150	1000
D169000	.10 L	.62	.10 L	1.0L	204.	72.	50.	62.	70	1500
D169001	1.7	4.3	.10 L	1.0L	130.	90.	45.	46.	150	5000
D169002	.10 L	.93	.10 L	1.0L	94.	58.	35.	84.	50	1000
D169003	1.0	3.7	.10 L	1.0L	208.	100.	65.	73.	150	3000
D169004	.71	3.5	.10 L	1.0L	178.	90.	60.	39.	150	5000
D169005	.35	6.4	.10 L	1.0L	170.	78.	70.	80.	150	3000
D169006	.97	4 6	.10 L	1.0L	172.	86.	60.	46.	150	5000
D169007	.77	4.3	.10 L	1.0L	100.	136.	60.	101.	70	2000
D169008	.10 L	5.4	.10 L	1.0L	130.	68.	60.	102.	150	3000
D169012	.10 L	5.7	.10 L	1.0L	50.	40.	40.	31.	70	500
D169013	.10 L	.10 L	.10 L	1.0L	46.	118.	195.	34.	70	500
D176216	1.0 L	5.5	.20 L	1.0L	190.	80.	50.	31.	200	3000
D176217	1.0 L	2.0	.20 L	1.0L	92.	67.	40.	40.	100	2000

Table 2.--Major and minor oxide and trace-element composition of the laboratory ash of 16 coal samples from selected sites in the Raton coal field, New Mexico--Continued

SAMPLE	BE PPM-S	CE PPM-S	CO PPM-S	CR PPM-S	GA PPM-S	GE PPM-S	LA PPM-S	MO PPM-S	NB PPM-S	ND PPM-S
D168801	10	N	30	70	30	N	70	10	20	N
D168802	3	N	15	50	30	N	70	7	20	N
D168803	15	N	30	50	50	N	70	7	20	N
D169000	7	N	15	50	30	N	70	7	20 L	N
D169001	3	N	15	30	30	N	100	7	20 L	N
D169002	3	N	10	70	30	N	70	N	20	N
D169003	7	N	20	50	30	N	100	10	20	N
D169004	7	N	15	70	30	N	70	10	20	N
D169005	20	500 L	70	70	30	N	150	15	20	150
D169006	3	N	15	30	30	N	70	7	20 L	N
D169007	5	N	20	50	30	N	100	7	20	N
D169008	20	500 L	70	50	30	20 L	150	15	20	150
D169012	5	N	10 L	15	30	N	70	10	20 L	N
D169013	3	N	10	10	30	N	70	10	30	N
D176216	7	500 L	15	30	30	N	100 L	7	30	N
D176217	5	500 L	15	50	30	N	100 L	7	30	N

SAMPLE	NI PPM-S	SC PPM-S	SR PPM-S	V PPM-S	Y PPM-S	YB PPM-S	ZR PPM-S
D168801	50	30	2000	200	70	7	300
D168802	30	20	1500	150	30	3	200
D168803	30	20	700	150	70	7	200
D169000	15	20	500	150	30	3	150
D169001	30	20	3000	100	50	5	200
D169002	10	15	1500	150	30	3	150
D169003	30	30	2000	200	70	7	200
D169004	30	20	2000	200	70	7	200
D169005	150	30	1500	200	200	20	200
D169006	30	15	3000	150	50	5	150
D169007	50	20	1500	150	70	7	150
D169008	150	30	1500	150	150	15	150
D169012	10 L	10	1500	70	50	5	150
D169013	10 L	10	200	70	30	3	200
D176216	30	15	2000	150	70	5	200
D176217	50	15	1500	150	50	3	70

Table 3.--Amounts of seven trace elements in 16 coal samples from selected sites in the Raton coal field, New Mexico

[Analyses on air-dried (32°C) coal. All values are in parts per million. L after a value means less than the value shown]

SAMPLE	AS PPM	F PPM	HG PPM	SB PPM	SE PPM	TH PPM	U PPM
D168801	1.	20.L	0.05	0.5	1.4	2.9	1.2
D168802	1.	40.	.01	.3	1.9	3.4	1.2
D168803	5.	90.	.04	.7	1.3	7.6	1.8
D169000	1.	160.	.05	.5	1.8	8.0	2.3
D169001	1.	90.	.06	.2	1.2	4.5	.7
D169002	2.	195.	.08	.4	1.8	7.7	3.2
D169003	1.	65.	.05	.3	1.4	5.0	1.2
D169004	1.	40.	.10	.2	1.6	3.7	1.5
D169005	1.	95.	.06	.3	1.2	4.1	1.0
D169006	1	65.	.09	.2	1.5	4.9	1.3
D169007	1.	120.	.04	.2	1.1	3.4	1.4
D169008	1.	80.	.04	.2	1.0	3.9	.7
D169012	1.L	95.	.02	.2	.7	3.0L	1.5
D169013	2.	90.	.05	.5	1.6	15.5	4.1
D176216	2	50.	.13	.3	2.1	4.4	1.0
D176217	2.	180.	.04	.4	2.1	10.3	1.5

Table 4.--Major, minor, and trace-element composition of 16 coal samples from selected sites in the Raton coal field, New Mexico, reported on whole-coal basis

[Values are in either percent or parts per million. Si, Al, Ca, Mg, Na, K, Fe, Mn, Ti, P, Cl, Cd, Cu, Li, Pb, and Zn values were calculated from analysis of ash. As, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal. The remaining analyses were calculated from spectrographic determinations on ash. L after a value means less than the value shown and N means not detected]

SAMPLE	SI %	AL %	CA %	MG %	NA %	K %	FE %	MN PPM	TI %	P PPM
D168801	1.4	0.94	0.17	0.070	0.033	0.018	0.34	9.9 L	0.050	430.
D168802	2.2	1.5	.24	.113	.049	.037	.51	15. L	.077	750.
D168803	2.6	1.7	.26	.077	.022	.065	.53	18. L	.073	230.
D169000	5.0	2.6	.25	.156	.112	.19	.60	29. L	.11	81. L
D169001	1.3	.95	.92	.091	.058	.005	.47	19.	.058	630.
D169002	8.9	4.0	3.1	.332	.138	.37	.81	59. L	.21	170. L
D169003	1.8	1.2	.50	.107	.063	.031	.43	14. L	.064	410.
D169004	1.8	1.2	.89	.121	.043	.023	.37	15. L	.072	310.
D169005	1.2	.91	.26	.082	.023	.016	.47	9.8	.031	97.
D169006	1.5	1.1	1.2	.150	.092	.016	.44	22.	.052	430.
D169007	2.2	1.5	.95	.165	.031	.015	.40	18. L	.080	380.
D169008	1.3	.84	.29	.059	.024	.022	.46	9.6 L	.032	27. L
D169012	4.5	1.5	.50	.105	.058	.31	.49	30.	.071	71. L
D169013	8.9	5.1	.082	.101	.126	.087	.61	49. L	.17	140. L
D176216	1.7	1.0	.88	.114	.107	.041	.36	11.	.072	410. L
D176217	4.6	2.4	1.0	.179	.087	.22	.62	27.	.11	900. L

SAMPLE	CL %	AS PPM	CD PPM	CU PPM	F PPM	HG PPM	LI PPM	PB PPM	SB PPM	SE PPM
D168801	0.006L	1.	0.06L	12.5	20.L	0.05	5.0	2.2	0.5	1.4
D168802	.010L	1.	.10L	14.4	40.	.01	7.9	4.4	.3	1.9
D168803	.012L	5.	.12L	15.2	90.	.04	9.1	6.4	.7	1.3
D169000	.019L	1.	.19L	37.9	160.	.05	13.4	9.3	.5	1.8
D169001	.008L	1.	.08L	10.8	90.	.06	7.5	3.8	.2	1.2
D169002	.038L	2.	.38L	35.9	195.	.08	22.2	13.4	.4	1.8
D169003	.009L	1.	.09L	18.8	65.	.05	9.1	5.9	.3	1.4
D169004	.010L	1.	.10L	17.8	40.	.10	9.0	6.0	.2	1.6
D169005	.006L	1.	.06L	10.8	95.	.06	4.9	4.4	.3	1.2
D169006	.010L	1.	.10L	17.2	65.	.09	8.6	6.0	.2	1.5
D169007	.011L	1.	.11L	11.4	120.	.04	15.5	6.8	.2	1.1
D169008	.006L	1.	.06L	8.1	80.	.04	4.2	3.7	.2	1.0
D169012	.016L	1.L	.16L	8.1	95.	.02	6.5	6.5	.2	.7
D169013	.032L	2.	.32L	14.5	90.	.05	37.3	61.6	.5	1.6
D176216	.019L	2.	.09L	18.0	50.	.13	7.6	4.8	.3	2.1
D176217	.041L	2.	.21L	19.0	180.	.04	13.8	8.2	.4	2.1

Table 4.--Major, minor, and trace-element composition of 16 coal samples from selected sites in the Raton coal field, New Mexico, reported on whole-coal basis--Continued

SAMPLE	TH PPM	U PPM	ZN PPM	B PPM-S	BA PPM-S	BE PPM-S	CE PPM-S	CO PPM-S	CR PPM-S	GA PPM-S
D168801	2.9	1.2	2.7	10	500	0.7	N	2	5	2
D168802	3.4	1.2	4.5	15	500	.3	N	1.5	5	3
D168803	7.6	1.8	10.1	15	100	1.5	N	3	7	7
D169000	8.0	2.3	11.5	15	300	1.5	N	3	10	5
D169001	4.5	.7	3.8	15	500	.2	N	1.5	2	2
D169002	7.7	3.2	32.1	20	500	1	N	5	30	10
D169003	5.0	1.2	6.6	15	300	.7	N	2	5	3
D169004	3.7	1.5	3.9	15	500	.7	N	1.5	7	3
D169005	4.1	1.0	5.1	10	200	1.5	30 L	5	5	2
D169006	4.9	1.3	4.6	15	500	.3	N	1.5	3	3
D169007	3.4	1.4	11.5	7	200	.7	N	2	7	3
D169008	3.9	.7	6.3	10	200	1.5	30 L	5	3	2
D169012	3.0L	1.5	5.0	10	70	.7	N	1.5 L	2	5
D169013	15.5	4.1	10.7	20	150	1	N	3	3	10
D176216	4.4	1.0	2.9	20	300	.7	50 L	1.5	3	3
D176217	10.3	1.5	8.2	20	500	1	100 L	3	10	7

SAMPLE	GE PPM-S	LA PPM-S	MO PPM-S	NB PPM-S	ND PPM-S	NI PPM-S	SC PPM-S	SR PPM-S	V PPM-S	Y PPM-S	YB PPM-S	ZR PPM-S
D168801	N	5	0.7	1.5	N	3	2	150	15	5	0.5	20
D168802	N	7	.7	2	N	3	2	150	15	3	.3	20
D168803	N	7	.7	2	N	3	2	70	15	7	.7	20
D169000	N	15	1.5	3 L	N	3	3	100	30	5	.5	30
D169001	N	7	.7	1.5 L	N	2	1.5	200	7	5	.5	15
D169002	N	30	N	7	N	5	7	700	70	10	1	70
D169003	N	10	1	2	N	3	3	200	20	7	.7	20
D169004	N	7	1	2	N	3	2	200	20	7	.7	20
D169005	N	10	1	1.5	10	10	2	100	15	15	1.5	15
D169006	N	7	.7	2 L	N	3	1.5	300	15	5	.5	15
D169007	N	10	.7	2	N	7	2	150	15	7	.7	15
D169008	1.5 L	10	1	1.5	10	10	2	100	10	10	1	10
D169012	N	10	1.5	3 L	N	1.5 L	1.5	200	10	7	.7	20
D169013	N	20	3	10	N	3 L	3	70	20	10	1	70
D176216	N	10 L	.7	3	N	3	1.5	200	15	7	.5	20
D176217	N	20 L	1.5	7	N	10	3	300	30	10	.7	15

Rock samples, on table 5, related to previously described coal samples (here included in parentheses)

Samples D169014 and D169015

York Canyon bed, Raton Formation, Paleocene age, York Canyon mine, long wall panel, 7th right, Colfax County, New Mexico, lat. 36°52'13" N, long. 104°53'37" W.

D169015--channel sample, carbonaceous shale 3 inches thick

(D169001--main coal bed sample, 48 inches thick)

D169014--channel sample, silty carbonaceous shale 3 inches thick at base of coal

(D169000--lower coal bench sample, 27 inches thick)

Samples D169016, D169017, and D169018

York Canyon bed, Raton Formation, Paleocene age, Kaiser Steel strip mine (south end), Colfax County, New Mexico, lat. 36°52'13" N, long. 104°55'14" W.

D169018--channel sample, carbonaceous shale and mudstone (roof) 4 inches thick

D169017--channel sample, carbonaceous shale 10 inches thick

(D169005--upper coal bench 16 inches thick)

D169016--channel sample, basal carbonaceous shale and mudstone 4 inches thick

(D169004--main coal seam 106 inches thick)

Samples D169019, D169020, D169021, and D169022

York Canyon bed, Raton Formation, Paleocene age, Kaiser Steel strip mine (north end), Colfax County, New Mexico, lat. 36°52'38" N, long. 104°55'17" W.

D169022--channel sample, carbonaceous mudstone (roof) 6 inches thick

D169021--channel sample, carbonaceous shale 7 inches thick

(D169008--top bench of coal, 14 inches thick)

D169020--channel sample, coaly shale and shaly coal split 10 inches thick

(D169007--second bench of coal, 18 inches thick)

D169019--channel sample, carbonaceous shale and mudstone 4 inches thick at base of coal

Sample D169027

Outcrop sample (3 in.) at base of coal, Raton bed, Vermejo Formation, Late Cretaceous age, tributary to Spring Canyon, Vermejo Park, Colfax County, New Mexico, lat. 36°55'30", long. 105°01'10" W.

Table 5.--Major, minor, and trace-element composition of 10 rock samples from selected sites in the Raton coal field, New Mexico, reported on a whole-rock basis

[Values are in either percent or parts per million. SiO_2, Al_2O_3, CaO, MgO, Na_2O, K_2O, Fe_2O_3, MnO, TiO_2, P_2O_5, Cl, Cd, Cu, Li, Pb, and Zn values were calculated from analyses of rock ash. As, F, Hg, Sb, Se, Th, U, total carbon, organic carbon, carbonate carbon, and total sulfur values are from direct determinations on air-dried (32°C) rock. The remaining analyses, indicated by an S after the element title, were calculated from spectrographic determinations on ash. These spectrographic results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc. but are reported arbitrarily as mid-points of those brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of the spectrographic data is approximately one bracket at 68 percent, or two brackets at 95 percent confidence. L after a value means less than the value shown and N means not detected]

SAMPLE	SIO2 %	AL2O3 %	CAO %	MGO %	NA2O %	K2O %	FE2O3 %	MNO %	TIO2 %	P2O5 %
D169014	60.	21.	0.15	0.89	0.79	2.0	2.2	0.018L	0.85	0.091L
D169015	18.	7.0	4.4	.46	.18	.42	1.1	.007L	.28	.037L
D169016	56.	21.	.46	1.05	.13	2.2	2.3	.018L	.70	.088L
D169017	48.	18.	4.1	1.12	.08	1.6	3.6	.032	.65	.084L
D169018	52.	18.	.27	1.07	.76	1.9	3.0	.016L	.72	.080L
D169019	48.	20.	.20	.91	.13	1.6	2.0	.015L	.65	.077L
D169020	52.	21.	.25	.94	.22	1.2	1.9	.016L	.73	.082L
D169021	51.	19.	.51	1.24	.30	1.2	3.8	.017L	.73	.083L
D169022	54.	20.	.20	1.09	.80	1.7	2.9	.017L	.80	.085L
D169027	42.	14.	.34	.47	.05	2.6	1.9	.013L	.58	.064L

SAMPLE	CL %	AS PPM	CD PPM	CU PPM	F PPM	HG PPM	LI PPM	PB PPM	SB PPM	SE PPM
D169014	0.091L	2.	0.9L	42.	716.	0.04	38.	27.	0.6	1.0
D169015	.037L	5.	.4L	20.	176.	.05	17.	13.	.6	2.1
D169016	.088L	3.	.9L	44.	764.	.06	37.	22.	.7	2.0
D169017	.084L	5.	.8L	65.	488.	.12	35.	25.	.6	2.6
D169018	.080L	4.	.8L	50.	552.	.20	53.	20.L	.4	1.5
D169019	.077L	8.	.8L	65.	680.	.18	38.	27.	.9	3.2
D169020	.082L	4.	.8L	49.	476.	.07	42.	20.	.6	2.1
D169021	.083L	5.	.8L	56.	604.	.09	41.	25.	.8	2.0
D169022	.085L	3.	.9L	53.	632.	.17	66.	21.L	.5	2.0
D169027	.064L	1.	.6L	26.	440.	.05	6.	16.L	.4	.9

Table 5.--Major, minor, and trace-element composition of 10 rock samples from selected sites in the Raton coal field, New Mexico, reported on a whole-rock basis--Continued

SAMPLE	TH PPM	U PPM	ZN PPM	B PPM-S	BA PPM-S	BE PPM-S	CO PPM-S	CR PPM-S	GA PPM-S	LA PPM-S	TOTAL S%
D169014	16.2	6.6	75.	50	700	N	N	50	30	70	0.06
D169015	6.0	2.8	17.	20	200	N	3 L	20	10	N	.32
D169016	13.6	4.6	32.	50 L	700	3	N	50	30	70	.22
D169017	13.4	5.9	62.	50 L	700	N	15	20	20	70	.33
D169018	11.6	5.0	156.	50 L	700	N	15	70	20	N	.54
D169019	14.6	6.7	35.	50 L	500	N	10	50	20	50	.44
D169020	15.1	5.6	168.	50	700	N	N	70	20	70	.17
D169021	14.0	5.5	77.	50 L	700	N	15	50	20	70	.23
D169022	10.7	5.5	191.	50 L	700	2	15	70	20	70	.28
D169027	8.2	4.2	39.	50	500	N	N	10	20	N	.23

SAMPLE	NB PPM-S	NI PPM-S	SC PPM-S	SN PPM-S	SR PPM-S	V PPM-S	Y PPM-S	YB PPM-S	ZR PPM-S	TOTAL C%	ORGNC C%	CRBNT C%
D169014	30	10 L	15	N	300	150	30	3	200	2.83	2.8	0.02
D169015	7	3 L	5	N	700	50	7	1	50	52.2	51.	.96
D169016	15	10 L	15	15	150	150	15	3	150	3.49	3.5	.01L
D169017	15	15	15	N	150	150	15	2	150	8.22	7.4	.83
D169018	15	20	15	N	150	150	20	2	200	12.0	12.	.01L
D169019	15	15	10	N	200	100	15	2	100	13.4	13.	.01L
D169020	15	7 L	15	N	200	150	15	1.5	150	9.45	9.4	.01L
D169021	15	15	15	N	200	150	15	1.5	150	8.99	8.5	.50
D169022	15	20	15	20	150	70	20	2	150	8.03	8.0	.01L
D169027	15 L	N	7 L	N	100	50	15	1.5	100	24.4	24.	.01L

Table 6.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate, ultimate, Btu, and forms-of-sulfur analyses for 10 Raton field coal samples

[All values except Btu are in percent and are reported on the as-received basis]

	Arithmetic mean (abundance)	Observed range Minimum	Observed range Maximum	Geometric mean (expected value)	Geometric deviation
Proximate and ultimate analyses					
Moisture	1.8	1.3	2.5	1.8	1.2
Volatile matter	36.1	31.2	42.3	36	1.1
Fixed carbon	50.7	43.5	54.4	50.6	1.1
Ash	11.4	5.8	22.8	10.4	1.6
Hydrogen	5.2	4.7	6	5.2	1.1
Carbon	72.7	61.8	77.8	72.5	1.1
Nitrogen	1.7	1.2	2	1.6	1.1
Oxygen	8.6	7.8	10.4	8.6	1.1
Sulfur	.5	.4	.6	.5	1.2
Btu	13,100	11,620	14,230	13,070	1.1
Forms of sulfur					
Sulfate	0.01	0.00	0.02	0.01	1.4
Pyritic	.06	.02	.11	.05	1.6
Organic	.43	.30	.56	.42	1.2

Table 6a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate, ultimate, and forms-of-sulfur analyses for 86 Rocky Mountain province coal samples

[All values except Btu are in percent and are reported on the as-received basis]

	Arithmetic mean (abundance)	Observed range Minimum	Observed range Maximum	Geometric mean (expected value)	Geometric deviation
Proximate and ultimate analyses					
Moisture	12.9	1.6	35.0	10.5	2.0
Volatile matter	36.0	22.7	46.7	35.7	1.1
Fixed carbon	42.0	17.1	52.5	41.5	1.2
Ash	9.1	2.1	32.2	7.7	1.8
Hydrogen	5.6	4.4	6.7	5.6	1.1
Carbon	59.7	27.1	75.2	58.9	1.2
Nitrogen	1.2	.5	1.6	1.1	1.3
Oxygen	23.8	8.2	47.9	22.4	1.4
Sulfur	.6	.2	5.1	.5	1.8
Btu	10,480	4,660	13,370	11,110	1.5
Forms of sulfur					
Sulfate	0.05	0.01L	1.59	0.02	2.4
Pyritic	.19	.02	2.64	.11	2.9
Organic	.32	.06	1.11	.22	3.0

Table 7.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 17 major and minor oxides and trace elements in the ash of 16 Raton field coal samples

[All samples were ashed at 525°C. L after a value means less than the value shown]

Element or oxide	Arithmetic mean (abundance)	Range		Geometric mean (expected value)	Geometric deviation
		Minimum	Maximum		
Ash %	13.9	6.2	38.2	12.0	1.7
SiO_2 %	45	32	60	45	1.2
Al_2O_3 %	24	17	30	24	1.2
CaO %	9.1	.36	17	5.7	2.7
MgO %	1.72	.53	2.49	1.60	1.5
Na_2O %	.70	.26	1.53	.63	1.6
K_2O %	.65	.08	2.3	.45	2.4
Fe_2O_3 %	6.2	2.8	11	5.8	1.5
MnO %	.023	.015	.029	.022	1.3
TiO_2 %	1	.73	1.3	1	1.2
P_2O_5 %	1	.1 L	1.7	.28	5.4
SO_3 %	5.4	.62	6.4	1.9	4.4
Cd ppm	1 L	------	1 L	-------	---
Cu ppm	143	46	208	128	1.6
Li ppm	83	40	136	80	1.3
Pb ppm	59	35	195	55	1.5
Zn ppm	59	31	102	54	1.5

Table 7a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 17 major and minor oxides and trace elements in the ash of 295 Rocky Mountain province coal samples

[All samples were ashed at 525°C; L after a value means less than the value shown]

Oxide or element	Arithmetic mean (abundance)	Observed range Minimum	Observed range Maximum	Geometric mean (expected value)	Geometric deviation
Ash %	13.3	1.76	88.2	10.9	1.9
SiO_2 %	46	15	79	44	1.4
Al_2O_3 %	21	4.3	35	19	1.4
CaO %	8.9	.21	35	6.2	2.4
MgO %	1.63	.22	7.10	1.4	1.8
Na_2O %	1.39	.08	8.56	.68	3.3
K_2O %	.65	.05	3.0	.45	2.3
Fe_2O_3 %	7.6	1.1	26	4.5	2.8
MnO %	.049	.004	.55	.029	2.8
TiO_2 %	.89	.02L	1.8	.81	1.6
P_2O_5 %	.41	.056	3.6	.14	4.2
SO_3 %	8.4	.10L	29	5.1	2.7
Cd ppm	.7	.5 L	4.0	.59	1.9
Cu ppm	87	22	1,260	77	1.6
Li ppm	88	10 L	328	73	1.9
Pb ppm	45	20 L	195	41	1.5
Zn ppm	77	13	1,820	62	1.9

Table 8.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 37 elements in 16 Raton field coal samples (whole-coal basis). For comparison, average shale values are listed (Turekian and Wedepohl, 1961)

[As, F, Sb, Th, and U values used to calculate the statistics were determined directly on whole coal. All other values used were calculated from determinations made on coal ash. L after a value means less than the value shown. Statistical values for Mn and Cd could not be calculated owing to variability of the lower limits]

Element or oxide	Arithmetic mean (abundance)	Range Minimum	Range Maximum	Geometric mean (expected value)	Geometric deviation	Average shale
Si %	3.1	1.2	8.9	2.5	2.0	7.3
Al %	1.8	.84	5.1	1.5	1.7	8.0
Ca %	.74	.08	3.1	.49	2.5	2.21
Mg %	.126	.059	.33	.115	1.5	1.55
Na %	.068	.022	.14	.056	1.9	.96
K %	.09	.005	.37	.04	3.5	2.66
Fe %	.49	.34	.81	.48	1.3	4.72
Mn ppm	---	9.6 L	30	---	---	850
Ti %	.08	.03	.21	.07	1.7	.46
P ppm	310	27 L	750	220	2.3	700
As ppm	1	1 L	5	1	1.6	13
Cd ppm	---	.1 L	.4 L	---	---	.3
Cu ppm	16.9	8.1	37.9	15.3	1.6	45
F ppm	95	20 L	195	78	1.9	740
Hg ppm	.06	.01	.13	.05	1.8	.4
Li ppm	11.1	4.2	37.3	9.5	1.8	66
Pb ppm	8.5	2.2	61.6	6.5	2.1	20
Sb ppm	.3	.2	.7	.3	1.5	1.5
Se ppm	1.5	.7	2.1	1.4	1.3	.6
Th ppm	5.7	2.9	15.5	5	1.7	12
U ppm	1.6	.7	4.1	1.4	1.6	3.7
Zn ppm	7.9	2.7	32.1	6.5	1.9	95
B ppm	15	7	20	15	1.4	100
Ba ppm	300	70	500	300	1.9	580
Be ppm	1	.2	1.5	.7	1.8	3
Co ppm	3	1.5 L	5	2	1.6	19
Cr ppm	7	2	30	5	2.0	90
Ga ppm	5	2	10	3	1.8	19
Mo ppm	1	.7	3	1	1.6	2.6
Nb ppm	3	1.5 L	10	3	2.0	11
Ni ppm	5	1.5 L	10	3	2.0	68
Sc ppm	2	1.5	7	2	1.5	13
Sr ppm	200	70	700	150	1.8	300
V ppm	20	7	70	15	1.7	130
Y ppm	7	3	15	7	1.5	26
Yb ppm	.7	.3	1.5	.7	1.5	2.6
Zr ppm	20	10	70	20	1.7	160

Table 8a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 37 elements in 295 Rocky Mountain province coal samples (whole-coal basis). For comparison average shale values are listed (Turekian and Wedepohl, 1961)

[As, F, Sb, Se, Th, and U values used to calculate the statistics were determined directly on whole-coal. All other values used were calculated from determinations made on coal ash. L means less than the value shown]

Element	Arithmetic mean (abundance)	Observed range Minimum	Observed range Maximum	Geometric mean (expected value)	Geometric deviation	Average shale
Si %	3.2	0.9	23	2.3	2.3	7.3
Al %	1.6	.14	13	1.1	2.3	8.0
Ca %	.61	.05	3.7	.48	2.0	2.21
Mg %	.107	.015	.76	.089	1.8	1.55
Na %	.155	.002	.76	.055	4.2	.96
K %	.092	.003	1.7	.041	3.6	2.66
Fe %	.64	.10	4.2	.34	3.1	4.72
Mn ppm	33	2.7	492	20	2.6	850
Ti %	.062	.001L	.54	.047	2.1	.46
P ppm	280	8.2	1800	120	3.7	700
As ppm	2	1 L	50	2	2.5	13
Cd ppm	.8	.021	.50	.5	2.7	.3
Cu ppm	10.8	1.3	100	8.4	2.0	45
F ppm	95	20 L	920	69	2.2	740
Hg ppm	.08	.01	1.48	.05	2.4	.4
Li ppm	13	.44 L	82.9	8.0	2.7	66
Pb ppm	6.5	.95	62	4.7	2.2	20
Sb ppm	.4	.05 L	5.2	.3	2.2	1.5
Se ppm	1.6	.10L	5.7	1.2	2.1	.6
Th ppm	4.2	1.7	34.8	2.9	2.5	12
U ppm	1.9	.1	23.8	1.1	2.8	3.7
Zn ppm	10.7	1.0	380	6.8	2.6	95
B ppm	70	7	300	70	2.2	100
Ba ppm	300	3	1,500	150	2.6	580
Be ppm	.7	.05	3	.5	2.3	3
Co ppm	2	.3	10	1.5	2.0	19
Cr ppm	5	.5	70	5	2.2	90
Ga ppm	5	.3	30	3	2.3	19
Mo ppm	2	.2	15	1.5	2.3	2.6
Nb ppm	7	.3	30	5	2.6	11
Ni ppm	3	.7	20	2	2.1	68
Sc ppm	2	.3	15	1.5	2.0	13
Sr ppm	100	5	700	100	2.1	300
V ppm	15	1.5	100	100	2.1	130
Y ppm	7	.5	30	5	2.1	26
Yb ppm	.7	.03	3	.5	2.2	2.6
Zr ppm	30	3	100	20	2.3	160

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4. The desert land forms of Peru; a preliminary photographic atlas, by M. J. Grolier, G. E. Ericksen, J. F. McCauley, and E. C. Morris. 146 p., 110 figs. 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

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