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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE QUIETUS QUADRANGLE, BIG HORN AND POWDER RIVER COUNTIES, MONTANA

[Report includes 44 plates]

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COAL RESOURCE OCCURRENCE

Introduction

Purpose

This text is for use in conjunction with the coal resource occurrence maps (plates 1-43) and the coal development map (plate 44) of the Quietus quadrangle, Big Horn and Powder River Counties, Montana (U.S. Geological Survey Open-File Report 78-654). The maps are intended to support land-use planning and coal leasing activities of the Bureau of Land Management as required by their Energy Minerals Activities Recommendation System (EMARS), and to provide information leading to a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. The only coal beds included in this resource inventory are those 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden, as specified for Reserve Base calculations for subbituminous coals in the coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey (1976).

Location

The Quietus 7 1/2-minute quadrangle is in the southeastern part of Big Horn County and the southwestern part of Powder River County, Montana about 1/2 mile (1 km) north of the Wyoming State Line. It is about 32 airline miles (52 km) northeast of Sheridan, Wyoming, and 73 airline miles (118 km) southeast of Hardin, Montana.

Accessibility

The northeast part of the quadrangle is served by a graveled road that connects northward with graveled roads leading to the communities of Decker and Birney, Montana. The remainder of the quadrangle is accessible only by unimproved dirt roads and trails.

The Burlington Northern Railroad operates an east-west route from Sheridan, Wyoming to Gillette, Wyoming that comes within 19 miles (31 km) of the Quietus quadrangle.

Physiography

The quadrangle has been dissected by the westward-flowing perennial stream, Trail Creek, and its tributaries into steepwalled flat-bottomed valleys separated by rolling upland surfaces. The maximum local relief is about 400 feet (122 m) from the bottom of Trail Creek to the top of the divide to the south. The surface elevations in the quadrangle range from 3,600 to 4,180 feet (1,100 to 1,275 m) above mean sea level.

Climate

Southeastern Montana in the vicinity of the Quietus quadrangle has a semi-arid climate. Average annual precipitation at Decker, Montana, about 23 miles (37 km) to the west, is about 12 inches (30 cm) and the annual variation in temperature is commonly from about 100°F to -40°F (38°C to -40°C).

Land status

The quadrangle lies within the Northern Powder River Basin Known Recoverable Coal Resource Area. The Federal government owns all of the coal within the quadrangle except for the coal in about 3 square miles (7.8 sq. kms) that belongs to the State of Montana (see plate 2). In 1977, no Federal coal was covered by outstanding Federal coal leases, prospecting permits, or licenses.

General Geology

Sources of data

The geology of the Quietus quadrangle was first mapped in the early 1940's as part of the large Moorhead coal field (Bryson and Bass, 1973). Portions of the quadrangle were later investigated for strippable coal deposits by Matson, Blumer, and Wegelin (1973). In 1976, Culbertson and Klett mapped the geology of the Quietus quadrangle on a topographic base at a scale of 1:24,000, and a report

is in preparation. The quality of coal, and the resources of surface-minable coal in a small part of the Quietus quadrangle (drainage basin of East Trail Creek) is discussed in a recent report by Culbertson, Hatch, and Affolter (1978).

Data on coal-bed thicknesses in-and-adjacent to the quadrangle are from measurements at the outcrop, measurements from coal test holes reported by Matson, Blumer, and Wegelin (1973), measurements from coal test holes drilled from 1975-1977 by the Montana Bureau of Mines and Geology, and measurements derived from interpretation of geophysical logs of oil and gas test wells. The measurements from coal test holes are considered to be accurate to within about 1 foot (0.3 m), and measurements from gamma-ray logs of oil and gas test holes are probably of similar accuracy. Thicknesses obtained only from the resistivity log of oil and gas test holes may be less reliable. Coal beds are generally highly resistive; however, some other types of rocks such as limestone and some kinds of sandstone are also highly resistive, so misinterpretations are possible. The coal beds shown in wells at localities 9, 17, and 18 on plates 1 and 3 are interpretations from resistivity logs only.

Stratigraphy

The uppermost 220 feet (67 m) of the coal-bearing rocks underlying the quadrangle are assigned to the Wasatch Formation of Eocene age; the remainder belong to the Tongue River Member of the Fort Union Formation of Paleocene age.

The Tongue River Member is about 2,100 feet (700 m) thick in the Quietus quadrangle, or perhaps less, depending upon the placement of its gradational contact with the underlying Lebo Shale Member of the Fort Union Formation. It consists mostly of interbedded lenticular beds of friable yellowish-gray to light-gray siltstone, gray shale, very fine to medium-grained sandstone, and light- to medium-gray clayey siltstone, silty shale, brown carbonaceous shale, and coal beds. Most of the beds of siltstone and sandstone are weakly cemented, but some are very limy and locally grade into impure limestone that weathers to form resistant

ledges on the outcrop. Most of the beds of sandstone and siltstone are not persistent, so that the nature of the coal-bearing rocks changes from place to place.

The contact between the Fort Union Formation and the overlying Wasatch Formation is placed at the top of the Roland coal bed of Baker (1929), following the practice of Baker (1929) and other workers. The Wasatch Formation is similar lithologically to the Fort Union, except that it seems to contain a higher percentage of shale and it contains a few zones of mollusk-bearing limestone, siltstone, and shale. On the east side of the quadrangle it contains a coquinal limestone 1 or 2 feet (0.3-0.6 m) thick that locally caps a bench 40 to 50 feet (12-15 m) above the base of the formation.

The Wasatch and Fort Union Formations were deposited during the Eocene and Paleocene epochs in rivers, flood plains, swamps, and small lakes which shifted back and forth on a vast, flat alluvial plain.

The sedimentary rocks overlying and underlying the Anderson coal bed in part of the Quietus quadrangle have been analyzed for their trace element content by the U.S. Geological Survey (Hinkley, 1978). These rocks contain no greater amount of trace elements of environmental concern than do similar rock types found in other coal fields in the Northern Great Plains region.

Structure

The Quietus quadrangle lies on the gently-dipping east flank of the Powder River Basin. The regional dip, which is less than 1/2 degree to the southwest, has been strongly modified by ten normal faults that trend east, or east-northeast (pl. 10). The maximum displacement is about 300 feet (91 m), and the predominant direction of displacements is down on the south. The faults have created a series of flexures in the strata between the faults, but only locally are the dips more than 1 or 2 degrees.

Coal Geology

Nineteen coal beds, ranging in thickness from 1 to 33 feet (0.3-10.1 m) were identified on the surface or in the subsurface in the Quietus quadrangle (pl. 3). Of these, eight coal beds are thick enough and shallow enough to be included in calculations of the Reserve Base. The other eleven are either too thin or too deeply buried.

The uppermost coal bed is the Arvada coal bed. This coal is successively underlain by: a noncoal interval about 60-85 feet (18-26 m) thick; the Roland coal bed of Baker (1929); a noncoal interval about 80 feet (24 m) thick: the Trail coal bed; a noncoal interval about 85 feet (26 m) thick; the Waddle coal bed; a noncoal interval about 90 feet (27 m) thick; the Smith coal bed; a noncoal interval about 110 feet (34 m) thick; the Anderson coal bed; a noncoal interval about 55 to 70 feet (17 to 21 m) thick; the Dietz coal bed; a noncoal interval 85 to 165 feet (26 to 50 m) thick; the Canyon coal bed; a noncoal interval 75 to 140 feet (23 to 43 m) thick; the White coal bed; a noncoal interval 40 to 135 feet (12 to 41 m) thick; the Cook coal bed; a noncoal interval 10 to 60 feet (3 to 18 m) thick; the Otter coal bed; an interval 130 to 155 feet (40 to 47 m) thick containing a thin local bed; the Wall coal bed; an interval 215 to 240 feet (66 to 73 m) thick containing at least one local coal bed; the Brewster-Arnold coal bed; a noncoal interval 170 to 260 feet (52 to 79 m) thick; the King coal bed; a noncoal interval 90 to 190 feet (27 to 58 m) thick; the Knobloch coal bed; a noncoal interval 220 to 245 feet (67 to 75 m) thick; the Roberts coal bed; a noncoal interval about 230 feet (70 m) thick; and the Kendrick coal bed.

Coal bed thicknesses that are shown on the coal data map (pl. 1), the coal data sheet (pl. 3), and the isopach maps are the thicknesses of coal as recorded either at outcrops or in the drill holes, and are rounded to the nearest foot. Partings are excluded from the coal bed thickness where they are known to exist; however, the coal beds generally are free of partings.

In the past, the thicker coal beds have caught fire at the outcrop and have burned back under shallow cover. The heat from the burning coal has baked and fused the overlying rocks to form a resistant reddish-colored rock called clinker (also locally called scoria, or red shale). Clinker resulting from near-surface burning of the Anderson coal bed may be more than 50 feet (15 m) thick in the southwestern part of the quadrangle.

The chemical analyses of coal from eight core holes in the Quietus quadrangle (tables 1 and 2) show that the apparent rank of the coal is subbituminous C and that the ash and sulfur content is generally low. These coals are similar in chemical composition to other coals in the Powder River region, and the content of elements of environmental concern are generally low when compared to coals in the Interior province (Culbertson, Hatch, and Affolter, 1978, p. 28).

Table 1.--Proximate, ultimate, heating value, and forms-of-sulfur analyses of cores of the Anderson and Dietz coal beds, Quietus quadrangle, Big Horn County, Montana.

[All analyses except heating value are in percent. Forms of analyses: 1, as received; 2 moisture-free; 3 moisture and ash free. All analyses by Coal Analysis section, U.S. Bureau of Mines, Pittsburgh, Pennsylvania. 1 foot = 0.305 m.]

Locality No. (Plate 1)	Hole Name	Depth Interval (feet)	Lab. No.	Form of Analysis	Proximate				Ultimate					Forms of Sulfur			Heating Value
					Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Sulfur	Oxygen	Sulfate	Pyritic	Organic	(Btu/lb.)
								Anderson bed									
3	HWC-20	93.4 to 119.5	D186445	1	27.5	29.7	38.3	4.5	6.5	50.8	1.0	0.3	36.9	0.01	0.13	0.20	8720
				2	N/A	41.0	52.8	6.2	4.7	70.0	1.4	.5	17.2	.01	.18	.28	12025
				3	N/A	43.7	56.3	N/A	5.0	74.7	1.5	.5	18.3	.01	.19	.30	12820
		120.5 to 122.0	D186446	1	23.3	26.9	26.3	23.5	5.5	36.3	.7	4.5	29.4	.02	3.12	1.40	9478
				2	N/A	35.1	34.2	30.7	3.8	47.3	1.0	5.9	11.3	.02	4.07	1.82	9443
				3	N/A	50.6	49.4	N/A	5.5	68.2	1.4	8.5	16.3	.03	5.88	2.63	12182
5	HWC-25	73.0 to 75.5	D186448	1	29.8	28.0	37.0	5.2	6.4	48.8	.9	.3	38.5	.01	.14	.12	8287
				2	N/A	39.9	52.7	7.4	4.3	69.5	1.3	.4	17.1	.01	.20	.17	11609
				3	N/A	43.1	56.9	N/A	4.7	75.0	1.4	.4	18.5	.01	.22	.18	12753
		75.5 to 106.0	D186449	1	29.9	29.3	35.7	5.1	6.7	48.3	1.0	.7	38.3	.01	.25	.44	8368
				2	N/A	41.8	50.9	7.3	4.8	68.9	1.4	1.0	16.7	.01	.36	.63	11934
				3	N/A	45.1	54.9	N/A	5.1	74.3	1.5	1.1	18.0	.01	.39	.68	12875
								Dietz bed									
5	HWC-25	165.5 to 176.6	D186450	1	28.6	29.0	35.5	6.5	6.4	48.2	1.0	0.6	36.9	0.01	0.20	0.37	8303
				2	N/A	40.6	49.7	9.7	4.5	67.5	1.3	.8	16.2	.01	.28	.51	11622
				3	N/A	45.0	55.0	N/A	5.0	74.7	1.5	.9	17.9	.01	.31	.57	12873

Table 2.--Proximate, heating value, and forms-of-sulfur analyses of cores of the Anderson and Dietz coal beds, Quietus quadrangle, Big Horn County, Montana.

[All analyses except heating value in percent. Forms of analyses: A, as received; B, moisture-free; C, moisture and ash free. 1 foot = 0.305 m. From Matson, Blumer, and Wegelin, 1973, p. 51-52.]

Locality No. (Plate 1)	Hole Name	Depth Interval (in feet)	Form of Analysis	Proximate				Forms of Sulfur				Heating Value (Btu/lb.)
				Moisture	Volatile matter	Fixed Carbon	Ash	Sulfur	Sulfate	Pyritic	Organic	
Anderson bed												
6	SH-17	180 to 188	A	25.690	33.144	36.697	4.469	.202	.008	.034	.160	8835
			B		44.603	49.384	6.013	.271	.011	.045	.215	11890
			C		47.456	52.544		.289	.012	.048	.229	12657
		188 to 197	A	25.630	30.252	40.491	3.627	.093	.008	.000	.084	8777
			B		40.678	54.445	4.876	.125	.011	.000	.113	11802
			C		42.763	57.237		.131	.012	.000	.119	12467
		197 to 200	A	24.330	29.712	32.771	13.187	1.034	.118	.706	.210	7863
			B		39.265	43.308	17.428	1.366	.156	.936	.278	10391
			C		47.522	52.448		1.655	.188	1.130	.336	12584
12	SH-13	88 to 96	A	25.550	32.810	38.548	3.092	.211	.008	.000	.202	8896
			B		44.070	51.777	4.153	.283	.011	.000	.272	11949
			C		45.979	54.021		.295	.012	.000	.283	12467
		96 to 102	A	28.530	29.500	38.588	3.382	.097	.000	.000	.097	8506
			B		41.276	53.992	4.732	.136	.000	.000	.136	11902
			C		43.326	56.674		.142	.000	.000	.142	12493
14	SH-19	74 to 100	A	24.160	30.905	39.151	5.784	.170	.034	.034	.102	8390
			B		40.750	51.623	7.627	.225	.045	.045	.135	11063
			C		44.115	55.885		.243	.049	.049	.146	11976
		84 to 92	A	23.830	31.525	40.401	4.244	.284	.026	.095	.164	8802
			B		41.388	53.040	5.572	.373	.034	.124	.215	11555
			C		43.830	56.170		.395	.036	.132	.227	12237
		92 to 100	A	26.640	29.497	40.425	3.438	.191	.025	.066	.100	8306
			B		40.208	55.105	4.686	.260	.034	.091	.136	11322
			C		42.185	57.815		.273	.036	.095	.143	11879
15	SH-18	63 to 72	A	28.540	30.561	36.249	4.650	.219	.041	.065	.114	8258
			B		42.766	50.727	6.507	.307	.057	.091	.159	11556
			C		45.743	54.257		.328	.061	.097	.170	12360
		72 to 80	A	27.630	33.369	34.956	4.046	.247	.041	.025	.181	8245
			B		46.108	48.301	5.590	.341	.057	.034	.250	11393
			C		48.839	51.161		.361	.060	.036	.265	12068
		80 to 83	A	27.220	29.929	38.941	3.911	.231	.050	.033	.149	8438
			B		41.122	53.504	5.373	.318	.068	.045	.204	11594
			C		43.457	56.543		.336	.072	.048	.216	12252
Dietz bed												
15	SH-18	151 to 156	A	25.830	29.854	34.329	9.987	.477	.000	.033	.444	7722
			B		40.251	46.284	13.465	.643	.000	.044	.599	10411
			C		46.514	53.486		.743	.000	.051	.692	12032

Roland coal bed of Baker (1929)

[pls. 4-8]

The Roland coal bed was named by Taff (1909) in the Sheridan coal field, Wyoming. A coal assumed to be the same bed was called the Roland bed in the northern extension of the Sheridan coal field, Montana by Baker (1929). Subsequent work in the Sheridan coal field has shown that the Roland bed of Baker (1929) lies about 125 feet (38 m) above the original Roland bed of Taff (1909).

The top of the Roland bed of Baker (1929) is generally used in southern Montana as the contact between the Fort Union and overlying Wasatch Formations.

The Roland bed of Baker (1929) crops out along the higher ridges and hills in the Quietus quadrangle. It ranges in thickness from 7 to 10 feet (2.1 to 2.7 m) thick in the northern part of the quadrangle, but splits into 2 benches to the south. It thins southwestward to about 3 feet (1 m) thick. An unknown amount of coal was mined from the Roland coal bed in the 1930's from a mine in sec. 26, T. 8 S., R. 44 E. (pl. 1). Almost all of the Roland coal bed is under less than 200 feet (61 m) of overburden and has potential for recovery by surface-mining methods. Overburden on the coal reaches a maximum thickness of slightly more than 200 feet (61 m) in the southwest corner of the quadrangle.

Chemical analyses have not been made of the Roland coal bed of Baker (1929) in this quadrangle.

Anderson coal bed

[pls. 9-13]

The Anderson coal bed was named by Baker (1929), probably for outcrops along Anderson Creek about 15 miles (24 km) west of the Quietus quadrangle. It crops out in the western part of the Quietus quadrangle and ranges in thickness from 24 to 33 feet (7.3 to 10.1 m). It is thickest in the northern part of the quadrangle (pl. 9).

The Anderson bed is under less than 200 feet (61 m) of overburden and has potential for surface mining in the valleys in the central part of the quadrangle (pl. 11). The maximum thickness of overburden is about 500 feet (152 m).

Chemical analyses of cores of the Anderson coal bed are shown in tables 1 and 2. In general, on an as-received basis, the coal contains about 4 percent ash, 0.1 to 0.3 percent sulfur, and 8250 to 8900 Btu/lb (4585 to 4945 Kcal/kg). At localities 3 and 6, however, the lowermost 1.5 to 3 feet (0.4 to 0.9 m) of the bed has high ash and relatively high sulfur content.

Dietz coal bed

[pls. 14-18]

The name Dietz is used in this report as it was applied by Baker (1929) in the northern extension of the Sheridan coal field. The name is from the adjacent Sheridan coal field where Taff (1909) recognized and named, in descending order, the Dietz 1, 2, and 3 coal beds. Baker (1929, p. 35-36) correlated his Dietz bed with the Dietz bed of Taff (1909). The stratigraphic relations of coal in the Dietz interval within the two coal fields are still being worked out, and the exact correlation is uncertain.

The coal bed here called Dietz is 5 to 13 feet (1.5 to 3.9 m) thick in the quadrangle, thinning to the southwest (pl. 14). It locally contains a shale parting 1 or 2 feet (0.3 to 0.6 m) thick. The Dietz bed is under less than 200 feet (61 m) of overburden and has potential for surface mining in valleys in the western part of the quadrangle, and in a small area in the northeast (pl. 16). The maximum thickness of overburden is slightly more than 600 feet (183 m) in the southwest corner of the quadrangle.

Two chemical analyses of the Dietz coal bed (tables 1 and 2) indicate that on an as-received basis the ash content is 6 to 10 percent, the sulfur content is 0.5 to 0.6 percent, and the heating value is 7700 to 8300 Btu per pound (4278 to 4611 Kcal/kg).

Canyon coal bed

[pls. 19-23]

The Canyon coal bed was named by Baker (1929) for outcrops in the northern extension of the Sheridan coal field. The same coal is referred to as the Upper Canyon coal bed by Culbertson and others (1976) in the Stroud Creek quadrangle, which is the quadrangle to the northwest of the Quietus quadrangle. The Canyon bed ranges in thickness from 15 to 23 feet (4.5 to 7 m) in the Quietus quadrangle, and locally contains a parting near the top (pl. 3 and 19). The overburden ranges in thickness from about 300 feet (90 m) in the west to more than 800 feet (244 m) in the southwestern corner of the quadrangle (pl. 21).

Chemical analyses have not been made of the Canyon coal bed in the Quietus quadrangle.

White coal bed

[pls. 24-28]

The White coal bed is named for a coal bed encountered at a depth of 470 feet (143 m) in an oil and gas test hole, the Samuel Gary 30-3 Federal White, about 1 mile (1.6 km) west of the Quietus quadrangle in NW 1/4 sec. 30, T. 8 S., R. 44 E. It probably is not correlative with any named bed on the outcrop.

The White coal bed is 5 to 7 feet (1.5 to 2.1 m) thick in five drill holes and was not recognized in two drill holes (pls. 3 and 24). Where the White coal is 5 feet (1.5 m) or more thick, its overburden ranges in thickness from less than 400 feet (122 m) to more than 800 feet (244 m).

Chemical analyses have not been made of the White coal bed in the Quietus quadrangle.

Cook coal bed

[pls. 29-33]

The Cook coal bed was named by Bass (1932) for coal outcrops in the Cook Creek Mountains about 40 miles (64 km) northeast of the Quietus quadrangle. It was mapped southwestward by Warren (1959) in the Birney-Broadus coal field, and south along Hanging Woman Creek by Culbertson and others (1976). The Cook coal bed ranges in thickness from 10 to 17 feet (3 to 5.1 m) in the Quietus quadrangle, and locally contains a parting about 2 feet (0.6 m) thick (pls. 3 and 29). The overburden ranges in thickness from about 400 feet (120 m) to more than 1,000 feet (305 m) in the southwestern part of the quadrangle (pl. 41).

Chemical analyses have not been made of the Cook coal bed in the Quietus quadrangle.

Otter coal bed

[pls. 34-38]

The Otter coal bed was named by Bryson and Bass (1973) for exposures along Otter Creek northeast of the Quietus quadrangle. The coal bed here called Otter is 5 to 8 feet (1.5 to 2.4 m) thick in three drill holes, and is missing in four drill holes (pls. 3 and 34). Where it is 5 feet (1.5 m) or more thick its overburden ranges in thickness from about 700 feet (210 m) to 900 feet (270 m).

Chemical analyses have not been made of the coal in the Otter coal bed in the Quietus quadrangle.

Brewster-Arnold coal bed

[pls. 39-43]

The Brewster-Arnold coal bed was named by Bass (1924) for coal at the Brewster-Arnold mine about 16 miles (26 km) northwest of the Quietus quadrangle. The coal bed is 5 feet (1.5 m) of more thick in about half of the Quietus quadrangle, ranging up to 9 feet (2.7 m) in the northwest corner (pls. 3 and 39). It is beneath less than 1,000 feet (305 m) of overburden only in small parts of the quadrangle (pl. 41).

Chemical analyses have not been made of coal from the Brewster-Arnold coal bed in the Quietus quadrangle.

Coal resources

Coal resource estimates in this report are restricted to the Reserve Base part of the Identified Coal Resource, which is the part most likely to be developed in the foreseeable future (see U.S. Geological Survey Bulletin 1450-B for a discussion of these terms). The Reserve Base for subbituminous coal is coal that is more than 5 feet (1.5 m) thick, under less than 1,000 feet (305 m) of overburden, and within 3 miles (4.8 km) of a complete measurement of the coal bed. Reserve Base coal is further subdivided into categories according to its nearness to a measurement of the coal bed. Measured coal is coal within 1/4 mile (0.4 km) of a measurement, Indicated coal extends 1/2 mile (0.8 km) beyond Measured coal to a distance of 3/4 mile (1.2 km) from the measurement, and Inferred coal extends 2 1/4 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement.

The total Reserve Base for federally owned coal in the Quietus quadrangle is estimated to be about 4.2 billion short tons (3.8 billion metric tons). Table 3 shows the Reserve Base subdivided according to coal bed, resource category, and thickness of overburden; plate 2 shows the total Reserve Base for each section of land underlain by federally owned coal. The Identified Resources plate for each bed shows the Reserve Base coal in that bed in each section of land underlain by federally owned coal. About 4 percent of the total Reserve Base is classified as measured; 22 percent at indicated; and 74 percent as inferred. About 12 percent (517 million short tons or 469 million metric tons) is under less than 200 feet (61 m) of overburden; the remainder is under 200-1,000 feet (61 to 305 m) of overburden.

Table 3.--Coal Reserve Base for surface-mining methods (0-200 feet overburden) and underground-mining methods (200-1,000 feet overburden) in Federal coal lands in the Quietus quadrangle, Big Horn and Powder River Counties, Montana

[In millions of short tons. To convert short tons to metric tons, multiply by 0.907]

Coal bed name	Overburden 0-200 feet				Overburden 200-1,000 feet				Grand Total
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	
Roland of Baker (1929)-	10.10	31.06	4.76	45.92	-----	0.08	0.15	0.23	46.15
Anderson----------	42.31	197.93	185.74	425.98	35.04	224.87	960.16	1,220.07	1,646.05
Dietz----------	5.35	17.09	22.60	45.04	8.97	82.16	403.44	494.57	539.61
Canyon----------	-----	-----	-----	-----	29.84	180.73	787.59	998.16	998.16
White----------	-----	-----	-----	-----	3.01	24.07	113.99	141.07	141.07
Cook----------	-----	-----	-----	-----	22.20	152.59	610.89	785.68	785.68
Otter----------	-----	-----	-----	-----	2.41	13.73	15.04	31.18	31.18
Brewster-Arnold--------	-----	-----	-----	-----	1.85	10.52	24.25	36.62	36.62
Total	57.76	246.08	213.10	516.94	103.32	688.75	2,915.51	3,707.58	4,224.52

Coal Reserves are defined as the economically minable part of the Reserve Base tonnage. In this quadrangle, only coal recoverable by surface-mining methods is considered to be economically minable. Reserves for this quadrangle are determined by multiplying the amount of Reserve Base coal under less than 200 feet (61 m) of overburden by a recovery factor of 85 percent. The total Reserves for federally owned coal in the Quietus quadrangle is estimated to be 439 million short tons (399 million metric tons) of which 82 percent is in the thick Anderson coal bed. Reserves for the three coal beds containing surface-minable coal are shown by section of federally owned coal on the Identified Resources plate of these coal beds (pls. 8, 13, and 18).

COAL DEVELOPMENT POTENTIAL

Development potential of coal recoverable by surface-mining methods

Areas where the coal beds are more than 5 feet (1.5 m) thick and are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining and are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden removed per short ton of coal recovered). The formula used to calculate the mining ratio for subbituminous coal is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor (0.85)

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on plates 6, 11, and 16. The mining-ratio values for each development-potential category are based on economic and technological criteria, and were derived in consultation with A. F. Czarnowsky, Area Mining Supervisor, U.S. Geological Survey.

In the Quietus quadrangle, the amount of Reserve Base coal in the high development potential category is 467 million short tons (424 million metric tons), of which 91 percent is in the Anderson coal bed (table 4). Reserve Base coal in the moderate and low development potential categories are, respectively, 14 and 36 million short tons (13 and 33 million metric tons). Plate 44 shows the areas underlain by coal beds having high, moderate, and low development potential for recovery by surface-mining methods.

Table 4.--Coal Reserve Base for surface-minable coal according to its development potential, in Federal coal lands in the Quietus quadrangle, Big Horn and Powder River, Counties, Montana

[In millions of short tons. Development potentials are based on mining ratios (cubic yards of overburden/ton of recoverable coal). To convert short tons to metric tons, multiply by 0.907; to convert mining ratios in yd^3/short ton coal to m^3/metric ton coal, multiply by 0.842]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Roland of Baker (1929)	40.32	3.25	2.35	45.92
Anderson	425.98	-----	-----	425.98
Dietz	-----	11.43	33.61	45.04
Total	466.30	14.68	35.96	516.94

Development potential of coal recoverable by underground-mining methods

The Reserve Base for federally owned coal beneath 200-1,000 feet (61-305 m) of overburden is estimated to be about 3.7 billion short tons (3.4 billion metric tons) as shown in table 3. Coal at these depths would be recoverable only by underground-mining methods. Coal is not now being mined underground in the Powder River Basin and recovery factors have not been established so the development potential of this coal was not evaluated.

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