

THE GEOLOGICAL SURVEY OF WYOMING

Gary B. Glass, State Geologist

REPORT OF INVESTIGATIONS NO. 27

ANALYSES AND MEASURED SECTIONS OF 25 COAL
SAMPLES FROM THE HANNA COAL FIELD OF
SOUTHCENTRAL WYOMING
(Collected between 1975 and 1979)

by
Gary B. Glass and Jay T. Roberts



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U.S. Department of Energy in Pittsburgh, Pennsylvania, and to the U.S. Geological Survey in Denver, Colorado, for analysis. One sample (79-1) was analyzed by a commercial laboratory (Wyoming Analytical Laboratories) in Laramie, Wyoming.

INTRODUCTION

Between 1975 and 1979, personnel of the Geological Survey of Wyoming collected 25 face-channel coal samples from active mines or outcrops located in the Hanna Coal Field in southcentral Wyoming (Figure 1). Representative splits of these samples were sent to the

Proximate and ultimate analyses, heat values, ash composition, and trace element concentrations were determined by various of these laboratories. Also determined were forms of sulfur, fusibi-

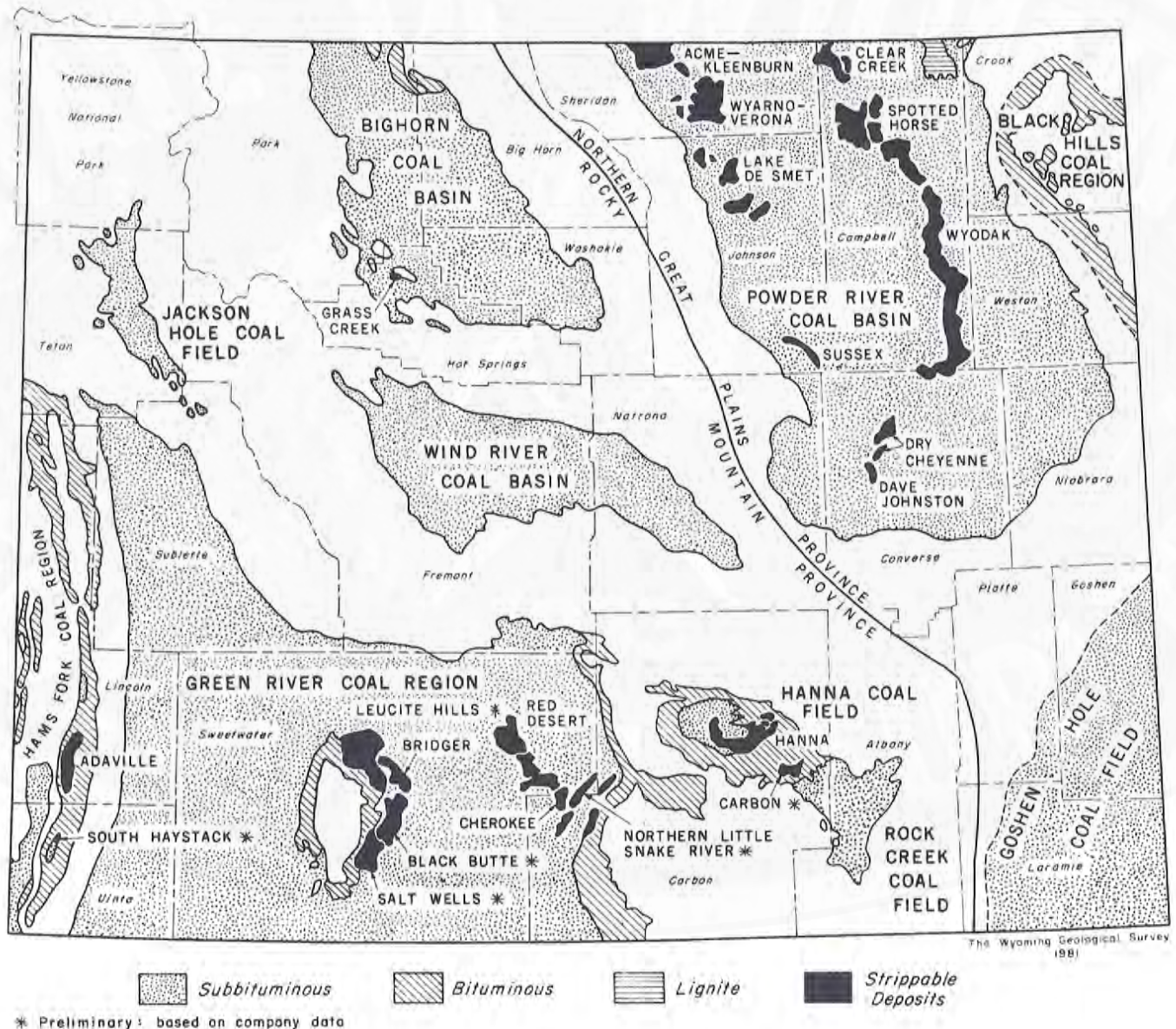


Figure 1. Wyoming coal-bearing areas.

lity temperatures of ash, Hardgrove grindability indices, and free-swelling indices of several samples. To complement the analyses, detailed megascopic descriptions of the coal beds and measured sections of the overlying rocks were made at each sampling site (Appendix).

It is stressed at the onset that there are not enough analyses in this report to characterize any individual coals or mines. The chemical and physical characterization of Wyoming's coals by either individual coal bed or coals in specific mines, coal fields, or geologic formations is deferred until other published and unpublished analyses are integrated with these. Such characterization is part of ongoing studies at the Geological Survey of Wyoming (Glass, 1975; 1978; McClurg and others, 1983).

ACKNOWLEDGMENTS

We would especially like to acknowledge the fine analytical work provided by the Coal Analysis Section of the U.S. Department of Energy (formerly a part of the U.S. Bureau of Mines) in Pittsburgh, Pennsylvania, and by the U.S. Geological Survey's Branch of Analytical Laboratories in Denver, Colorado. Under a cooperative arrangement, these analyses were performed at no charge, a service equally acknowledged and fully appreciated.

The help of Vernon E. Swanson and Joseph R. Hatch of the U.S. Geological Survey's Branch of Coal Resources is also appreciated. Student assistants Glenn Miller and Sanford Kaplan are to be complimented for their aid. Special mention is also given to Fred Porter and Phyllis Ranz of the Wyoming Geological Survey's drafting section.

Last, but certainly not least, we thank all the coal mining companies that permitted sampling in or around their mines.

SAMPLED COALS AND SAMPLING SITES

For the most part, the sampled coal beds (complimented by those of Glass, 1975) represent the more important mineable beds in the Hanna Coal Field (Glass and Roberts, 1979; 1980a; 1980b). With a few exceptions, the sampled coals are all either actively or recently mined beds. These coals were generally sampled in active strip mines and sampling sites were chosen on the basis of freshness of exposure and ease of sampling the entire height of the bed.

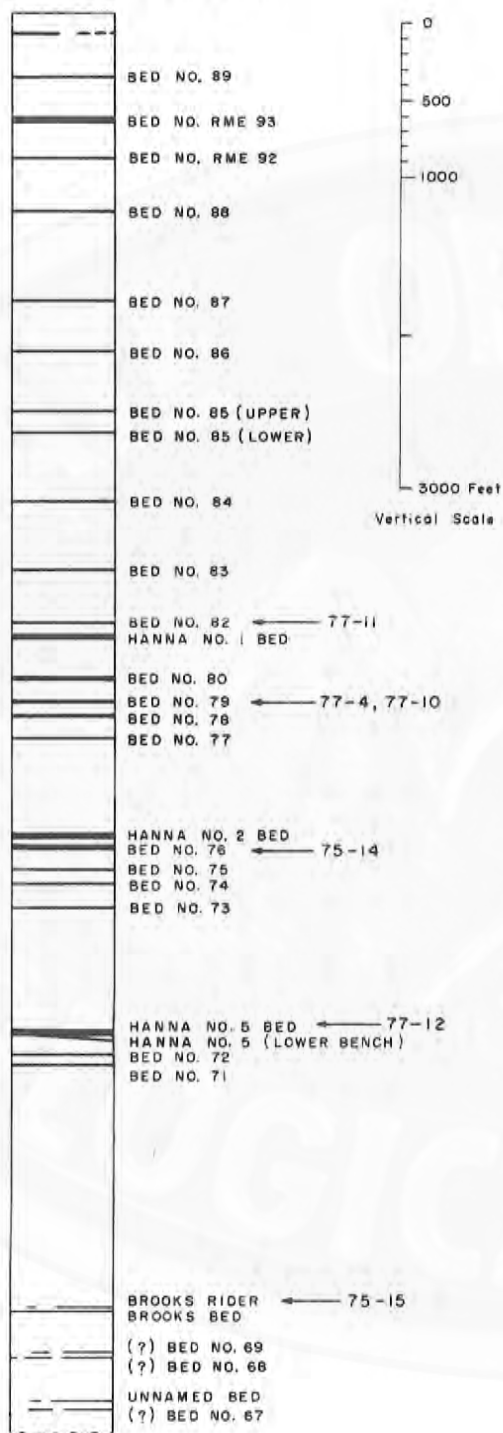
Samples 75-4, 75-5, and 75-6, however, are atypical in that (1) they do not represent actively mined coals and (2) they were not freshly exposed samples. Any use of the analyses of these three beds must acknowledge that the samples were extremely weathered where they were sampled and certainly may not typify fresh samples of the same coals. These samples and their analyses are only presented in this report for completeness.

Locations of sample sites within the Hanna Coal Field are shown on Figure 2. A detailed location map of each sample site is provided in the Appendix.

The 25 collected samples represent an estimated 21 different coal beds varying in age from Upper Cretaceous to Eocene. In all, 14 samples were collected from the Ferris Formation in the Seminole Mining District, 1 sample from the Ferris Formation in the Hanna Mining District, 7 samples from the Hanna Formation in the Hanna Mining District, 1 sample from the Mesaverde Formation in the Corral Creek Mining District, and 2 samples from the Mesaverde Formation at sites lying outside the mining district boundaries defined by Glass and Roberts (1979).

Figure 3 shows the approximate stratigraphic positions of the sampled Ferris and Hanna Formation coal beds. Because of inadequate geologic control, even the relative stratigraphic positions of the

HANNA FORMATION



FERRIS FORMATION

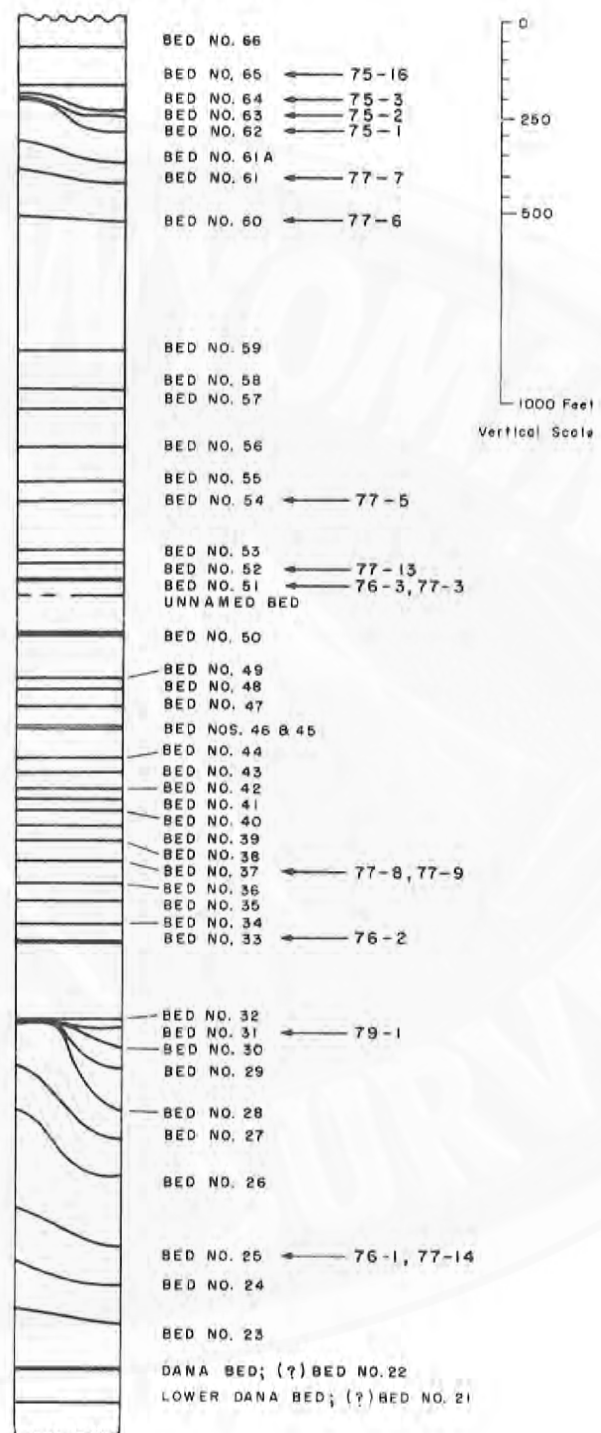


Figure 3. Relative stratigraphic positions of sampled coal beds in the Hanna and Ferris Formations. (Annotated arrows point to sampled coal beds.)

sampled Mesaverde Formation coals are unknown at this time (Sample Nos. 75-4, 75-5, and 75-6).

FIELD SAMPLING TECHNIQUE

All the analyses in this report are of face-channel samples. In this sampling method, a hand pick is used to cut a vertical channel (approximately 6 inches wide by 2 inches deep) from the top to the bottom of an exposed coal face (Glass, 1975). Individual samples then represent the entire thickness of each sampled coal, excluding all unmined portions of the bed. Usually these unmined portions are noncoaly partings of shale or other rock. Conversely, all noncoaly partings that are mined along with the coal are left in the samples. This deviates from older procedures that required a sampler to pick out and discard all partings of shale, pyrite, or other noncoaly material greater than 3/8 inch thick -- in essence cleaning the coal. This older conventional practice was avoided because Wyoming's coals are not cleaned after mining. Since the analyses of "as-used" coals are as important to the prediction of plant emissions as they are to the prediction of its combustion behavior in those plants, the removal of mined impurities could lessen the value of the analyses for both these purposes.

HANDLING AND PREPARATION OF SAMPLES

As the coal was cut from a channel, it was placed in plastic bags. These bags were then sealed in airtight steel cans and shipped back to Laramie. At the Survey's laboratory in Laramie, the coal samples were crushed to one inch or smaller fragments (1-inch X 0) using a commercial jaw crusher. Two representative splits of about one to three pounds each were then obtained by repeatedly passing the crushed coal through a riffle-type sample splitter. One split was later shipped to the U.S. Department of Energy and the other to the U.S. Geological Survey for analysis.

COAL ANALYSES AND PHYSICAL TESTS

Proximate and ultimate analyses as well as determinations of heat values, forms of sulfur, and fusibility temperatures of ash are reported for all samples. Free-swelling indices and Hardgrove grindability indices are also provided for several samples. With one exception (Sample 79-1), concentrations of major, minor, and trace elements are reported for each sample as well. Major and minor elements include silicon (Si), aluminum (Al), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), titanium (Ti), phosphorous (P), sulfur (S), and chlorine (Cl). Trace elements include arsenic (As), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), cerium (Ce), cobalt (Co), chromium (Cr), copper (Cu), fluorine (F), gallium (Ga), germanium (Ge), mercury (Hg), lanthanum (La), lithium (Li), molybdenum (Mo), niobium (Nb), neodymium (Nd), nickel (Ni), lead (Pb), antimony (Sb), scandium (Sc), selenium (Se), strontium (Sr), thorium (Th), uranium (U), vanadium (V), yttrium (Y), ytterbium (Yb), zinc (Zn), and zirconium (Zr).

These analyses and tests were performed by either the U.S. Department of Energy's Coal Analysis Section in Pittsburgh, Pennsylvania, the U.S. Geological Survey's Branch of Analytical Laboratories in Denver, Colorado, or by Wyoming Analytical Laboratories, Inc. in Laramie, Wyoming. Table 1 shows the analyses or tests performed by each of the laboratories.

Routine coal analyses and physical tests

The U.S. Department of Energy's Coal Analysis Section and Wyoming Analytical Laboratories did the routine proximate and ultimate analyses as well as the determinations of heat values and the forms of sulfur. The results of these analyses are given in Table 2 on an as-received, dry, and dry, ash-free basis. The fusibility temperatures of ash, Hardgrove grindability index, and free-

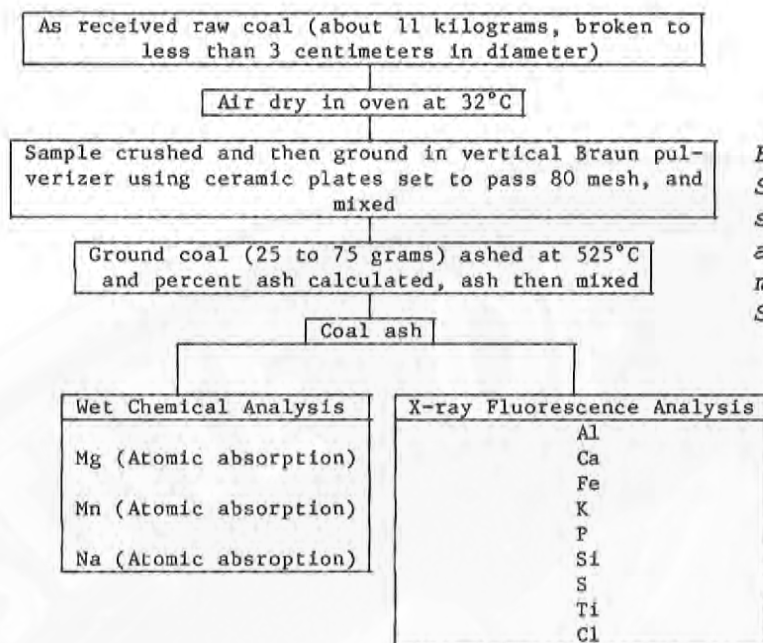


Figure 4. The U.S. Geological Survey's laboratory sequence of sample preparation and chemical analysis for major and minor elements in coal (modified from Swanson and Huffman, 1976).

swelling index of several samples are also provided. The results of these tests are shown in Table 3. Mean values for the proximate and ultimate analyses, forms of sulfur, and heat values of samples, arranged by geologic formation, are given in Table 4. Mean values and standard deviations for the fusibility temperatures of ash, Hardgrove grindability indices, and free-swelling indices are listed by geologic formation in Table 5. Since these mean values are only derived from 24 samples, they do not necessarily characterize the formations from which they were sampled.

The analytical methods used by the U.S. Department of Energy and Wyoming Analytical Laboratories, Inc. are described in Part 26 of the Annual Book of ASTM Standards (American Society of Testing and Materials 1979) and in U.S. Bureau of Mines Bulletin 638 (Office of Coal Research, 1967).

Major and minor elements in coal ash

The U.S. Geological Survey determined

concentrations of eleven major and minor elements in each sample. These elements were silicon (Si), aluminum (Al), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), manganese (Mn), titanium (Ti), phosphorus (P), and sulfur (S). A twelfth element, chlorine (Cl), was determined for only some of the samples. Analysis for all these elements was done on 525°C. laboratory ash. The U.S. Geological Survey's sequence of sample preparation and chemical analysis is shown in Figure 4.

With one exception, Tables 6 and 7 give the results of these analyses as percent oxides in the ash and as percent elements calculated back to whole-coal, respectively. The one exception is chlorine, which is reported as percent chlorine in both the ash (Table 6) and whole-coal (Table 7). Table 8 lists the mean values and standard deviations of the oxides of the ash, and Table 9 does the same on the whole-coal basis. Values in both these tables are arranged by geologic formation.

Table 1. Analyses and physical tests performed by the various laboratories.

U. S. Department of Energy	Wyoming Analytical Laboratories, Inc. ¹	U. S. Geological Survey
Proximate analysis (percent)	Proximate analysis (percent)	Major and minor elements (percent) ²
Moisture	Moisture	Silicon (Si)
Volatile matter	Volatile matter	Aluminum (Al)
Fixed carbon	Fixed carbon	Calcium (Ca)
Ash	Ash	Magnesium (Mg)
Ultimate analysis (percent)	Ultimate analysis (percent)	Sodium (Na)
Hydrogen (H)	Hydrogen (H)	Potassium (K)
Carbon (C)	Carbon (C)	Iron (Fe)
Nitrogen (N)	Nitrogen (N)	Manganese (Mn)
Oxygen (O)	Oxygen (O)	Titanium (Ti)
Sulfur (S)	Sulfur (S)	Phosphorous (P)
Ash	Ash	Sulfur (S)
		Chlorine (Cl)
Heat value (Btu/pound)	Heat value (Btu/pound)	Trace elements (ppm) ³
Forms of sulfur (percent)	Forms of sulfur (percent)	Arsenic (As)
Sulfate	Sulfate	Beryllium (Be)
Pyritic	Pyritic	Boron (B)
Organic	Organic	Barium (Ba)
Fusibility of ash (temp., °F)	Fusibility of ash (temp., °F)	Cadmium (Cd)
Initial deformation temp.	Initial deformation temp.	Cerium (Ce)
Softening temperature	Softening temperature	Cobalt (Co)
Fluid temperature	Fluid temperature	Chromium (Cr)
Hardgrove grindability index		Copper (Cu)
Free-swelling index		Fluorine (F)
		Gallium (Ga)
		Germanium (Ge)
		Mercury (Hg)
		Lanthanum (La)
		Lithium (Li)
		Molybdenum (Mo)
		Niobium (Nb)
		Neodymium (Nd)
		Nickel (Ni)
		Lead (Pb)
		Antimony (Sb)
		Scandium (Sc)
		Selenium (Se)
		Strontium (Sr)
		Thorium (Th)
		Uranium (U)
		Vanadium (V)
		Yttrium (Y)
		Ytterbium (Yb)
		Zinc (Zn)
		Zirconium (Zr)

¹ Sample No. 79-1 only

² Reported as percent of 525°C laboratory ash

³ Reported as parts per million 525°C laboratory ash and/or parts per million on a whole-coal basis

Table 2. Proximate and ultimate analyses, forms of sulfur, and heat values of 24

SAMPLE NO. LAB NO.	COUNTY, SEC. TWP. RGE.	COAL FIELD MINE NAME, MINE TYPE	FORMATION AGE	COAL NAME, BED THICKNESS ² SAMPLE THICKNESS ²
75-1 K-54483	Carbon 29 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 62 9.35 9.35
75-2 K-54484	Carbon 29 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 63 5.2 5.2
75-3 K-54485	Carbon 29 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 64 6.2 6.2
75-4 ⁴ K-55549 & K-56014	Carbon 9 24N 85W	Hanna O'Brien Spring Abandoned Deep	Mesaverde Cretaceous	O'Brien Spring Bed 4.0 3.2
75-5 ⁴ K-55550 & K-56015	Carbon 22 22N 79W	Hanna Wissler Abandoned Deep	Mesaverde Cretaceous	Bed No. 112-A 4.1 4.1
75-6 ⁴ K-55551 & K-56016	Carbon 24 21N 78W	Hanna Burn Right Abandoned Deep	Mesaverde Cretaceous	Burn Right Bed 8.0 8.0
75-14 ?	Carbon 32 23N 81W	Hanna Seminole No. 2 Active Strip	Hanna Paleocene	Bed No. 76 11.2 7.8
75-15 ?	Carbon 10 22N 82W	Hanna Rimrock Inactive Strip	Hanna Paleocene	Brooks Rider 1.4 1.4
75-16 K-58216	Carbon 33 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 65 9.7 9.7
76-1 K-69486	Carbon 12 22N 84W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 25 11.05 11.05
76-2 K-69487	Carbon 1 22N 84W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 33 8.15 7.85
76-3 K-69488	Carbon 6 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 51 8.2 8.2
77-3 K-84736	Carbon 5 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 51 7.3 7.1
77-4 K-84746	Carbon 2 22N 81W	Hanna Rosebud Pit No. 6 Active Strip	Hanna Paleocene	Bed No. 79 (Upper Bench) 7.5 6.4
77-5 K-84737	Carbon 9 22N 83W	Hanna Seminole No. 1 Active Strip	Hanna Paleocene	Bed No. 54 4.0 4.0

coal samples from the Hanna Coal Field.

PROXIMATE ANALYSIS (PERCENT)				ULTIMATE ANALYSIS (PERCENT)					SULFUR FORMS (PERCENT)			BTU/ POUND	BASIS ³
MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	H	C	N	O	S	SULFATE	PYRITIC	ORGANIC		
10.2	36.2	46.9	6.7	5.4	62.5	1.2	23.6	0.6	0.02	0.22	0.33	10,860	1
-	40.3	52.2	7.5	4.8	69.6	1.3	16.2	0.6	0.02	0.24	0.37	12,090	2
-	43.5	56.5	-	5.2	75.3	1.4	17.4	0.7	0.02	0.26	0.40	13,070	3
9.5	35.9	43.5	7.1	5.5	62.7	1.2	22.9	0.6	0.02	0.22	0.39	10,940	1
-	44.0	48.2	7.8	4.9	69.3	1.3	16.0	0.7	0.02	0.24	0.43	12,080	2
-	47.8	52.2	-	5.3	75.2	1.4	17.3	0.8	0.02	0.26	0.47	13,110	3
10.8	38.5	44.1	6.6	5.6	62.8	1.1	23.5	0.4	0.02	0.17	0.18	10,880	1
-	43.1	49.5	7.4	4.9	70.3	1.2	15.8	0.4	0.02	0.19	0.20	12,190	2
-	46.6	53.4	-	5.3	76.0	1.3	17.0	0.4	0.02	0.21	0.22	13,170	3
29.4	29.4	31.4	9.9	5.5	39.4	1.3	43.7	0.3	0.03	0.11	0.20	5,995	1
-	41.6	44.2	14.1	3.2	55.8	1.8	24.7	0.5	0.03	0.15	0.28	8,485	2
-	48.3	51.7	-	3.7	64.9	2.1	28.9	0.5	0.04	0.17	0.33	9,870	3
34.6	28.5	24.7	12.3	5.9	33.0	0.9	47.6	0.3	0.02	0.07	0.19	4,915	1
-	43.5	37.8	18.7	3.2	50.5	1.4	25.8	0.5	0.03	0.10	0.29	7,520	2
-	53.6	46.4	-	3.9	62.1	1.7	31.8	0.6	0.04	0.13	0.36	9,245	3
16.3	36.0	39.7	8.0	5.5	52.6	1.2	32.2	0.5	0.01	0.12	0.35	8,840	1
-	43.1	47.3	9.6	4.3	62.9	1.4	21.2	0.6	0.01	0.15	0.42	10,550	2
-	47.7	52.3	-	4.8	69.6	1.5	23.5	0.7	0.01	0.16	0.46	11,670	3
10.3	39.4	40.5	9.8	5.7	61.0	1.4	21.4	0.7	0.02	0.16	0.48	10,690	1
-	43.9	45.2	10.9	5.1	68.0	1.6	13.7	0.8	0.02	0.18	0.54	11,920	2
-	49.3	50.7	-	5.7	76.3	1.8	15.3	0.9	0.03	0.20	0.60	13,380	3
14.6	32.3	42.7	10.4	5.2	54.9	1.3	27.1	1.1	0.33	0.01	0.71	9,250	1
-	37.8	50.0	12.2	4.2	64.3	1.5	16.5	1.3	0.39	0.01	0.83	10,830	2
-	43.1	56.9	-	4.8	73.2	1.7	18.8	1.5	0.44	0.01	0.95	12,330	3
13.9	34.6	46.0	5.5	5.5	60.8	1.3	26.4	0.5	0.06	0.06	0.42	10,330	1
-	40.1	53.5	6.4	4.6	70.7	1.5	16.3	0.6	0.07	0.07	0.48	11,990	2
-	42.9	57.1	-	5.0	75.5	1.6	17.2	0.7	0.07	0.07	0.52	12,810	3
14.4	31.6	45.2	8.8	5.3	57.4	0.9	27.1	0.4	0.02	0.16	0.21	9,790	1
-	36.9	52.8	10.3	4.4	67.0	1.1	16.7	0.5	0.02	0.18	0.25	11,440	2
-	41.2	58.8	-	4.9	74.8	1.2	18.6	0.5	0.02	0.20	0.28	12,750	3
14.1	29.7	46.3	9.9	5.5	57.2	1.0	26.0	0.4	0.03	0.15	0.24	9,760	1
-	34.6	53.9	11.5	4.5	66.6	1.1	15.7	0.5	0.03	0.17	0.28	11,350	2
-	39.1	60.9	-	5.1	75.2	1.3	17.8	0.5	0.04	0.20	0.32	12,830	3
12.5	31.9	47.3	8.3	5.4	60.1	1.2	24.3	0.6	0.02	0.16	0.46	10,300	1
-	36.5	54.0	9.5	4.6	68.6	1.4	15.1	0.7	0.02	0.18	0.52	11,770	2
-	40.3	59.7	-	5.0	75.9	1.5	16.7	0.8	0.02	0.20	0.58	13,000	3
12.5	34.0	45.1	8.4	5.3	57.5	1.3	27.1	0.5	0.00	0.07	0.44	10,000	1
-	38.8	51.6	9.6	4.4	65.7	1.4	18.2	0.6	0.00	0.08	0.51	11,430	2
-	42.9	57.1	-	4.9	72.7	1.6	20.2	0.7	0.00	0.09	0.56	12,640	3
12.4	34.4	47.3	5.9	5.6	61.4	1.4	24.7	1.0	0.03	0.22	0.75	10,580	1
-	39.3	53.9	6.8	4.8	70.1	1.6	15.6	1.1	0.04	0.25	0.86	12,080	2
-	42.2	57.8	-	5.2	75.2	1.7	16.8	1.2	0.04	0.27	0.92	12,960	3
12.5	31.1	39.2	17.2	5.1	51.2	1.2	24.0	1.3	0.04	0.39	0.84	8,830	1
-	35.5	44.8	19.7	4.2	58.6	1.3	14.7	1.5	0.05	0.44	0.97	10,090	2
-	44.2	55.8	-	5.3	73.0	1.6	18.4	1.8	0.06	0.55	1.20	12,570	3

Table 2 continued.

SAMPLE NO. LAB NO.	COUNTY, SEC. TWP. RGE.	COAL FIELD MINE NAME, MINE TYPE	FORMATION AGE	COAL NAME, BED THICKNESS ² SAMPLE THICKNESS ²
77-6 K-84738	Carbon 17 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 60 3.6 3.6
77-7 K-84740	Carbon 17 23N 83W	Hanna Medicine Bow Active Strip	Ferris Paleocene	Bed No. 61 7.1 7.1
77-8 & 9 ⁵ K-84739	Carbon 16 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 37 7.9 7.9
77-10 K-84743	Carbon 18 23N 81W	Hanna Seminole No. 2 North Active Strip	Hanna Paleocene	Bed No. 79 19.6 19.6
77-11 K-84744	Carbon 36 23N 81W	Hanna Rosebud Pit No. 5 Active Strip	Hanna Eocene	Bed No. 82 7.9 7.9
77-12 K-84745	Carbon 7 22N 81W	Hanna Seminole No. 2 South Active Strip	Hanna Paleocene	Hanna No. 5 (Upper Bench) 8.7 7.9
77-13 K-84741	Carbon 5 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 52 2.9 2.5
77-14 ⁶ K-84742	Carbon 16 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 25 9.67 9.67
79-1 ⁷ 2487	Carbon 23 22N 83W	Hanna Seminole No. 1 Active Strip	Ferris Paleocene	Bed No. 31 8' 8'

¹Analyses performed by U. S. Department of Energy's Coal Analysis Section in Pittsburgh, Pennsylvania.

²Thicknesses are in feet.

³The analyses are reported as: 1, sample as-received; 2, sample dry (moisture-free); 3, sample dry, ash-free (moisture and ash-free).

⁴Analyses reported for sample nos. 75-4, 75-5, 75-6 are averages of two separate splits (all samples were badly weathered).

⁵Samples 77-8 and 77-9 were combined for this analysis.

⁶Sample was weathered.

⁷Analysis performed by Wyoming Analytical Laboratories, Inc., Laramie, Wyoming.

PROXIMATE ANALYSIS (PERCENT)			ULTIMATE ANALYSIS (PERCENT)						SULFUR FORMS (PERCENT)			BTU/ POUND	BASIS ⁵
MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	H	C	N	O	S	SULFATE	PYRITIC	ORGANIC		
10.8	37.2	43.2	8.8	5.5	60.9	1.2	23.0	0.6	0.00	0.22	0.35	10,400	1
-	41.6	48.5	9.9	4.8	68.3	1.4	15.0	0.6	0.00	0.25	0.39	11,660	2
-	46.2	53.8	-	5.3	75.8	1.5	16.6	0.7	0.00	0.27	0.44	12,940	3
8.2	33.5	37.5	20.8	5.0	51.0	1.3	21.2	0.7	0.03	0.24	0.47	9,140	1
-	36.5	40.9	22.6	4.5	55.6	1.4	15.1	0.8	0.03	0.26	0.51	9,950	2
-	47.1	52.9	-	5.8	71.8	1.8	19.6	1.0	0.04	0.34	0.66	12,860	3
12.3	35.6	38.7	13.4	5.4	56.0	1.2	23.5	0.6	0.02	0.12	0.43	9,540	1
-	40.6	44.1	15.3	4.6	63.8	1.4	14.3	0.6	0.03	0.13	0.49	10,870	2
-	47.9	52.1	-	5.4	75.3	1.6	16.9	0.8	0.03	0.16	0.57	12,830	3
9.2	39.7	41.9	9.2	5.7	62.2	1.3	20.4	1.1	0.10	0.52	0.52	11,100	1
-	43.7	46.2	10.1	5.1	68.6	1.4	13.4	1.3	0.11	0.58	0.57	12,230	2
-	48.6	51.4	-	5.7	76.3	1.6	14.9	1.4	0.13	0.64	0.63	13,610	3
14.0	35.1	43.7	7.2	5.7	58.0	0.9	26.6	1.7	0.09	0.54	1.01	10,190	1
-	40.8	50.8	8.4	4.9	67.4	1.1	16.4	1.9	0.11	0.63	1.18	11,850	2
-	44.5	55.5	-	5.3	75.5	1.2	17.9	2.1	0.12	0.69	1.29	12,930	3
10.3	36.3	47.3	6.1	5.7	64.4	1.3	22.0	0.6	0.04	0.16	0.38	11,190	1
-	40.5	52.7	6.8	5.1	71.7	1.5	14.3	0.6	0.04	0.18	0.42	12,480	2
-	43.4	56.6	-	5.4	76.9	1.6	15.3	0.7	0.04	0.19	0.45	13,380	3
12.3	32.6	47.7	7.4	5.4	60.7	1.1	24.7	0.6	0.00	0.23	0.34	10,440	1
-	37.1	54.4	8.5	4.6	69.3	1.3	15.6	0.7	0.00	0.26	0.39	11,900	2
-	40.6	59.4	-	5.1	75.7	1.4	17.1	0.7	0.00	0.28	0.43	13,010	3
25.4	33.5	32.8	8.3	5.3	42.9	0.9	41.9	0.6	0.35	0.02	0.25	6,520	1
-	45.0	43.9	11.1	3.4	57.6	1.2	25.9	0.8	0.47	0.03	0.34	8,750	2
-	50.6	49.4	-	3.8	64.8	1.4	29.2	0.9	0.53	0.04	0.38	9,840	3
14.8	33.5	43.7	8.0	5.5	58.4	1.0	26.5	0.6	0.02	0.23	0.32	9,940	1
-	39.3	51.3	9.4	4.6	68.5	1.2	15.7	0.7	0.02	0.27	0.38	11,660	2
-	43.4	56.6	-	5.0	75.6	1.3	17.4	0.7	0.02	0.30	0.42	12,870	3

Table 3. Fusibility of ash, Hardgrove grindability indices, and free-swelling indices of 24 coal samples from the Hanna Coal Field.¹

SAMPLE NUMBER	LABORATORY NUMBER	FUSIBILITY OF ASH (TEMPERATURE °F) ²			HARDGROVE GRINDABILITY INDEX	FREE-SWELLING INDEX
		INITIAL DEFORMATION	SOFTENING TEMPERATURE	FLUID TEMPERATURE		
75-1	K-54483	2,070	2,120	2,170	53	Noncaking
75-2	K-54484	2,070	2,120	2,170	48	½
75-3	K-54485	2,070	2,120	2,170	43	Noncaking
75-4 ³	K-55549	2,910+	-	-	48	Noncaking
75-5 ³	K-55550	2,910+	-	-	-	Noncaking
75-6 ³	K-55551	2,910+	-	-	40	Noncaking
75-14	?	-	-	-	-	-
75-15	?	-	-	-	-	-
75-16	K-58216	2,110	2,160	2,200	52	Noncaking
76-1	K-69486	2,125	2,265	2,355	-	-
76-2	K-69487	2,275	2,355	2,460	-	-
76-3	K-69488	2,135	2,250	2,365	-	-
77-3	K-84736	2,220	2,260	2,300	-	-
77-4	K-84746	2,190	2,240	2,330	-	-
77-5	K-84737	2,130	2,180	2,300	-	-
77-6	K-84738	2,100	2,140	2,180	-	-
77-7	K-84740	2,350	2,400	2,460	-	-
77-8, 9	K-84739	2,350	2,400	2,460	-	-
77-10	K-84743	2,080	2,130	2,260	-	-
77-11	K-84744	2,090	2,140	2,190	-	-
77-12	K-84745	2,080	2,130	2,250	-	-
77-13	K-84741	2,110	2,140	2,170	-	-
77-14	K-84742	2,400	2,430	2,470	-	-
79-1 ⁴	2487	2,160	2,230	2,300	-	-

¹Tests performed by the U. S. Department of Energy's Coal Analysis Section in Pittsburgh, Pennsylvania.

²Performed in a reducing atmosphere.

³Analyses reported for sample nos. 75-4, 75-5, and 75-6 are averages of two separate splits (all samples were badly weathered).

⁴Tests performed by Wyoming Analytical Laboratories, Inc., Laramie, Wyoming.

Trace elements in coal

The U.S. Geological Survey's Branch of Analytical Laboratories determined concentrations of up to 31 different trace elements in each of the samples.

As many as 22 of these elements were identified in analyses of 525°C. laboratory ash. These elements were boron (B), barium (Ba), beryllium (Be), cadmium (Cd), cerium (Ce), copper (Cu), gallium (Ga), germanium (Ge), lanthanum

Table 4. Mean values of proximate and ultimate analyses, forms of sulfur, and heat values of 24 coal samples from the Hanna Coal Field, arranged by geologic formation.

NUMBER AVER- AGED	PROXIMATE ANALYSIS (PERCENT)				ULTIMATE ANALYSES (PERCENT)					SULFUR FORMS (PERCENT)			BTU/ POUND	BASIS ¹	
	MOISTURE	VOLATILE		FIXED CARBON	ASH	H	C	N	O	S	SULFATE	PYRITIC			ORGANIC
		MATTER	MATTER												
Mesaverde Formation ²															
3	26.8	31.3	31.9	10.1	5.6	41.7	1.1	41.2	0.4	0.02	0.10	0.25	6,580	1	
	-	42.7	43.2	14.1	3.6	56.4	1.5	23.9	0.5	0.02	0.13	0.33	8,850	2	
	-	49.9	50.1	-	4.1	65.5	1.8	28.1	0.6	0.03	0.15	0.38	10,260	3	
Ferris Formation															
14	13.0	34.5	43.4	9.1	5.4	57.9	1.1	25.8	0.6	0.04	0.16	0.35	9,920	1	
	-	39.6	49.9	10.5	4.5	66.5	1.3	16.5	0.6	0.05	0.18	0.40	11,370	2	
	-	44.3	55.7	-	5.1	74.2	1.5	18.5	0.7	0.06	0.21	0.45	12,700	3	
Hanna Formation															
7	11.9	35.5	43.2	9.4	5.5	59.0	1.3	23.7	1.1	0.09	0.29	0.67	10,260	1	
	-	40.2	49.1	10.7	4.8	67.0	1.4	14.9	1.2	0.11	0.32	0.78	11,640	2	
	-	45.0	55.0	-	5.3	74.9	1.6	16.8	1.4	0.12	0.36	0.86	13,020	3	

¹The analyses are reported as 1, sample as-received; 2, sample dry (moisture-free); and 3, sample dry, ash-free (moisture and ash-free).

²All the Mesaverde samples were weathered.

Table 5. Mean values and standard deviations¹ of the fusability of ash, Hardgrove grindability indices, and free-swelling indices of 24 coal samples from the Hanna Coal Field, arranged by geologic formation.

NUMBER AVERAGED	FUSABILITY OF ASH (TEMPERATURE °F.) ²			HARDGROVE GRINDABILITY INDEX	FREE-SWELLING INDEX
	INITIAL DEFORMATION	SOFTENING TEMPERATURE	FLUID TEMPERATURE		
		Mesaverde Formation			
3	2,910+	-	-	44 ³	Noncaking
		-	-	(4)	-
		Ferris Formation			
14	2,182	2,242	2,304	49 ⁴	Noncaking
	(112)	(111)	(120)	(4)	-
		Hanna Formation			
5	2,114	2,164	2,266	-	-
	(42)	(42)	(48)	-	-

¹Standard deviation is shown in parentheses below each mean.

²Samples which showed no initial deformation at 2910°F + were omitted from calculation of mean.

³Average of two analyses.

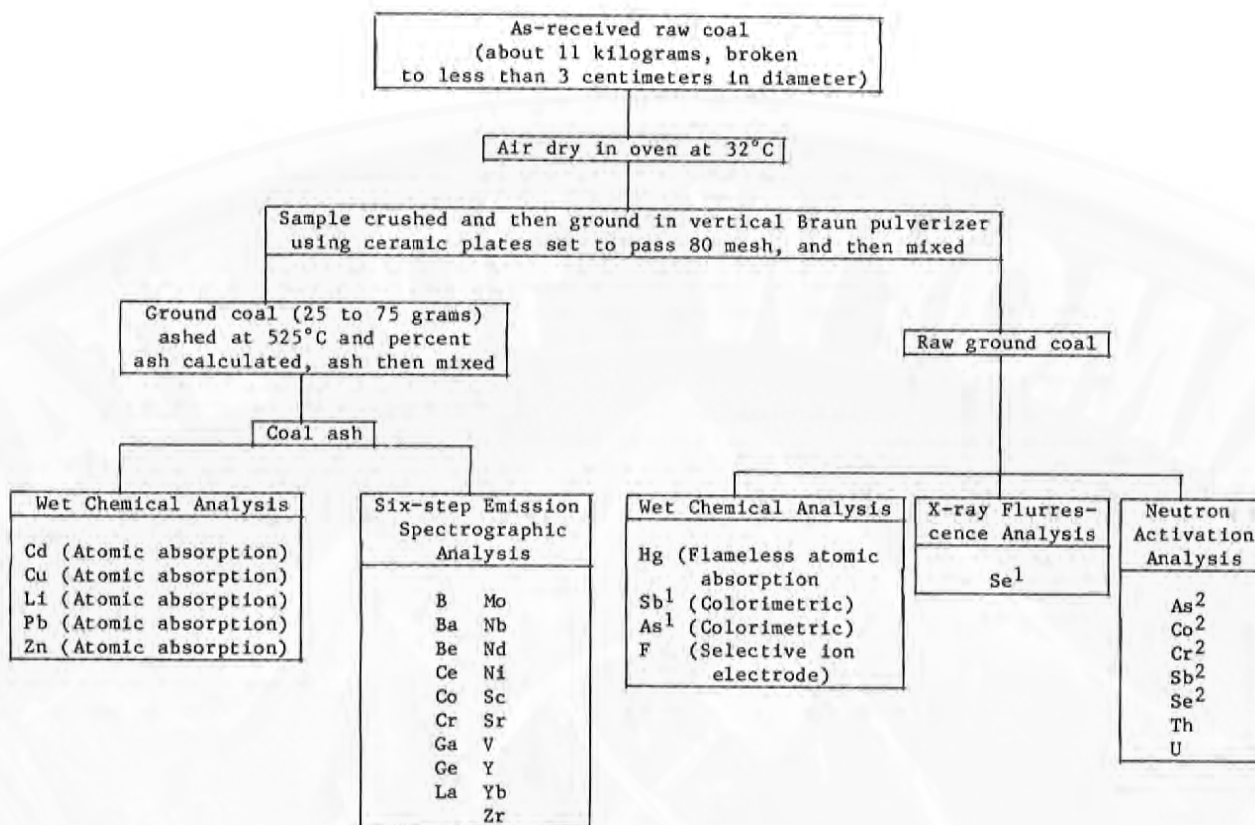
⁴Average of four analyses.

(La), lithium (Li), molybdenum (Mo), niobium (Nb), neodymium (Nd), nickel (Ni), lead (Pb), scandium (Sc), strontium (Sr), vanadium (V), yttrium (Y), ytterbium (Yb), zinc (Zn), and zirconium (Zr). Cobalt (Co) and chromium (Cr) concentrations were determined from laboratory ash until 1977. In 1977, analyses for these two elements were performed on raw coal, not on the ash.

Figure 5 shows the U.S. Geological Survey's sequence of sample preparation and analytical techniques for all 31 elements. This table was modified from Swanson and Huffman (1976) because the U.S. Geological Survey's analytical techniques for five trace elements changed in 1977. Up until 1977, cobalt and chromium were determined by a six-step emission spectrographic analysis; antimony and arsenic by wet chemical analysis; and selenium by x-ray fluorescence analysis. In 1977, all five of these elements were analyzed using neutron activation methods.

Analyses of up to 14 of the elements were quantitative determinations. These were arsenic, cadmium, chromium (in 1977), cobalt (in 1977), copper, fluorine, mercury, lithium, lead, selenium, antimony, thorium, uranium, and zinc. The other elements, including chromium and cobalt prior to 1977, were determined semiquantitatively by emission spectroscopy. The results of the semiquantitative emission spectrographic analyses are actually identified with geometric brackets whose boundaries are part of the ascending series 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, 1.2, and so forth, but which are reported as mid-points of the brackets. The mid-points of these brackets are 0.15, 0.2, 0.3, 0.5, 0.7, 1.0, and so forth. The precision of the reported value is approximately plus-or-minus one bracket at the 68-percent confidence level, or two brackets at the 95-percent confidence level (Swanson and Huffman, 1976).

The results of the U.S. Geological



¹ Analytical techniques used for these elements in 1975 and 1976.

² Analytical techniques used for these elements in 1977, only.

Figure 5. The U.S. Geological Survey's laboratory sequence of sample preparation and chemical analysis for trace elements in coal (modified from Swanson and Huffman, 1976).

Survey's trace element analyses are given in Table 10 as parts per million (ppm) of the laboratory ash, and in Table 11 as parts per million on a whole-coal basis. In this report, no attempt was made to

statistically summarize the trace element data, but a discussion of the statistical methods used by the U.S. Geological Survey is found on pages 21 and 22 of Glass (1978).

Table 6. Major and minor oxide and chlorine composition of the 525°C laboratory ash of 24 coal samples from the Hanna Coal Field.

SAMPLE NUMBER	LAB NUMBER	MAJOR AND MINOR OXIDES AND CHLORINE AS PERCENT OF THE ASH													TOTAL
		ASH	SiO ₂	Al ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	Fe ₂ O ₃	MnO	TiO ₂	P ₂ O ₅	SO ₃	Cl	
75-1	D176222	8.7	23	10	23	3.39	0.19	0.23	6.5	0.11	0.60	1.0L ¹	13	0.20L	81.22L
75-2	D176223	8.9	31	9.0	20	2.77	0.18	0.87	6.8	0.15	0.54	1.0L	12	0.20L	84.51L
75-3	D176224	7.9	31	14	19	2.57	0.26	0.63	6.3	0.17	0.69	1.0L	11	0.20L	86.82L
75-4	D176627	12.4	49	25	3.6	0.65	0.14	0.29	4.6	0.010	0.74	0.10L	5.5	0.10L	89.73L
75-5	D176628	16.8	58	21	1.9	0.51	0.18	0.39	3.7	0.003	0.81	0.13	3.2	0.10L	89.92L
75-6	D176629	9.6	54	23	2.3	0.28	0.09L	0.28	6.4	0.025	0.99	0.10L	4.0	0.10L	91.56L
75-14	D177434	11.9	41	20	12	3.34	0.14	1.1	5.6	0.021	0.73	1.4	6.2	-	91.53
75-15	D177435	12.4	45	18	8.2	1.58	0.14	1.2	8.8	0.080	0.64	0.18	10	-	95.82
75-16	D177436	7.9	20	11	30	2.97	0.14	0.45	6.7	0.10	0.37	1.9	18	-	91.63
76-1	D183108	9.1	28	17	21	2.25	0.88	0.46	4.1	0.025	0.77	1.0L	8.2	0.20L	83.88L
76-2	D183109	12.2	44	18	12	3.22	0.71	1.5	3.0	0.046	0.87	1.0L	7.2	0.20L	91.75L
76-3	D183110	10.3	31	14	20	2.08	0.11	0.87	4.2	0.079	0.67	1.0L	9.9	0.20L	84.11L
77-3	D197308	10.1	28	12	22	2.63	0.18	0.70	4.7	0.11	0.58	1.6	12	-	84.50
77-4	D197319	6.5	17	12	20	2.33	0.13	0.55	8.9	0.19	0.58	2.8	19	-	83.48
77-5	D197309	19.8	51	16	7.9	1.42	0.15	1.0	4.4	0.037	0.86	1.3	8.1	-	92.17
77-6	D197310	9.9	37	11	18	1.98	0.32	0.77	5.4	0.093	0.56	1.2	10	-	86.32
77-7	D197313	22.0	61	17	5.5	1.57	0.14	2.0	3.6	0.052	0.75	1.0L	5.0	-	97.61L
77-8	D197311	7.9	28	12	22	3.5	0.15	0.60	4.4	0.046	0.92	3.1	12	-	86.72
77-9	D197312	19.9	58	20	5.2	1.18	0.13	1.8	3.0	0.017	0.69	1.0L	5.7	-	96.72L
77-10	D197316	10.6	46	19	4.0	2.39	0.15	1.3	11	0.20	0.85	1.0L	8.6	-	94.49L
77-11	D197317	8.6	35	19	6.9	1.31	0.11	0.66	15	0.054	1.3	1.8	14	-	95.13
77-12	D197318	7.1	31	16	16	2.92	0.24	0.84	4.8	0.083	0.61	2.4	9.9	-	84.79
77-13	D197314	8.6	36	10	17	2.71	0.17	0.88	6.3	0.059	0.57	1.0L	11	-	85.69L
77-14	D197315	10.9	24	14	24	3.4	0.31	0.31	4.9	0.16	0.76	1.7	18	-	91.54

¹L means less than

Table 7. Major and minor element composition of 24 coal samples from the Hanna Coal Field reported on a whole-coal basis¹.

SAMPLE NUMBER	LAB NUMBER	MAJOR AND MINOR ELEMENTS AS PERCENT ON A WHOLE-COAL BASIS										
		Si	Al	Ca	Mg	Na	K	Fe	Mn	Ti	P	Cl
75-1	D176222	0.95	0.47	1.4	0.177	0.012	0.016	0.39	0.0075	0.031	0.038L ²	0.017L
75-2	D176223	1.3	0.42	1.5	0.149	0.012	0.065	0.42	0.0100	0.029	0.039L	0.018L
75-3	D176224	1.1	0.60	1.1	0.122	0.015	0.042	0.55	0.0110	0.032	0.034L	0.016L
75-4	D176627	2.8	1.6	0.32	0.048	0.012	0.030	0.40	0.0010	0.055	0.0054L	0.012L
75-5	D176628	4.5	1.9	0.23	0.052	0.022	0.055	0.44	0.0004	0.081	0.0097	0.017L
75-6	D176629	2.4	1.2	0.16	0.016	0.007L	0.022	0.43	0.0018	0.057	0.0042L	0.010L
75-14	D177434	2.3	1.2	1.0	0.239	0.012	0.11	0.47	0.0020	0.052	0.074	-
75-15	D177435	2.6	1.2	0.72	0.118	0.012	0.12	0.76	0.0077	0.047	0.0097	-
75-16	D177436	0.73	0.48	1.7	0.141	0.008	0.029	0.37	0.0063	0.017	0.067	-
76-1	D183108	1.2	0.82	1.4	0.123	0.059	0.035	0.26	0.0017	0.042	0.040L	0.018L
76-2	D183109	2.5	1.2	1.0	0.237	0.064	0.15	0.26	0.0044	0.064	0.053L	0.024L
76-3	D183110	1.5	0.76	1.5	0.129	0.0084	0.074	0.30	0.0063	0.041	0.045L	0.021L
77-3	D197308	1.3	0.64	1.6	0.160	0.013	0.059	0.33	0.0084	0.035	0.071	-
77-4	D197319	0.52	0.41	0.93	0.091	0.0063	0.030	0.40	0.0096	0.023	0.079	-
77-5	D197309	4.7	1.7	1.1	0.170	0.022	0.16	0.61	0.0057	0.10	0.112	-
77-6	D197310	1.7	0.58	1.3	0.118	0.024	0.063	0.37	0.0071	0.033	0.052	-
77-7	D197313	6.3	2.0	0.86	0.208	0.023	0.37	0.55	0.0088	0.099	0.096L	-
77-8	D197311	1.0	0.50	1.2	0.167	0.0088	0.039	0.24	0.0028	0.044	0.107	-
77-9	D197312	5.4	2.1	0.74	0.142	0.019	0.30	0.42	0.0027	0.082	0.087L	-
77-10	D197316	2.3	1.1	0.50	0.153	0.012	0.11	0.82	0.0165	0.054	0.046L	-
77-11	D197317	1.4	0.86	0.42	0.068	0.0070	0.047	0.90	0.0036	0.067	0.068	-
77-12	D197318	1.0	0.60	0.81	0.125	0.013	0.050	0.24	0.0046	0.026	0.074	-
77-13	D197314	1.4	0.46	1.0	0.141	0.011	0.063	0.38	0.0040	0.029	0.038L	-
77-14	D197315	1.2	0.81	1.9	0.223	0.025	0.028	0.37	0.0135	0.050	0.081	-

¹Calculated from analysis of 525°C laboratory ash

²L means less than

Table 8. Mean values and standard deviations of the major and minor oxide and chlorine compositions of the 525°C laboratory ash of 24 coal samples from the Hanna Coal Field, arranged by geologic formation.

NUMBER AVERAGED	MEAN VALUES AND STANDARD DEVIATIONS AS PERCENT OF ASH													
	ASH	SiO ₂	Al ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	Fe ₂ O ₃	MnO	TiO ₂	P ₂ O ₅	SO ₃	Cl	TOTAL
3	12.9 (3.0)	54 (4)	23 (2)	2.6 (0.7)	0.48 (0.15)	0.14L ² (0.04)	Mesaverde Formation							
							0.32 (0.05)	4.9 (1.1)	0.013 (0.009)	0.85 (0.11)	0.11L (0.01)	4.2 (1.0)	0.10L (0)	90.71L -
14	11.0 (4.2)	34 (12)	14 (3.3)	18 (6.6)	2.59 (0.681)	0.28 (0.22)	Ferris Formation							
							0.86 (0.52)	5.0 (1.3)	0.081 (0.051)	0.67 (0.14)	1.3L (0.6)	11 (3.7)	0.20L (0)	87.98L -
7	11.0 (4.2)	38 (11)	17 (2.5)	11 (5.2)	2.18 (0.725)	0.15 (0.038)	Hanna Formation							
							0.95 (0.26)	8.4 (3.5)	0.095 (0.066)	0.80 (0.25)	1.6L (0.81)	11 (4.0)	- (0)	91.17L -

¹ Standard deviation is shown in parentheses below each mean

² L means less than

Table 9. Mean values and standard deviations of the major and minor element compositions of 25 coal samples from the Hanna Coal Field reported on a whole-coal basis, arranged by geologic formation.

NUMBER AVERAGED	Si	Al	Ca	Mg	Na	K	Fe	Mn	Ti	P	Cl

¹Standard deviation is shown in parentheses below each mean

²L means less than

³Average of only six analyses

Table 10. Trace element composition of 525°C laboratory ash of 25 coal samples

SAMPLE NUMBER	ASH %	TRACE ELEMENT CONCENTRATIONS IN PARTS PER MILLION OF THE ASH												LABORATORY NUMBER
		B	Ba	Be	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mn	
75-1	8.7	300	5000	3	2.0	N ²	10L ³	30	78	30	N	48	860	D176222
75-2	8.9	300	2000	3	2.0	N	10L	50	107	20	N	25	1150	D176223
75-3	7.9	300	3000	3	1.0	N	10L	30	79	30	N	48	1350	D176224
75-4	12.4	70	500	15	1.0	500	50	50	96	30	150	37	80	D176627
75-5	16.8	100	2000	10	3.0	500L	20	50	95	30	150	27	60	D176628
75-6	9.6	500	1000	7	3.0	500L	30	30	97	30	150	50	190	D176629
75-14	11.9	300	3000	7	1.0L	500	15	150	98	30	200	64	165	D177434
75-15	12.4	700	1500	15	1.0	N	15	100	162	30	100	45	620	D177435
75-16	7.9	300	7000	N	1.0L	N	15	50	56	20	100L	20	800	D177436
76-1	9.1	500	5000	3	1.0L	500L	15	70	68	20	100L	63	190	D183108
76-2	12.2	500	5000	3	1.0L	500L	10	70	137	30	100L	82	360	D183109
76-3	10.3	300	3000	3	1.0	500L	15	70	110	20	100L	31	610	D183110
77-3	10.1	300	1500	N	1.0L	N	D ⁵	70	100	20	N	26	830	D197308
77-4	6.5	700	2000	3	1.0L	N	15	30	89	20	N	17	1470	D197319
77-5	19.8	300	1500	3	1.0L	N	D	70	118	30	N	54	290	D197309
77-6	9.9	500	1500	N	1.0L	N	D	30	80	20	N	31	720	D197310
77-7	22.0	150	1500	3	1.0L	N	D	70	86	30	N	91	400	D197313
77-8	7.9	500	5000	N	1.0L	N	D	70	108	20	N	19	360	D197311
77-9	19.9	150	1500	N	1.0L	N	D	70	82	30	N	72	135	D197312
77-10	10.6	300	1000	3	1.0L	N	20	70	109	30	150	82	1560	D197316
77-11	8.6	700	1500	N	1.0L	N	20	70	178	30	N	65	420	D197317
77-12	7.1	700	2000	3	1.0L	N	10	30	60	30	D	45	650	D197318
77-13	8.6	700	2000	N	1.0L	N	D	30	66	20	N	21	460	D197314
77-14	10.9	700	3000	N	1.0L	N	20	20	60	30	N	74	1240	D197315

¹ Concentrations of Cd, Cu, Li, Mn, Pb, and Zn determined by atomic absorption analyses of ash.
All other elements determined by semiquantitative six-step spectrographic analyses of ash.

² "N" means not detected.

³ "L" means less than.

⁴ "—" means no analysis was made for this element.

⁵ "D" means detected, but below the level of determination.

from the Hanna Coal Field, Wyoming¹.

LABORATORY NUMBER	TRACE ELEMENT CONCENTRATIONS IN PARTS PER MILLION OF THE ASH												SAMPLE NUMBER
	Mo	Nb	Nd	Ni	Pb	Sc	Sr	V	Y	Yb	Zn	Zr	
D176222	30	20L	- ⁴	30	40	15	1000	150	30	3	52	150	75-1
D176223	30	20L	-	50	40	15	1000	150	50	3	96	70	75-2
D176224	15	20L	-	50	45	15	2000	150	30	3	83	150	75-3
D176627	20	30	150	70	75	20	200	100	150	15	140	500	75-4
D176628	10	30	150	70	55	15	1500	100	100	10	106	300	75-5
D176629	10	30	150L	70	60	15	700	70	70	7	322	300	75-6
D177434	15	20	150	70	40	30	500	300	70	7	120	150	75-14
D177435	30	20L	150L	70	53	30	700	300	100	7	134	150	75-15
D177436	20	20L	N	30	35	15	2000	150	70	3	70	150	75-16
D183108	10	30	N	30	30	15	2000	150	70	5	64	100	76-1
D183109	15	50	N	30	30	15	1500	150	50	7	35	150	76-2
D183110	30	30	N	50	30	15	1500	300	70	7	53	100	76-3
D197308	15	N	-	30	45	10	1500	150	20	2	91	100	77-3
D197319	20	N	-	50	25L	10	1500	150	30	2	105	70	77-4
D197309	20	N	-	30	40	15	1000	300	30	3	82	150	77-5
D197310	15	N	-	15	30	10	1500	100	20	2	26	100	77-6
D197313	15	N	-	30	40	15	500	150	30	3	90	100	77-7
D197311	15	N	-	30	40	15	1500	150	50	3	64	100	77-8
D197312	15	N	-	30	40	10	500	150	20	2	134	150	77-9
D197316	15	N	N	70	35	20	300	200	100	7	161	100	77-10
D197317	15	N	-	70	25L	30	1500	200	70	5	184	150	77-11
D197318	15	N	-	30	35	15	1500	150	50	3	54	200	77-12
D197314	15	N	-	20	40	10	1500	150	30	2	36	70	77-13
D197315	10	N	-	70	30	0	1500	70	20	0	122	150	77-14

Table 11. Trace element composition of 24 coal samples from the Hanna Coal Field

SAMPLE NUMBER	TRACE ELEMENT CONCENTRATIONS IN PARTS PER MILLION ON A WHOLE-COAL BASIS															LABORATORY NUMBER
	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	F	Ga	Hg	La	Li	Mn	
75-1	5.0	20	500	0.2	0.17	N ²	1.0L ³	2.0	6.8	120	2.0	0.07	N	4.2	75.0	D176222
75-2	3.0	30	200	0.3	0.18	N	1.0L	5.0	9.5	80	2.0	0.03	N	2.2	100.0	D176223
75-3	2.0	20	200	0.2	0.08	N	0.7L	2.0	6.2	105	2.0	0.04	N	3.8	110.0	D176224
75-4	1.0	10	70	2.0	0.12	70	7.0	7.0	11.9	65	3.0	0.02	20	4.6	9.9	D176627
75-5	1.0	15	300	1.5	0.50	100L	3.0	10.0	16.0	60	5.0	0.02	20	4.5	4.5	D176628
75-6	1.0	50	100	0.7	0.29	50L	3.0	3.0	9.3	80	3.0	0.04	15	4.8	18.0	D176629
75-14	2.0	30	300	1.0	0.12L	70	2.0	20.0	11.7	80	3.0	0.11	20	7.6	20.0	D177434
75-15	2.0	100	200	2.0	0.12	N	2.0	15.0	20.1	70	3.0	0.08	15	5.6	77.0	D177435
75-16	2.0	20	500	N	0.08L	N	1.0	5.0	4.4	50	1.5	0.03	7L	1.6	63.0	D177436
76-1	1.0	50	500	0.3	0.09L	50L	1.5	7.0	6.2	55	2.0	0.04	10L	5.7	17.3	D183108
76-2	1.0	70	700	0.3	0.12L	70L	1.5	10.0	16.7	85	3.0	0.04	15L	10.0	43.9	D183109
76-3	2.5	30	300	0.3	0.10	50L	1.5	7.0	11.3	70	2.0	0.06	10L	3.2	62.8	D183110
77-3	3.29	30	150	N	0.10L	N	0.9	4.8	10.1	60	2.0	0.02	N	2.6	83.8	D197308
77-4	2.20	50	150	0.2	0.07L	N	1.5	3.2	5.8	40	1.5	0.03	N	1.1	95.6	D197319
77-5	3.79	70	300	0.7	0.20L	N	1.6	15.9	23.4	150	7.0	0.14	N	10.7	57.4	D197309
77-6	1.04	50	150	N	0.10L	N	1.0	4.5	7.9	50	2.0	0.02	N	3.1	71.3	D197310
77-7	7.82	30	300	0.7	0.22L	N	2.6	16.1	18.9	150	7.0	0.09	N	20.0	88.0	D197313
77-8	1.86	50	500	N	0.08L	N	0.9	3.8	8.5	60	1.5	0.01L	N	1.5	28.4	D197311
77-9	17.30	30	300	N	0.20L	N	2.2	12.7	16.3	150	7.0	0.07	N	14.3	26.9	D197312
77-10	7.77	30	100	0.3	0.11L	N	3.5	10.0	11.6	130	3.0	0.06	15	8.7	165.4	D197316
77-11	4.15	70	150	N	0.09L	N	3.4	5.5	15.3	65	2.0	0.15	N	5.6	36.1	D197317
77-12	2.70	50	150	0.2	0.07L	N	1.1	2.8	4.3	75	2.0	0.04	D ⁵	3.2	46.2	D197318
77-13	2.19	70	150	N	0.09L	N	1.0	3.8	5.7	35	1.5	0.01	N	1.8	39.6	D197314
77-14	0.58	70	300	N	0.11L	N	2.7	2.0	6.5	45	3.0	0.03	N	8.1	135.2	D197315

¹Concentrations of As, F, Hg, Sb, Se, Th, and U were determined on raw coal; concentrations of Co and Cr were only determined on raw coal in 1977; concentrations of Co and Cr in 1975 and 1976 were recalculated from ash compositions; concentrations of all other elements were recalculated.

²"N" means not detected.

³"L" means less than.

⁴"—" means no analysis was made for this element.

⁵"D" means detected, but below the level of determination.

reported on a whole-coal basis¹.

LABORATORY NUMBER	TRACE ELEMENT CONCENTRATIONS IN PARTS PER MILLION ON A WHOLE-COAL BASIS																SAMPLE NUMBER
	Mo	Nb	Nd	Ni	Pb	Sb	Sc	Se	Sr	Th	U	V	Y	Yb	Zn	Zr	
D176222	2.0	1.5L	- ⁴	2.0	3.5	0.5	1.5	0.9	100	3.0L	2.2	15	2	0.2	4.5	15	75-1
D176223	3.0	2.0L	-	5.0	3.6	0.9	1.5	0.6	100	3.0L	2.1	15	5	0.3	8.5	7	75-2
D176224	1.0	1.5L	-	5.0	3.6	0.3	1.0	0.6	150	3.0L	1.2	10	2	0.2	6.6	10	75-3
D176627	2.0	3.0	20	10.0	9.3	0.5	2.0	2.4	20	3.0L	2.2	15	20	2.0	17.4	70	75-4
D176628	1.5	5.0	20	10.0	9.2	0.4	2.0	2.5	200	6.3	1.8	15	15	1.5	17.8	50	75-5
D176629	1.0	3.0	15L	7.0	5.8	0.2	1.5	2.9	70	3.0L	1.0	7	7	0.7	30.9	30	75-6
D177434	2.0	2.0	20	10.0	4.8	0.5	3.0	0.8	70	7.5	2.9	30	10	1.0	14.3	20	75-14
D177435	3.0	2.0L	20L	10.0	6.6	1.5	3.0	0.9	100	6.0	4.1	30	15	1.0	16.6	20	75-15
D177436	1.5	1.5L	N	2.0	2.8	0.3	1.0	0.4	150	3.0L	0.7	10	5	0.2	5.5	10	75-16
D183108	1.0	3.0	N	3.0	2.7	0.4	1.5	1.5	200	3.0L	0.9	15	7	0.5	5.8	10	76-1
D183109	2.0	7.0	N	3.0	3.7	0.4	2.0	0.6	200	3.0L	1.6	20	7	1.0	4.3	20	76-2
D183110	3.0	3.0	N	5.0	3.1	0.6	1.5	0.9	150	3.0L	1.8	30	7	0.7	5.5	10	76-3
D197308	1.5	N	-	3.0	4.5	0.56	1.0	0.62	150	3.0L	2.09	15	2	0.2	9.2	10	77-3
D197319	1.5	N	-	3.0	1.6L	0.19	0.7	0.53	100	2.3L	0.60	10	2	0.15	6.8	5	77-4
D197309	5.0	N	-	7.0	7.9	1.38	3.0	1.28	200	6.3	5.60	70	7	0.7	16.2	30	77-5
D197310	1.5	N	-	1.5	3.0	0.38	1.0	0.51	150	2.7L	1.07	10	2	0.2	2.6	10	77-6
D197313	3.0	N	-	7.0	8.8	0.98	3.0	0.01L	100	7.6	3.57	30	7	0.7	19.8	20	77-7
D197311	1.0	N	-	2.0	3.2	0.32	1.0	0.54	100	2.7L	1.34	10	5	0.2	5.1	7	77-8
D197312	3.0	N	-	7.0	8.0	1.00	2.0	0.97	100	3.9L	3.48	30	5	0.5	26.7	30	77-9
D197316	1.5	N	N	7.0	3.7	0.31	2.0	0.80	30	7.4	2.98	20	10	0.7	17.1	10	77-10
D197317	1.5	N	-	7.0	2.2L	0.22	2.0	2.31	150	3.5	1.02	15	7	0.5	15.8	15	77-11
D197318	1.0	N	-	2.0	2.5	0.01L	1.0	0.68	100	2.6L	1.13	10	3	0.2	3.8	15	77-12
D197314	1.5	N	-	1.5	3.4	0.26	1.0	0.41	150	2.5L	0.88	15	2	0.15	3.1	7	77-13
D197315	1.0	N	-	7.0	3.3	0.18	D	0.57	150	2.6L	0.86	7	2	D	13.3	15	77-14

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APPENDIX: MEASURED SECTIONS OF 25
COAL SAMPLES COLLECTED FROM THE HANNA
COAL FIELD BETWEEN 1975 and 1979

The measured sections in this appendix are arranged in the same order as the various tables of analyses. Each measured section is described in a tabular form with illustrations.

SAMPLE NO. 75-1

INDEX MAPS: See Figure 6

STATE: Wyoming

COAL NAME(S): Bed No. 62

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 29

AGE: Paleocene

TOWNSHIP: 23N

COAL FIELD: Hanna (Seminole District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 7

COAL DESCRIPTION: See Figure 8

TOTAL SECTION MEASURED (FEET): 83.8

THICKNESS OF COAL (FEET): 9.35

COVER AT SAMPLING POINT (FEET): 73.9

THICKNESS SAMPLED (FEET): 9.35

ELEVATION TOP OF SAMPLED COAL: 6,461 feet

TYPE OF SAMPLE: Face-channel

STRIKE: Not measureable

CONDITION OF SAMPLE: Unweathered

DIP: 0°

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Medicine Bow

DATE OF SAMPLING: 6/19/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/5/75

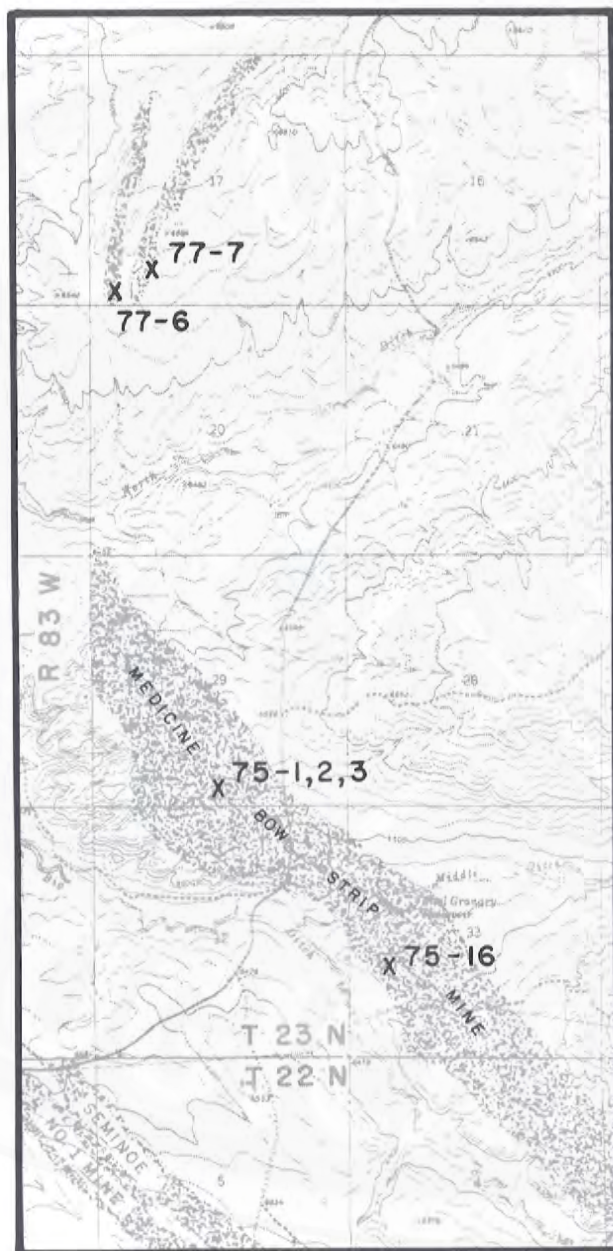
K-54483

U.S. Geological Survey: 11/26/75

D176222

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,716 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous

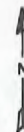
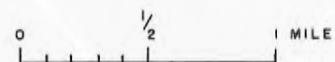


EXPLANATION

75-16 Sample site and
X sample number



Strip mine



Base map modified from U.S. Geological Survey's
Pats Bottom (1971) 7 1/2' topographic map.

Figure 6. Detailed location map of sample sites in Medicine Bow strip mine (SAMPLE NUMBERS 75-1, 75-2, 75-3, 75-16, 77-6 and 77-7).

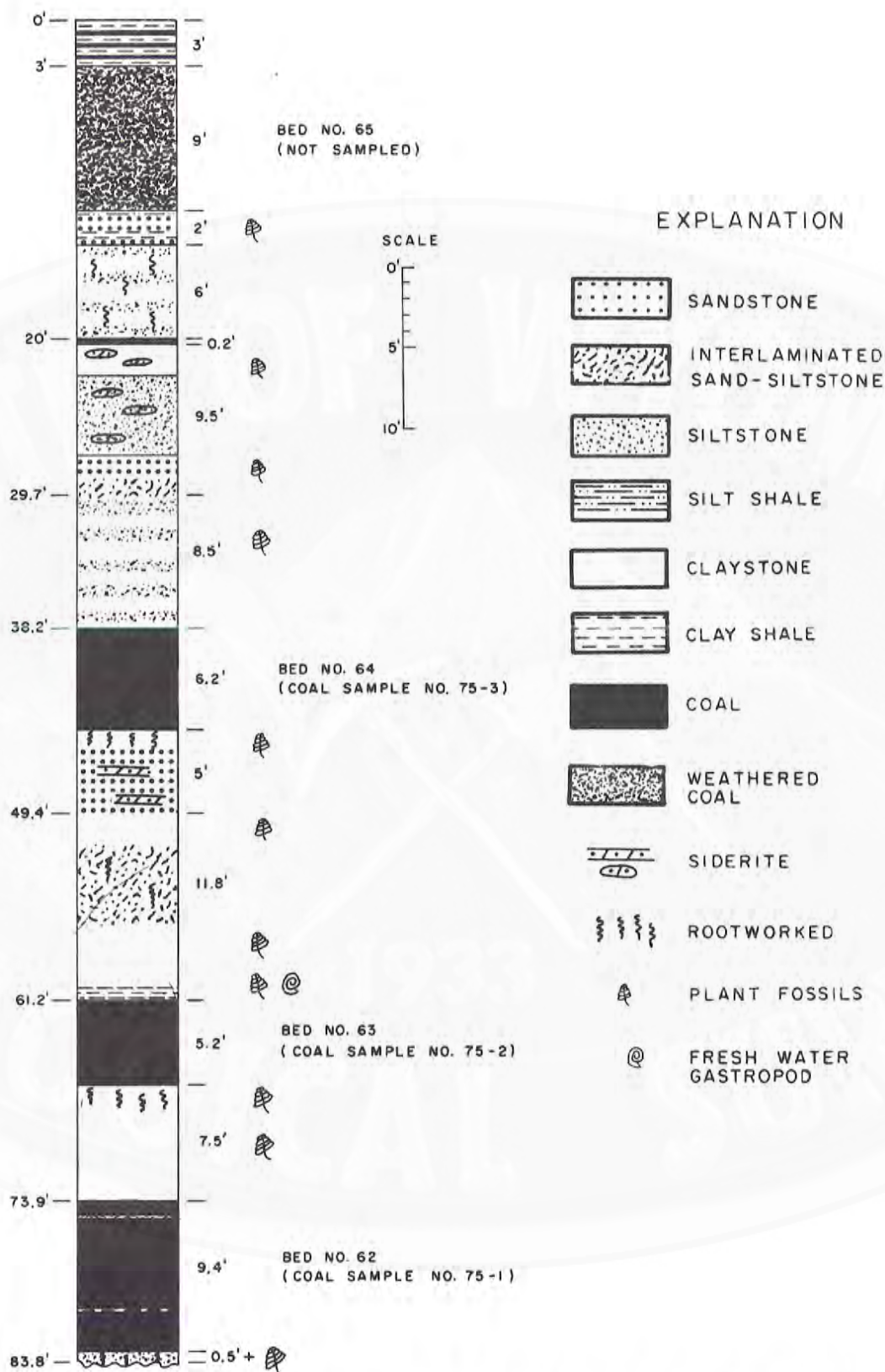


Figure 7. Measured section at Medicine Bow strip mine, Bed Numbers 62, 63, 64, and 65 (SAMPLE NUMBERS 75-1, 75-2, and 75-3).



COAL: Banded; vitrain bands and moderately bright to bright attritus; white sulfur powder common.

SILTSTONE: Coaly laminae and lenses rare.

COAL: Banded; vitrain bands and bright attritus; vitrain lenses to 1.5 inches thick; gypsum on joint faces.

CLAY SHALE: Slickensides common; coaly laminae rare.

COAL: Banded; vitrain bands and moderately bright attritus; powdery gypsum film on joint faces; thick vitrain lenses at top.

THICKNESS OF BED: 9.35 feet

THICKNESS SAMPLED: 9.35 feet

Figure 8. Megascopic description of Bed No. 62 in Medicine Bow strip mine (SAMPLE NO. 75-1).

SAMPLE NO. 75-2

INDEX MAPS: See Figure 6

COAL NAME(S): Bed No. 63

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminole District)

COAL-BEARING AREA: Hanna Coal Field

STATE: Wyoming

COUNTY: Carbon

SECTION: 29

TOWNSHIP: 23N

RANGE: 83W

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 7

TOTAL SECTION MEASURED (FEET): 83.8

COVER AT SAMPLING POINT (FEET): 61.2

ELEVATION TOP OF SAMPLED COAL: 6,474 feet

STRIKE: Not measureable

DIP: 0°

MAJOR JOINT ORIENTATIONS IN COAL:

102°, 120°

COAL DESCRIPTION: See Figure 9

THICKNESS OF COAL (FEET): 5.2

THICKNESS SAMPLED (FEET): 5.2

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Unweathered

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Medicine Bow

DATE OF SAMPLING: 6/19/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/5/75

U.S. Geological Survey: 11/26/75

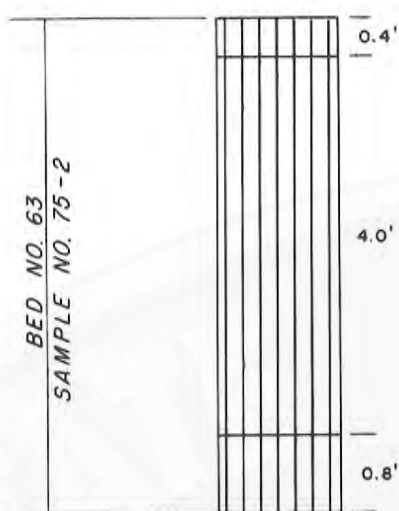
LABORATORY NUMBERS

K-54483

D176223

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,858 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous



COAL: Banded; vitrain bands and moderately dull attritus.

COAL: Banded; vitrain bands and bright attritus; vitrain lenses to three inches thick near top; amber nodules common in upper foot.

COAL: Banded; vitrain bands and moderately dull to dull attritus.

THICKNESS OF BED: 5.2 feet

THICKNESS SAMPLED: 5.2 feet

Figure 9. Megascopic descriptions of Bed No. 63 in Medicine Bow strip mine (SAMPLE NO. 75-2).

SAMPLE NO. 75-3

INDEX MAPS: See Figure 6

STATE: Wyoming

COAL NAME(S): Bed No. 64

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 29

AGE: Paleocene

TOWNSHIP: 23N

COAL FIELD: Hanna (Seminole District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 7

COAL DESCRIPTION: See Figure 10

TOTAL SECTION MEASURED (FEET): 83.8

THICKNESS OF COAL (FEET): 6.2

COVER AT SAMPLING POINT (FEET): 38.2

THICKNESS SAMPLED (FEET): 6.2

ELEVATION TOP OF SAMPLED COAL: 6,497 feet

TYPE OF SAMPLE: Face-channel

STRIKE: Not measureable

CONDITION OF SAMPLE: Unweathered

DIP: 0°

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Medicine Bow

102°, 120°

DATE OF SAMPLING: 6/19/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/5/75

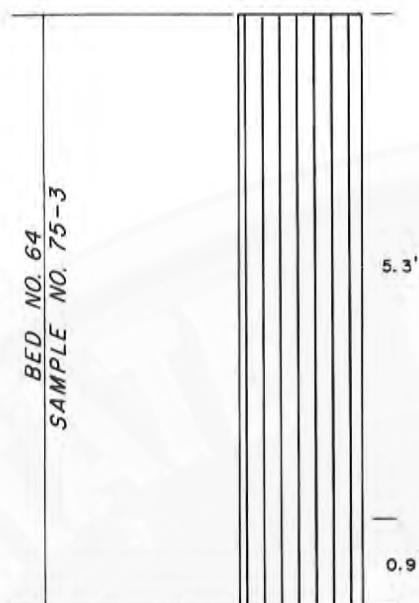
K-54485

U.S. Geological Survey: 11/26/75

D176224

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,721 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous



COAL: Banded; vitrain bands and moderately bright attritus; fusain lenses common; gypsum film on joints common; vitrain lenses to one foot thick near base.

COAL: Banded; vitrain bands and dull to moderately dull attritus; joints well developed.

THICKNESS OF BED: 6.2 feet

THICKNESS SAMPLED: 6.2 feet

Figure 10. Megascopic description of Bed no. 64 in Medicine Bow strip mine (SAMPLE NO. 75-3).

SAMPLE NO. 75-4

INDEX MAPS: See Figure 11

STATE: Wyoming

COAL NAME(S): O'Brien Spring

COUNTY: Carbon

GEOLOGIC FORMATION: Pine Ridge Sandstone

SECTION: 9

AGE: Upper Cretaceous

TOWNSHIP: 24N

COAL FIELD: Hanna (Corral Creek District)

RANGE: 85W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Seminoe Dam SW 7 1/2-minute

MEASURED SECTION: See Figure 12

COAL DESCRIPTION: See Figure 13

TOTAL SECTION MEASURED (FEET): 225.5

THICKNESS OF COAL (FEET): 4.0

COVER AT SAMPLING POINT (FEET): 0

THICKNESS SAMPLED (FEET): 3.2

ELEVATION TOP OF SAMPLED COAL: 6,600 feet±

TYPE OF SAMPLE: Face-channel

STRIKE: N84°E

CONDITION OF SAMPLE: Very weathered

DIP: 52°S

TYPE OF EXPOSURE: Deep mine entrance

MINE NAME: O'Brien Spring (abandoned)

DATE OF SAMPLING: 7/17/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 9/23/75, 10/29/75

K-55549, K-56014

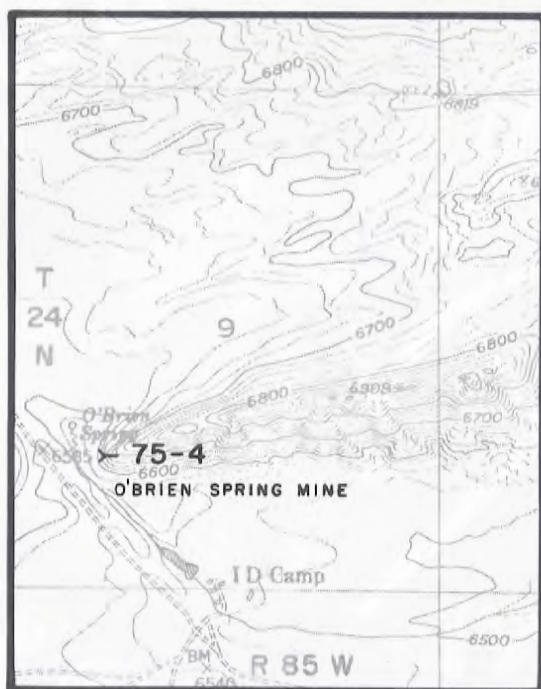
U.S. Geological Survey: 9/16/75

D176627

MOIST, MINERAL-MATTER-FREE HEAT VALUE: Too weathered for accurate analysis

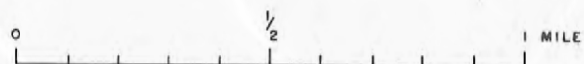
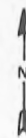
APPARENT RANK OF COAL: Too weathered for determination

MISCELLANEOUS COMMENTS: Section was measured at mine entrance and outcrop above mine.



EXPLANATION

75-4 Sample site and sample number



Base map modified from U.S. Geological Survey's
Seminole Dam SW (1953) 7 1/2' topographic map.

Figure 11. Detailed location map of the O'Brien Spring coal sample site at the O'Brien Spring underground mine (SAMPLE NO. 75-4).

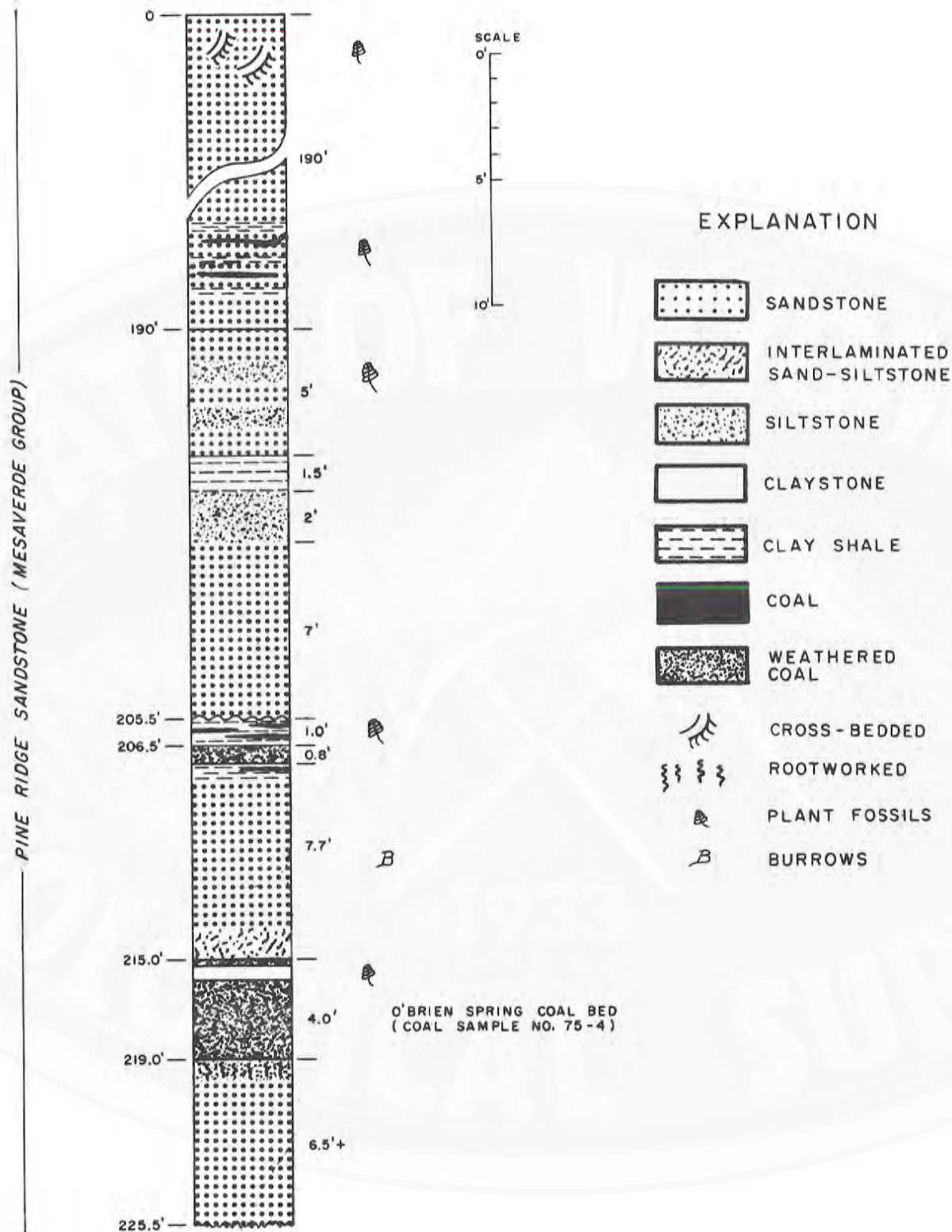


Figure 12. Measured section at O'Brien Spring underground coal mine, O'Brien Spring coal bed (SAMPLE NO. 75-4).



*COAL: Too weathered for detailed description.

*CLAYSTONE: Single unit; pure crystalline kaolinite in places (tonstein); plant fragments rare.

COAL: Very weathered; shaly in places; fairly well jointed; very damp when sampled.

*EXCLUDED FROM ANALYSIS

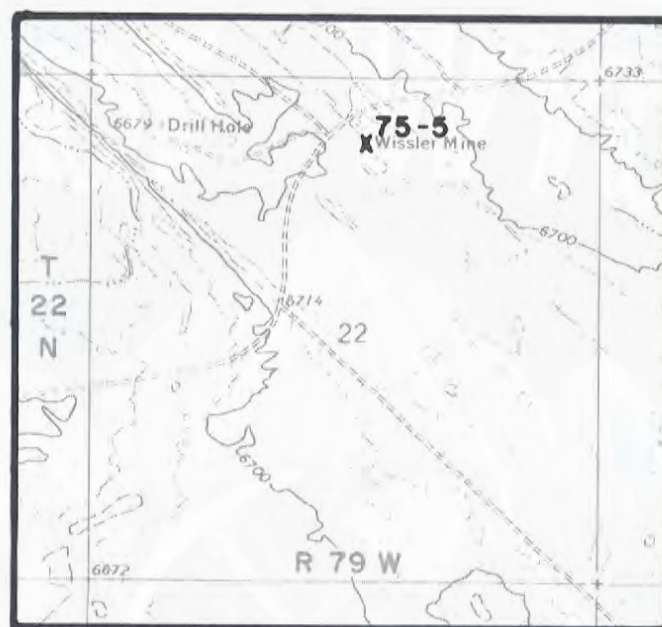
THICKNESS OF BED: 4.0 feet

THICKNESS SAMPLED: 3.2 feet

Figure 13. Megascopic description of the O'Brien Spring coal bed at O'Brien Spring underground mine (SAMPLE NO. 75-4).

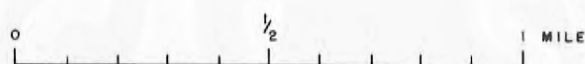
SAMPLE NO. 75-5

INDEX MAPS: See Figure 14	STATE: Wyoming
COAL NAME(S): Bed No. 112-A	COUNTY: Carbon
GEOLOGIC FORMATION: Mesaverde Formation	SECTION: 22
AGE: Upper Cretaceous	TOWNSHIP: 22N
COAL FIELD: Hanna (NE of Carbon District)	RANGE: 79W
COAL-BEARING AREA: Hanna Coal Field	QUADRANGLE: Halfway Hill 7 1/2-minute
MEASURED SECTION: See Figure 15	COAL DESCRIPTION: See Figure 16
TOTAL SECTION MEASURED (FEET): 22.0	THICKNESS OF COAL (FEET): 4.1
COVER AT SAMPLING POINT (FEET): 17.5	THICKNESS SAMPLED (FEET): 4.1
ELEVATION TOP OF SAMPLED COAL: 6,702 feet±	TYPE OF SAMPLE: Face-channel
STRIKE: 314-323°	CONDITION OF SAMPLE: Very weathered
DIP: 28-31°S	TYPE OF EXPOSURE: Deep mine entrance
	MINE NAME: Wissler (abandoned)
DATE OF SAMPLING: 7/17/75	
SAMPLE COLLECTOR: Wyoming Geological Survey	
COMPLETION DATE OF ANALYSES	LABORATORY NUMBERS
U.S. Bureau of Mines: 9/23/75, 10/29/75	K-55550, K-56015
U.S. Geological Survey: 9/16/75	D176628
MOIST, MINERAL-MATTER-FREE HEAT VALUE: Too weathered for accurate analysis	
APPARENT RANK OF COAL: Too weathered for determination.	
MISCELLANEOUS COMMENTS: The section was measured and the sample was collected at the collapsed entrance to the mine.	



EXPLANATION

x 75-5 *Sample site and sample number*



Base map modified from U.S. Geological Survey's Halfway Hill (1971) 7 1/2' topographic map.

Figure 14. Detailed location map of the Bed No. 112-A sample site at Wissler underground mine (SAMPLE NO. 75-5).

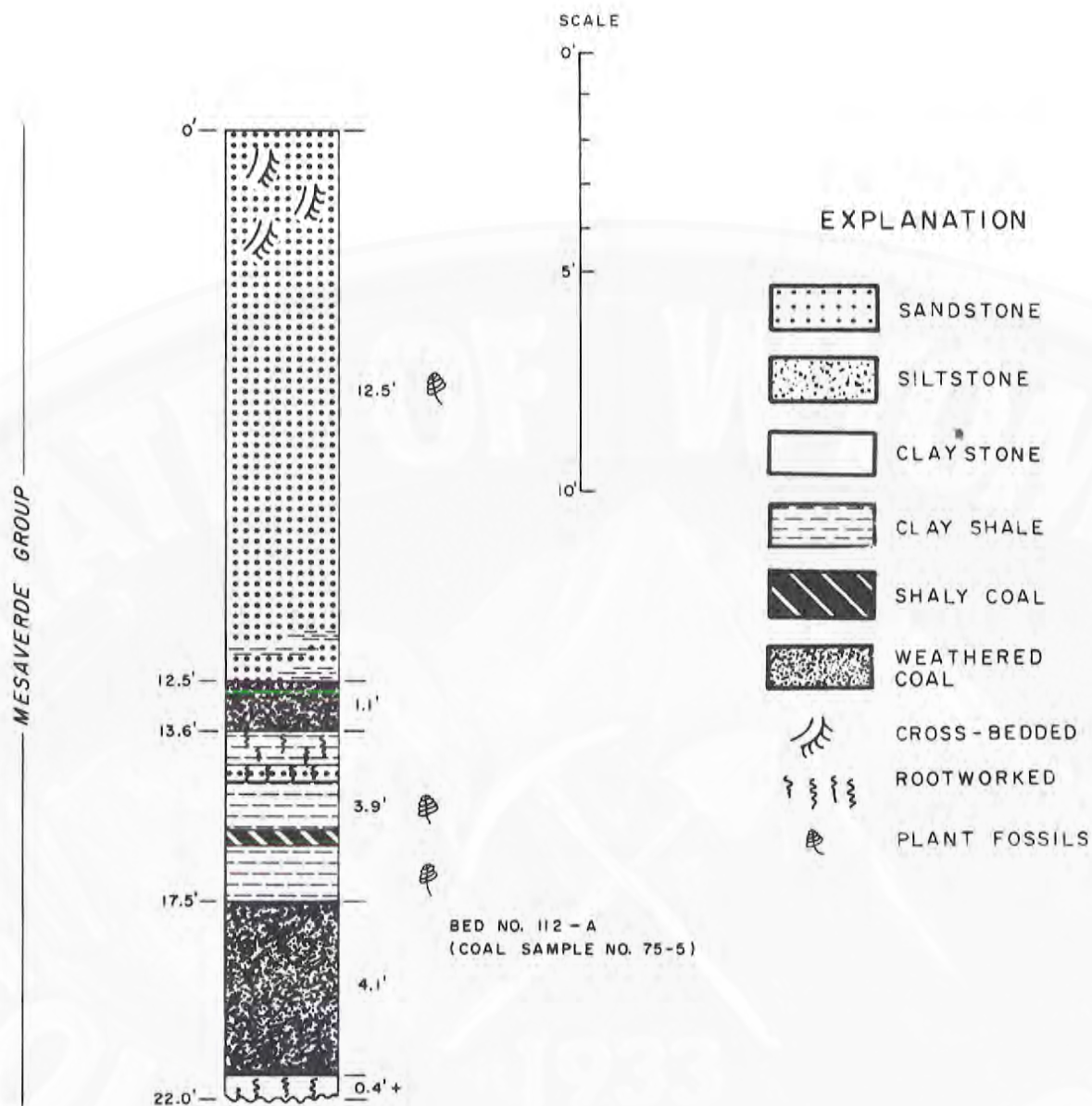


Figure 15. Measured section at Wissler underground coal mine, Bed No. 112-A (SAMPLE NO. 75-5).



4.1' COAL: Too weathered for detailed description;
blocky fracture; damp when sampled

THICKNESS OF BED: 4.1 feet

THICKNESS SAMPLED: 4.1 feet

Figure 16. Megascopic description of Bed No. 112-A at Wissler underground mine (SAMPLE NO. 75-5).

SAMPLE NO. 75-6

INDEX MAPS: See Figure 17

STATE: Wyoming

COAL NAME(S): Burn Right

COUNTY: Carbon

GEOLOGIC FORMATION: Mesaverde Formation

SECTION: 24

AGE: Upper Cretaceous

TOWNSHIP: 21N

COAL FIELD: Hanna (East of Carbon District)

RANGE: 78W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Foote Creek Lake 7 1/2-minute

MEASURED SECTION: See Figure 18

COAL DESCRIPTION: See Figure 19

TOTAL SECTION MEASURED (FEET): 24.1

THICKNESS OF COAL (FEET): 8.0

COVER AT SAMPLING POINT (FEET): 4.1

THICKNESS SAMPLED (FEET): 8.0

ELEVATION TOP OF SAMPLED COAL: 6,980 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 300° approximately

CONDITION OF SAMPLE: Very weathered

DIP: 17°S

TYPE OF EXPOSURE: Deep mine entrance

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Burn Right (abandoned)

30-35°

DATE OF SAMPLING: 7/18/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 10/29/75

LABORATORY NUMBERS

U.S. Geological Survey: 9/16/75

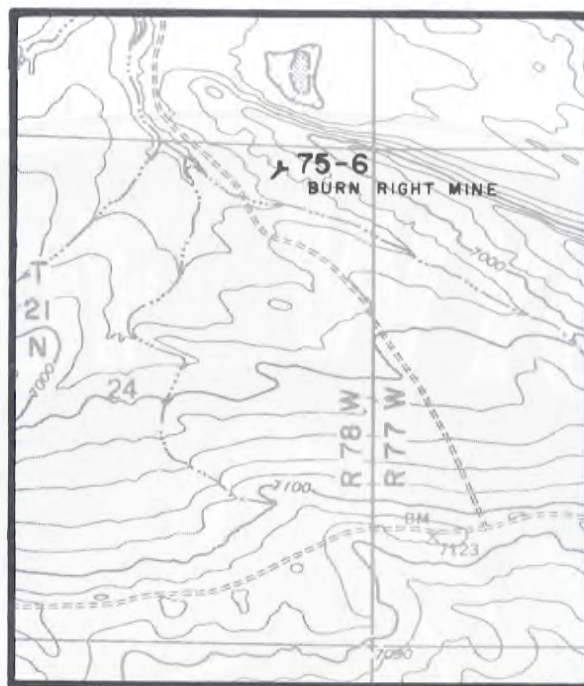
K-55551, K-56016

D176629

MOIST, MINERAL-MATTER-FREE HEAT VALUE: Too weathered for accurate analysis

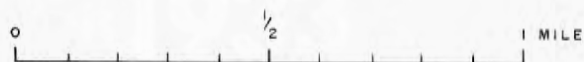
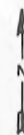
APPARENT RANK OF COAL: Too weathered for determination

MISCELLANEOUS COMMENTS: The coal was sampled outside of the mine entrance; the entire thickness of the bed may not have been sampled.



EXPLANATION

x 75-6 Sample site and sample number



Base map modified from U.S. Geological Survey's
Foote Creek Lake (1971) 7 1/2' topographic map.

Figure 17. Detailed location map of the Burn Right coal sample site at Burn Right underground mine (SAMPLE NO. 75-6).

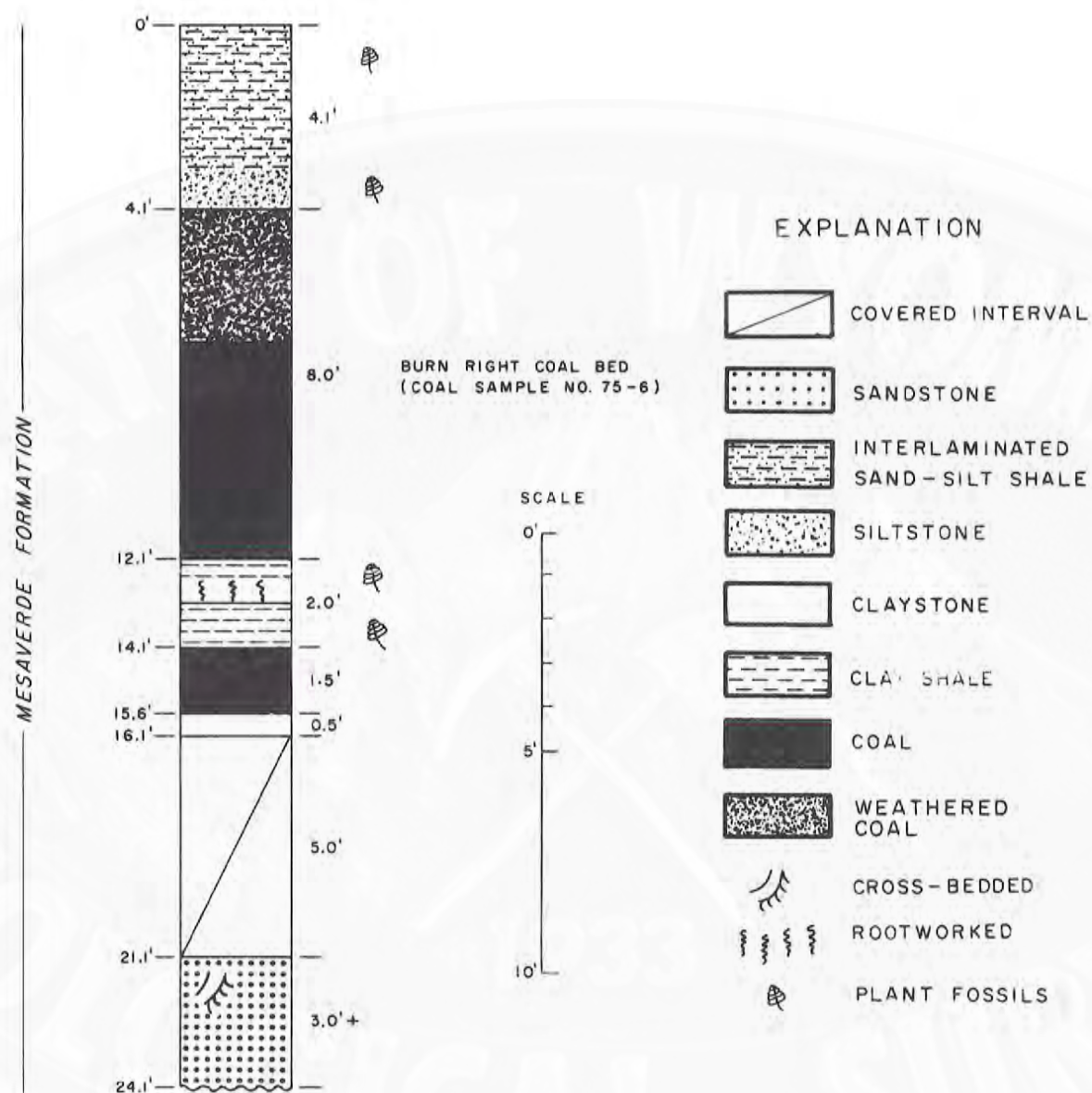
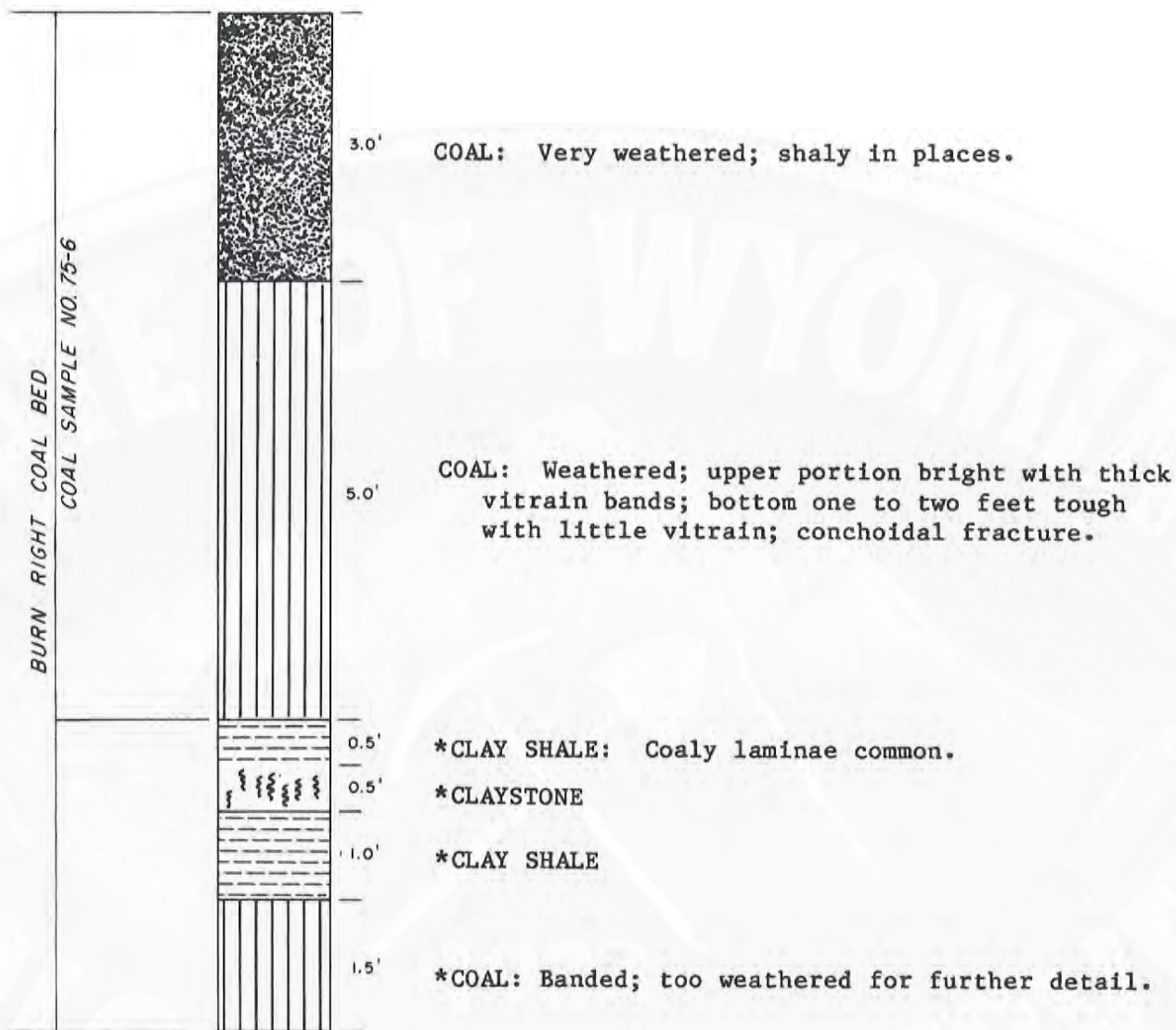


Figure 18. Measured section at the Burn Right coal sample site at Burn Right underground mine (SAMPLE NO. 75-6).



*EXCLUDED FROM ANALYSIS

THICKNESS OF BED: 11.5 feet

THICKNESS SAMPLED: 8.0 feet

Figure 19. Megascopic description of the Burn Right coal bed at Burn Right underground mine (SAMPLE NO. 75-6).

SAMPLE NO. 75-14

INDEX MAPS: See Figure 20

COAL NAME(S): Bed No. 76

GEOLOGIC FORMATION: Hanna

AGE: Paleocene

COAL FIELD: Hanna (Hanna District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 21

TOTAL SECTION MEASURED (FEET): 67.2

COVER AT SAMPLING POINT (FEET): 55.5

ELEVATION TOP OF SAMPLED COAL: 7,335 feet

STRIKE: 321°

DIP: 10°N

MAJOR JOINT ORIENTATIONS IN COAL:

335-345°

STATE: Wyoming

COUNTY: Carbon

SECTION: 32

TOWNSHIP: 23N

RANGE: 81W

QUADRANGLE: Elmo 7 1/2-minute

COAL DESCRIPTION: See Figure 22

THICKNESS OF COAL (FEET): 11.2

THICKNESS SAMPLED (FEET): 7.8

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Fresh

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Seminole No. 2

DATE OF SAMPLING: 8/19/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 2/5/76(?)

U.S. Geological Survey: 6/11/76

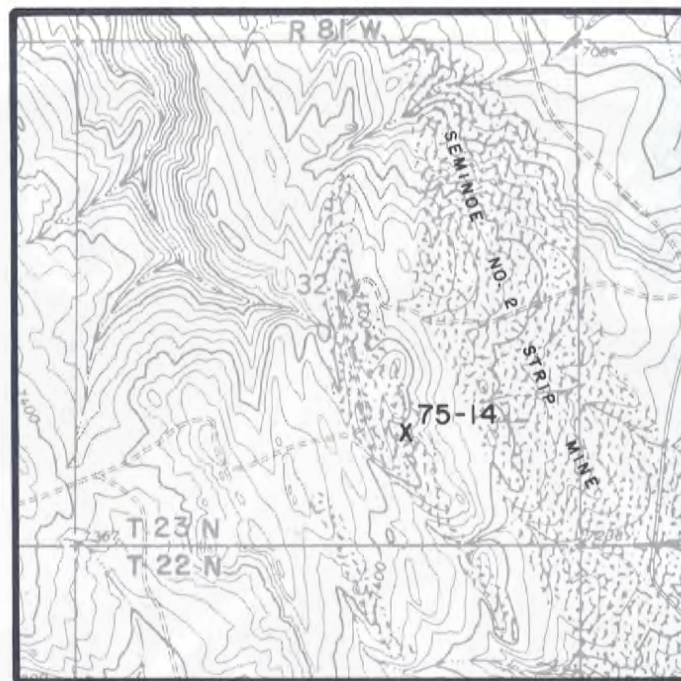
LABORATORY NUMBERS

K-58214

D177434

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,968 Btu/pound

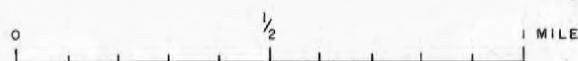
APPARENT RANK OF COAL: High Volatile C Bituminous



EXPLANATION

x 75-14 Sample site and sample number

 Strip mine



Base map modified from U.S. Geological Survey's Elmo (1971) 7 1/2' topographic map.

Figure 20. Detailed location map of the Bed No. 76 sample site in Seminoe No. 2 strip mine (SAMPLE NO. 75-14).

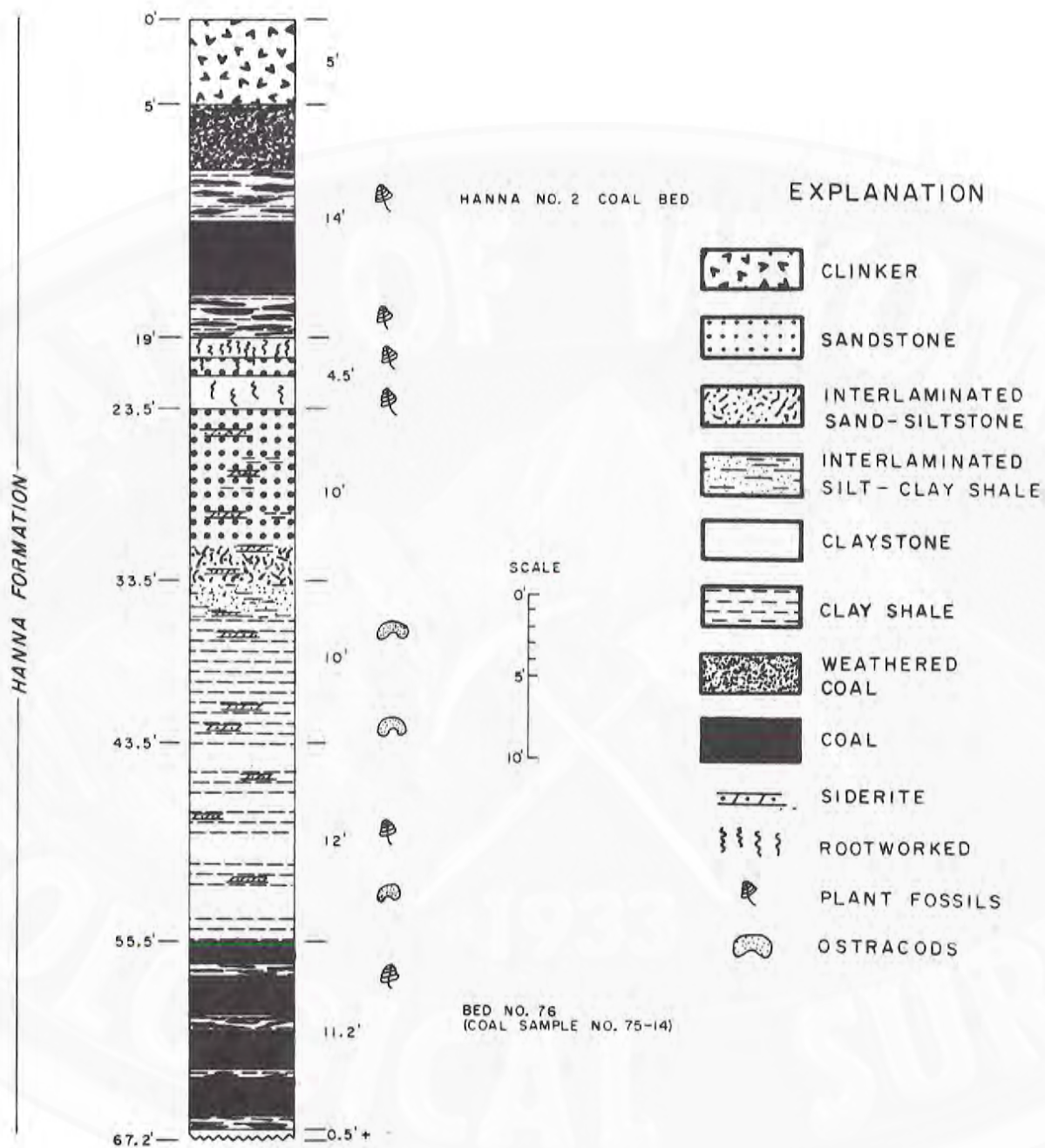
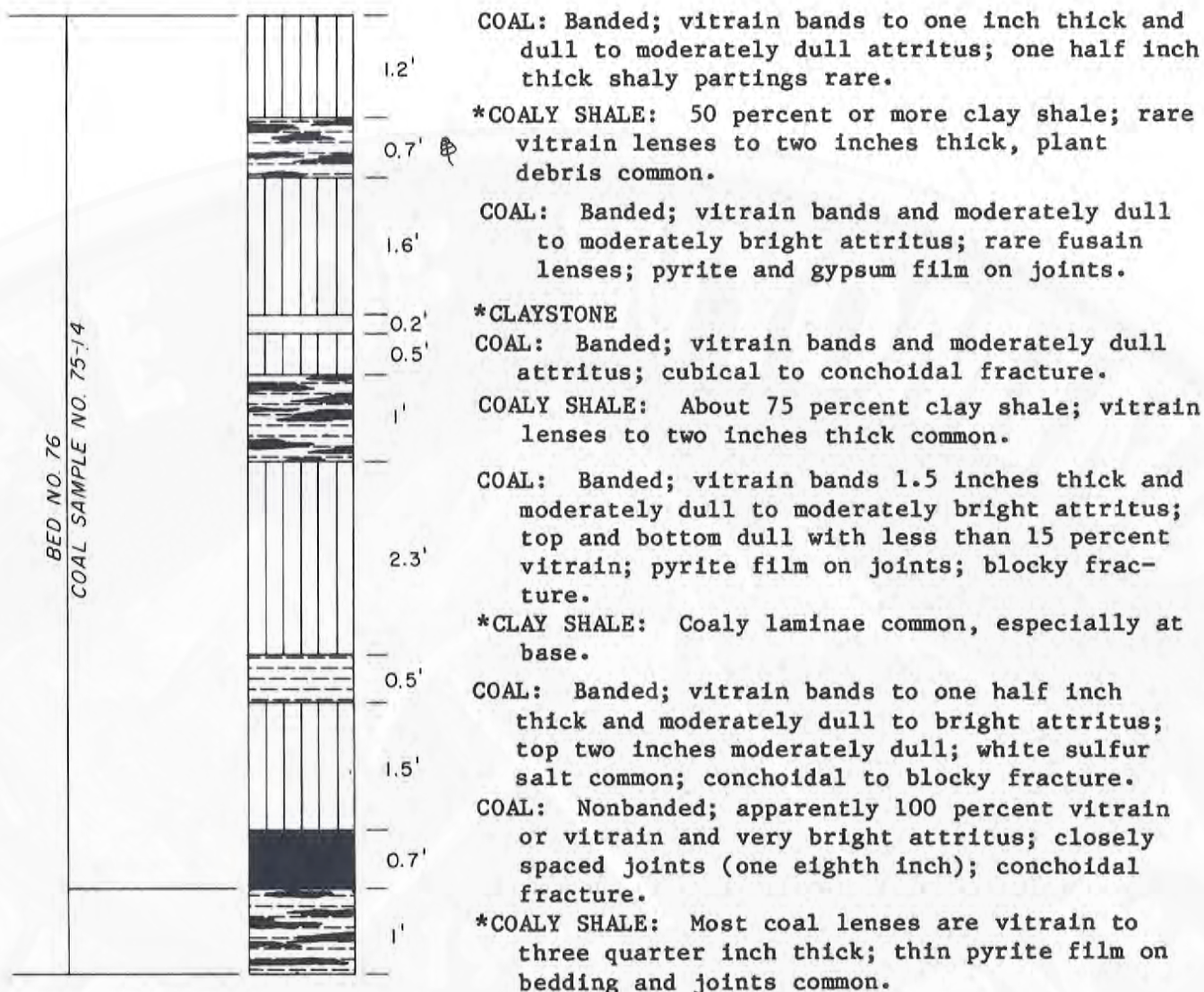


Figure 21. Measured section in Seminole No. 2 strip mine, Bed No. 76 and Hanna No. 2 (SAMPLE NO. 75-4).



* EXCLUDED FROM ANALYSIS

THICKNESS OF BED: 11.2 feet

THICKNESS SAMPLED: 7.8 feet

Figure 22. Megascopic description of Bed No. 76 in Seminole No. 2 strip mine (SAMPLE NO. 75-14).

SAMPLE NO. 75-15

INDEX MAPS: See Figure 23

COAL NAME(S): Brooks Rider

GEOLOGIC FORMATION: Hanna

AGE: Paleocene

COAL FIELD: Hanna (Seminoe District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 24

TOTAL SECTION MEASURED (FEET): 37.0

COVER AT SAMPLING POINT (FEET): 19.5

ELEVATION TOP OF SAMPLED COAL: 7,060 feet

STRIKE: 82°

DIP: 8°N

MAJOR JOINT ORIENTATIONS IN COAL:

22-26°. 110-114°

STATE: Wyoming

COUNTY: Carbon

SECTION: 10

TOWNSHIP: 22N

RANGE: 82W

QUADRANGLE: Tenmile Spring 7 1/2-minute

COAL DESCRIPTION: See Figure 25

THICKNESS OF COAL (FEET): 1.4

THICKNESS SAMPLED (FEET): 1.4

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Very weathered

TYPE OF EXPOSURE: Inactive strip mine

MINE NAME: Rimrock

DATE OF SAMPLING: 7/11/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 2/5/76(?)

U.S. Geological Survey: 6/11/76

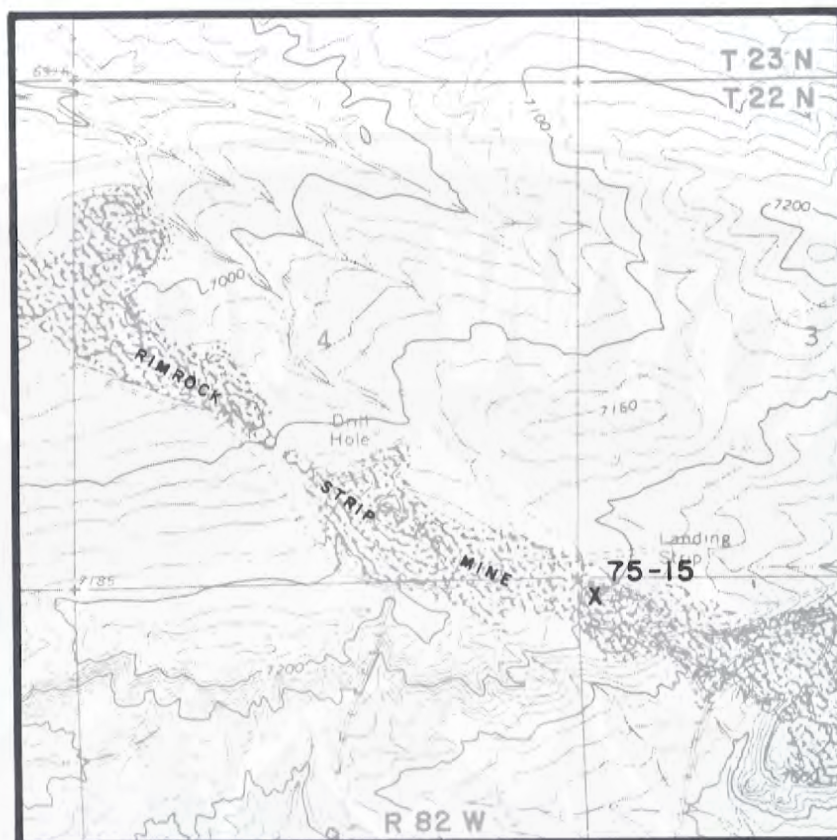
LABORATORY NUMBERS

K-58215

D177435

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,430 Btu/pound (May be affected by weathering)

APPARENT RANK OF COAL: Subbituminous B (Coal was weathered; rank is suspect)

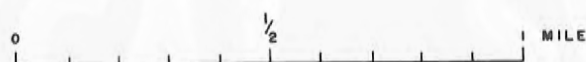
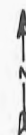


EXPLANATION

X 75-15 Sample site and sample number



Strip mine



Base map modified from U.S. Geological Survey's
Tenmile Spring (1971) 7 1/2' topographic map.

Figure 23. Detailed location map of the Brooks Rider coal sample site in Rimrock strip mine (SAMPLE NO. 75-15).

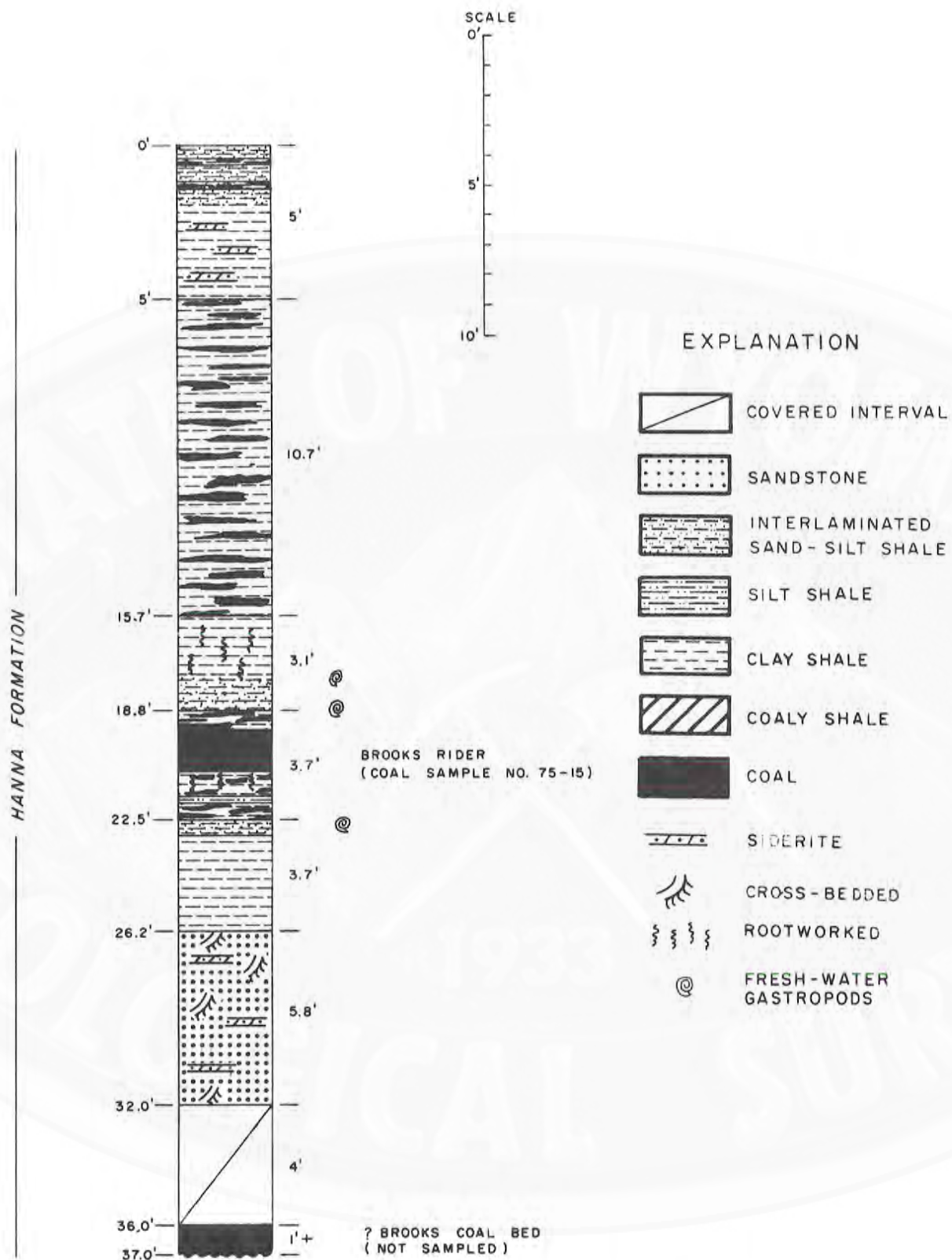
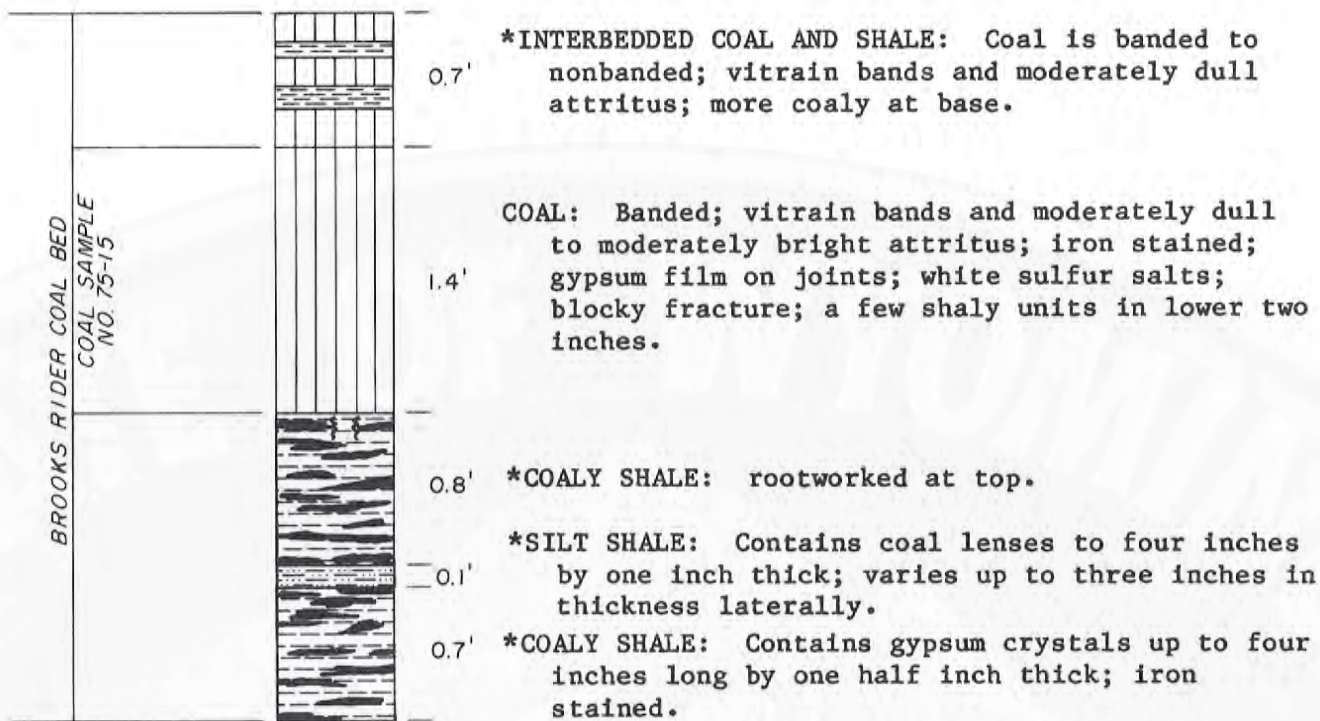


Figure 24. Measured section in Rimrock strip mine, Brooks and Brooks Rider coal beds (SAMPLE NO. 75-15).



*EXCLUDED FROM SAMPLE

THICKNESS OF BED: 3.7 feet

THICKNESS SAMPLED: 1.4 feet

Figure 25. Megascopic description of the Brooks Rider coal bed in Rimrock strip mine (SAMPLE NO. 75-15).

SAMPLE NO. 75-16

INDEX MAPS: See Figure 6

STATE: Wyoming

COAL NAME(S): Bed No. 65

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 33

AGE: Paleocene

TOWNSHIP: 23N

COAL FIELD: Hanna (Seminole District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 26

COAL DESCRIPTION: See Figure 27

TOTAL SECTION MEASURED (FEET): 76.8

THICKNESS OF COAL (FEET): 9.7

COVER AT SAMPLING POINT (FEET): 42.0

THICKNESS SAMPLED (FEET): 9.7

ELEVATION TOP OF SAMPLED COAL: 6,440 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 350°

CONDITION OF SAMPLE: Unweathered

DIP: 3°N

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Medicine Bow

49°, 105°

DATE OF SAMPLING: 8/20/75

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 2/6/76

K-58216

U.S. Geological Survey: 6/11/76

D177436

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,988 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: A fault was exposed on the south side of pit; the strike of the fault was 280-290° with the south side up 30 feet +.

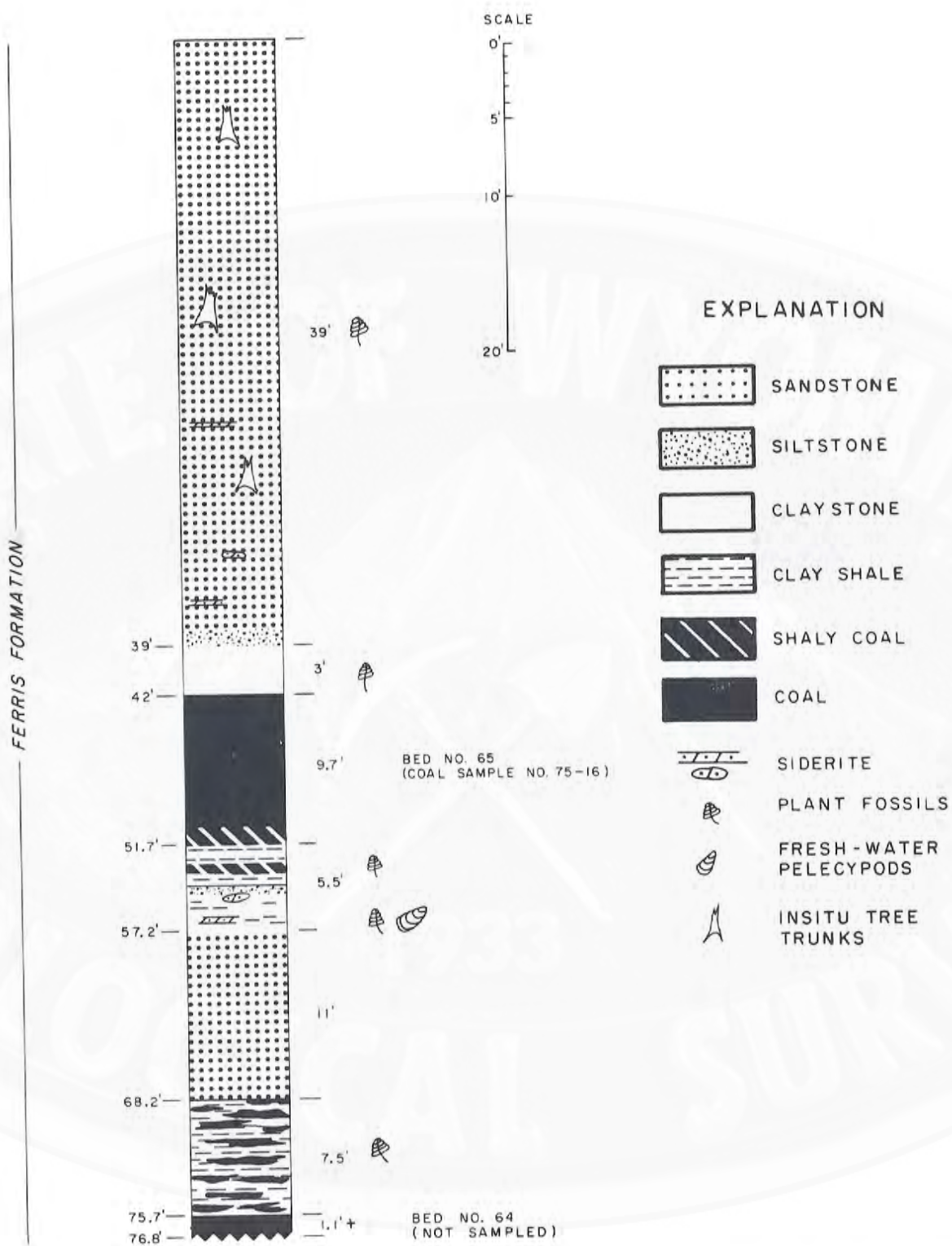
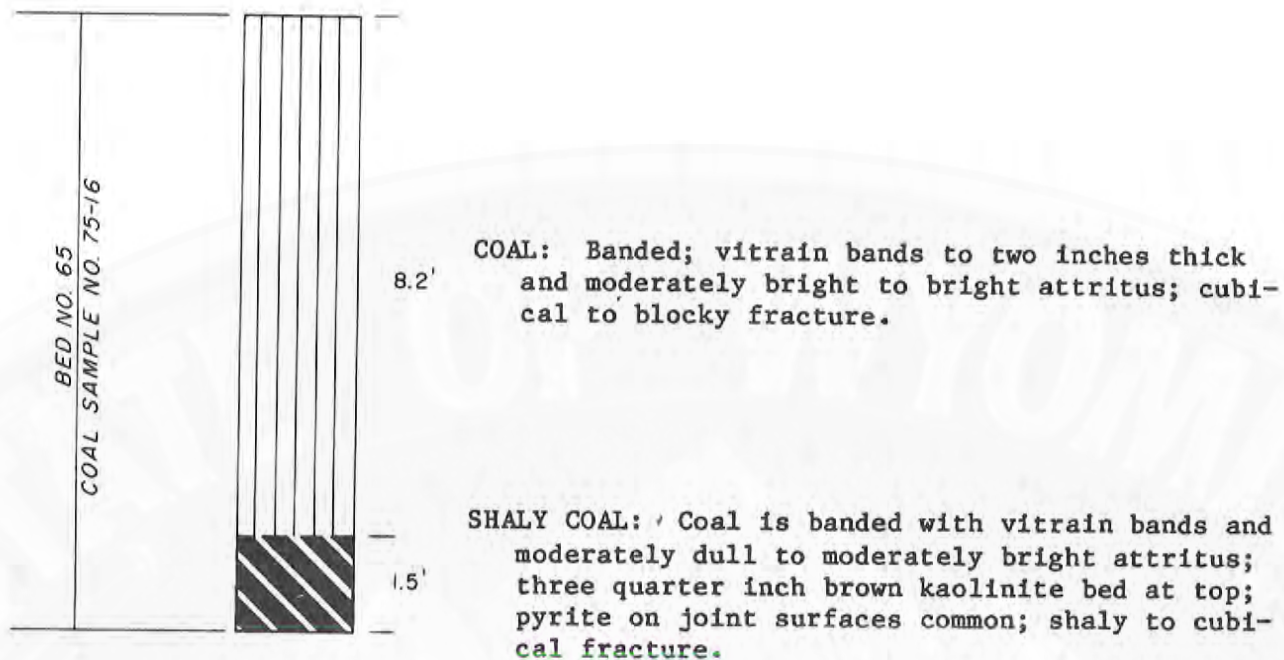


Figure 26. Measured section at the Medicine Bow strip mine, Bed Nos. 64, and 65 (SAMPLE NO. 75-16).



THICKNESS OF BED: 9.7 feet

THICKNESS SAMPLED: 9.7 feet

Figure 27. Megascopic description of Bed No. 65 in Medicine Bow strip mine (SAMPLE NO. 75-16).

SAMPLE NO. 76-1

INDEX MAPS: See Figure 28

COAL NAME(S): Bed No. 25

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminole District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 29

TOTAL SECTION MEASURED (FEET): 118.9

COVER AT SAMPLING POINT (FEET): 103.8

ELEVATION TOP OF SAMPLED COAL: 6,470 feet_±

STRIKE: 320°

DIP: 16°N

STATE: Wyoming

COUNTY: Carbon

SECTION: 12

TOWNSHIP: 22N

RANGE: 84W

QUADRANGLE: Pats Bottom 7 1/2-minute

COAL DESCRIPTION: See Figure 30

THICKNESS OF COAL (FEET): 11.05

THICKNESS SAMPLED (FEET): 11.05

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Slightly weathered

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Seminole No. 1

DATE OF SAMPLING: 7/14/76

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 1/10/77

U.S. Geological Survey: 12/10/76

LABORATORY NUMBERS

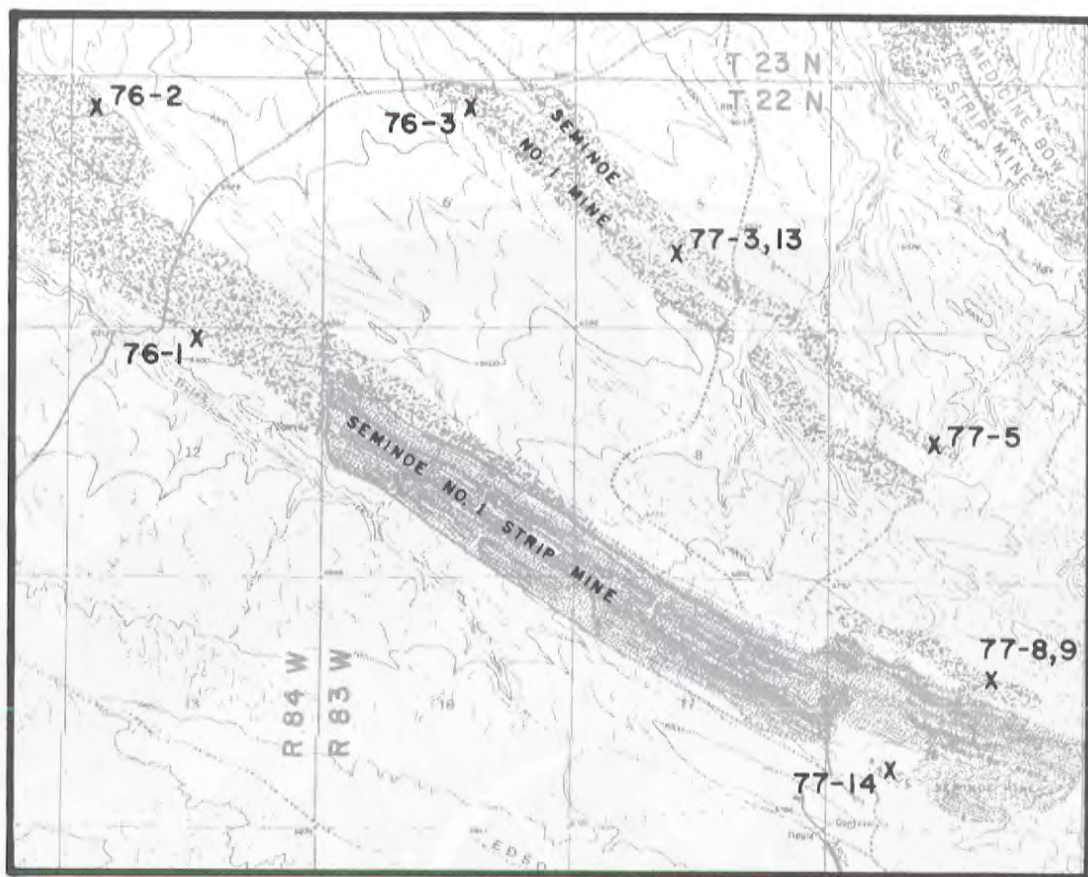
K-69486

D183108

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,826 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

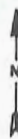


EXPLANATION

X 76-3 Sample site and sample number

 Strip mine

0 $\frac{1}{2}$ 1 MILE



Base map modified from U.S. Geological Survey's
Pats Bottom (1971) 7 $\frac{1}{2}$ ' topographic map.

Figure 28. Detailed location map of sample sites in Seminoe No. 1 strip mine (SAMPLE NOS. 76-1, 76-2, 76-3, 77-3, 77-5, 77-8, 77-9, 77-13, and 77-14).

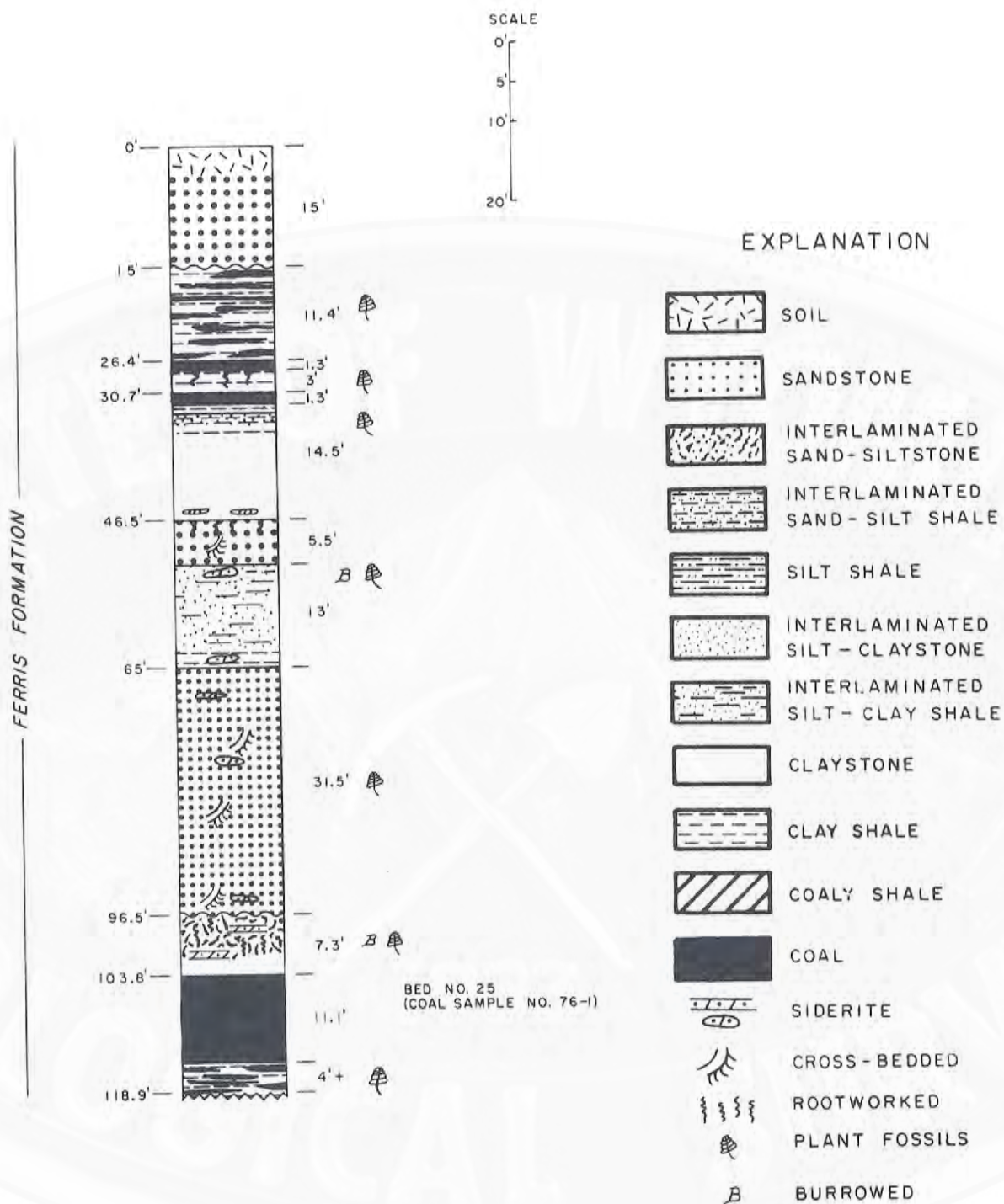
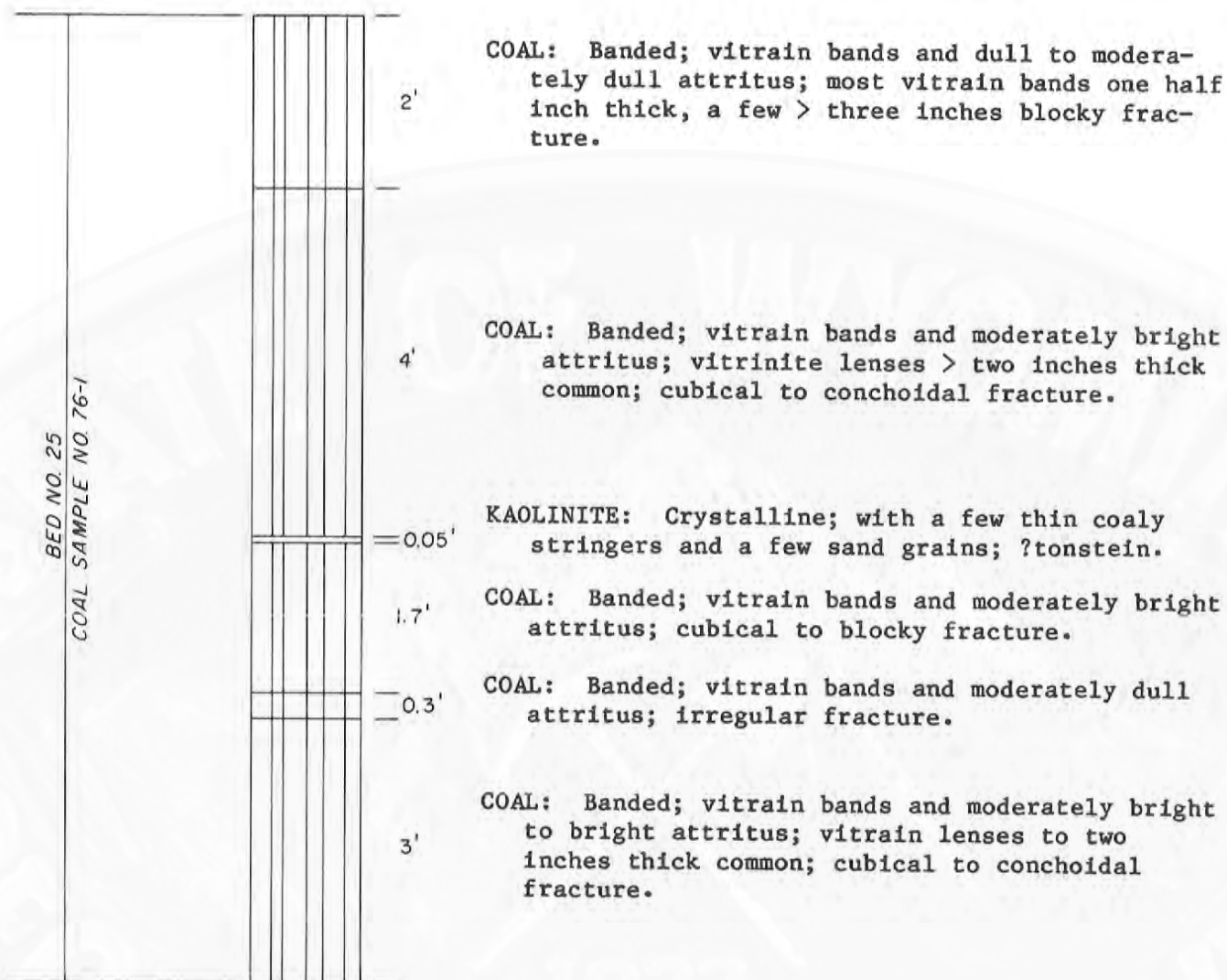


Figure 29. Measured section in Seminole No. 1 strip mine, Bed No. 25 (SAMPLE NO. 76-1).



THICKNESS OF BED: 11.05 feet

THICKNESS SAMPLED: 11.05 feet

Figure 30. Megascopic description of Bed No. 25 in Seminole No. 1 strip mine (SAMPLE NO. 76-1).

SAMPLE NO. 76-2

INDEX MAPS: Figure 28

COAL NAME(S): Bed No. 33

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminole District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 31

TOTAL SECTION MEASURED (FEET): 80.7

COVER AT SAMPLING POINT (FEET): 72.4

ELEVATION TOP OF SAMPLED COAL: 6,444 feet

STRIKE: 318°

DIP: 15°N

MAJOR JOINT ORIENTATIONS IN COAL:

185°, 275°, 318°, 346°

DATE OF SAMPLING: 7/16/76

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 1/10/77

U.S. Geological Survey: 12/10/76

STATE: Wyoming

COUNTY: Carbon

SECTION: 1

TOWNSHIP: 22N

RANGE: 84W

QUADRANGLE: Pats Bottom 7 1/2-minute

COAL DESCRIPTION: See Figure 32

THICKNESS OF COAL (FEET): 8.14

THICKNESS SAMPLED (FEET): 7.85

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Fresh

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Seminole No. 1

LABORATORY NUMBERS

K-69487

D183109

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,929 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Nearby sandstone-filled channel cuts out entire sequence above coal; channel trends 105° across pit. Channel filling: fine to medium grained, subangular to subrounded, friable, cross bedded to massive sandstone; sideritic zones to two feet in diameter common; also siderite nodules 2-6 inches in diameter; shale fragments common near base; fossilized logs are common and are inclined to bedding.

Rank of coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

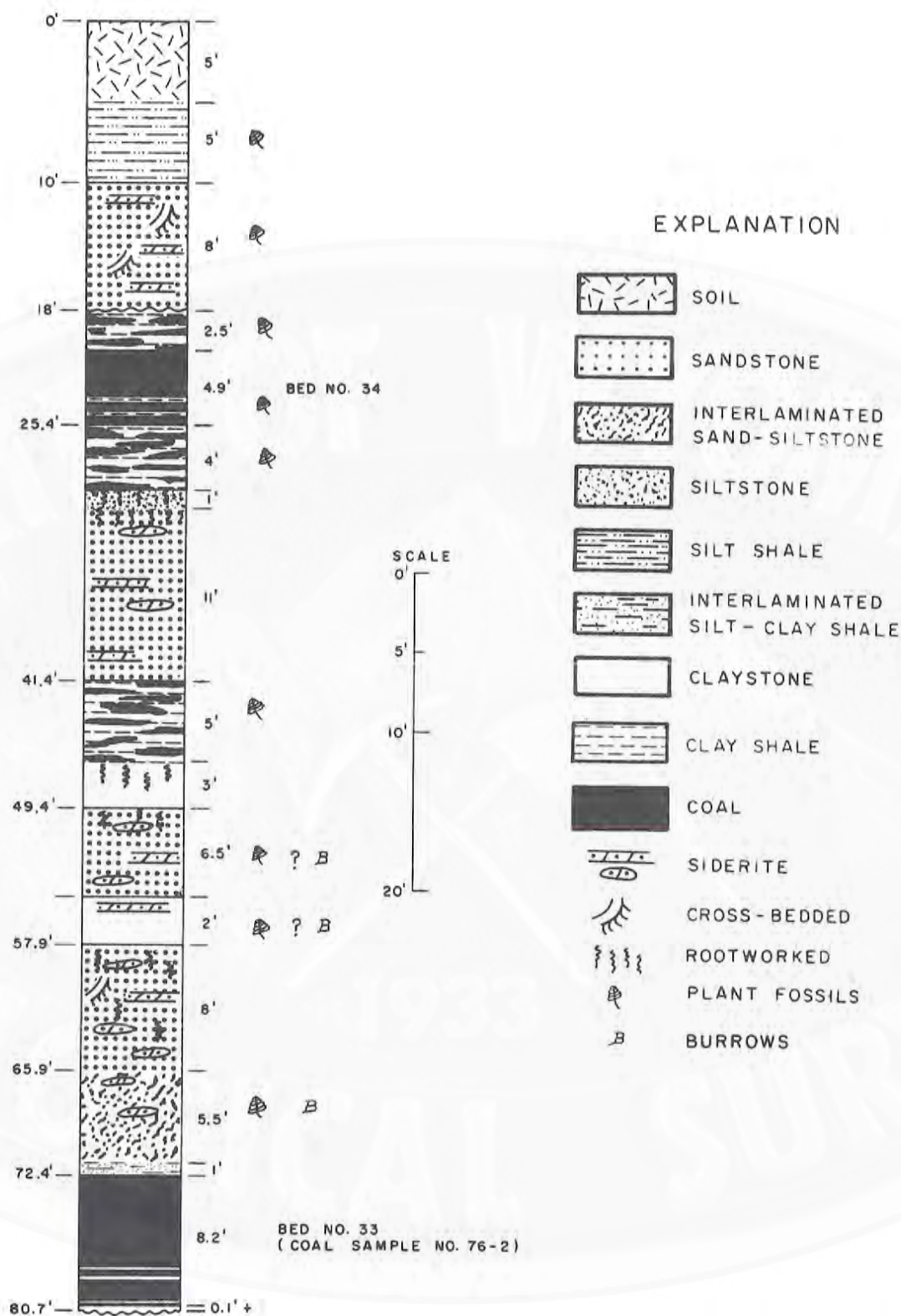
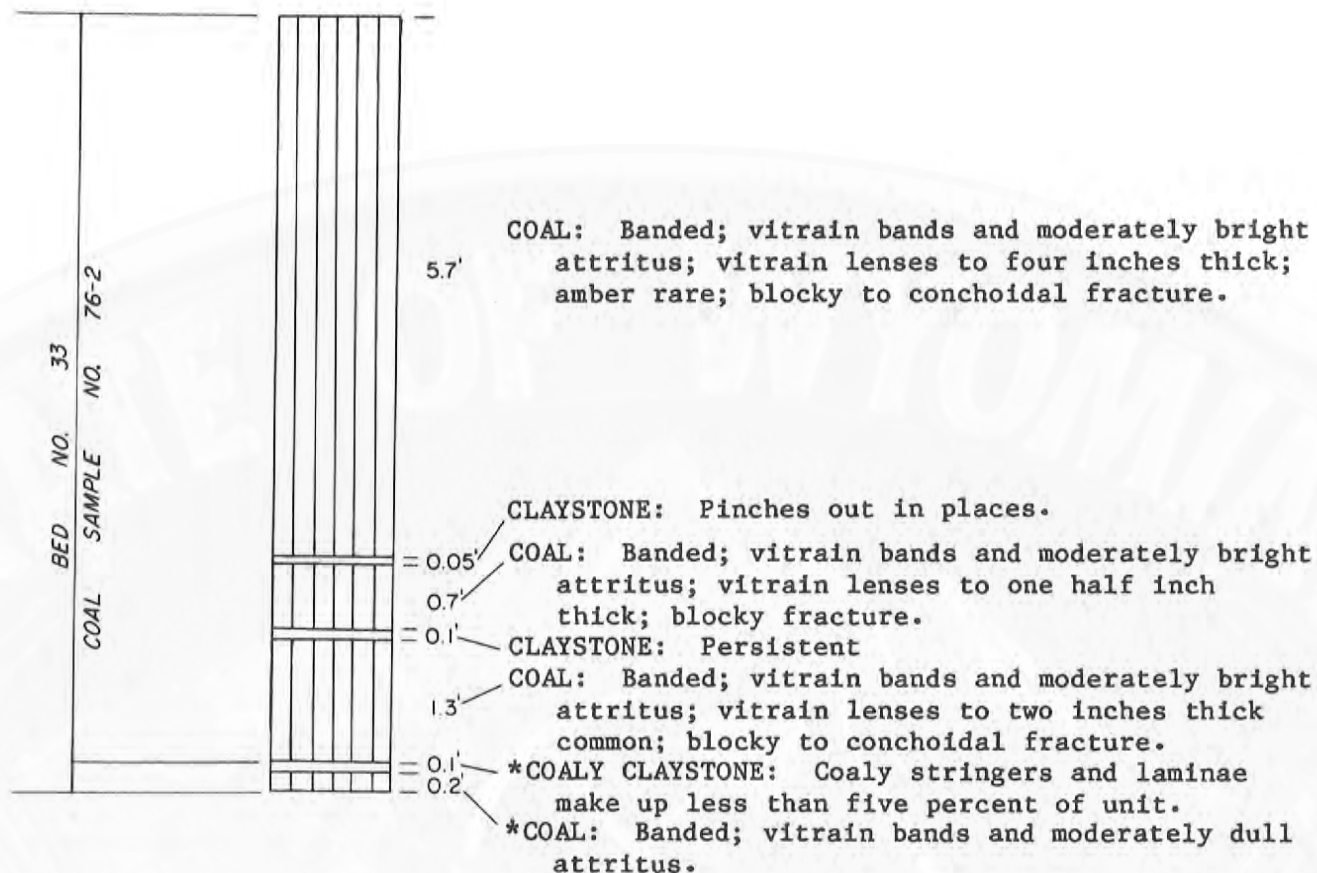


Figure 31. Measured section in Seminole No. 1 strip mine, Bed Nos. 33 and 34 (SAMPLE NO. 76-2).



THICKNESS OF BED: 8.15 feet

THICKNESS SAMPLED: 7.85 feet

*EXCLUDED FROM SAMPLE

Figure 32. Megascopic description of Bed No. 33 in Seminole No. 1 strip mine (SAMPLE NO. 76-2).

SAMPLE NO. 76-3

INDEX MAPS: See Figure 28
COAL NAME(S): Bed No. 51
GEOLOGIC FORMATION: Ferris
AGE: Paleocene
COAL FIELD: Hanna (Seminoe District)
COAL-BEARING AREA: Hanna Coal Field
MEASURED SECTION: See Figure 33
TOTAL SECTION MEASURED (FEET): 76.2
COVER AT SAMPLING POINT (FEET): 58.5
ELEVATION TOP OF SAMPLED COAL: 6,460 feet
STRIKE: 320°
DIP: 10°N
MAJOR JOINT ORIENTATIONS IN COAL:
300°, 340°, 315°, 200°
STATE: Wyoming
COUNTY: Carbon
SECTION: 6
TOWNSHIP: 22N
RANGE: 83W
QUADRANGLE: Pats bottom 7 1/2-minute
COAL DESCRIPTION: See Figure 34
THICKNESS OF COAL (FEET): 8.2
THICKNESS SAMPLED (FEET): 8.2
TYPE OF SAMPLE: Face-channel
CONDITION OF SAMPLE: Fresh
TYPE OF EXPOSURE: Active strip mine
MINE NAME: Seminoe No. 1
DATE OF SAMPLING: 7/16/76
SAMPLE COLLECTOR: Wyoming Geological Survey
COMPLETION DATE OF ANALYSES
U.S. Bureau of Mines: 1/10/77
U.S. Geological Survey: 12/10/76
LABORATORY NUMBERS
K-69488
D183110
MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,319 Btu/pound
APPARENT RANK OF COAL: Subbituminous A
MISCELLANEOUS COMMENTS: Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

FERRIS FORMATION

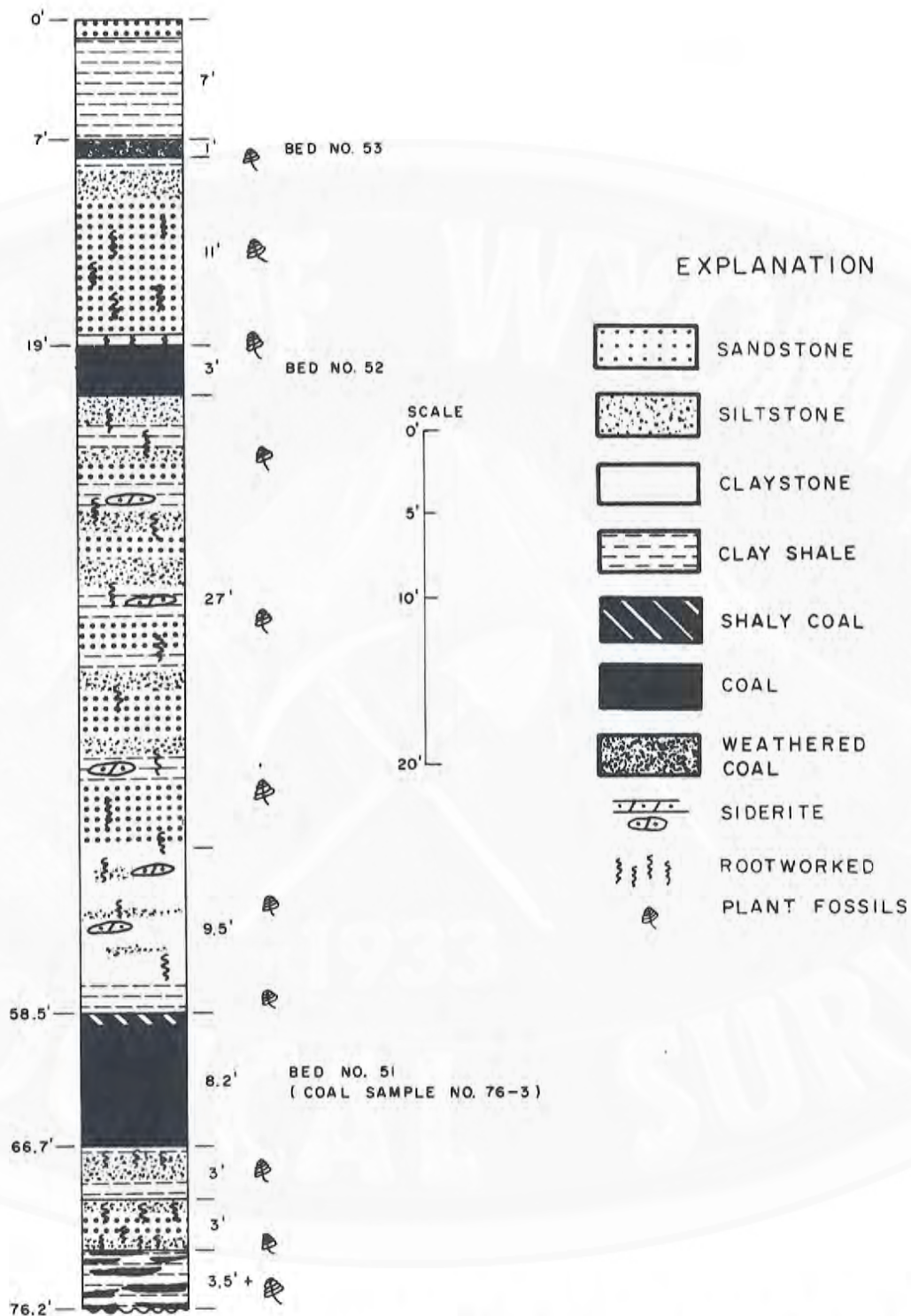
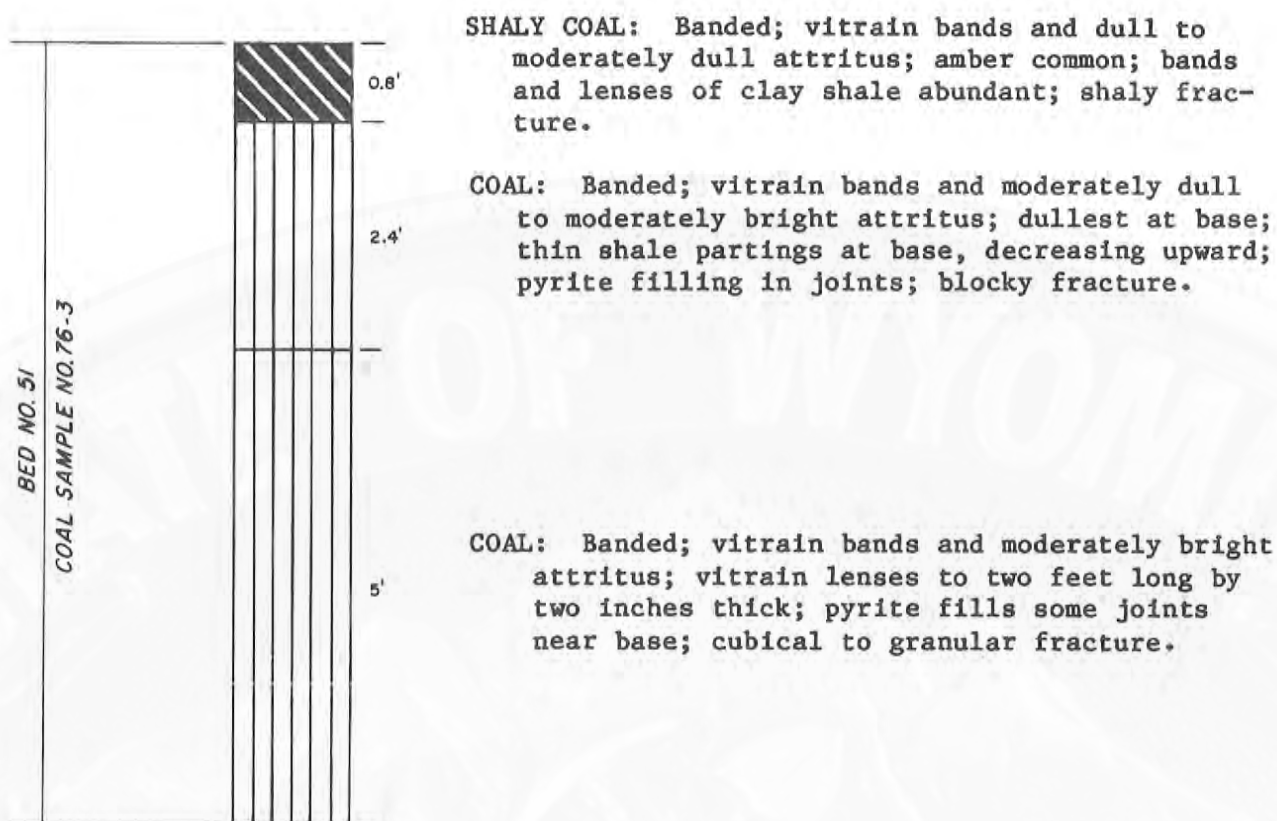


Figure 33. Measured section in Seminole No. 1 strip mine, Bed Nos. 51 and 52 (SAMPLE NO. 76-3).



THICKNESS OF BED: 8.2 feet

THICKNESS SAMPLES: 8.2 feet

Figure 34. Megascope description of Bed No. 51 in Seminole No. 1 strip mine (SAMPLE NO. 76-3).

SAMPLE NO. 77-3

INDEX MAPS: See Figure 28

COAL NAME(S): Bed No. 51

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminoe District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 35

TOTAL SECTION MEASURED (FEET): 102.9

COVER AT SAMPLING POINT (FEET): 95.7

ELEVATION TOP OF SAMPLED COAL: 6,459 feet

STRIKE: 325°

DIP: 17°N

MAJOR JOINT ORIENTATIONS IN COAL:
111-115°

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/22/78

U.S. Geological Survey: 11/27/78

STATE: Wyoming

COUNTY: Carbon

SECTION: 5

TOWNSHIP: 22N

RANGE: 83W

QUADRANGLE: Pats Bottom 7 1/2-minute

COAL DESCRIPTION: See Figure 36

THICKNESS OF COAL (FEET): 7.3

THICKNESS SAMPLED (FEET): 7.1

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Fresh

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Seminoe No. 1

LABORATORY NUMBERS

K-84736

D197308

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,001 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

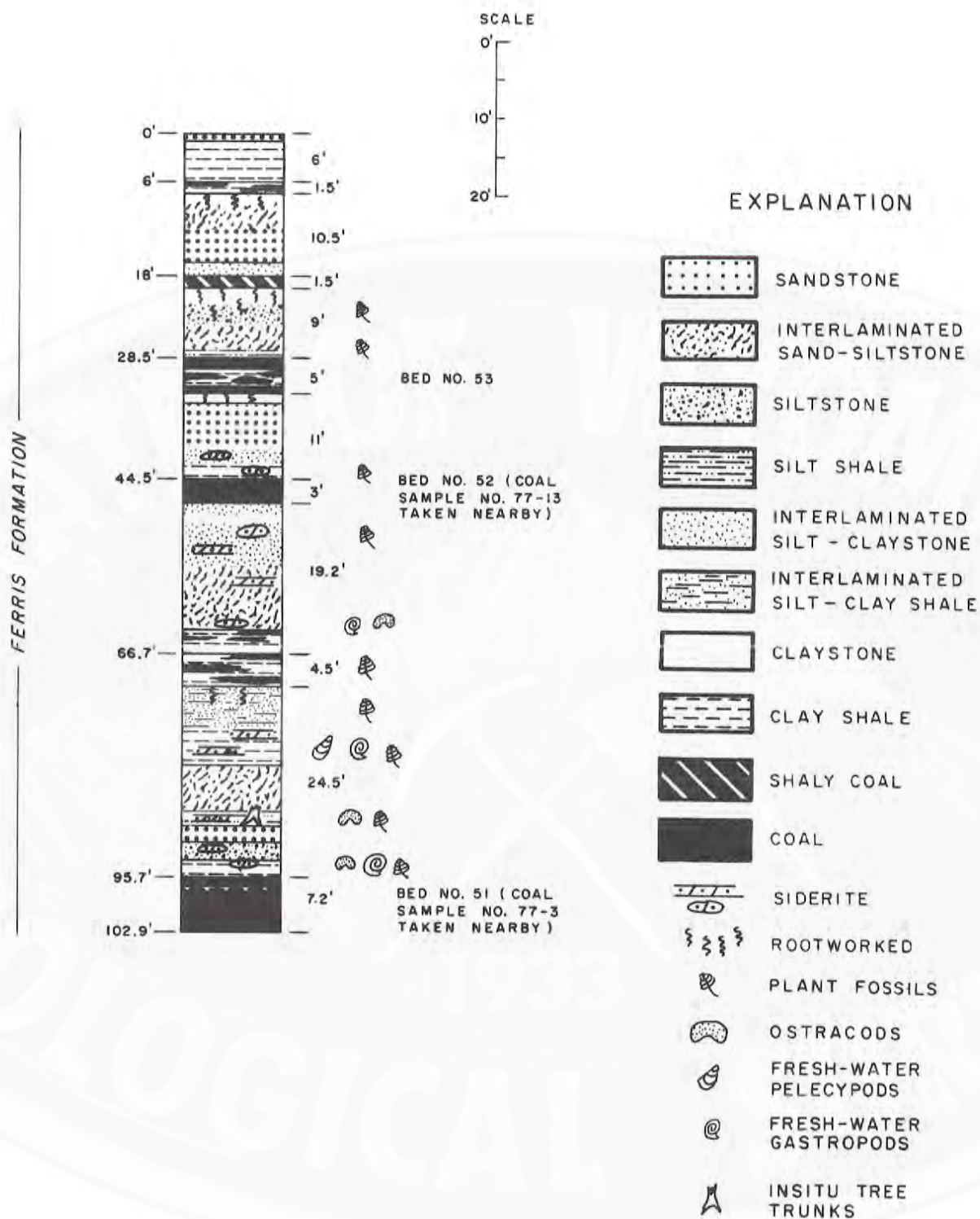
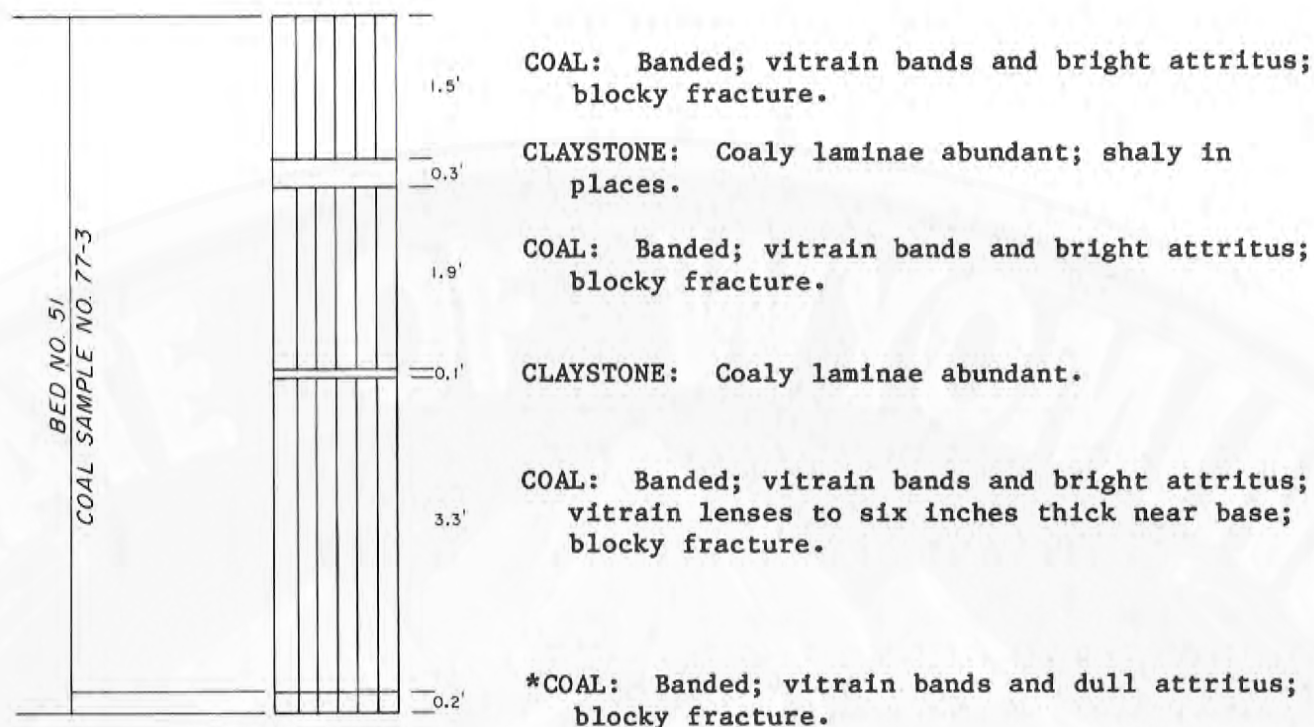


Figure 35. Measured section in Seminole No. 1 strip mine, Bed Nos. 51, 52, and 53 (SAMPLE NOS. 77-3 and 77-13 taken nearby were 7.3 feet and 2.9 feet thick respectively).



*EXCLUDED FROM SAMPLE.

THICKNESS OF BED: 7.3 feet

THICKNESS SAMPLED: 7.1 feet

Figure 36. Megascopic description of Bed No. 51 in Seminole No. 1 strip mine (SAMPLE NO. 77-3).

SAMPLE NO. 77-4

INDEX MAPS: See Figure 37

STATE: Wyoming

COAL NAME(S): Bed No. 79 (upper bench)

COUNTY: Carbon

GEOLOGIC FORMATION: Hanna

SECTION: 2

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Hanna District)

RANGE: 81W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Como West 7 1/2-minute

MEASURED SECTION: See Figure 38

COAL DESCRIPTION: See Figure 39

TOTAL SECTION MEASURED (FEET): 100.0

THICKNESS OF COAL (FEET): 7.5

COVER AT SAMPLING POINT (FEET): 77.1

THICKNESS SAMPLED (FEET): 6.4

ELEVATION TOP OF SAMPLED COAL: 6,943 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 40°

CONDITION OF SAMPLE: Fresh

DIP: 10°N

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Rosebud (Pit No. 6)

DATE OF SAMPLING: 10/25/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/20/78

K-84746

U.S. Geological Survey: 11/27/78

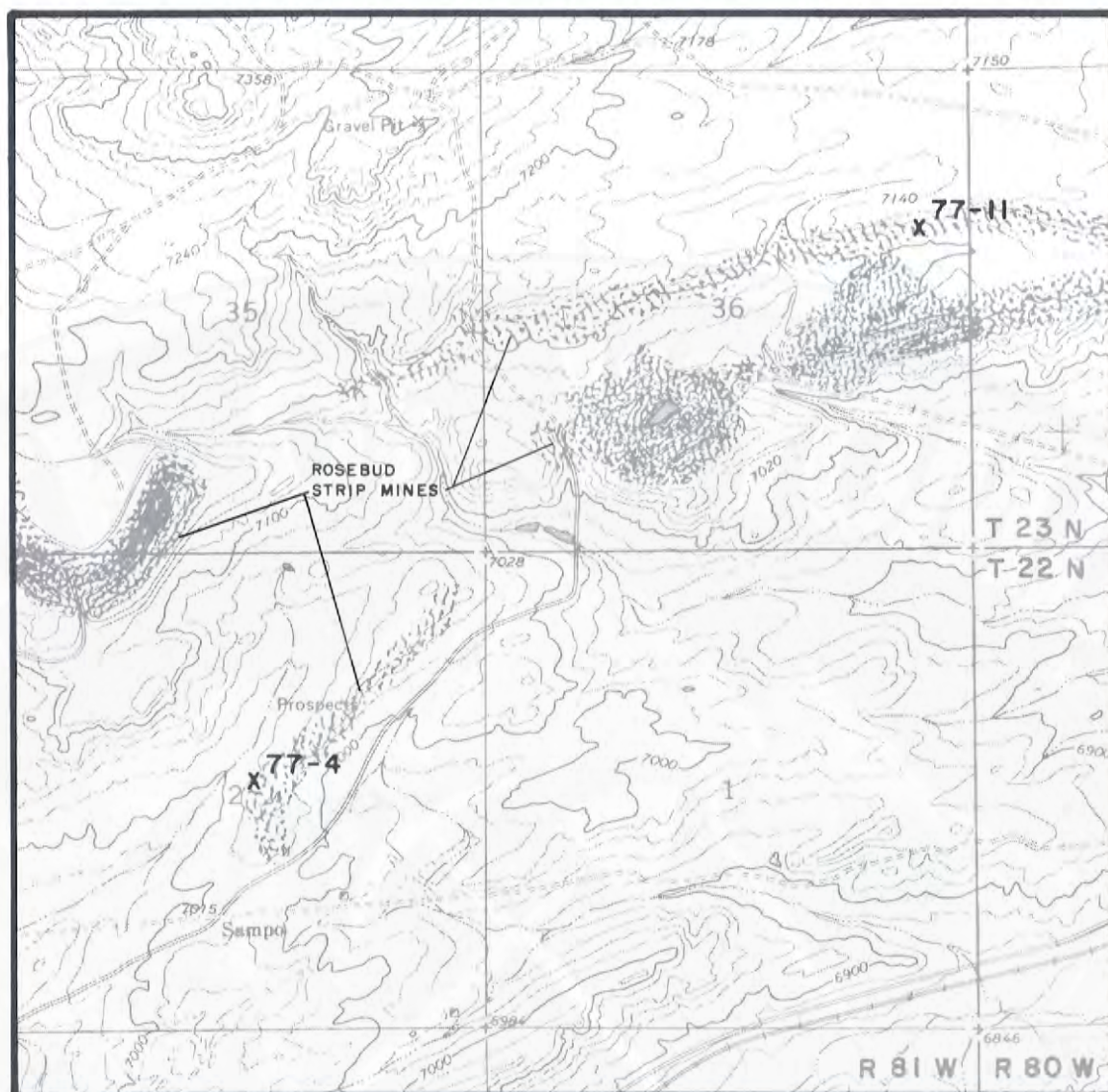
D197319

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,309 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Floor of strip very "rolly", small scale faulting (up to 5 feet throw) commonly cuts coal, but not other rocks; Fault at south end of pit trends 75° with 5-10 feet of throw.

Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

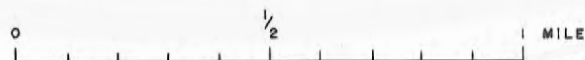
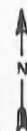


EXPLANATION

x 77-4 Sample site and sample number



Strip mine



Base map modified from U.S. Geological Survey's Como West (1971) 7 1/2' topographic map.

Figure 37. Detailed location map of the Bed No. 79 and Bed No. 82 sample sites in Rosebud strip mine (SAMPLE NOS. 77-4 and 77-11).

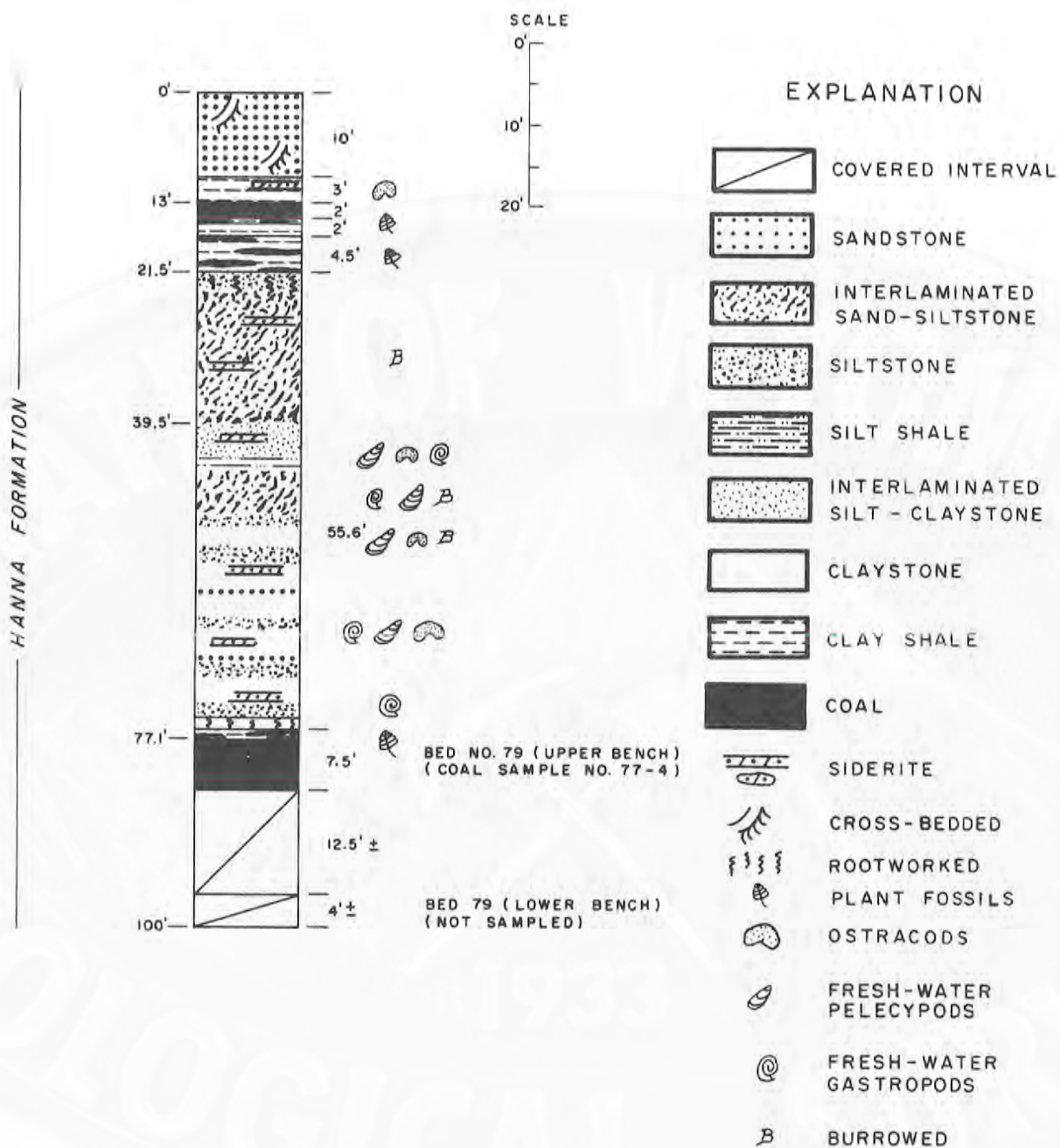


Figure 38. Measured section in Rosebud strip mine, Bed No. 79 (upper bench) (SAMPLE NO. 77-4).



*COALY SHALE: Interlaminated coal and clay shale
SHALY COAL: Banded; vitrain bands and bright attritus; thin shaly partings common.

COALY SHALE: Interlaminated coal and clay shale; less than 25 percent coal; vitrain lenses to one inch thick rare, pyrite nodules to three quarter inch diameter rare.

COAL: Banded; vitrain bands and moderately bright attritus; vitrain lenses to two inches thick by 2 feet long common; gypsum filled joints; blocky fracture.

COAL: Banded; vitrain bands and bright attritus; vitrain lenses to one inch thick by several inches long; detrital, granular, coaly lenses to six inches thick near bottom; blocky fracture.

* EXCLUDED FROM SAMPLE

THICKNESS OF BED: 7.5 feet

THICKNESS SAMPLED: 6.4 feet

Figure 39. Megascopic description of Bed No. 79 (upper bench) in Rosebud strip mine (SAMPLE NO. 77-4).

SAMPLE NO. 77-5

INDEX MAPS: See Figure 28

STATE: Wyoming

COAL NAME(S): Bed No. 54

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 9

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Seminoe District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 40

COAL DESCRIPTION: See Figure 41

TOTAL SECTION MEASURED (FEET): 68.7

THICKNESS OF COAL (FEET): 4.0

COVER AT SAMPLING POINT (FEET): 62.7+

THICKNESS SAMPLED (FEET): 4.0

ELEVATION TOP OF SAMPLED COAL: 6,577 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 125°

CONDITION OF SAMPLE: Fresh

DIP: 10°N

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminoe No. 1

127°, 200°

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/20/78

LABORATORY NUMBERS

U.S. Geological Survey: 11/27/78

K-84737

D197309

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,854 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

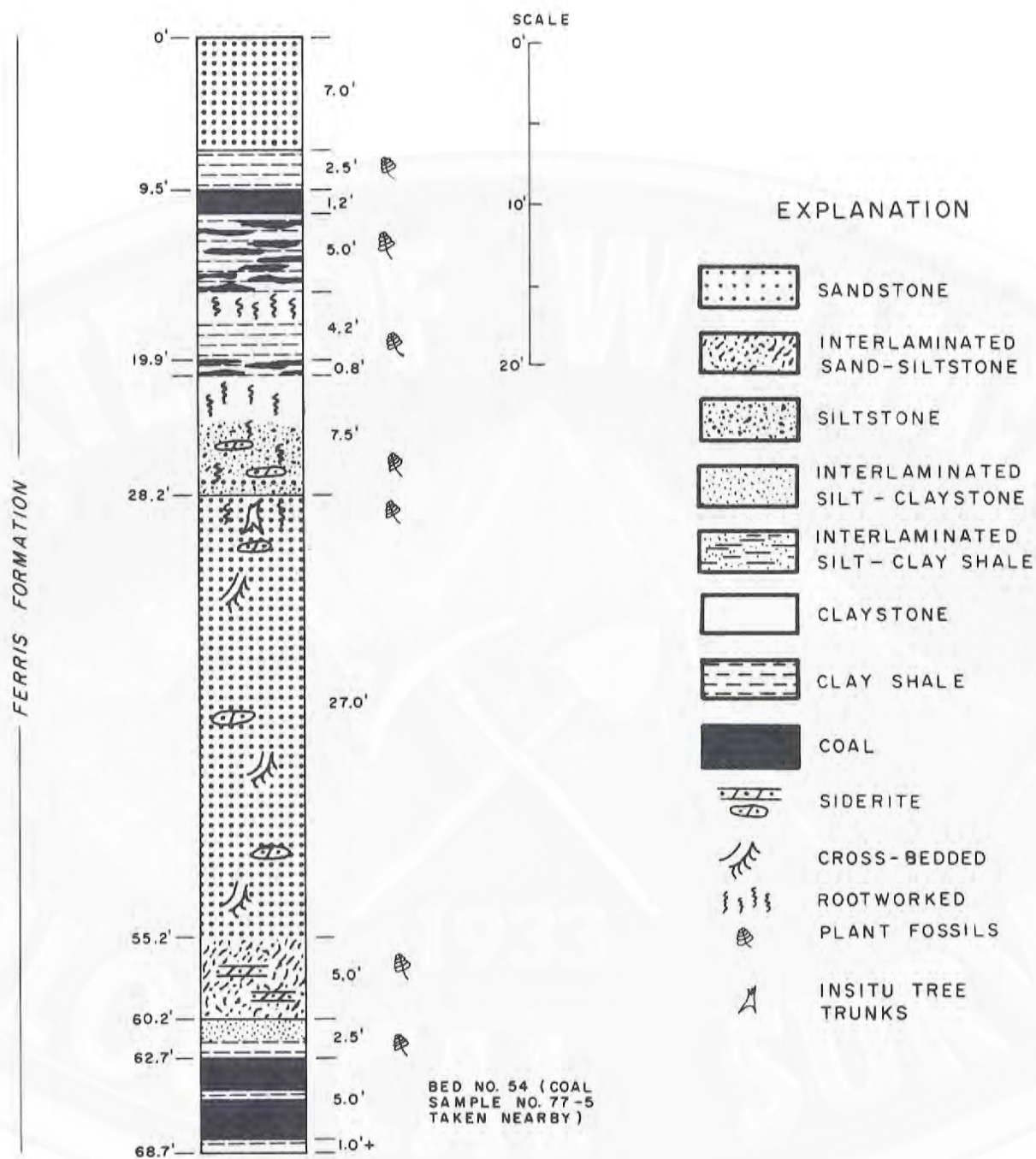
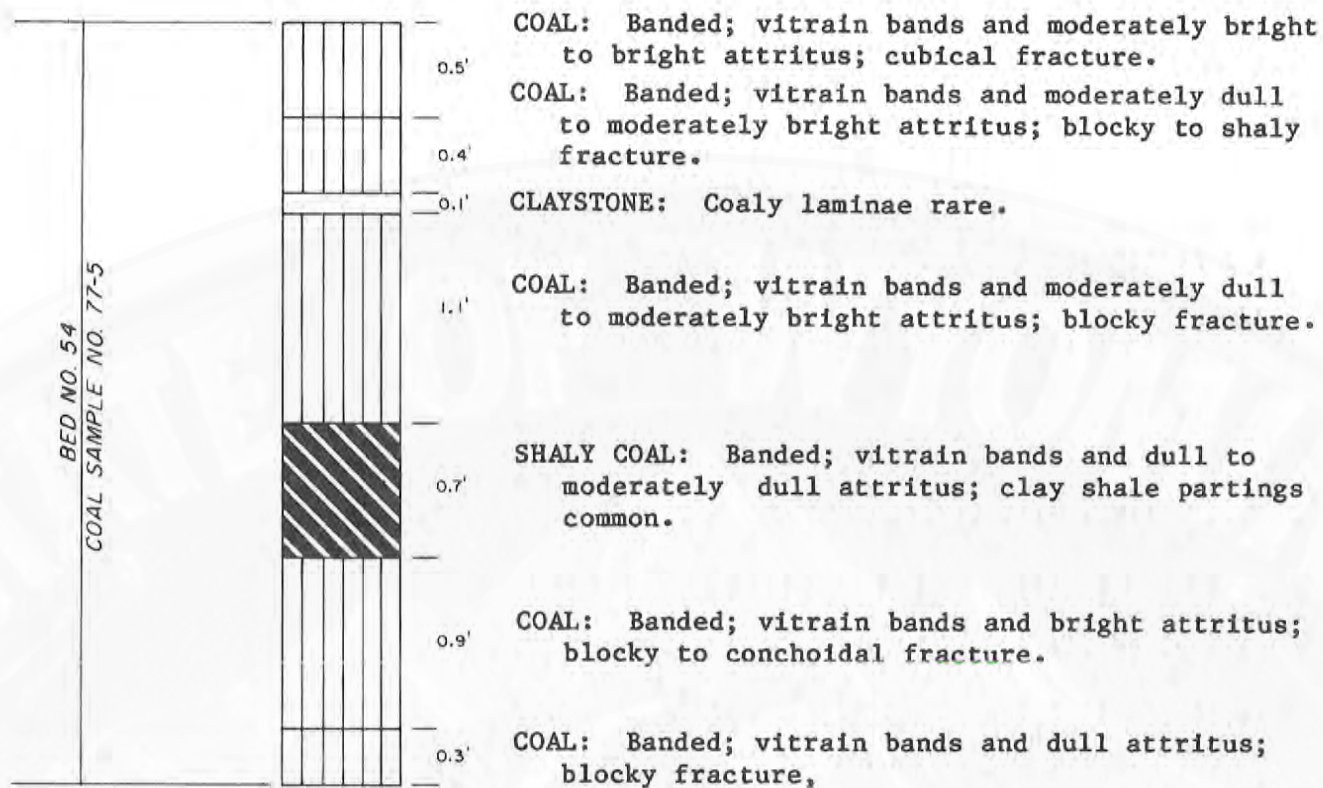


Figure 40. Measured section in Seminole No. 1 strip mine, Bed No. 54 (SAMPLE NO. 77-5 taken nearby was 4 feet thick).



THICKNESS OF BED: 4.0 feet

THICKNESS SAMPLED: 4.0 feet

Figure 41. Megascopic description of Bed No. 54 in Seminole No. 1 strip mine (SAMPLE NO. 77-5).

SAMPLE NO. 77-6

INDEX MAPS: See Figure 6

COAL NAME(S): Bed No. 60

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminoe District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 42

TOTAL SECTION MEASURED (FEET): 44.7

COVER AT SAMPLING POINT (FEET): 40.6+

ELEVATION TOP OF SAMPLED COAL: 6,509 feet+

STRIKE: 5°

DIP: 7°S

MAJOR JOINT ORIENTATIONS IN COAL:

57-60°, 28°, 350°

STATE: Wyoming

COUNTY: Carbon

SECTION: 17

TOWNSHIP: 23N

RANGE: 83W

QUADRANGLE: Pats Bottom 7 1/2-minute

COAL DESCRIPTION: See Figure 43

THICKNESS OF COAL (FEET): 3.6

THICKNESS SAMPLED (FEET): 3.6

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Fresh

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Medicine Bow

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/21/78

U.S. Geological Survey: 11/27/78

LABORATORY NUMBERS

K-84738

D197310

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,507 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous

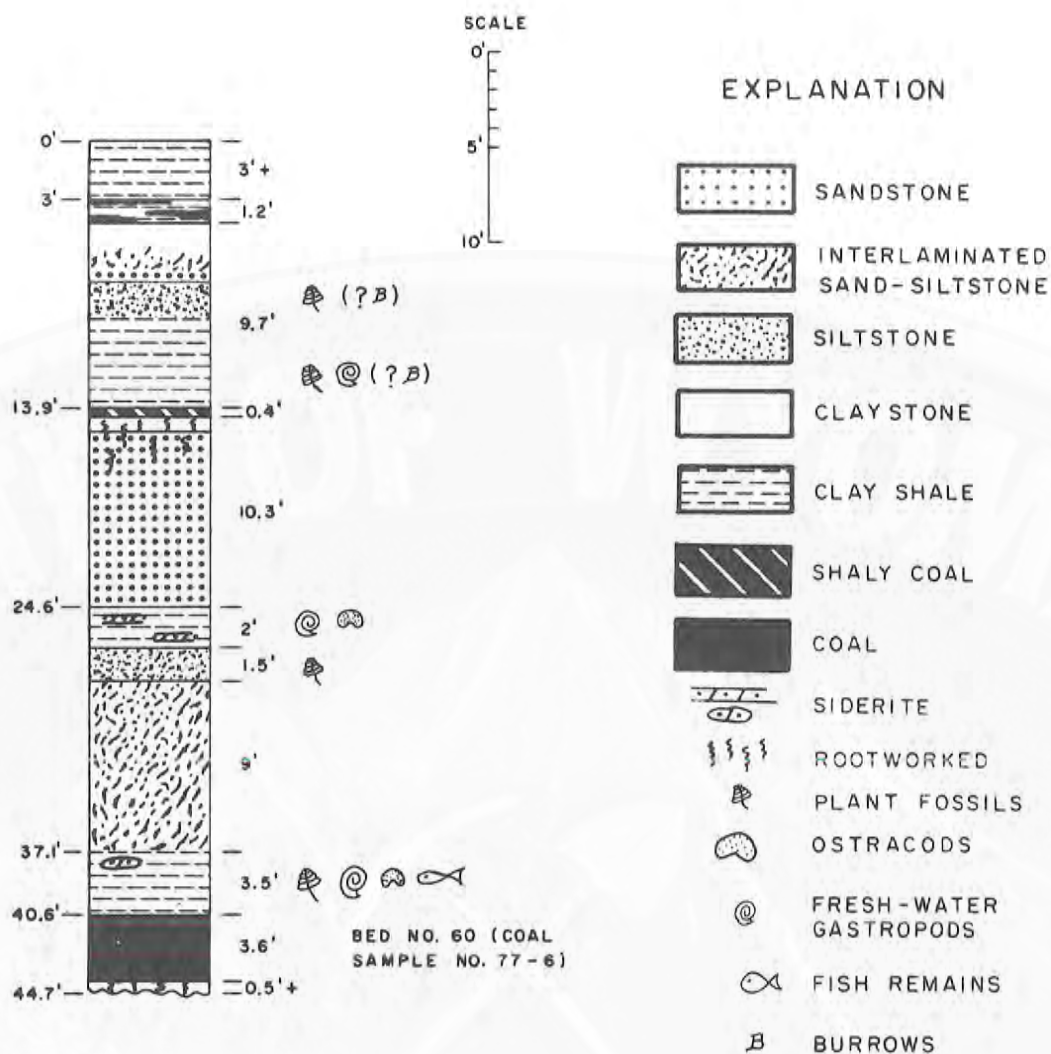


Figure 42. Measured section in Medicine Bow strip mine, Bed No. 60 (SAMPLE NO. 77-6).



COAL: Banded; vitrain bands and bright attritus; interbeds of nonbanded coal one half to three quarters inch thick near base, rare.

THICKNESS OF BED: 3.6 feet

THICKNESS SAMPLED: 3.6 feet

Figure 43. Megascopic description of Bed No. 60 in Medicine Bow strip mine (SAMPLE NO. 77-6).

SAMPLE NO. 77-7

INDEX MAPS: See Figure 6

COAL NAME(S): Bed No. 61

GEOLOGIC FORMATION: Ferris

AGE: Paleocene

COAL FIELD: Hanna (Seminole District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 44

TOTAL SECTION MEASURED (FEET): 58.9

COVER AT SAMPLING POINT (FEET): 50.9+

ELEVATION TOP OF SAMPLED COAL: 6,499 feet±

STRIKE: 5°

DIP: 5°S

MAJOR JOINT ORIENTATIONS IN COAL:

20°, 152°

STATE: Wyoming

COUNTY: Carbon

SECTION: 17

TOWNSHIP: 23N

RANGE: 83W

QUADRANGLE: Pats Bottom 7 1/2-minute

COAL DESCRIPTION: See Figure 45

THICKNESS OF COAL (FEET): 7.1

THICKNESS SAMPLED (FEET): 7.1

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Slightly weathered

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Medicine Bow

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/20/78

U.S. Geological Survey: 11/27/78

LABORATORY NUMBERS

K-84740

D197313

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,800 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous

MISCELLANEOUS COMMENTS: The section was measured approximately 200 feet south of the sample site.

FERRIS FORMATION

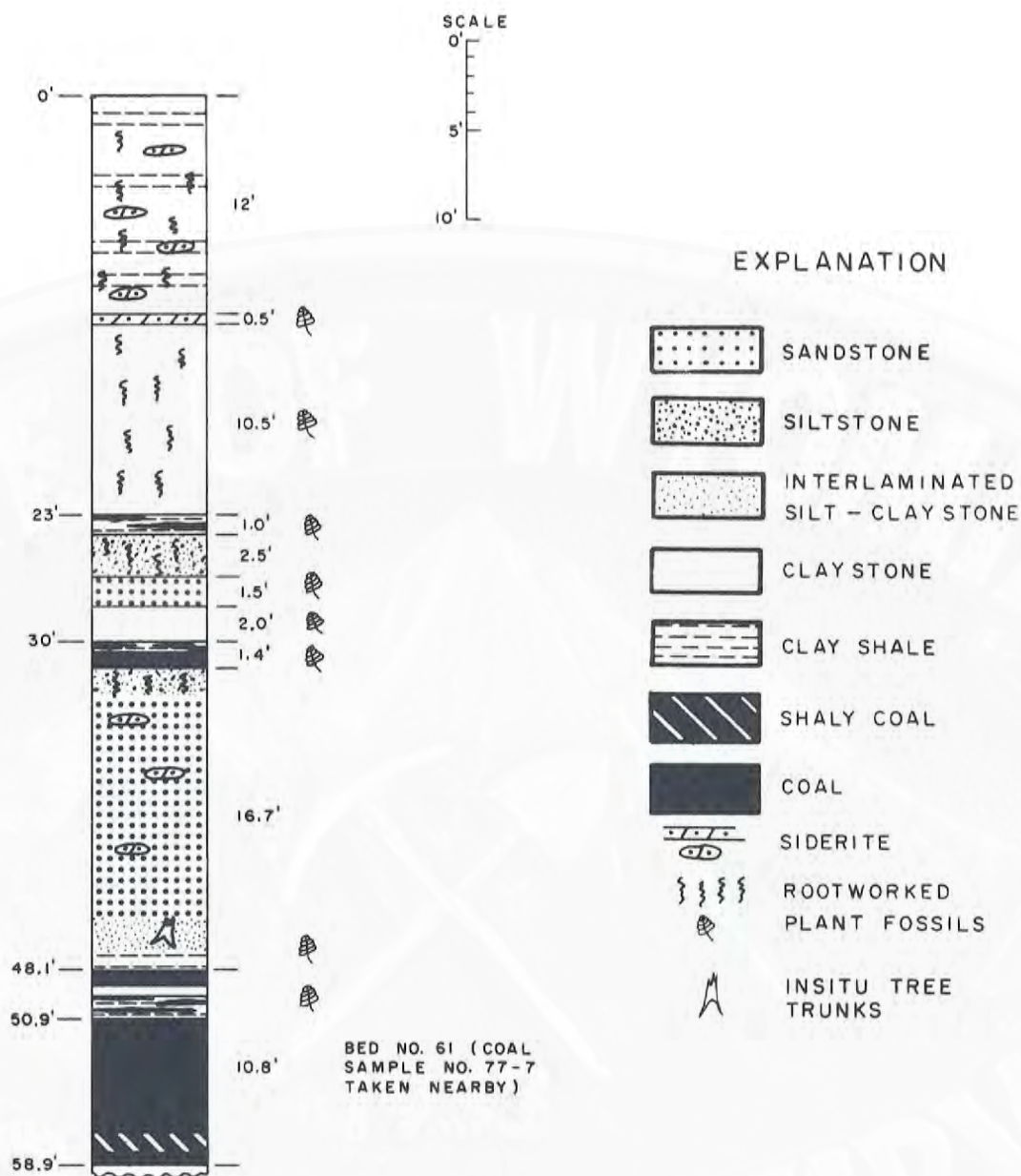
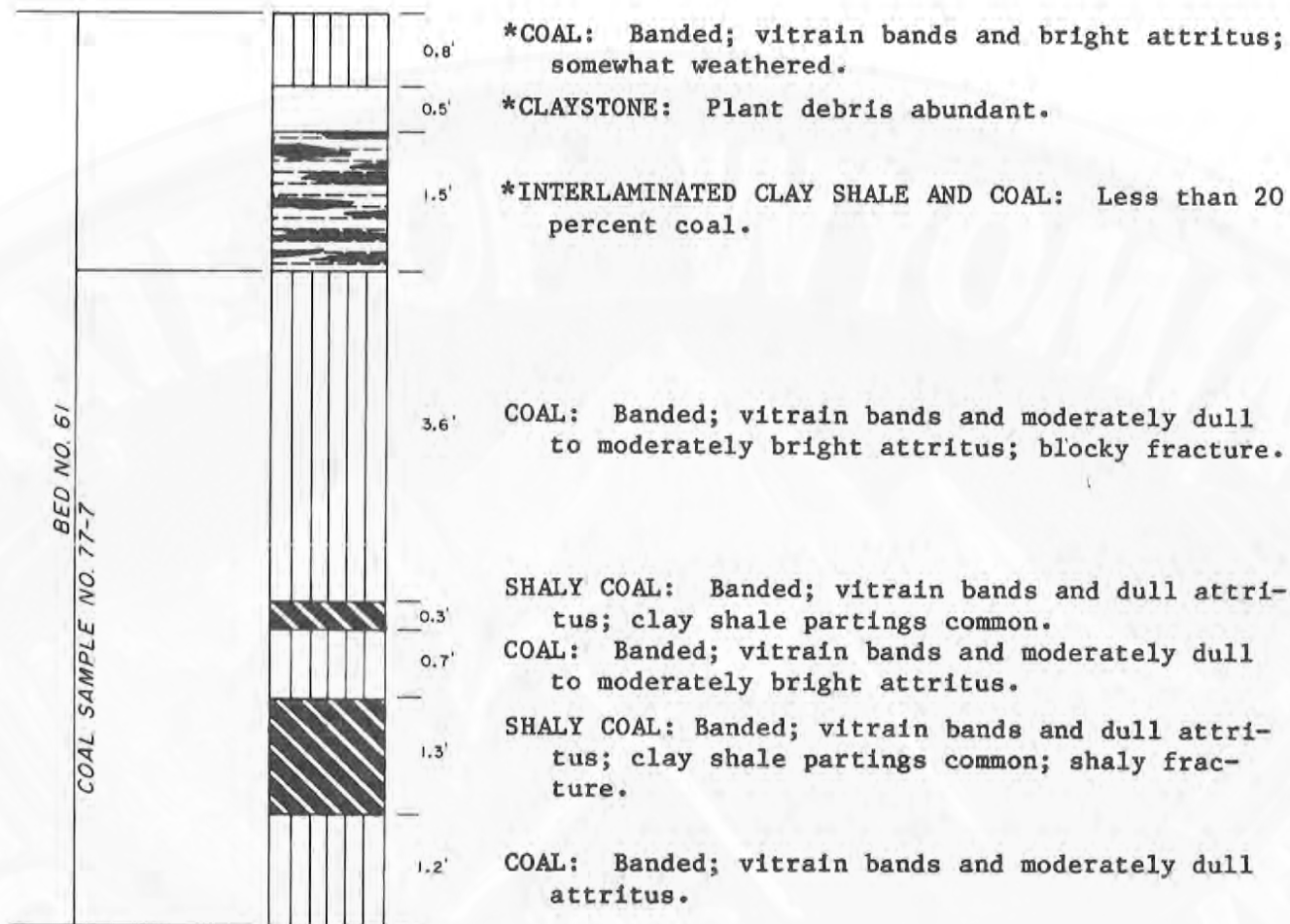


Figure 44. Measured section in Medicine Bow strip mine, Bed No. 61 (SAMPLE NO. 77-1 taken nearby was 9.9 feet thick).



*EXCLUDED FROM SAMPLE

THICKNESS OF BED: 9.9 feet

THICKNESS SAMPLED: 7.1 feet

Figure 45. Megascopic description of Bed No. 61 in Medicine Bow strip mine (COAL SAMPLE No. 77-7).

SAMPLE NOS. 77-8 and 77-9

INDEX MAPS: See Figure 28

STATE: Wyoming

COAL NAME(S): Bed No. 37 (upper and lower)

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 16

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Seminoe District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 46

COAL DESCRIPTION: See Figure 47

TOTAL SECTION MEASURED (FEET): 69.1

THICKNESS OF COAL (FEET): 7.9

COVER AT SAMPLING POINT (FEET): 61.8+

THICKNESS SAMPLED (FEET): 7.9

ELEVATION TOP OF SAMPLED COAL: 6,718 feet±

TYPE OF SAMPLE: Face-channel

STRIKE: 110°

CONDITION OF SAMPLE: Slightly weathered

DIP: 23°N

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminoe No. 1

115-125°, 200°

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/22/78

K-84739

U.S. Geological Survey: 11/27/78

D197311, D197312

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,162 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: The section was measured approximately 1,200 feet N.60°W. of the sample site.

Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

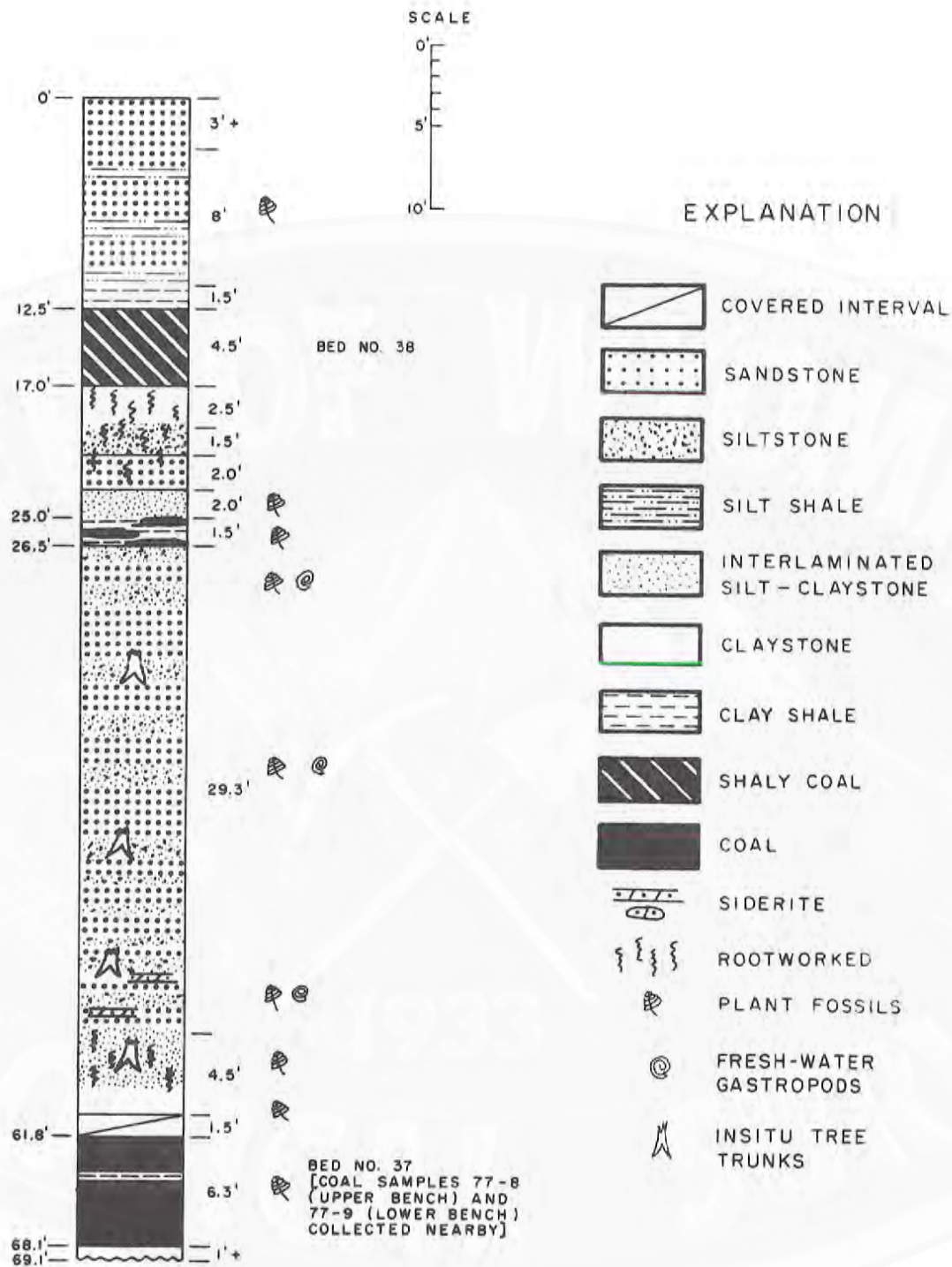
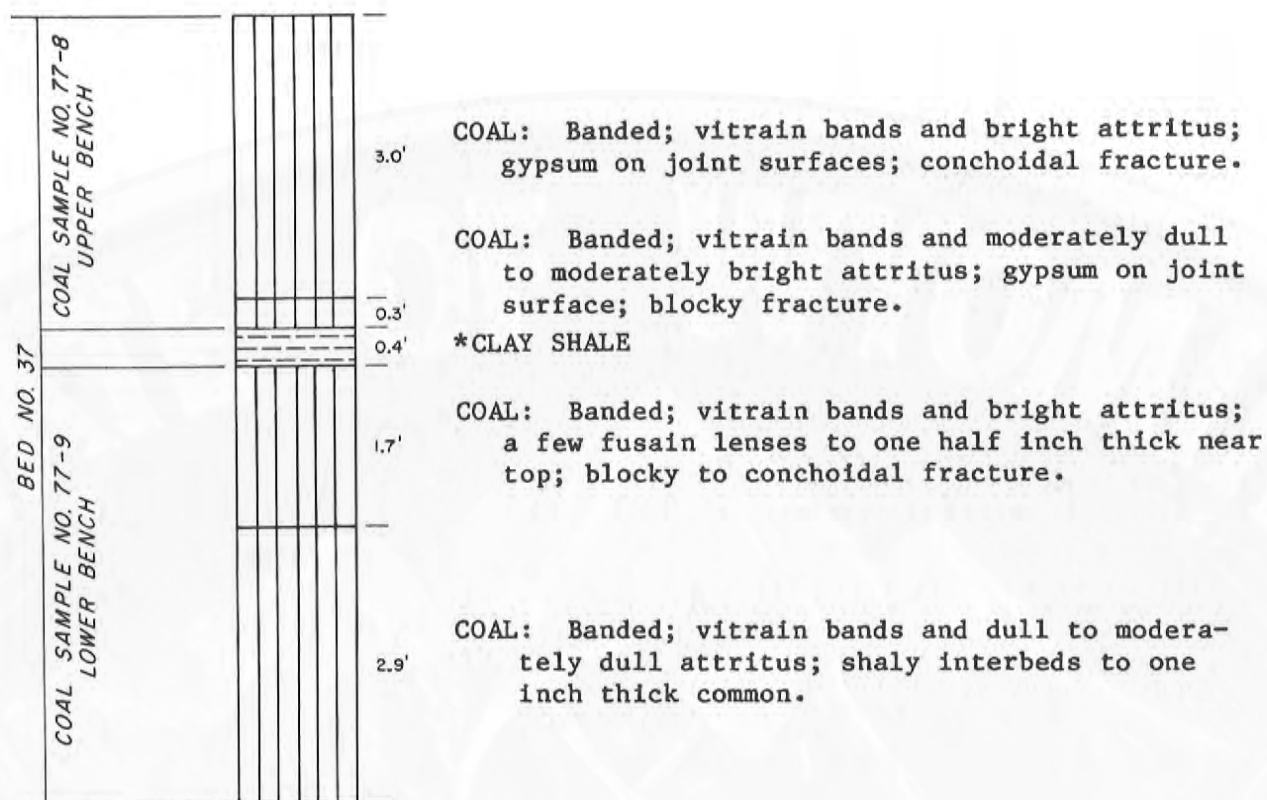


Figure 46. Measured section in Seminole No. 1 strip mine, Bed Nos. 37 and 38 (SAMPLE NOS. 77-8 and 77-9 taken nearby were 3.3 feet and 4.6 feet thick, respectively).



* EXCLUDED FROM SAMPLE

	UPPER BENCH SAMPLE NO. 77-8	LOWER BENCH SAMPLE NO. 77-9
THICKNESS OF BED:	3.3 feet	4.6 feet
THICKNESS SAMPLED:	3.3 feet	4.6 feet

Figure 47. Megascopic description of Bed No. 37 (upper and lower benches) in Seminoe No. 1 strip mine (SAMPLE NOS. 77-8 and 77-9).

SAMPLE NO. 77-10

INDEX MAPS: See Figure 48

STATE: Wyoming

COAL NAME(S): Bed No. 79

COUNTY: Carbon

GEOLOGIC FORMATION: Hanna

SECTION: 18

AGE: Paleocene

TOWNSHIP: 23N

COAL FIELD: Hanna (Hanna District)

RANGE: 81W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Elmo 7 1/2-minute

MEASURED SECTION: See Figure 49

COAL DESCRIPTION: See Figure 50

TOTAL SECTION MEASURED (FEET): 100.7

THICKNESS OF COAL (FEET): 19.6

COVER AT SAMPLING POINT (FEET): 83.3

THICKNESS SAMPLED (FEET): 19.6

ELEVATION TOP OF SAMPLED COAL: 7,047 feet+

TYPE OF SAMPLE: Face-channel

STRIKE: 290-315°

CONDITION OF SAMPLE: Fresh

DIP: 6°N

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminole No. 2 North

170°, 190°

DATE OF SAMPLING: 10/25/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 9/1/78

K-84743

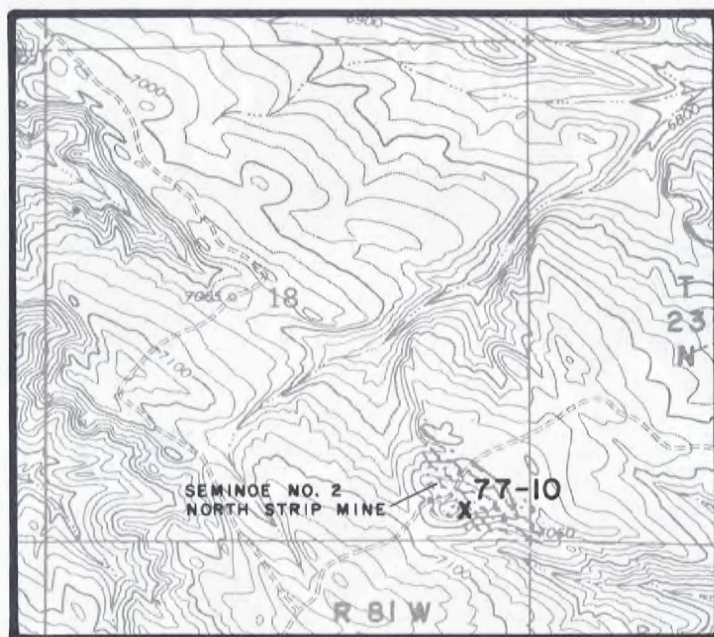
U.S. Geological Survey: 11/27/78

D197316

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 12,352 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous

MISCELLANEOUS COMMENTS: Called Bed No. 77 by the mining company; floor of strip mine is very rolly at south end; large (300-yard wide) channel sandstone at south end of pit, lifts out to north and south.



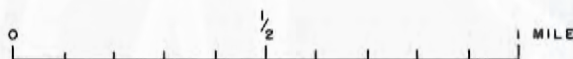
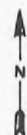
EXPLANATION

77-10 *Sample site and sample number*

X



Strip mine



Base map modified from U.S. Geological Survey's Elmo (1971) 7 1/2' topographic map.

Figure 48. Detailed location map of the Bed No. 79 sample site in Seminoe No. 2 North strip mine (SAMPLE NO. 77-10).

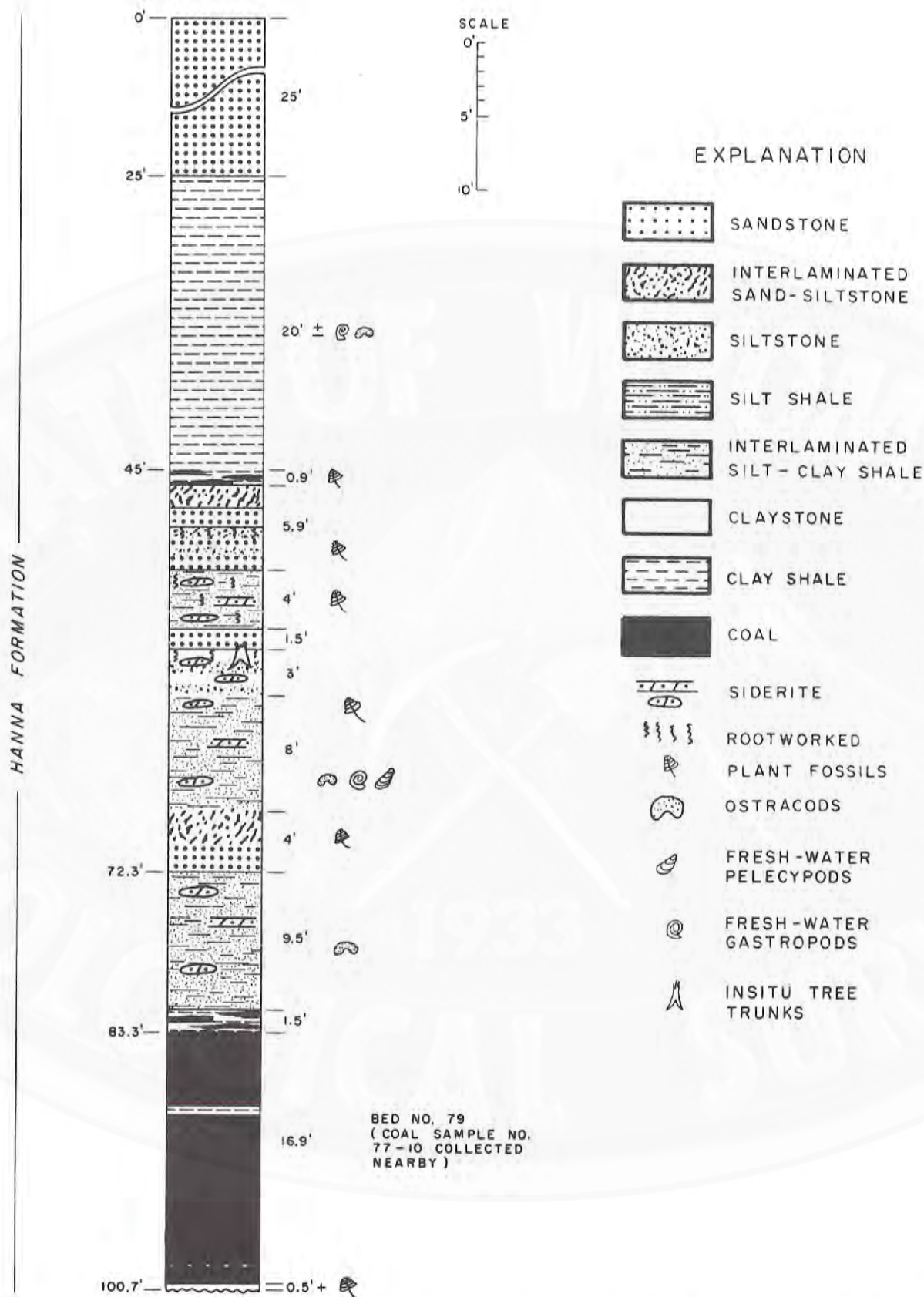
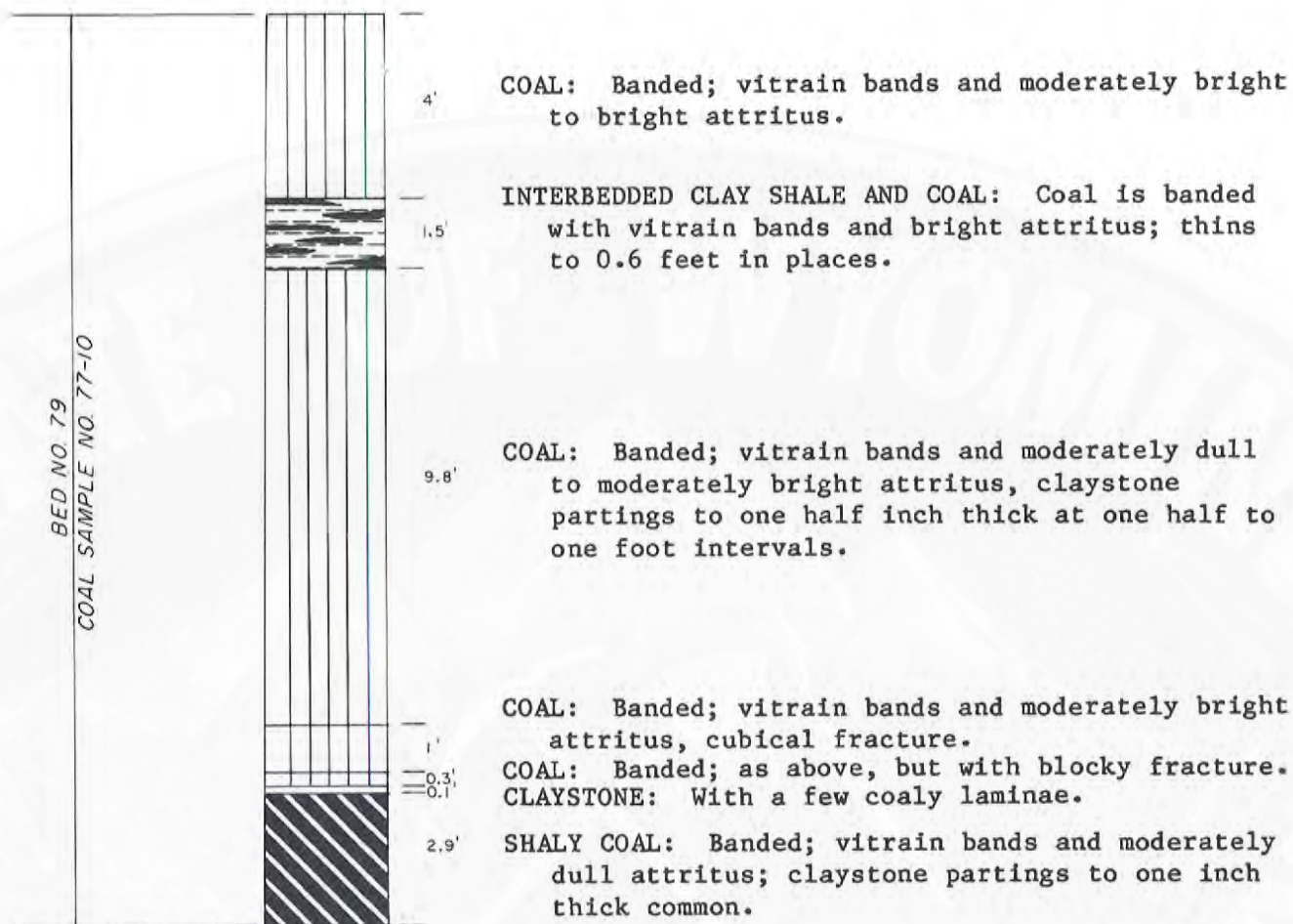


Figure 49. Measured section in Seminole No. 2 North strip mine, Bed No. 79 (SAMPLE NO. 77-10 taken nearby was 19.6 feet thick).



THICKNESS OF BED: 19.6 feet

THICKNESS SAMPLED: 19.6 feet

Figure 50. Megascopic description of Bed No. 79 in Seminoe No. 2 North strip mine (SAMPLE NO. 77-10).

SAMPLE NO. 77-11

INDEX MAPS: See Figure 37

COAL NAME(S): Bed No. 82

GEOLOGIC FORMATION: Hanna

AGE: Eocene

COAL FIELD: Hanna (Hanna District)

COAL-BEARING AREA: Hanna Coal Field

MEASURED SECTION: See Figure 51

TOTAL SECTION MEASURED (FEET): 53.1

COVER AT SAMPLING POINT (FEET): 43.8+

ELEVATION TOP OF SAMPLED COAL: 7,090 feet+

STRIKE: Approximately 275°

DIP: 6°N

MAJOR JOINT ORIENTATIONS IN COAL:

316°, 332°, 9°, 36°, 70°

STATE: Wyoming

COUNTY: Carbon

SECTION: 36

TOWNSHIP: 23N

RANGE: 81W

QUADRANGLE: Como West 7 1/2-minute

COAL DESCRIPTION: See Figure 52

THICKNESS OF COAL (FEET): 7.9

THICKNESS SAMPLED (FEET): 7.9

TYPE OF SAMPLE: Face-channel

CONDITION OF SAMPLE: Fresh

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Rosebud Pit No.5

DATE OF SAMPLING: 10/25/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

U.S. Bureau of Mines: 8/19/78

U.S. Geological Survey: 11/27/78

LABORATORY NUMBERS

K-84744

D197317

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,065 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Rank of coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

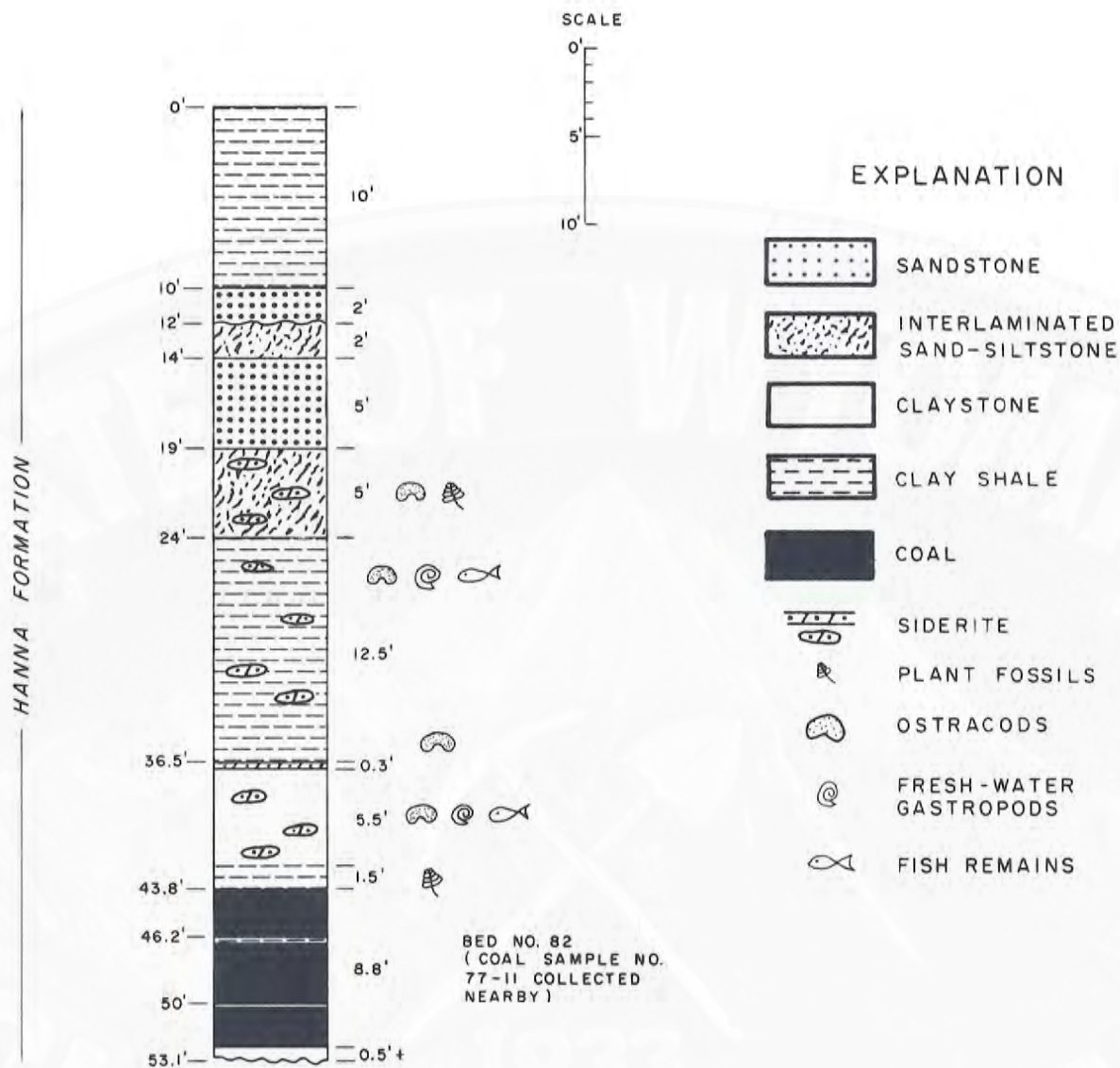
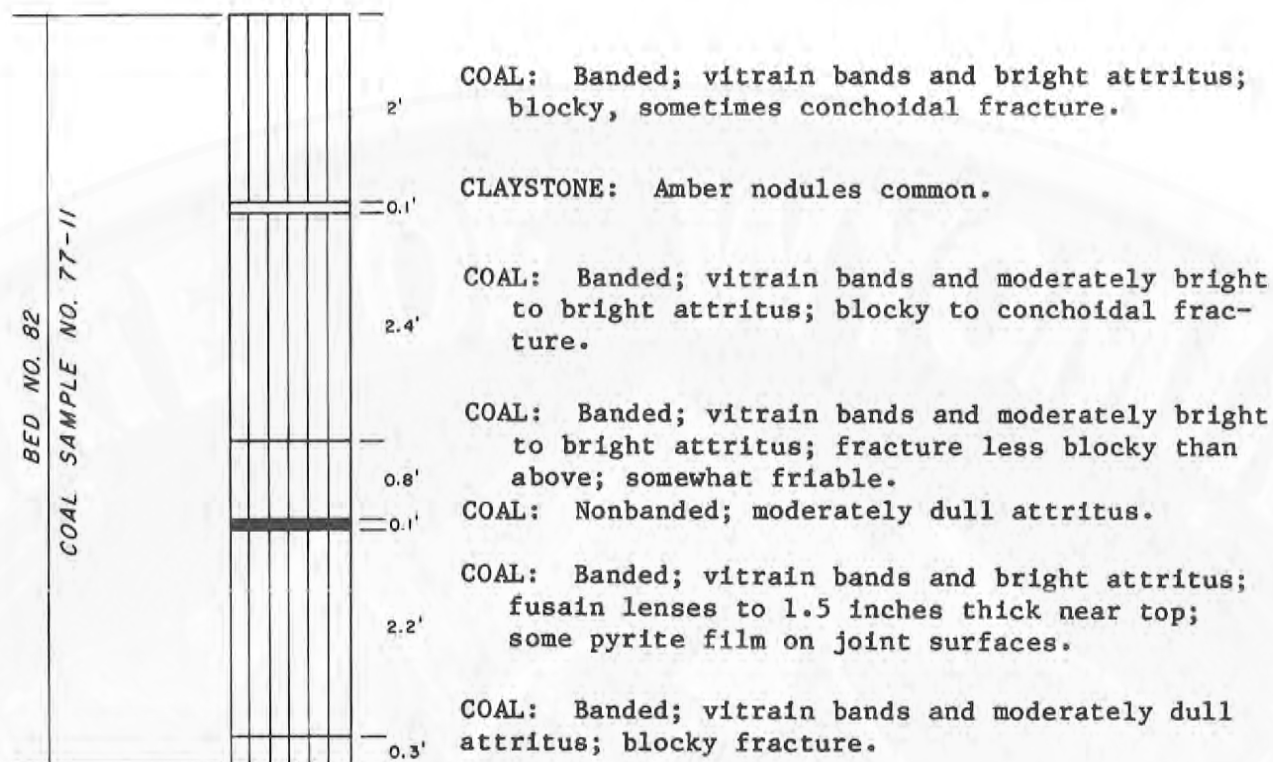


Figure 51. Measured section in Rosebud strip mine, Bed No. 82 (SAMPLE NO. 77-11 taken nearby was 7.9 feet thick).



THICKNESS OF BED: 7.9 feet

THICKNESS SAMPLED: 7.9 feet

Figure 52. Megascopic description of Bed No. 82 in Rosebud strip mine (SAMPLE NO. 77-11).

SAMPLE NO. 77-12

INDEX MAPS: See Figure 53

STATE: Wyoming

COAL NAME(S): Hanna No. 5 (upper bench)

COUNTY: Carbon

GEOLOGIC FORMATION: Hanna

SECTION: 7

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Hanna District)

RANGE: 81W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Elmo 7 1/2-minute

MEASURED SECTION: See Figure 54

COAL DESCRIPTION: See Figure 55

TOTAL SECTION MEASURED (FEET): 53

THICKNESS OF COAL (FEET): 8.7

COVER AT SAMPLING POINT (FEET): 19+

THICKNESS SAMPLED (FEET): 7.9

ELEVATION TOP OF SAMPLED COAL: 7,080 feet+

TYPE OF SAMPLE: Face-channel

STRIKE: Approximately 45°

CONDITION OF SAMPLE: Fresh

DIP: 10°S

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminoe No. 2 South

95-97°

DATE OF SAMPLING: 10/25/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/20/78

K-84745

U.S. Geological Survey: 11/27/78

D197318

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,994 Btu/pound

APPARENT RANK OF COAL: High Volatile C Bituminous

MISCELLANEOUS COMMENTS: The section was measured approximately 1,000 feet southwest of the sample site; sand-silt sequence between upper and middle benches thins to north, thickens into sandstone unit to south. Fault is visible at south end of mine, strikes nearly perpendicular to pit.



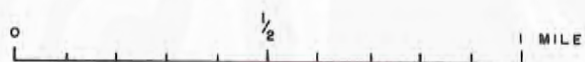
EXPLANATION

77-12 *Sample site and sample number*

X



Strip mine



Base map modified from U.S. Geological Survey's Elmo (1971) 7 1/2' topographic map.

Figure 53. Detailed location map of the Hanna No. 5 (upper bench) coal sample site in Seminoe No. 2 South strip mine (SAMPLE NO. 77-12).

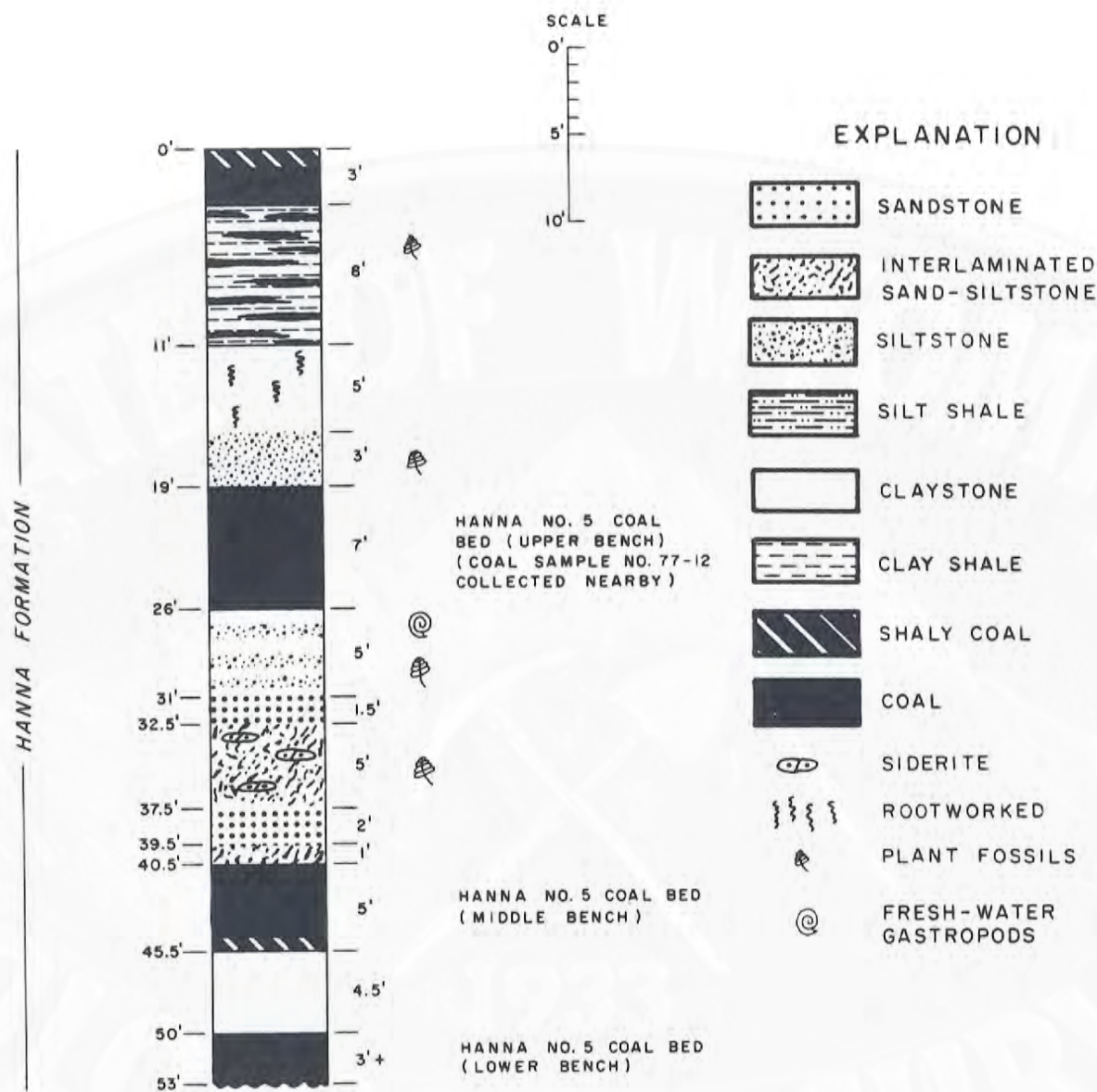
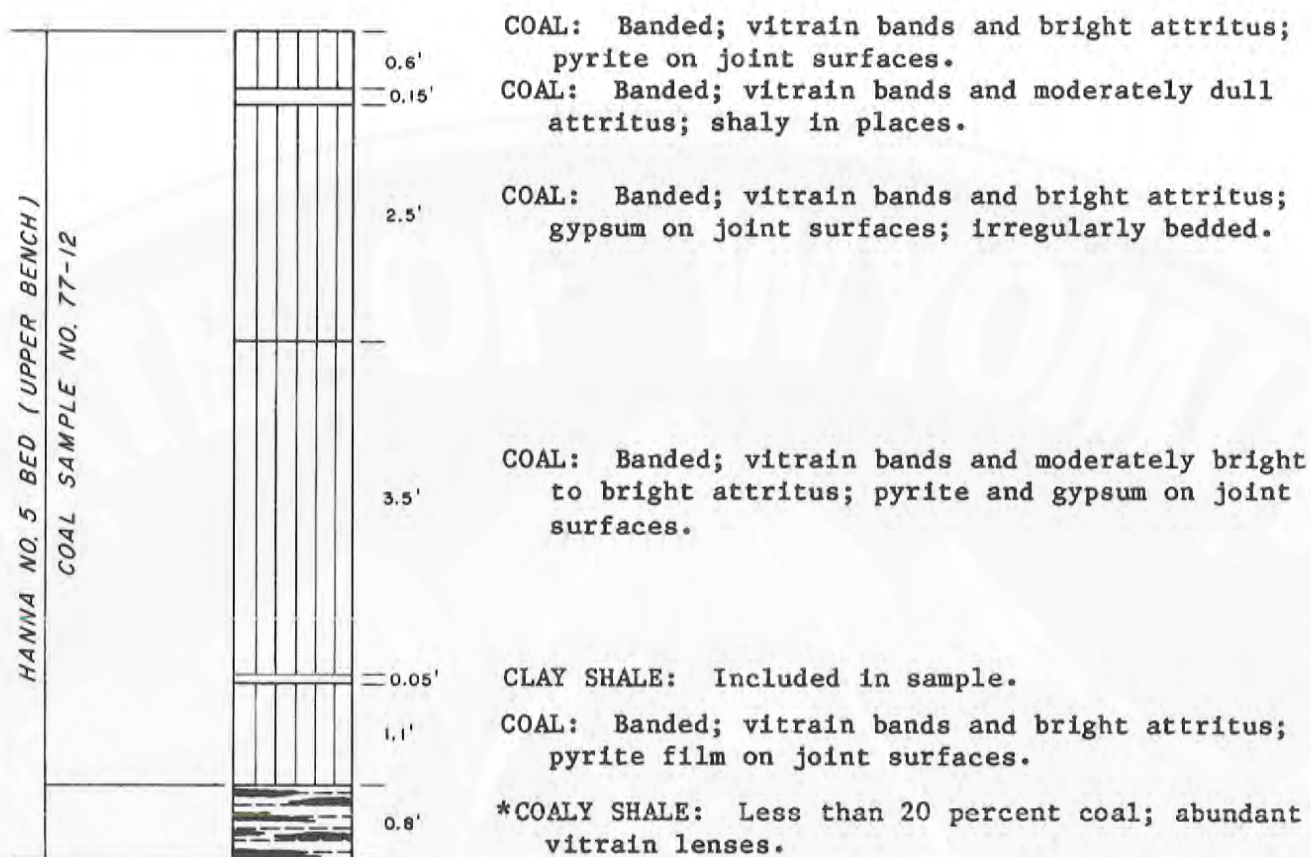


Figure 54. Measured section in Seminole No. 2 South strip mine, Hanna No. 5 (upper bench) (SAMPLE NO. 77-12 taken nearby was 8.7 feet thick).



* EXCLUDED FROM SAMPLE

THICKNESS OF BED: 8.7 feet

THICKNESS SAMPLED: 7.9 feet

Figure 55. Megascopic description of the Hanna No. 5 (upper bench) in Seminole No. 2 South strip mine (SAMPLE NO. 77-12).

SAMPLE NO. 77-13

INDEX MAPS: See Figure 28

STATE: Wyoming

COAL NAME(S): Bed No. 52

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 5

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Seminoe District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Pats Bottom 7 1/2-minute

MEASURED SECTION: See Figure 35

COAL DESCRIPTION: See Figure 56

TOTAL SECTION MEASURED (FEET): 102.9

THICKNESS OF COAL (FEET): 2.9

COVER AT SAMPLING POINT (FEET): 44.5

THICKNESS SAMPLED (FEET): 2.5

ELEVATION TOP OF SAMPLED COAL: 6,510 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 325°

CONDITION OF SAMPLE: Fresh

DIP: 17°N

TYPE OF EXPOSURE: Active strip mine

MINE NAME: Seminoe No. 1

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/20/78

K-84741

U.S. Geological Survey: 11/27/78

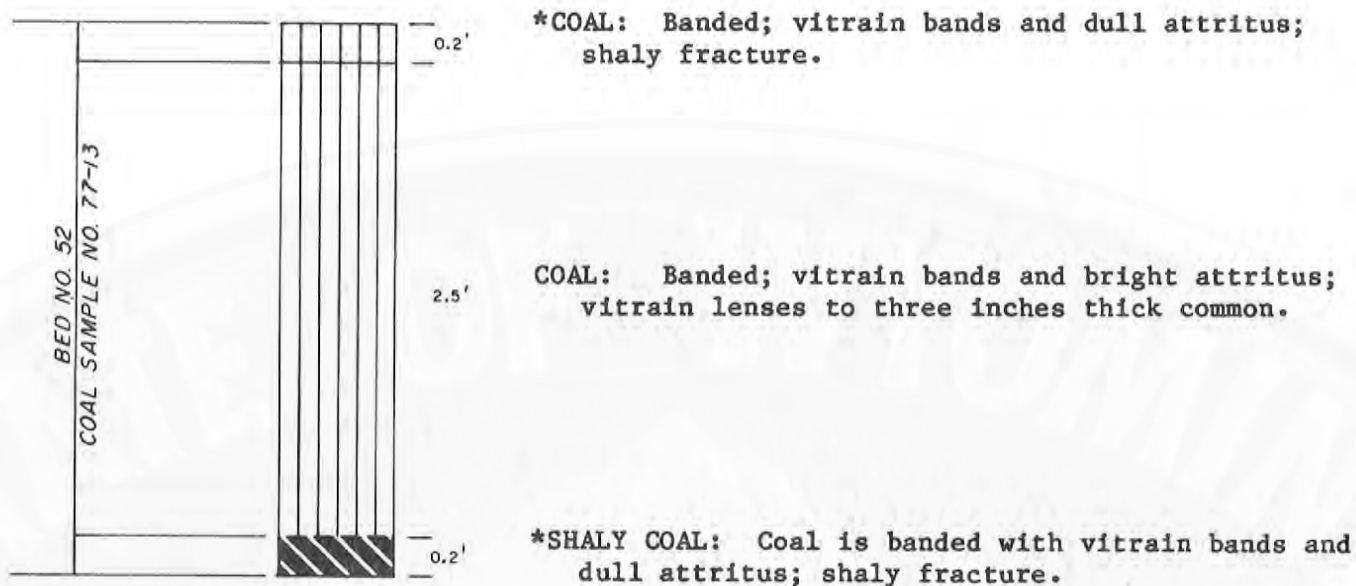
D197314

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 11,350 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: Called Bed 54 by the mining company.

Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.



* EXCLUDED FROM SAMPLE

THICKNESS OF BED: 2.9 feet

THICKNESS SAMPLED: 2.5 feet

Figure 56. Megascopic description of Bed No. 52 in Seminole No. 1 strip mine (SAMPLE NO. 77-13).

SAMPLE NO. 77-14

INDEX MAPS: See Figure 28

STATE: Wyoming

COAL NAME(S): Bed No. 25

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 16

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Seminole District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Walcott 7 1/2-minute

MEASURED SECTION: See Figure 57

COAL DESCRIPTION: See Figure 58

TOTAL SECTION MEASURED (FEET): 58.4

THICKNESS OF COAL (FEET): 9.67

COVER AT SAMPLING POINT (FEET): 43.2

THICKNESS SAMPLED (FEET): 9.67

ELEVATION TOP OF SAMPLED COAL: 6,747 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 288°

CONDITION OF SAMPLE: Very weathered

DIP: 20°N

TYPE OF EXPOSURE: Active Strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminole No. 1

285°, 238°

DATE OF SAMPLING: 10/26/77

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

U.S. Bureau of Mines: 8/23/78

K-84742

U.S. Geological Survey: 11/27/78

D197315

MOIST, MINERAL-MATTER-FREE HEAT VALUE: Too weathered for accurate analysis

APPARENT RANK OF COAL: Too weathered for determination

MISCELLANEOUS COMMENTS: Called Bed No. 21 by the mining company.

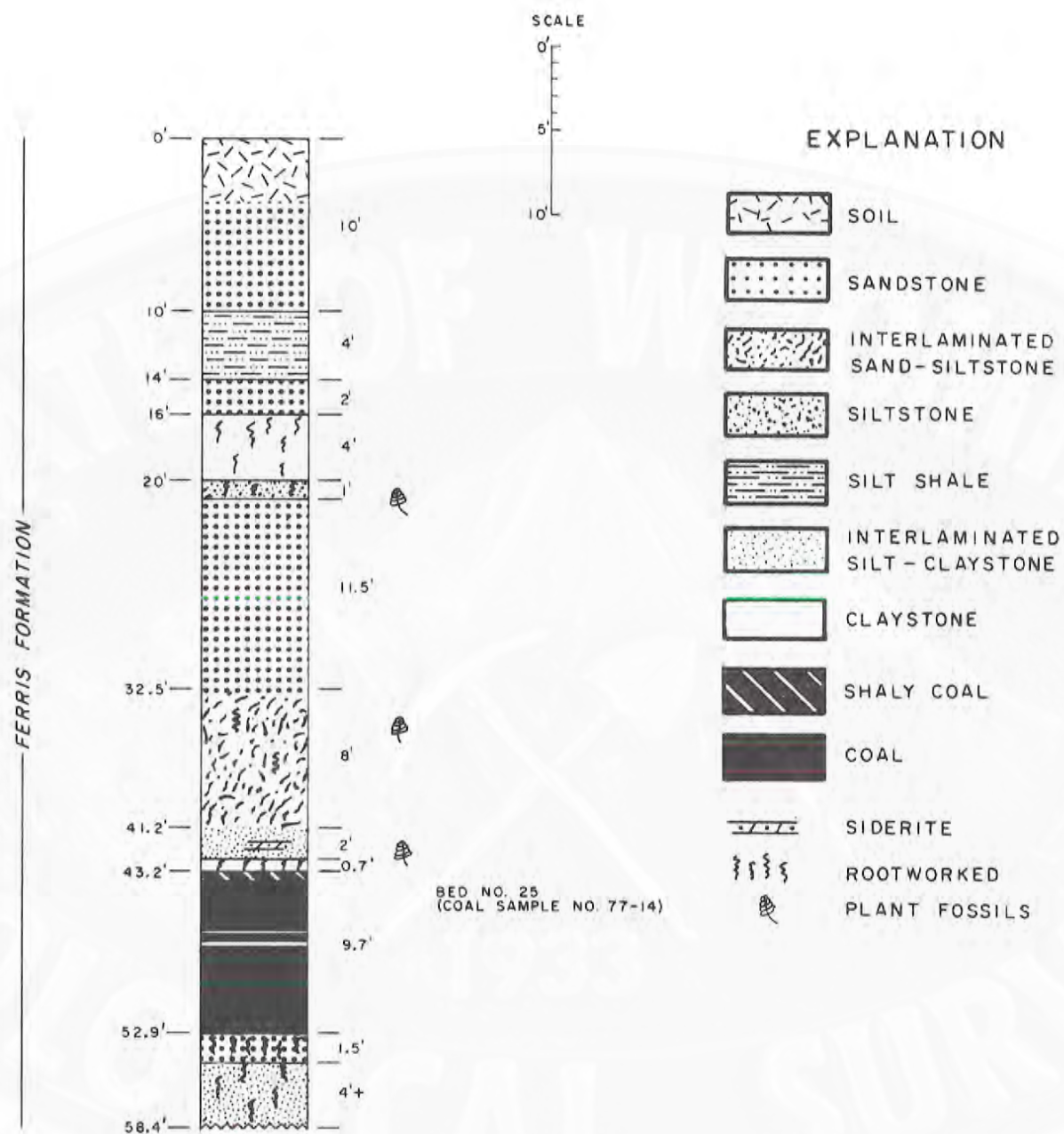
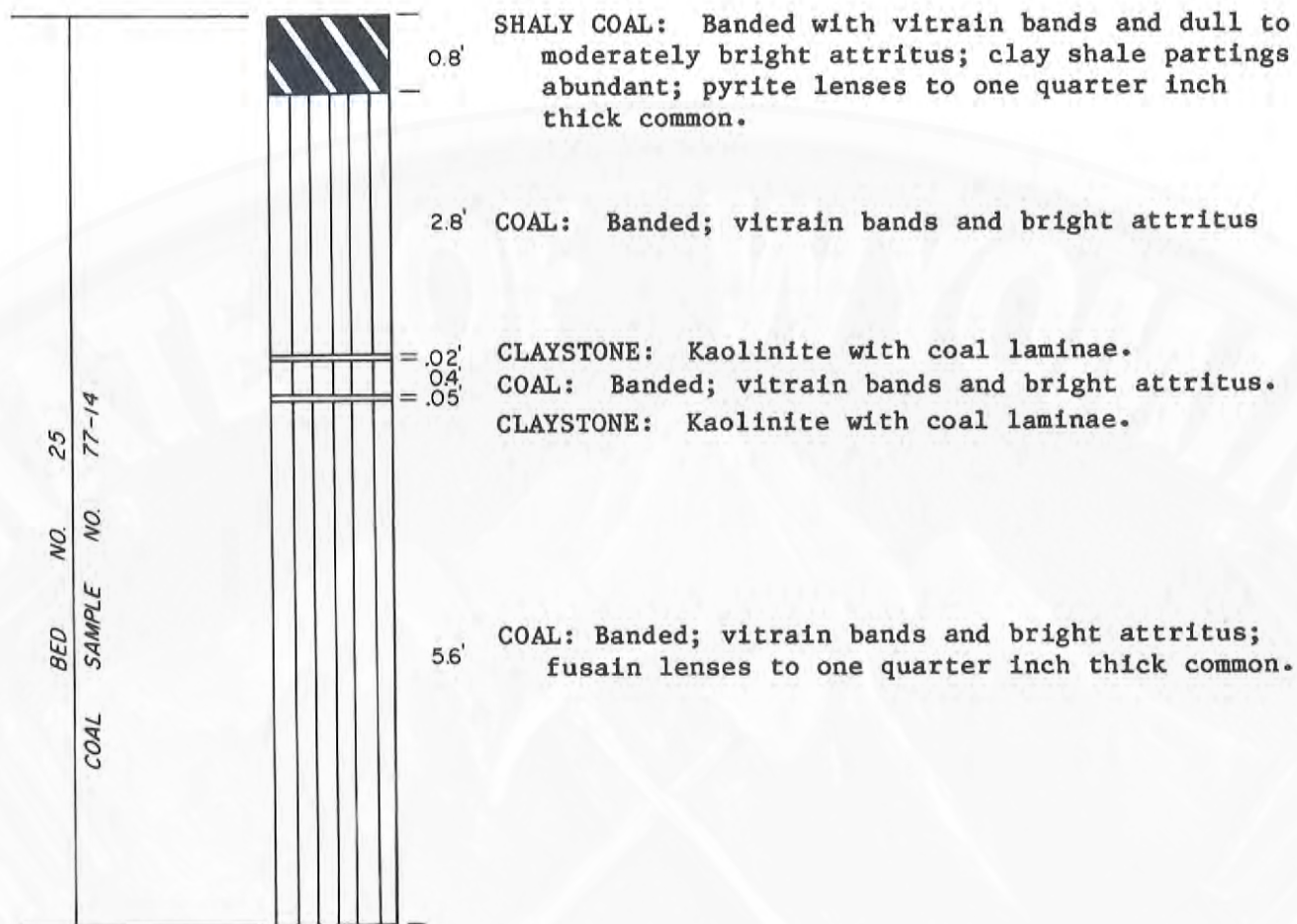


Figure 57. Measured section in Seminole No. 1 strip mine, Bed No. 25 (SAMPLE NO. 77-14).



THICKNESS OF BED: 9.67 feet

THICKNESS SAMPLED: 9.67 feet

Figure 58. Megascopic description of Bed No. 25 in Seminole No. 1 strip mine (SAMPLE NO. 77-14).

SAMPLE NO. 79-1

INDEX MAPS: See Figure 59

STATE: Wyoming

COAL NAME(S): Bed No. 31

COUNTY: Carbon

GEOLOGIC FORMATION: Ferris

SECTION: 23

AGE: Paleocene

TOWNSHIP: 22N

COAL FIELD: Hanna (Seminoe District)

RANGE: 83W

COAL-BEARING AREA: Hanna Coal Field

QUADRANGLE: Dana 7 1/2-minute

MEASURED SECTION: See Figure 60

COAL DESCRIPTION: see Figure 60

TOTAL SECTION MEASURED (FEET): 14.1

THICKNESS OF COAL (FEET): 8.0

COVER AT SAMPLING POINT (FEET): 0

THICKNESS SAMPLED (FEET): 8.0

ELEVATION TOP OF SAMPLED COAL: 6,740 feet

TYPE OF SAMPLE: Face-channel

STRIKE: 95°

CONDITION OF SAMPLE: Slightly weathered

DIP: 21°N

TYPE OF EXPOSURE: Active strip mine

MAJOR JOINT ORIENTATIONS IN COAL:

MINE NAME: Seminoe No. 1

200°, 106°

DATE OF SAMPLING: 11/16/79

SAMPLE COLLECTOR: Wyoming Geological Survey

COMPLETION DATE OF ANALYSES

LABORATORY NUMBERS

Wyoming Analytical Labs: 3/5/80

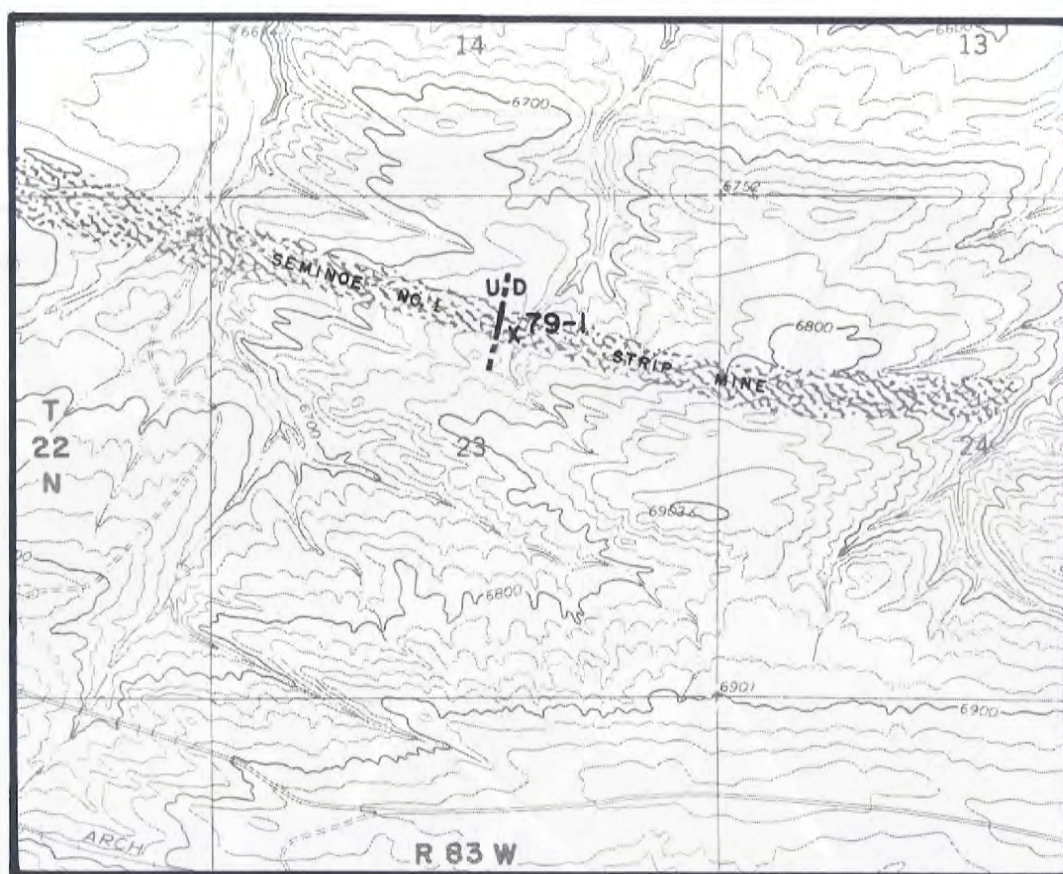
2487

MOIST, MINERAL-MATTER-FREE HEAT VALUE: 10,886 Btu/pound

APPARENT RANK OF COAL: Subbituminous A

MISCELLANEOUS COMMENTS: The sample was collected from the strip mine low wall; a fault near the sample site strikes 190° and dips 70° east.

Rank of the coal is assumed to be Subbituminous A because other coals in the area are nonagglomerating.

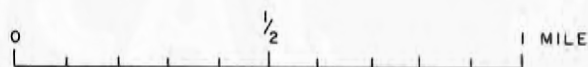
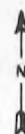


EXPLANATION

X 79-1 Sample site and sample number

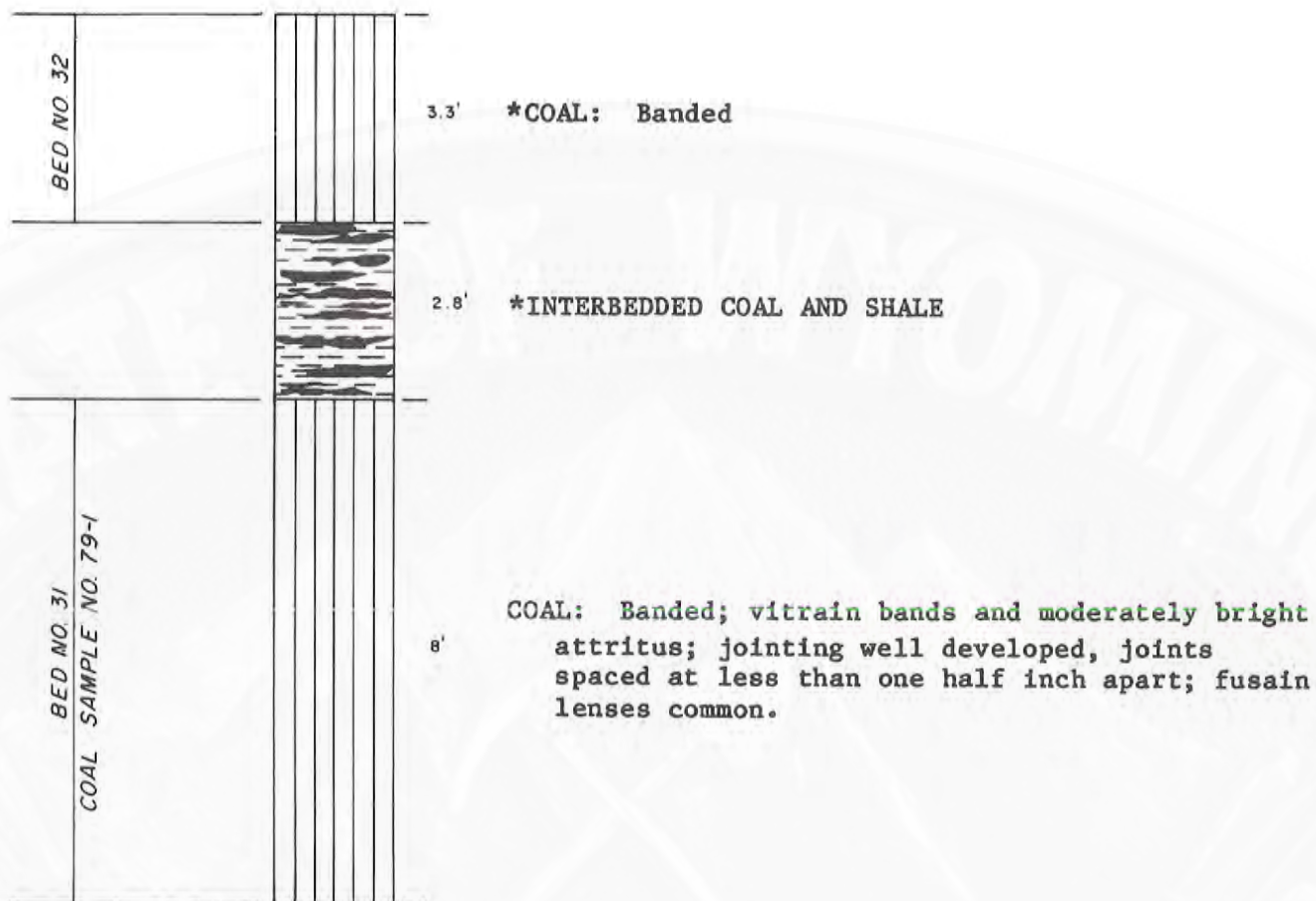


Strip mine



Base map modified from U.S. Geological Survey's Dana (1971) 7 1/2' topographic map.

Figure 59. Detailed location map of the Bed No. 31 sample site in Seminoe No. 1 strip mine (SAMPLE NO. 79-1).



* EXCLUDED FROM ANALYSIS

THICKNESS OF BED: 8.0 feet

THICKNESS SAMPLED: 8.0 feet

Figure 60. Megascopic description of Bed No. 31 in Seminoe No. 1 strip mine (SAMPLE NO. 79-1).

