DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Summary of results of the Coal Resource Occurrence and Coal Development Potential mapping program in part of the Powder River Basin, Montana and Wyoming

by

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

[1]Reston, Virginia

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ILLUSTRATIONS

(ON ACCOMPANYING PLATE)

FIGURES

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CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters/metric ton
acre-feet	0.12335	hectare-meters
British thermal units/pound (Btu/lb)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (Btu/lb	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9 (F-32)	Celsius

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Abstract

As an aid to leasing, the recently concluded (1982) Coal Resource Occurrence and Coal Development Potential (CRO/CDP) mapping program of the U.S. Geological Survey provides information about unleased Federal coal resources. For the Powder River Basin of southeast Montana and northeast Wyoming, 243 CRO/CDP map reports at a scale of 1:24,000 on 7 1/2-minute quadrangles were published, and the coal resource data were entered in the National Coal Resources Data System (NCRDS).

Tertiary coal beds in the Powder River Basin are the Nation's largest resource of low-sulfur subbituminous coal. Some lignite is present in quadrangles along the eastern margin of the basin; however, more than 98 percent of the unleased Federal coal resources in the Powder River Basin are subbituminous in rank. Estimates from the CRO/CDP program indicate that the total nonleased Federal coal in Tertiary beds in part of the Powder River Basin is approximately 775 billion short tons. Not included in the above estimate are coal beds less than 5 feet thick, beds under more than 3,000 feet of overburden, previously leased coal, and non-Federal coal. About 70 to 80 quadrangles, for the most part on the west and south sides of the basin, may have significant reserve base coal in Tertiary beds that were not evaluated. Of these, 44 quadrangles in the Sheridan, Buffalo, and Lake DeSmet coal fields of Wyoming almost certainly have large coal resources. The total original coal resources in the Powder River Basin would probably exceed 1 trillion short tons if the coal resources in these excluded beds and areas were added to the total nonleased Federal coal resources.

Surface-minable nonleased Federal coal in that part of the basin evaluated consists of about 74 billion short tons in Montana and 125 billion short tons in Wyoming. Coal-bearing areas are classified as having HIGH, MODERATE, and LOW coal development potential (CDP). These areas are characterized as having overburden-to-coal ratios of 1-10, 10-15, and 15 plus, respectively. The CDP area outlines follow legal subdivisions on quadrangle maps; the smallest size area shown is 40 acres. The best of the nonleased Federal coal resources in the Powder River Basin is about 100 billion short tons of surface minable (less than 500 ft of overburden) HIGH development potential coal of which about 62 billion short tons are in Wyoming. The total of nonleased Federal coal resources between 500 and 3,000 ft of overburden in the 243 quadrangles is roughly 576 billion short tons--67 billion in Montana and 509 billion in Wyoming; these resources have a LOW CDP for mining. However, roughly 75 billion of the 509 billion short tons of unleased Federal coal resources in areas 6, 7, and 8 of Wyoming have a HIGH development potential for in situ gasification. The current (1984) status of the energy market ($1.12 per gallon for gasoline), however, dims the development prospects for in situ gasification projects in the Powder River Basin.

One of the primary benefits of this study is that the coal resources with HIGH and MODERATE development potential for surface mining and for in situ gasification are located by 7 1/2-minute quadrangles on regional small-scale index maps of the Powder River Basin. In the basin, 198 quadrangles contain more than 1 million short tons each of unleased strippable Federal coal of HIGH and MODERATE development potential. On the average, 31 percent of the area covered by the quadrangles has a HIGH development potential for surface mining. Of the 243 quadrangles tallied, 32 percent of the area, on the average, was eliminated from the estimate because it included nonFederal coal land, leased coal, or contained no coal beds more than 5 feet thick. A more thorough basinwide coal-resource assessment can be made after all 70 to 80 excluded quadrangles are evaluated, especially the 44 quadrangles in the Sheridan-Buffalo area that have great amounts of coal.

The principal contribution of this study is that the classified coal-resource data published in 243 separate reports are tabulated and presented in this summary report. Clearly, this will afford government, industry, or other interested parties the opportunity to examine and evaluate a great deal of coal-resources data for the Powder River Basin more easily and quickly.

INTRODUCTION

Two laws passed in 1976--the Federal Coal Leasing Amendments Act and the Federal Land Policy and Management Act, P.L. 94-377 and P.L. 94-579 respectively--requires that a comprehensive inventory of unleased Federal coal lands be made available to the public. The U.S. Geological Survey (USGS) began a Coal Investigations Program in fiscal year 1977 designated as the Coal Resource Occurrence and Coal Development Potential (CRO/CDP) map study of nonleased Federal coal (Wayland, 1981). The primary objective of the CRO/CDP program was to "determine the reserves of unleased Federal coal and to characterize for Federal land-use planning, the relative development potential of each leasable 40-acre tract" (Wayland, 1981, p. 543). The CRO/CDP program was officially completed in 1982, and all the contracted map reports for the Powder River Basin have been published. The CRO/CDP program was only part of a much broader ongoing USGS coal-investigations effort designed to provide timely information on coal resources and coal lands for the Nation. The agencywide work included the 1:100,000-scale coal folio series undertaken by the Geologic Division; the Energy Lands Program; the National Coal Resources Data System (NCRDS); the Water Resources Division regional work involving water quality studies; and exploratory coal drilling by the Geologic Division and Conservation Division (the Conservation Division was merged initially into the Minerals Management Service, MMS, and now is part of the Bureau of Land Management, BLM).

Furthermore, additional coal-resource studies in the Powder River Basin were completed by USGS geologists from 1975 to 1981; some of the reports of these investigations that are listed in table 2 provide more detailed coal-resource tonnage estimates than are available in the CRO/CDP reports.

By June 1982, 243 7 1/2-minute quadrangle coal resource reports covering parts of the Powder River Basin had been published as open-file reports of the U.S. Geological Survey. The reports are listed in table 1, and the quadrangles are identified on map A of the accompanying plate. The CRO/CDP map reports were compiled from all publicly available coal-resource information including well data. Except for a few quadrangles completed by USGS geologists, fieldwork was not an integral part of this mapping program. The USGS found it necessary to issue contracts for most of the work in order to meet the time limitations of lease negotiations. Two private contractors did most of the work in the Powder River Basin. In Montana, 95 CRO/CDP quadrangle reports were done by the Colorado School of Mines Research Institute, Golden, and in Wyoming, 134 quadrangle reports were completed by IntraSearch Inc. of Denver, CO (see table 1). The

Table 1. CRO/CDP quadrangle reports, Powder River Basin

[Coal-resource data from the 243 studies listed below have been tabulated and presented in this summary report. All reports in this table are U.S. Geological Survey (USGS)/Open-File Reports at the scale of 1:24,000. The year of the report is indicated by the digits preceding the hyphen in the report number. Most reports were done by contractors; some were done by USGS geologists. Titles of all reports begin- "Coal resource occurrence and coal development potential maps of the--". The reports contain text as well as maps. CSMRI, Colorado School of Mines Research Institute]

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
	Reports on northern Powder River Basin, Montana						
1---	Miller Creek NW	78-637	17	7	Rosebud and Custer	CSMRI	4
2---	Moon Creek School	78-636	14	7	Custer	do	4
3---	Griffin Coulee SW	78-647	17	7	Rosebud and Treasure	do	5
4---	McKerlich Creek	78-641	15	10	Rosebud	do	5
5---	Crain Place	78-644	18	11	do	do	5
6---	Miller Creek SW	78-646	17	12	Custer and Rosebud	do	4
7---	Miller Creek	78-635	16	7	Custer	do	4
8---	Jack Creek	78-639	16	8	do	do	4
9---	Beebe SW[1]	78-634	8	3	do	do	4
10---	Iron Spring[1]	78-631	6	3	Big Horn and Treasure	do	5
11---	Minnehaha Creek South	78-833	21	16	Treasure and Big Horn	do	5
12---	McClure Creek	78-834	22	15	Rosebud and Treasure	do	5
13---	Trail Creek School	78-835	20	13	Rosebud	do	5
14---	Colstrip West	78-648	20	13	do	do	5
15---	Colstrip East	78-836	18	13	do	do	5
16---	Hammond Draw NW	78-645	18	10	do	do	5
17---	John Hen Creek	78-643	18	10	do	do	5
18---	Brandenberg NW	78-642	17	7	Custer and Rosebud	do	4
19---	HS School	78-638	16	7	Custer	do	4
20---	Fourmile Creek	78-640	16	8	do	do	4
21---	Carey-Malone School	78-837	20	11	do	do	4
22---	Kirkpatrick Hill	78-838	20	10	do	do	4
23---	Padlock Ranch[1]	78-633	9	3	Big Horn	do	5
24---	Iron Spring SW[1]	78-632	9	3	do	do	5
25---	Wolf School	79-020	24	17	Big Horn and Treasure	do	5
26---	Sarpy School	79-018	22	13	Big Horn, Rosebud, and Treasure	do	5
27---	Rough Draw	79-017	28	22	Rosebud	do	5
28---	Colstrip SW	79-007	24	17	do	do	5
29---	Colstrip SE	79-006	23	17	Rosebud	do	5
30---	Hammond Draw SW	79-012	22	16	do	do	5
31---	Hammond Draw	79-011	23	16	do	do	5
32---	Brandenberg	79-004	20	13	Custer, Rosebud, and Powder River	do	4
33---	Hayes Point	79-013	22	16	Custer and Powder River	do	4
34---	North Stacey School	79-016	27	22	do	do	4

Table 1. CRO/CDP quadrangle reports, Powder River Basin[1]--Continued

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
		Reports on northern Powder River Basin, Montana (cont'd)					
35---	Foster Creek School	79-009	23	14	Custer and Powder River	CSMRI	4
36---	Volborg	79-019	23	13	do	do	4
37---	Divide School	79-008	19	10	do	do	4
38---	Jeans Fork NE	79-014	19	6	Big Horn	do	5
39---	Chalky Point	79-005	20	9	Big Horn and Rosebud	do	5
40---	Black Spring	79-003	21	16	do	do	5
41---	Jimtown	79-015	21	10	do	do	5
42---	Badger Peak	79-002	25	16	Rosebud	do	5
43---	Garfield Peak	79-010	23	13	do	do	5
44---	Ashland NE	79-001	22	19	do	do	5
45---	Cook Creek Reservior	79-084	27	35	Powder River and Rosebud	do	4
46---	Beaver Creek School	79-079	31	32	Powder River	do	4
47---	Stacey	79-099	26	25	do	do	4
48---	Elk Ridge	79-085	26	19	do	do	4
49---	Box Elder Creek	79-081	26	16	do	do	4
50---	Coalwood	79-082	22	17	do	do	4
51---	Ashland	79-078	23	16	Rosebud	do	3
52---	Willow Crossing	79-101	26	14	Powder River and Rosebud	do	3
53---	Coleman Draw	79-083	28	31	Powder River	do	3
54---	Home Creek Butte	79-091	34	41	do	do	3
55---	Samuelson Ranch	79-097	28	25	do	do	3
56---	Leslie Creek	79-093	25	16	do	do	3
57---	Olive	79-095	18	11	do	do	3
58---	Cook Creek Butte	79-646	22	13	Rosebud and Big Horn	do	3
59---	Clubfoot Creek	78-041	23	34	Rosebud	W.J. Mapel and B.K. Martin	3
60---	Birney Day School	79-080	33	35	do	CSMRI	3
61---	Green Creek	79-089	36	42	do	do	3
62---	King Mountain	79-092	37	43	Powder River and Rosebud	do	3
63---	Yager Butte	79-102	36	44	Powder River	do	3
64---	Threemile Buttes	79-100	31	53	do	do	3
65---	Sonnette	79-098	33	38	do	do	3
66---	Epsie	79-086	28	25	do	do	3
67---	Epsie NE	79-087	21	11	do	do	3
68---	Spring Creek Ranch	79-777	21	13	Big Horn	do	1
69---	Kirby	79-650	28	28	do	do	1
70---	Taintor Desert	79-779	28	27	Big Horn and Rosebud	do	1
71---	Birney SW	79-645	27	22	do	do	1
72---	Birney	78-030	24	44	Rosebud	W.J. Mapel and B.K. Martin	1
73---	Browns Mountain	78-039	36	69	do	do	1

Table 1. CRO/CDP quadrangle reports, Powder River Basin--Continued

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
Reports on northern Powder River Basin, Montana (cont'd)							
74---	Poker Jim Butte	78-651	32	64	Rosebud and Powder River	W.J. Mapel, B.K. Martin, and B.A. Butler	1
75---	Fort Howes	79-104	26	53	do	E.J. McKay and L.N. Robinson	1
76---	Goodspeed Butte	79-088	34	37	Powder River	CSMRI	2
77---	Phillips Butte	79-096	36	41	do	do	2
78---	Hodsdon Flats	79-090	36	40	do	do	2
79---	Yarger Butte	79-103	24	24	do	do	2
80---	Lonesome Peak	79-094	24	21	do	do	2
81---	Bar V Ranch NE	79-644	29	26	Big Horn	do	1
82---	Half Moon Hill	79-648	31	37	do	do	1
83---	Tongue River Dam	79-780	30	30	Big Horn and Rosebud	do	1
84---	Spring Gulch	79-778	34	32	do	do	1
85---	Lacey Gulch	78-037	30	49	Rosebud	W.J. Mapel, B.K. Martin, and B.A. Butler	1
86---	Strowd Creek	78-038	33	54	Rosebud and Big Horn	do	1
87---	Hamilton Draw	78-040	32	54	Rosebud, Big Horn and Powder River	do	1
88---	Otter	79-105	21	59	Powder River	E.J. McKay and L.N. Robinson	1
89---	Reanus Cone	79-788	32	39	do	CSMRI	2
90---	Sayle	79-789	34	41	do	do	2
91---	Bloom Creek	79-784	33	36	do	do	2
92---	Huckins School	79-786	33	41	do	do	2
93---	Baldy Peak	79-781	27	30	do	do	2
94---	Bear Scull Mountain	79-783	27	23	do	do	2
95---	Bar V Ranch	79-643	27	25	Big Horn	do	1
96---	Pearl School	79-776	34	43	do	do	1
97---	Decker	79-647	33	45	do	do	1
98---	Holmes Ranch	79-649	34	37	do	do	1
99---	Pine Butte School	78-652	30	64	do	W.C. Culbertson, L.N. Robinson, and T.M. Gaffke	1
100---	Forks Ranch	78-653	31	59	do	do	1
101---	Quietus	78-654	26	44	Big Horn and Powder River	W.C. Culbertson and L.N. Robinson	1
102---	Bear Creek School	79-106	20	59	Powder River	E.J. McKay, B.A. Butler, and L.N. Robinson	1

Table 1. CRO/CDP quadrangle reports, Powder River Basin--Continued

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
			Reports on northern Powder River Basin, Montana (cont'd)				
103---	Sayle Hall	79-790	35	46	Powder River	CSMRI	2
104---	Bradshaw Creek	79-785	34	39	do	do	2
105---	Moorhead	79-787	30	30	Powder River [Campbell Co., Wyo.]	do	2
106---	Three Bar Ranch	79-791	32	35	do	do	2
107---	Bay Horse	79-782	27	27	do	do	2
108---	Wild Bill Creek	79-792	24	13	do	do	2
			Reports on southern Powder River Basin, Wyoming				
1---	Box Elder Draw	79-162	35	49	Sheridan, Wyo. [Big Horn and Powder River Cos., Montana]	IntraSearch, Inc.	7
2---	Cabin Creek NW	79-163	33	59	Sheridan [Powder River Co., Montana]	do	7
3---	Cabin Creek NE	78-064	24	39	Sheridan and Campbell [Powder River Co., Montana]	do	7
4---	Black Draw	78-065	27	39	Campbell [Powder River Co., Montana]	do	6
5---	Dead Horse Lake	78-066	29	40	Campbell	do	6
6---	Corral Creek	78-067	23	40	"	do	6
7---	Homestead Draw	78-829	30	30	"	do	6
8---	Rocky Butte	78-830	27	24	"	do	6
9---	Fawn Draw	79-164	30	59	Sheridan	do	7
10---	Cabin Creek SE	79-165	43	49	Sheridan and Campbell	do	7
11---	Kline Draw	78-831	30	34	Campbell	do	6
12---	Reservoir Creek	78-832	27	39	"	do	6
13---	Homestead Draw SW	78-655	31	44	"	do	6
14---	White Tail Butte	79-021	30	39	"	do	6
15---	Rocky Butte Southwest	79-022	29	24	"	do	6
16---	Arvada	79-166	35	45	Sheridan	do	7
17---	Arvada NE	79-167	35	55	Sheridan and Campbell	do	7
18---	Larey Draw	79-023	35	54	Campbell	do	6
19---	Spotted Horse	79-024	33	50	"	do	6
20---	Recluse	79-025	34	46	"	do	6
21---	Pitch Draw	79-026	31	41	"	do	6
22---	Oliver Draw	79-027	29	19	"	do	6
23---	Jewell Draw	79-168	39	45	Sheridan and Johnson	do	7
24---	Lariat	79-169	27	55	Sheridan, and Johnson	do	7

Table 1. CRO/CDP Quadrangle Reports, Powder River Basin--Continued

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
			Reports on southern Powder River Basin, Wyoming (cont'd)				
25---	Croton	79-028	36	65	Campbell	IntraSearch, Inc.	6
26---	Truman Draw	79-029	38	75	Campbell	do	6
27---	Wildcat	79-030	34	75	do	do	6
28---	Calf Creek	79-031	31	40	do	do	6
29---	Weston SW	79-032	32	15	do	do	6
30---	Mitchell Draw	79-170	27	40	Johnson	do	7
31---	Livingston Draw	79-171	39	50	Johnson and Campbell	do	7
32---	Echeta	79-033	28	40	Campbell	do	6
33---	Twentymile Butte	79-034	30	40	do	do	6
34---	Oriva Northwest	79-035	33	57	do	do	6
35---	Rawhide School	79-036	31	40	do	do	6
36---	Moyer Springs	79-037	29	25	do	do	6
37---	Somerville Flats West	79-172	40	40	Johnson	do	7
38---	Somerville Flats East	79-173	41	57	Johnson and Campbell	do	7
39---	Carr Draw	79-038	30	40	Campbell	do	6
40---	Jeffers Draw	79-039	31	45	do	do	6
41---	Oriva	79-040	33	52	do	do	6
42---	Gillette West	79-041	37	30	do	do	6
43---	Gillette East	79-042	26	15	do	do	6
44---	Fortin Draw	79-043	25	20	do	do	6
45---	Juniper Draw	79-174	28	40	Johnson	do	8
46---	Laskie Draw	79-175	29	45	Johnson and Campbell	do	8
47---	Morgan Draw	79-044	28	45	Campbell	do	8
48---	Scott Dam	79-045	29	35	do	do	8
49---	Four Bar J Ranch	79-046	31	55	do	do	8
50---	Appel Butte	79-047	30	31	do	do	8
51---	Gap ~~SW~~	79-048	27	20	do	do	8
52---	Coyote Draw	79-049	30	24	do	do	8
53---	Bowman Flat	79-176	39	40	Johnson	do	8
54---	Negro Butte	79-177	38	41	Johnson and Campbell	do	8
55---	Bogie Draw	79-050	28	35	Campbell	do	8
56---	Double Tanks	79-051	34	35	do	do	8
57---	Pleasantdale	79-052	30	40	do	do	8
58---	Scaper Reservoir	79-053	27	30	do	do	8
59---	Gap Southwest	79-054	33	14	do	do	8
60---	Saddle Horse Butte	79-055	25	14	do	do	8
61---	Whitetail Creek	79-056	15	3	do	do	8
62---	Hoe Ranch	79-178	29	39	Johnson	do	8
63---	Nipple	79-179	33	55	Johnson and Campbell	do	8
64---	Fats Draw	79-057	29	30	Campbell	do	8
65---	NE Quarter of Savageton 15'	79-058	35	30	do	do	8

Table 1. CRO/CDP Quadrangle Reports, Powder River Basin--Continued

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
			Reports on southern Powder River Basin, Wyoming (cont'd)				
66---	NW 1/4 of the North Star School 15'	79-059	36	40	Campbell	IntraSearch, Inc.	8
67---	NE 1/4 of the North Star School 15'	79-060	30	30	do	do	8
68---	Eagle Rock	79-061	34	25	do	do	8
69---	Neil Butte	79-062	27	21	do	do	8
70---	Rough Creek	79-063	25	9	do	do	8
71---	Fort Reno SE	79-180	30	45	Johnson and Campbell	do	8
72---	North Butte	79-064	24	23	Campbell	do	8
73---	Savageton	79-065	27	26	do	do	8
74---	SW 1/4 of North Star School 15'	79-066	31	40	do	do	8
75---	SE 1/4 of North Star School 15'	79-067	31	37	do	do	8
76---	Reno Junction	79-068	32	29	do	do	8
77---	Hilight	79-069	30	21	do	do	8
78---	Open A Ranch	79-070	29	19	do	do	8
79---	Rolling Pin Ranch	79-071	23	19	do	do	8
80---	South Butte	79-072	27	25	do	do	8
81---	NW 1/4 of Turner crest 15'	79-073	26	25	do	do	8
82---	NE 1/4 of Turner crest 15'	79-074	30	35	do	do	8
83---	Little Thunder Reservoir	79-075	29	29	do	do	8
84---	Reno Reservoir	79-076	23	14	do	do	8
85---	Piney Canyon NW	79-077	28	14	do	do	8
86---	Artesian Draw	79-308	23	9	do	do	9
87---	Pine Tree	80-042	25	16	do	J.M. Wunder	9
88---	SW 1/4 of Turner crest 15'	79-309	25	24	do	IntraSearch, Inc.	9
89---	SE 1/4 of Turner crest 15'	79-310	34	34	do	do	9
90---	Teckla SW	79-311	27	19	do	do	9
91---	Teckla	79-312	28	15	do	do	9
92---	Piney Canyon SW	79-313	27	14	do	do	9
93---	NE 1/4 of Edgerton 15'	79-314	14	3	Natrona, Converse, Johnson, and Campbell		9
94---	NW 1/4 of Ross 15'	79-315	22	8	Converse and Campbell	IntraSearch, Inc.	9
95---	NE 1/4 of Ross 15'	79-181	31	24	Converse and Campbell	IntraSearch, Inc.	9
96---	NW 1/4 of Coal Draw 15'	79-316	26	24	Converse and Campbell	IntraSearch, Inc.	9

Quadrangle number (see pl. 1)	Quadrangle name	USGS Open-File Report	Text pages	Map plates	Counties	Authors	Coal-resource area (see pls. 1-3)
	Reports on southern Powder River Basin, Wyoming (cont'd)						
97---	NE 1/4 of Coal Draw 15'	79-317	30	32	Converse and Campbell	IntraSearch, Inc.	9
98---	NW 1/4 of Betty Reservoir 15'	79-318	28	19	do	do	9
99---	NE 1/4 of Betty Reservoir 15'	79-319	26	19	do	do	9
100---	Coal Bank Draw	79-320	33	19	do	do	9
101---	Fiddleback Ranch	79-321	14	3	Campbell, Converse, and Weston	do	9
102---	Lance Creek 2 NW	79-322	14	3	Converse and Niobrara	do	9
103---	SW 1/4 of Ross 15'	79-323	12	3	Converse	do	9
104---	SE 1/4 of Ross 15'	79-324	27	24	do	do	9
105---	SW 1/4 of Coal Draw 15'	79-325	26	24	do	do	9
106---	SE 1/4 of Coal Draw 15'	79-451	26	20	do	do	9
107---	SW 1/4 of Betty Reservoir	79-452	22	8	do	do	9
108---	Tin Can Lake	79-453	25	9	do	do	9
109---	Esau Spring	79-454	19	19	Converse	do	9
110---	Lance Creek 2 SW	79-455	27	9	Converse and Niobrara	do	9
111---	NW 1/4 of Fifty-Five Ranch 15'	79-456	23	14	Converse	do	9
112---	NE 1/4 of Fifty-Five Ranch 15'	79-457	26	19	do	do	9
113---	NW 1/4 of Highland Flats 15'	79-458	26	24	do	do	9
114---	NE 1/4 of Highland Flats 15'	79-459	22	8	do	do	9
115---	Bill 4 NW	79-460	21	9	do	do	9
116---	Bill 4 NE	79-461	22	19	do	do	9
117---	Lance Creek 3 NW	79-462	36	4	Converse and Niobrara	do	9
118---	SW 1/4 of Fifty-Five Ranch 15'	79-463	12	3	Converse	do	9
119---	SE 1/4 of Fifty-Five Ranch 15'	79-464	28	24	do	do	9
120---	SW 1/4 of Highland Flats 15'	79-465	25	14	do	do	9
121---	SW 1/4 of Bill 15'	79-466	24	9	do	do	9
122---	Bill 4 SW	79-467	13	3	do	do	9
123---	Lance Creek 3 SW	79-468	22	14	Converse and Niobrara	do	9
124---	Campbell Hill	79-469	21	8	Converse and Natrona	do	9
125---	Glenrock NW	79-470	19	8	Converse	do	9
126---	Hylton Ranch	79-471	29	3	do	do	9
127---	Walker Creek School	79-472	14	3	do	do	9
128---	Lost Springs NW	79-473	30	3	Converse and Niobrara	do	9
129---	Cooley Draw	79-474	13	3	Niobrara	do	9
130---	Parkerton	79-475	13	3	Converse	do	9
131---	Glenrock	79-476	27	2	do	do	9
132---	Careyhurst	79-477	13	3	do	do	9
133---	Orpha	79-478	13	3	do	do	9
134---	Park	79-479	25	10	do	do	9
135---	Lost Springs	79-480	28	3	Converse and Niobrara	do	9

[1] The title of this report is "Coal resource occurrence map and coal resource development potential of the ---."

Table 2.--Other USGS reports, Powder River Basin

[The USGS reports in this table provide supplementary coal resource data for quadrangles (or other areas) in the Powder River Basin; some of these reports give coal resource tonnage estimates. Asterisks shown in Tables 3-11 indicate that additional information is presented in the reports listed here.]

Quadrangle number (see pl. 1)	Area or quadrangle name	Author(s)	Date	Report number
	Reports on the northern Powder River Basin, Montana			
	Hanging Woman Creek study area	Culbertson, W.C., Hatch, J.R., and Affolter, R.H.	1978	USGS Open-File Report 78-506
49	Box Elder Creek	McLellan, Marguerite	1981a	USGS map MF-1297
52	Willow Crossing	McKay, E.J.	1976a	USGS map MF-802
56	Leslie Creek	McLellan, Marguerite	1981b	USGS map MF-1296
62	King Mountain	McKay, E.J.	1976c	USGS map MF-817
72	Birney	Mapel, W.J.	1976b	USGS map MF-813
73	Browns Mountain	W.C. Culbertson and M.C. Klett	1976	USGS map MF-814
75	Fort Howes	McKay, E.J.	1976b	USGS map MF-807
85	Lacey Gulch	Sarnecki, J.C.	1977	USGS map MF-832
86	Stroud Creek	Culbertson, W.C., Mapel, W.J., and Klett, M.C.	1976	USGS map MF-822
96	Pearl School and Bar V Ranch	Galyardt, G.L. and Murray, F.N.	1981	USGS Open-File Report 81-870
98	Holmes Ranch	Doelger, N.E. and Fahy, J.W.	1980	USGS Open-File Report 80-212
99	Pine Butte School	Mapel, W.J.	1978a	USGS map MF-1014
100	Forks Ranch	Culbertson, W.C. and Klett, M.C.	1979a	USGS map MF-1086
101	Quietus	Culbertson, W.C. and Klett, M.C.	1979b	USGS map MF-1087
	Thompson Creek area, Big Horn County	Mapel, W.J. and Griffith, J.K.	1981	USGS map MF-1312
	Reports on southern Powder River Basin, Wyoming			
	Wyarno (Sheridan County	Culbertson, William C.	1975	USGS map MF-723
	Jones Draw (Sheridan County)	Culbertson, W.C., and Klett, Mark C.	1975a	USGS map MF-726
	SR Springs (Sheridan County)	Culbertson, W.C., and Klett, Mark C.	1975b	USGS map MF-727
	Verona (Sheridan County)	Mapel, W.J., and Dean, B.W.	1976	USGS map MF-762
	Bar N Draw (Sheridan County)	Mapel, W.J.	1976a	USGS map MF-763
	Buffalo Creek Run (Sheridan County)	Mapel, W.J., and Malahy, M.D.	1976	USGS map MF-792
	Horse Hill (Sheridan County)	Mapel, W.J.	1978c	USGS Open-File Report 78-793

Table 2.--Other USGS reports, Powder River Basin--Continued

Quadrangle number (see p. 1)	Area or quadrangle name	Author(s)	Date	Report number
		Reports on the southern Powder River Basin, Wyoming		
12	Reservoir Creek	Kent, B.H. and Berlage, L.J.	1981	USGS map MF-1336
20	Recluse 1° x 1/2° quadrangle	Kent, B.H. and Munson, B.E.	1978a	USGS map C-81-A
20	Recluse 1° x 1/2° quadrangle	Kent, B.H. and Munson, B.E.	1978b	USGS map C-81-B
20	Recluse 1° x 1/2° quadrangle	Kent, B.H. and Munson, B.E.	1978c	USGS map MF-1045
20	Recluse 1° x 1/2° quadrangle	Kent, B.H., Berlage, L.J. and Boucher, E.M.	1980	USGS map C-81-C
26	Truman Draw	Kent, B.H., Haddock, D.R., and Bohor, B.F.	1977	USGS map MF-917
27	Wildcat	Kent, B.H.	1976	USGS map MF-735
33	Twentymile Butte	Bohor, B.F., Kent, B.H. and Haddock, D.R.	1979	USGS map MF-1073
42	Gillette West	Law, B.E.	1978	USGS map MF-974
49	Four Bar J Ranch	Galyardt, G.L.	1980b	USGS Open-File Report 80-648
50	Appel Butte	Galyardt, G.L.	1980a	USGS Open-File Report 80-053
60	Saddle Horse Butte	Grazis, S.L.	1977	USGS map C-79
76	Reno Junction 1° x 1/2° quadrangle	Denson, N.M., Dover, J.H., and Osmonson, L.M.	1978a	USGS map MF-960
76	Reno Junction 1° x 1/2° quadrangle	Denson, N.M., Dover, J.H., and Osmonson, L.M.	1978b	USGS map MF-961
76	Reno Junction 1° x 1/2° quadrangle	Denson, N.M., Dover, J.H., and Osmonson, L.M.	1980	USGS map I-1201

Geological Survey geologists completed 14 quadrangles, most of them in the Birney-Broadus and Moorhead coal fields in Montana (see map A). The contractor's work was monitored at different stages of completion by USGS/Conservation Division geologists to ensure that contract specifications were met.

Although the CRO/CDP map program provides coal-resource information needed for leasing purposes, from a resource-assessment standpoint it has several limitations: (a) only unleased federally owned coal was appraised--the estimates include only Tertiary coal beds and exclude coal beds less than 5 ft thick and all Cretaceous coal beds; (b) Indian tribal lands are excluded from the estimates; (c) quadrangles in the western Powder River Basin of Wyoming were not evaluated in the CRO/CDP program because several detailed coal-resource studies in the Sheridan-Buffalo area were already completed by USGS geologists (see table 2), and also there was a lack of time and money to devote to that area; (d) some additional quadrangles in the basin straddle Indian Reservation boundaries and as much as 90 percent of the coal in the quadrangles was excluded; and (e) other largely unassessed quadrangles probably containing large quantities of coal are in the Sussex coal field along the southwestern margin of the basin in Wyoming. Nevertheless, this inventory effectively locates most Federal unleased strippable and in situ gasification coal of HIGH and MODERATE development potential in the evaluated part of the Powder River Basin.

Geographic setting

The Powder River Basin is a large north-northwest-trending topographic and structural basin in northeastern Wyoming and southeastern Montana. It is in the Northern Great Plains province (physiographic) where sedimentary rock underlies more than 20,000 square miles (mi^2) of land between the Bighorn Mountains to the west, the Laramie Mountains to the south, and the Black Hills to the east. Northward, the Powder River Basin is separated from the Williston Basin by the Miles City arch (McGregor, 1972, p. 269). Coal-bearing rock underlies about 16,000 mi^2 of land , of which nearly 10,000 mi^2 are in Wyoming and 6,000 mi^2 in Montana. Virtually all of Powder River County and parts of Big Horn, Rosebud, and Custer Counties, Montana, are in the northern Powder River Basin. All of Campbell County is in the southern Powder River Basin, as well as parts of Sheridan, Crook, Weston, Nibrara, Converse, Natrona, and Johnson Counties, WY (map A). The main drainages are north- and northeast-flowing tributaries of the Yellowstone River--Rosebud Creek, Tongue River, Powder River, and the Little Powder River. The central part of the basin in Wyoming is also traversed by the northeast-trending Belle Fourche River, which is a tributary to the Cheyenne River farther east. The southern part of the basin is drained by streams that join the North Platte River, which then flows eastward to a junction with the Missouri River. The average altitude in the basin is 5,000 ft (McGregor, 1972, p. 270).

Scope of present study

The results of the CRO/CDP map program in part of the Powder River Basin were published in 243 separate quadrangle coal resource reports (see table 1). I reviewed each of these map reports before the coal-resource data were entered into the National Coal Resource Data System (NCRDS), Reston, VA, 22092. The purpose of this report is to summarize the results of the review and to compile in a compact format the coal-resource data obtained from the 243 CRO/CDP map reports.

In order to evaluate a large amount of information on Federal coal resources, I prepared tables and maps showing the significant coal-resource data. Cumulative totals for the different categories of unleased Federal coal resources are given in tables 3-12

Table 3. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 1, northern Powder River Basin, Montana, as of January, 1980. [All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted; development potential for in situ gasification of coal beds was not evaluated.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage 1/ (CRO definition)	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Total	Surface	Underground	Total
Spring Creek Ranch (68) 3/	242.32	110.04	73.58	47.10	230.72	11.60 4/	0.74	0.0	0.74
Kirby (69)	3473.11	1406.40	437.03	403.75	2247.18	1225.93 4/	36.78	28.40	65.18
Taintor Desert (70)	3879.37	2032.19	280.42	424.97	2737.58	1141.79 4/	37.92	8.77	46.69
Birney SW (71)	1825.17	1005.81	116.68	469.75	1592.24	232.93 4/	60.05	34.81	94.86
*Birney (72)	1834.40	311.20	118.40	64.80	494.40	1340.00 5/	5/	5/	5/
*Browns Mountain (73)	1891.00	74.00	51.00	116.00	241.00	1650.00 5/	5/	5/	5/
Poker Jim Butte (74)	3735.00	791.00	135.00	129.00	1055.00	2680.00 5/	5/	5/	5/
*Ft. Howes (75)	1592.00	210.00	72.00	110.00	392.00	1200.00 5/	5/	5/	5/
Bar V Ranch NE (81) 3/	679.15	332.25	122.39	65.30	519.94	159.21 4/	9.83	148.28	158.11
Half Moon Hill (82)	5161.34	1462.18	766.74	1111.57	3340.49	1820.85 4/	9.16	454.27	463.43
Tongue River Dam (83)	4075.77	1017.88	539.30	730.02	2287.20	1788.57 4/	1.06	402.90	403.96
Spring Gulch (84)	3164.51	946.04	270.66	560.07	1776.77	1387.74 4/	120.38	152.87	273.25
*Lacey Gulch (85)	3043.00	546.00	130.00	117.00	793.00	2250.00 5/	5/	5/	5/
*Stroud Creek (86)	2892.00	650.00	190.00	52.00	892.00	2000.00 5/	5/	5/	5/
Hamilton Draw (87)	4776.00	1200.00	150.00	26.00	1376.00	3400.00 5/	5/	5/	5/
Otter (88)	2598.00	780.00	120.00	98.00	998.00	1600.00 4/	5/	5/	5/
*Bar V Ranch (95) 3/	351.51	111.53	47.96	32.36	191.85	159.66 4/	.04	.0	.04
*Pearl School (96)	6787.93	2913.12	751.84	645.76	4310.72	2477.21 4/	.0	6.79	6.79
Decker (97)	3419.14	820.14	520.96	837.63	2178.73	1240.41 4/	.51	47.93	48.44
*Holmes Ranch (98)	2415.03	261.43	333.95	860.52	1455.90	959.13 4/	4.60	295.70	300.30
*Pine Butte School (99)	3899.42	288.75	60.67	153.23	502.65	3396.77 5/	5/	5/	5/
*Forks Ranch (100)	3918.14	706.65	62.51	87.03	856.19	3061.95 5/	5/	5/	5/
*Quietus (101)	4224.52	466.30	14.68	35.96	516.94	3707.58 5/	5/	5/	5/
Bear Creek School (102)	3938.66	651.58	100.33	117.09	869.00	3069.66 5/	5/	5/	5/
TOTAL ------	73,816.49	19,094.49	5,466.10	7,294.91	31,855.50	41,960.99	281.07	1,580.72	1,861.79

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29 is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ Coal beds less than 5 ft thick not included.

3/ 95% Indian land.

4/ LOW development potential.

5/ Not evaluated in these quadrangles.

* Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in Table 2.

Table 4. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 2, northern Powder River Basin, Montana, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted; the development potential for in situ gasification of coal beds was not evaluated.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal 2/	Hypothetical coal tonnage 3/		
		High	Moderate	Low	Total	Total	Surface	Underground	Total
Goodspeed Butte (76)	3269.98	374.84	293.08	1151.75	1819.67	1450.31	91.19	471.55	562.74
Phillips Butte (77)	4680.95	477.36	455.95	1266.86	2200.17	2480.78	201.52	333.67	535.19
Hodsdon Flats (78)	2325.44 4/	391.83	359.20	865.45	1616.48	708.96	8.70	92.27	100.97
Yarger Butte (79)	560.01 4/	219.21	92.37	241.86	553.44	6.57	3.49	.0	3.49
Lonesome Peak (80)	296.86	79.58	52.22	41.77	173.57	123.29	.0	.0	.0
Reanus Cone (89)	3856.34	487.14	128.15	886.87	1502.16	2354.18	68.03	8.38	76.41
Sayle (90)	2482.22	1043.02	346.91	525.21	1915.14	567.08	390.31	662.73	1053.04
Bloom Creek (91)	950.33 4/	324.78	113.39	439.49	877.66	72.67	1.23	0.45	1.68
Huckins School (92)	758.17	318.45	121.66	275.81	715.92	42.25	.70	.0	.70
Baldy Peak (93)	1359.22 4/	673.17	101.76	44.05	818.98	540.24	34.62	40.65	75.27
Bear Scull Mtn. (94)	501.37	182.60	42.93	72.15	297.68	203.69	3.28	0.0	3.28
Sayle Hall (103)	4349.61	785.45	562.58	1022.74	2370.77	1978.84	10.55	115.70	126.25
Bradshaw Creek (104)	2002.91	510.71	253.68	549.49	1313.88	689.03	17.04	39.58	56.62
Moorhead (105)	558.57	159.29	63.77	283.46	506.52	52.05	7.83	2.66	10.49
Three Bar Ranch (106)	679.01	191.38	62.97	316.37	570.72	108.29	4.61	0.87	5.48
Bay Horse (107)	985.25	275.47	143.66	66.43	485.56	499.69	.0	17.11	17.11
Wild Bill Creek (108)	49.39	16.59	8.84	20.15	45.58	3.81	.0	.0	.0
TOTAL ------	29,665.63	6,510.87	3,203.12	8,069.91	17,783.90	11,881.73	843.10	1,785.62	2,628.72

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G. H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ LOW-development potential.

3/ Coal less than 5 ft thick is not included.

4/ Classified as lignite in rank in CRO/CDP report.

Table 5. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 3, northern Powder River Basin, Montana, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted; the development potential for in situ gasification of coal beds was not evaluated.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal 2/	Hypothetical coal tonnage 3/		
		High	Moderate	Low	Total	Total	Surface	Underground	Total
Ashland (51)	170.58	154.90	5.78	6.35	167.03	3.55	5.13	.23	5.36
*Willow Crossing (52)	1250.41	959.30	42.65	201.85	1203.80	46.61	18.39	4.83	23.22
Coleman Draw (53)	3364.68	2614.06	70.72	277.32	2962.10	402.58	112.07	167.31	279.38
Home Creek Butte (54)	911.05	166.12	98.05	142.42	406.59	504.46	329.20	1209.58	1538.78
Samuelson Ranch (55)	1086.71	217.46	45.45	54.25	317.16	769.55	.0	21.07	21.07
*Leslie Creek (56)	1263.37 4/	390.29	67.79	55.39	513.47	749.90	.0	.0	.0
Olive (57)	348.33 4/	262.28	1.0	3.76	267.04	81.29	.0	.0	.0
Cook Creek Butte (58)	128.99	29.70	51.01	47.96	128.67	0.32	13.01	17.18	30.19
Clubfoot Creek (59)	243.10	69.00	19.00	7.10	95.10	148.00	5/	5/	5/
Birney Day School (60)	976.91	115.88	83.10	415.42	614.40	362.51	.13	.0	.13
Green Creek (61)	2628.21	433.46	248.07	539.62	1221.15	1407.06	15.10	205.97	221.07
*King Mountain (62)	2078.53	794.90	185.15	406.66	1386.71	691.82	23.38	180.13	203.51
Yager Butte (63)	3347.07	886.64	456.02	1015.24	2357.90	989.17	31.36	54.25	85.61
Three Mile Buttes (64)	4020.76	557.67	335.80	1425.01	2318.48	1702.28	67.01	443.18	510.19
Sonnette (65)	2097.65	432.18	282.67	678.66	1393.51	704.14	24.33	495.55	519.88
Epsie (66)	976.81 4/	97.13	31.58	66.57	195.28	781.53	.0	86.43	86.43
Epsie NE (67)	979.24 4/	280.31	34.15	4.92	319.38	659.86	.0	7.84	7.84
Total ----	25,872.40	8,461.28	2,057.99	5,348.50	15,867.77	10,004.63	639.11	2,893.55	3,532.66

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ LOW development potential.

3/ Coal less than 5 ft thick not included.

4/ Classified as lignite in rank according to CRO/CDP report.

5/ Not evaluated in these quadrangles.

*Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in table 2.

Table 6. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 4, northern Powder River Basin, Montana, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted; the development potential for in situ gasification of coal beds was not evaluated.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage 1/ (CRO definition)	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Total	Surface	Underground	Total
Miller Creek NW (1)	7.34	5.92	0.99	0.43	7.34	4/	0.0	0.0	0.0
Moon Creek School (2)	2.49	2.24	.22	.03	2.49	4/	0.0	.0	.0
Miller Creek SW (6)	42.17	31.99	4.82	5.13	41.94	0.23 3/	.0	.0	.0
Miller Creek (7)	13.13	8.62	1.83	2.66	13.11	.02 3/	.0	.0	.0
Jack Creek (8)	3.51	3.10	.38	.03	3.51	4/	.0	.0	.0
Beebe SW (9)	.0	.0	.0	.0	.0	.0	.0	.0	.0
Brandenberg NW (18)	9.38	9.38	.0	.0	9.38	4/	.0	.0	.0
HS School (19)	1.90	1.80	.10	.0	1.90	4/	.0	.0	.0
Fourmile Creek (20)	9.01	6.12	2.6	0.29	9.01	4/	.0	.0	.0
Carey-Malone School (21)	121.87 5/	82.86	22.32	14.26	119.44	2.43 3/	.0	.0	.0
Kirkpatrick Hill (22)	21.54 5/	14.24	4.65	2.45	21.34	.20 3/	.0	.0	.0
Brandenberg (32)	170.63	79.72	23.31	65.80	168.83	1.80 3/	.0	.0	.0
Hayes Point (33)	535.68	148.51	81.48	285.84	515.83	19.85 3/	.0	.0	.0
North Stacey School (34)	525.33	192.86	63.69	215.14	471.69	53.64 3/	2.09	7.03	9.12
Foster Creek School (35)	261.63 5/	127.27	54.19	40.54	222.00	39.63 3/	.0	.0	.0
Volborg (36)	20.35 5/	12.01	3.20	5.06	20.27	.08 3/	.0	.0	.0
Divide School (37)	96.97 5/	89.37	4.60	3.0	96.97	4/	.0	.0	.0
Cook Creek Reservoir (45)	1660.61	589.02	148.13	287.71	1024.86	635.75 3/	20.87	248.91	269.78
Beaver Creek School (46)	1951.96	306.22	383.20	589.32	1278.74	673.22 3/	12.53	72.10	84.63
Stacey (47)	1541.08	127.52	105.98	648.62	882.12	658.96 3/	46.15	26.29	72.44
Elk Ridge (48)	691.15	152.18	30.00	45.30	227.48	463.67 3/	2.75	.36	3.11
*Box Elder Creek (49)	294.10	147.82	11.93	20.72	180.47	113.63 3/	.0	.0	.0
Coalwood (50)	161.47 5/	73.74	8.96	9.50	92.20	69.27 3/	.0	.0	.0
Total ------	8,143.30	2,212.51	956.58	2,241.83	5,410.92	2,732.38	84.39	354.69	439.08

1/The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at a depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/Coal less than 5 ft thick not included.

3/LOW development potential

4/Unknown or none

5/Classified as lignite in rank in CRO/CDP report.

*Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in table 2.

Table 7. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 5, northern Powder River Basin, Montana, as of January, 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted; development potential for in situ gasification of coal beds was not evaluated.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Total	Surface	Underground	Total
Griffin Coulee SW (3)	0.93	0.20	0.05	0.68	0.93	(3/)	0.0	0.0	0.0
McKerlich Creek (4)	5.81	3.87	0.84	1.10	5.81	(3/)	.0	.0	.0
Crain Place (5)	23.94	23.93	0.01	0.00	23.94	(3/)	.0	.0	.0
Iron Spring (10)	(4/)	(4/)	(4/)	(4/)	(4/)	(4/)	.0	.0	.0
Minnehaha Creek South (11)	39.46	24.75	10.17	4.54	39.46	(3/)	.0	.0	.0
McClure Creek (12)	296.67	82.96	64.29	134.23	281.48	15.19 5/	20.58	0.0	20.58
Trail Creek School (13)	51.90	37.26	6.94	7.70	51.90	(3/)	.0	.0	.0
Colstrip West (14)	40.86	32.16	3.83	4.87	40.86	(3/)	.0	.0	.0
Colstrip East (15)	128.87	58.52	15.04	55.31	128.87	(3/)	.0	.0	.0
Hammond Draw NW (16)	45.51	34.46	5.56	5.49	45.51	(3/)	.0	.0	.0
John Hen Creek (17)	80.98	74.00	4.00	2.98	80.98	(3/)	.0	.0	.0
Padlock Ranch (23)	(4/)	(4/)	(4/)	(4/)	(4/)	(4/)	.0	.0	.0
Iron Spring SW (24)	(4/)	(4/)	(4/)	(4/)	(4/)	(4/)	.0	.0	.0
Wolf School (25)	81.49	32.35	15.90	26.55	74.80	6.69 5/	.13	.0	.13
Sarpy School (26)	481.53	108.47	64.46	138.34	311.27	170.26 5/	155.23	249.09	404.32
Rough Draw (27)	509.54	113.81	85.13	190.99	389.93	119.61 5/	20.72	96.0	116.72
Colstrip SW (28)	310.69	151.45	51.02	105.90	308.37	2.32 5/	15.39	.0	15.39
Colstrip SE (29)	157.16	98.68	24.49	33.99	157.16	(3/)	16.62	.0	16.62
Hammond Draw SW (30)	107.57	74.28	17.17	16.12	107.57	(3/)	3.71	.0	3.71
Hammond Draw (31)	89.49	66.27	9.34	13.88	89.49	(3/)	.0	.0	.0
Jean's Fork NE (38) 6/	1.46	.0	.0	.0	.0	1.46 5/	.0	9.12	9.12
Chalky Point (39)	251.03	2.47	14.50	26.32	43.29	207.74 5/	143.81	96.71	240.52
Black Spring (40)	272.17	39.95	54.80	107.83	202.58	69.59 5/	121.25	2.9	124.15
Jimtown (41)	145.95	44.74	21.42	79.56	145.72	0.23 5/	.0	.0	.0
Badger Peak (42)	209.34	49.28	31.37	124.41	205.06	4.28 5/	14.27	2.38	16.65
Garfield Peak (43)	400.60	213.85	71.85	101.59	387.29	13.31 5/	25.99	4.31	30.30
Ashland NE (44)	119.77	60.21	20.16	39.40	119.77	(3/)	.0	.0	.0
Total ------	3,852.72	1,427.92	592.34	1,221.78	3,242.04	610.68	537.70	460.51	998.21

1/The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at a depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.
2/Coal less than 5 ft thick not included.
3/Unknown
4/All coal belongs to Crow Indian Tribe - not evaluated.
5/Low development potential.
6/95 percent Crow Indian land.

Table 8. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 6, southern Powder River Basin, Wyoming, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage 1/ (CRO definition)	CDP tonnage categories of strippable coal: High	Moderate	Low	Total	CDP tonnage category of underground-minable coal: Low	CDP tonnage categories of in situ gasification coal: High	Moderate	Low	Total	Hypothetical coal tonnage 2/: Surface	Underground	Total
*Black Draw (4)	3537.10	854.60	560.00	1107.10	2529.70	1007.40	0.0	0.0	1007.40	1007.40	.0	.0	.0
*Dead Horse Lake (5)	4123.60	975.29	459.73	1179.58	2614.60	1509.00	.0	.0	1509.00	1509.00	.0	.0	.0
*Corral Creek (6)	3630.20	1055.60	804.00	1145.90	3005.50	624.70	.0	.0	624.70	624.70	.0	.0	.0
*Homestead Draw (7)	2160.40	736.37	298.41	904.12	1938.90	221.50	.0	.0	221.50	221.50	.0	.0	.0
*Rocky Butte (8)	328.90	179.70	51.70	82.10	313.50	15.40	.0	.0	15.40	15.40	.0	.0	.0
*Kline Draw (11)	7458.70	770.68	983.97	542.25	2296.90	5161.80	.0	.0	5161.80	5161.80	.0	.0	.0
*Reservoir Creek (12)	7672.20	1266.30	1417.90	334.00	3010.20	4654.00	.0	.0	4654.00	4654.00	.0	.0	.0
*Homestead Draw SW (13)	7023.30	1945.37	1102.43	796.50	3844.30	3179.00	.0	.0	3179.00	3179.00	.0	.0	.0
*White Tail Butte (14)	5178.54	1996.38	260.12	1157.56	3414.06	1764.48	.0	.0	1764.48	1764.48	.0	.0	.0
*Rocky Butte SW (15)	715.52	125.32	94.63	335.74	555.69	159.83	.0	.0	159.83	159.83	.0	.0	.0
*Larey Draw (18)	9742.71	602.41	607.20	410.52	1620.13	8122.58	.0	.0	8122.58	8122.58	.0	.0	.0
*Spotted Horse (19)	9615.59	1414.37	654.34	722.56	2791.27	6824.32	.0	.0	6824.32	6824.32	.0	.0	.0
*Recluse (20)	7181.41	1552.41	702.22	814.46	3069.09	4112.32	.0	.0	4112.32	4112.32	.0	.0	.0
*Pitch Draw (21)	2492.04	1104.67	347.65	290.76	1743.08	748.96	.0	.0	748.96	748.96	.0	.0	.0
*Oliver Draw (22)	412.45	70.30	37.17	216.54	324.01	88.44	.0	.0	88.44	88.44	.0	.0	.0
*Croton (25)	10,328.14	613.38	470.75	170.55	1254.68	9073.46	.0	3710.05	3601.40	7311.45	.0	.0	.0
*Truman Draw (26)	12,256.91	1154.48	467.79	218.58	1840.85	10,416.06	20.45	5428.76	4966.85	10,416.06	8.56	.0	8.59
*Wildcat (27)	8874.31	1100.15	989.14	883.31	2972.60	5901.71	.0	980.86	4920.85	5901.71	.0	.0	.0
*Calf Creek (28)	3148.41	2543.23	43.74	9.22	2596.19	552.22	.0	.0	552.22	552.22	.0	.0	.0
*Weston SW (29)	339.40	30.26	.0	123.93	154.19	185.21	.0	.0	185.21	185.21	.0	.0	.0
Echeta (32)	8862.84	117.97	98.34	288.72	505.03	8357.81	2346.23	5213.03	798.55	8357.81	176.47	2537.41	2713.88
*Twentymile Butte (33)	10,891.48	873.84	256.26	87.30	1217.40	9674.08	601.40	4756.31	4316.37	9674.08	141.15	128.62	269.77
Oriva NW (34)	11,276.23	1127.55	615.94	467.42	2210.91	9065.32	.0	803.59	8261.73	9065.32	.0	.0	.0
Rawhide School (35)	7204.46	4170.60	295.06	310.01	4775.67	2428.79	.0	.0	2428.79	2428.79	.0	.0	.0
Moyer Springs (36)	669.76	163.45	.16	39.60	203.21	466.55	.0	.0	466.55	466.55	.0	.0	.0
Carr Draw (39)	6564.81	.0	1.46	125.55	127.01	6437.80	5761.64	213.69	462.47	6437.80	145.71	3082.08	3227.79
Jeffers Draw (40)	11,447.02	164.12	278.28	315.43	757.83	10,689.19	5958.01	3677.70	1053.48	10,689.19	11.36	433.58	444.94
Oriva (41)	9727.86	435.28	843.55	143.87	1422.70	8305.16	.0	1091.55	7213.61	8305.16	4.18	.0	4.18
*Gillette West (42)	8151.11	1830.62	869.13	186.15	2885.90	5265.21	.0	.0	5265.21	5265.21	.0	.0	.0
Gillette East (43)	2274.61	1586.80	23.16	6.90	1616.86	657.75	.0	.0	657.75	657.75	.0	.0	.0
Fortin Draw (44)	240.44	166.11	.0	6.58	172.69	67.75	.0	.0	67.75	67.75	.0	.0	.0
Total------	183,530.45	30,727.61	13,642.23	13,422.81	57,792.65	125,737.80	14,687.73	25,875.54	83,412.52	123,975.79	487.46	6,181.69	6,669.15

1/The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 feet. It does not include hypothetical coal.

2/Coal less than 5 ft thick is not included.

* Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in table 2.

Table 9. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 7, northern Powder River Basin, Wyoming, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	CDP tonnage categories of in situ gasification coal				Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Low	High	Moderate	Low	Total	Surface	Underground	Total
Box Elder Draw (1)	5248.09	32.86	108.62	653.82	795.30	4452.79	0.0	.0	4452.79	4452.79	110.18	95.09	205.27
Cabin Creek NW (2)	5692.91	249.30	504.40	567.76	1321.46	4371.45	.0	.0	4371.45	4371.45	90.42	0.66	91.08
Cabin Creek NE (3)	4328.00	1062.20	508.20	790.70	2361.10	1966.90	.0	.0	1966.90	1966.90	.0	.0	.0
Fawn Draw (9)	3956.98	137.12	99.57	774.64	1011.33	2945.65	.0	.0	2945.65	2945.65	75.83	495.98	571.81
Cabin Creek SE (10)	5275.17	206.83	89.16	2113.79	2409.78	2865.39	.0	.0	2865.39	2865.39	128.80	236.21	365.01
Arvada (16)	6776.50	27.70	39.02	522.50	589.22	6187.28	.0	4359.39	1827.89	6187.28	9.31	196.80	206.11
Arvada NE (17)	4773.23	550.76	539.18	268.00	1357.94	3415.29	.0	108.32	3306.97	3415.29	66.94	1449.17	1516.11
Jewell Draw (23)	11,854.68	33.09	55.45	211.22	299.76	11,554.92	1331.59	9736.43	486.90	11,554.92	.23	4.54	4.77
Lariat (24)	10,109.72	954.75	112.80	271.34	1338.89	8770.83	.0	5348.94	3421.89	8770.83	83.53	416.94	500.47
Mitchell Draw (30)	11,506.11	18.83	12.70	24.90	56.43	11,449.68	5371.79	6077.89	.0	11,449.68	46.33	327.98	374.31
Livingston Draw (31)	14,252.51	37.90	33.95	128.57	200.42	14,052.09	10,746.27	3305.82	.0	14,052.09	139.00	550.82	689.82
Somerville Flats West (37)	11,152.88	3.41	2.24	35.74	41.39	11,111.49	3078.98	7983.14	49.37	11,111.49	.0	630.71	630.71
Somerville Flats East (38)	8,258.00	7.66	6.76	117.97	132.39	8125.61	6216.79	684.70	1224.13	8125.61	.0	19.97	19.97
Total ------	103,184.78	3,322.41	2,112.05	6,480.95	11,915.41	91,269.37	26,745.42	37,604.63	26,919.33	91,269.37	750.57	4,424.87	5,175.44

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at a depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ Coal less than 5 ft thick not included.

Table 10. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 8, southern Powder River Basin, Wyoming, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage category of underground-minable coal	CDP tonnage categories of in situ gasification coal				Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Low	High	Moderate	Low	Total	Surface	Underground	Total
Juniper Draw (45)	9639.17	0.0	0.0	73.41	73.41	9565.76	2821.04	5299.07	1445.65	9565.76	0.0	3.86	3.86
Laskie Draw (46)	12,686.45	.0	.0	12.43	12.43	12,674.02	9040.34	3316.53	317.15	12,674.02	.0	55.0	55.0
Morgan Draw (47)	7179.25	.0	21.18	183.65	204.83	6974.42	5970.74	638.88	364.80	6974.42	.0	.0	.0
Scott Dam (48)	11,427.87	115.34	344.68	277.93	737.95	10,689.92	3322.18	6207.84	1159.90	10,689.92	1.81	366.79	368.6
*Four Bar J Ranch (49)	9428.79	453.22	911.70	42.54	1407.46	8021.33	.0	3126.35	4894.98	8021.33	.0	1.09	1.09
*Appel Butte (50)	9050.41	1221.30	249.58	115.78	1586.66	7463.75	.0	33.17	7430.58	7463.75	.0	2.24	2.24
The Gap (51)	5603.84	2238.11	752.96	15.56	3006.63	2597.21	.0	.0	2597.21	2597.21	.0	.0	.0
Coyote Draw (52)	1184.77	597.05	60.73	1.48	659.26	525.51	.0	.0	525.51	525.51	.0	.0	.0
Bowman Flat (53)	8280.51	.0	.0	126.30	126.30	8154.21	299.69	7388.58	465.94	8154.21	3.43	3.53	6.96
Negro Butte (54)	12,499.57	.0	.0	61.07	61.07	12,438.50	7692.36	3898.99	847.15	12,438.50	11.24	29.87	41.11
Bogie Draw (55)	10,712.51	.0	.51	417.73	418.24	10,294.27	2560.04	7088.93	645.30	10,294.27	.0	.0	.0
Double Tonko (56)	11,421.84	13.27	258.75	613.90	885.92	10,535.92	495.28	8637.19	1403.45	10,535.92	.0	.0	.0
Pleasantdale (57)	11,369.74	623.87	630.33	167.86	1422.06	9947.68	69.98	8279.69	1598.01	9947.68	.0	15.46	15.46
Scaper Reservoir (58)	11,556.52	1166.19	372.46	570.27	2108.92	9447.60	37.61	1796.86	7613.13	9447.60	90.88	157.81	248.69
The Gap S.W. (59)	5285.98	1690.31	960.27	5.74	2656.32	2629.66	0.0	0.0	2629.66	2629.66	.0	.0	.0
*Saddle Horse Butte (60)	557.31	20.35	.0	207.64	227.99	329.32	.0	.0	329.32	329.32	.0	.0	.0
Whitetail Creek (61)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Hoe Ranch (62)	5040.92	.0	.0	.0	.0	5040.92	.0	1776.16	3264.76	5040.92	.0	17.8	17.8
The Nipple (63)	8994.74	.0	.0	.0	.0	8994.74	.0	8902.91	91.83	8994.74	.0	.0	.0
*Fate Draw (64)	7105.02	.0	.0	119.80	119.80	6985.22	.0	6542.87	442.35	6985.22	.0	.0	.0
*NE 1/4 Savageton (65)	8539.76	.0	148.34	549.38	697.72	7842.04	.0	6997.93	844.11	7842.04	.0	.0	.0
*NW 1/4 North Star School (66)	10,784.64	375.20	337.05	449.79	1162.04	9622.60	.0	6403.75	3218.85	9622.60	31.8	2.29	34.09
*NE 1/4 North Star School (67)	10,938.79	619.98	82.41	480.99	1183.38	9755.41	478.46	2764.41	6512.54	9755.41	286.66	28.93	315.59
*Eagle Rock (68)	5718.48	1121.13	1323.03	411.23	2855.39	2863.09	.0	.0	2863.09	2863.09	.0	1.28	1.28
*Hail Butte (69)	2315.81	1275.64	299.12	205.31	1780.07	535.74	.0	.0	535.74	535.74	.0	.0	.0
*Rough Creek (70)	455.48	413.73	33.42	8.33	455.48	.0	.0	.0	.0	0.0	1.72	.0	1.72
Fort Reno SE (71)	8920.35	.0	.0	.0	.0	8920.35	217.55	8702.80	.0	8920.35	.0	.0	.0
*North Butte (72)	8441.54	.0	.0	.0	.0	8441.54	.0	8335.89	85.65	8421.54	.0	6.04	6.04
*Savageton (73)	7773.83	.0	3.89	303.89	307.78	7466.05	.0	6172.46	1293.59	7466.05	.02	.0	.02
*SW 1/4 North Star School (74)	8352.78	283.00	70.92	431.34	785.26	7567.52	.0	719.59	6847.93	7567.52	.46	7.90	8.36
*SE 1/4 North Star School (75)	10,797.63	1506.37	.0	489.41	1995.78	8801.85	.0	2464.13	6337.72	8801.85	.0	.0	.0
*Reno Junction (76)	6602.62	484.01	373.01	726.12	1583.14	5019.48	.0	.0	5019.48	5019.48	.0	.0	.0
*Hilight (77)	3673.15	2060.43	711.92	283.57	3055.92	617.23	.0	.0	617.23	617.23	.0	.0	.0
*Open A Ranch (78)	444.75	143.15	3.10	104.51	250.76	193.99	.0	.0	193.99	193.99	.0	.0	.0
*Rolling Pin Ranch (79)	6746.56	.0	.0	.0	.0	6746.56	305.98	5765.81	674.77	6746.56	.0	.0	.0
*South Butte (80)	5859.56	.0	.0	28.27	28.27	5831.29	.0	3876.79	1954.52	5831.29	.0	.0	.0
*NW 1/4 Turnercrest (81)	5989.77	148.69	143.49	194.68	486.86	5502.91	.0	213.02	5289.89	5502.91	48.11	.0	48.11
*NE 1/4 Turnercrest (82)	7407.65	634.19	160.03	359.50	1153.72	6253.93	.0	1244.69	5009.24	6253.93	.0	.0	.0
*Little Thunder Reservior (83)	6861.37	889.39	293.44	505.63	1688.46	5172.91	.0	.0	5172.91	5172.91	.0	.0	.0
*Reno Reservoir (84)	4219.58	3310.04	133.59	.0	3443.63	775.95	.0	.0	775.95	775.95	.0	.0	.0
*Piney Canyon N.W. (85)	536.88	81.35	5.14	198.87	285.36	251.52	.0	.0	251.52	251.52	20.41	2.95	23.36
Total ——	290,406.19	21,485.31	8,685.05	8,743.91	38,914.27	251,491.92	33,311.25	126,595.27	91,565.40	251,471.92	496.54	702.84	1,199.38

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ Coal less than 5 ft thick is not included.

*Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in table 2.

TABLE 11. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 9, southern Powder River Basin, Wyoming, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted.]

7 1/2-minute quadrangle name and number (see pl. 1 for location)	reserve base tonnage (CRO defintion) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	CDP tonnage categories of in situ gasification coal	Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Low	Low	Surface	Underground	Total
*Artesian Draw (86)	2095.53	0.0	0.0	0.0	0.0	2095.53	2095.53 3/	0.0	240.71	240.71
*Pine Tree (87)	3748.84	.0	.77	.33	1.10	3747.74	3747.74	.0	.0	.0
*SW 1/4 Turnercrest (88)	3981.32	26.25	57.99	389.40	473.64	3507.68	3507.68	143.73	273.55	417.28
*SE 1/4 Turnercrest (89)	5640.30	77.39	93.60	1070.37	1241.36	4398.94	4398.94	.0	8.94	8.94
*Teckla SW (90)	6355.22	548.58	1230.86	335.83	2115.27	4239.95	4239.95	.0	.0	.0
*Teckla (91)	4791.20	3072.68	535.13	.0	3607.81	1183.39	1183.39	.0	.0	.0
*Piney Canyon SW (92)	603.89	354.19	2.20	71.76	428.15	175.74	175.74	.0	.0	.0
NE 1/4 Edgerton (93) 4/	.0	.0	.0	.0	.0	.0	0.0	.0	.0	.0
NW 1/4 Rose (94)	252.54	.0	.0	.0	.0	252.54	252.54	.0	.18	.18
NE 1/4 Rose (95)	2066.00	.0	.0	390.94	390.94	1675.06	1675.06	5.07	6.12	11.19
NW 1/4 Coal Draw (96)	2879.58	75.29	58.45	388.92	522.66	2356.92	2356.92	.0	.0	.0
NE 1/4 Coal Draw (97)	3485.21	230.52	167.97	450.70	849.19	2636.02	2636.02	.0	268.19	268.19
NW 1/4 Betty Reservoir (98)	3909.47	809.07	275.43	252.02	1336.52	2572.95	2572.95	0.0	239.37	239.37
NE 1/4 Betty Reservoir (99)	1773.32	564.89	61.86	45.33	672.08	1101.24	1101.24	0.0	94.31	94.31
Coal Bank Draw (100)	398.00	24.72	16.01	253.11	293.84	104.16	104.16	12.91	.0	12.91
Fiddle Back Ranch (101) 4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Lance Creek 2 NW (102) 4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SW 1/4 Rose (103) 4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SE 1/4 Rose (104)	1833.54	1.31	60.7	803.83	865.84	967.70	967.70	56.44	3.4	59.84
SW 1/4 Coal Draw (105)	3048.36	86.57	65.67	341.66	493.90	2554.46	2554.46	32.70	59.60	92.30
SE 1/4 Coal Draw (106)	2578.80	0.0	0.0	63.62	63.62	2515.18	2515.18	0.83	0.0	0.83
SW 1/4 Betty Reservoir (107)	1498.30	.0	.0	.0	.0	1498.30	1498.30	.0	229.32	229.32
Tin Can Lake (108)	274.78	.0	.0	224.78	224.78	50.00	50.00	5.73	.61	6.34
Esau Spring (109)	705.32	47.65	26.51	562.65	636.81	68.51	68.51	3.94	.0	3.94
Lance Creek 2 SW (110)	84.46	25.87	14.60	43.99	84.46	.0	.0	.0	.0	.0
NW 1/4 Fifty-Five Ranch (111)	78.58	46.10	10.65	21.83	78.58	.0	.0	.0	.0	.0
NE 1/4 Fifty-Five Ranch (112)	530.83	101.21	45.85	235.60	382.66	148.17	148.17	.0	.0	.0
NW 1/4 Highland Flats (113)	1006.21	31.33	23.63	93.24	148.20	858.01	858.01	38.0	356.23	394.23
NE 1/4 Highland Flats (114)	961.26	.0	.0	.0	.0	961.26	961.26	.0	.37	.37
Bill 4 NW (115)	267.00	.0	.0	267.00	267.00	.0	.0	20.0	.0	20.0
Bill 4 NE (116)	324.92	27.01	33.27	264.64	324.92	.0	.0	4.6	.0	4.6
Lance Creek 3 NW (117)	27.99	12.81	.76	12.37	25.94	2.05	2.05	.0	.0	.0
SW 1/4 Fifty-Five Ranch (118) 4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

TABLE 11. Summary of estimates of unleased Federal coal resources in Tertiary rocks in coal-resource area 9, southern Powder River Basin, Wyoming, as of January 1980. [Prepared for CRO/CDP program. All values are x 10^6 short tons; to obtain metric tons multiply by 0.907; the rank of the coal is subbituminous except as noted.] (Continued)

7 1/2-minute quadrangle name and number (see pl. 1 for locatin)	reserve base tonnage (CRO definition) 1/	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal	CDP tonnage categories of in situ gasification Coal	Hypothetical coal tonnage 2/		
		High	Moderate	Low	Total	Low	Low	Surface	Underground	Total
SE 1/4 Fifty-Five Ranch (119)	443.24	120.42	126.73	164.19	411.34	31.90	0.20	2.44	0.02	2.46
SW 1/4 Highland Flats (120)	111.02	1.35	0.70	87.55	89.60	21.42	21.42	7.67	.79	8.46
SW 1/4 Bill (121)	212.16	.0	.0	22.63	22.63	189.53	189.53	0.0	1.77	1.77
Bill 4 SW (122)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Lance Creek 3 SW (123)	86.54	45.20	16.62	24.72	86.54	.0	.0	.0	.0	.0
Campbell Hill (124)	39.23	.0	.0	.0	.0	39.23	39.23	.0	.0	.0
Glenrock NW (125)	19.37	.0	.0	.0	.0	19.37	19.37	.0	.0	.0
Hyltou Ranch (126)	18.43	16.92	1.51	.0	18.43	.0	.0	.0	.0	.0
Walker Creek School (127)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Lost Springs NW (128)	3.60	.0	.0	3.60	3.60	.0	.0	.0	.0	.0
Cooley Draw (129)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Parkerton (130)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Glenrock (131)	.80	.0	.0	.80	.80	.0	.0	.0	.0	.0
Careyhurst (132)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Orpha (133)4/	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
The Park (134)	158.51	11.86	4.93	63.93	80.72	77.79	77.79	.0	.0	.0
Lost Springs (135)	1.80	.0	.0	1.80	1.80	.0	.0	.0	.0	.0
TOTAL ———	56,295.47	6,359.19	2,932.40	6,953.14	16,244.73	40,050.74	40,019.04	334.06	1,783.48	2,117.54

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.H., Jr., and others, 1983, p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ Coal less than 5 ft thick not included.

3/ This total also includes 168.71 x 10^6 tons of coal resources of MODERATE CDP for gasification.

4/ No significant unleased Federal coal resources identified in quadrangle.

*Quadrangles marked by an asterisk indicate additional coal resources data can be found in other geologic reports listed in table 2.

Table 12, Summary of nonleased federally owned coal resources in part of the Powder River Basin prepared for the CRO/CDP map program of the U.S. Geological Survey. [All values are X 10^6 short tons; to obtain metric tons multiply by 0.907.[

Total number of 7 1/2-min. quadrangles	Coal-resource area number	reserve base[1/] tonnage (CRO definition)	CDP tonnage categories of strippable coal				CDP tonnage categories of underground-minable coal				CDP tonnage categories of in situ gasification coal				Hypothetical coal tonnage[2/]
			High	Moderate	Low	Total	High	Moderate	Low	Total	High	Moderate	Low	Total	Total
						Northern Powder River Basin, Montana									
24	Area 1	73,816.49	19,094.49	5466.10	7294.91	31,855.50	0.0	0.0	14,205.03	41,960.99	0.0	0.0	0.0	0.0	1861.79
17	Area 2	29,665.63	6510.87	3203.12	8069.91	17,783.90	.0	.0	11,881.73	11,881.73	.0	.0	.0	.0	2628.72
17	Area 3	25,872.40	8461.28	2057.99	5348.50	15,867.77	.0	.0	10,004.63	10,004.63	.0	.0	.0	.0	3532.66
23	Area 4	8143.30	2212.51	956.58	2241.83	5410.92	.0	.0	2732.38	2732.38	.0	.0	.0	.0	439.08
27	Area 5	3852.72	1427.92	592.34	1221.78	3242.04	.0	.0	610.68	610.68	.0	.0	.0	.0	998.21
	Total ------	141,350.54	37,707.07	12,276.13	24,176.93	74,160.13	.0	.0	39,434.45	67,190.41	.0	.0	.0	.0	9,460.46
						Southern Powder River Basin, Wyoming									
31	Area 6	183,530.45	30,727.61	13,642.23	13,422.81	57,792.65	0.0	0.0	125,737.80	125,737.80	14,687.73	25,875.54	83,412.52	123,975.79	6669.15
13	Area 7	103,184.78	3322.41	2112.05	6480.95	11,915.41	.0	.0	91,269.37	91,269.37	26,745.42	37,604.63	26,919.33	91,269.37	5175.44
41	Area 8	290,406.19	21,485.31	8685.05	8743.91	38,914.27	.0	.0	251,491.92	251,491.92	33,311.25	126,595.27	91,565.40	251,471.92	1199.38
50	Area 9	56,295.47	6359.19	2932.40	6953.14	16,244.73	.0	.0	40,050.74	40,050.74	.0	.0	40,019.04	40,019.04	2117.54
	Total------	633,416.89	61,894.52	27,371.73	35,600.81	124,867.06	.0	.0	508,549.83	508,549.83	74,744.40	190,075.44	241,916.29	506,736.12	15,161.51
						Powder River Basin, Montana and Wyoming									
243	Grand Total---	774,767.43	99,601.59	39,647.06	59,777.74	199,027.19	.0	.0	547,984.28	575,740.24	74,744.40	190,075.44	241,916.29	506,736.12	24,621.97

1/ The reserve base for subbituminous coal according to USGS Circular 891 (Wood, G.W., Jr., and others, 1983 p. 29) is the total tonnage of coal in beds 60 inches or more thick and at depth of as much as 1,000 ft. As generally used in this report, however, the term "reserve base" includes identified coal beds to a depth of 3,000 ft. It does not include hypothetical coal.

2/ Coal less than 5 ft thick is not included.

and the locations of the coal resources are shown on quadrangle index maps (B and C of plate 1). Simultaneous use of the tables and maps allows a reader to locate and compare the large quantities of unleased HIGH and MODERATE development potential strippable Federal coal, and to determine where Federal coal has a HIGH and MODERATE potential for in situ gasification development

To facilitate reporting of the unleased Federal coal resources in the part of the Powder River Basin studied, I divided the area by State: Montana and Wyoming. The quadrangles are numbered consecutively from west to east and from north to south as you would read a book. The quadrangle number is the key to locate each quadrangle on the accompanying small scale maps (A, B, and C), to the correct reference (name) in the table of references (table 1), and to the different classes and amounts of coal resources reported in tables 3-11 for that particular quadrangle. Furthermore, each State is divided into smaller coal resource areas: five in Montana and four in Wyoming (see map A). No rule or pattern was used to determine the boundaries of the smaller coal-resource areas. The coal-resources subtotals for these areas are the principal subtotals of tonnages shown in the tabular compilation (table 12) of the unleased Federal coal resources in the studied part of the Powder River Basin.

Sources of data

The primary sources of coal information used in the compilation of the map reports are given in the "References cited" section of each published quadrangle report. The contractor or geologist compiling each of these reports used all published and unpublished coal data available at the time. Most information came from reports of previous investigations, interpreted oil-well logs, and coal borehole studies. For example, the USGS and Montana Bureau of Mines and Geology have carried out extensive core-drilling programs in the Powder River Basin since 1968 (Matson and Blumer, 1974). Most coal data incorporated into the CRO/CDP quadrangle reports were derived from earlier geologic investigations by USGS geologists. Twelve coal fields had been described in Wyoming (Glass, 1978) during earlier geologic studies of the Powder River Basin, and nearly the same number of coal fields are discussed in geologic reports on Montana (see lists in Warren, 1959, and Olive, 1957, p. 4-6).

There was a wide divergence in the amount and timeliness of coal data available to the compilers of the CRO/CDP reports. For some quadrangles, much recent surface and subsurface information was available on which to base the coal resource estimates, but for others, information is based on only a few wells and sparse coal outcrops. Therefore, the availability of coal-resource information can be characterized as sporadic--of course, the areas that yield the most coal-resources information are areas where coal mining has taken place. Many coal-resource reports are old (pre-1930), but much of the basic coal data that they contain is still valid. On the whole, all coal-field reports such as the Powder River (Stone and Lupton, 1910), Gillette (Dobbin and Barnett, 1927), and northward extension of the Sheridan coal field (Baker, 1929) contain valuable data but lack recent data required in preparing modern coal-resource studies.

Land use and ownership

About 87 percent of the land area in the basin is used for agricultural purposes, and roughly 90 percent of that area is rangeland suited for cattle and sheep grazing (U.S. Bureau of Land Management, 1981, p. 40). What crops there are consist mainly of dryland hay, both grass and alfalfa, or grain. Other land uses and designations include mining, oil and gas, transportation networks, national forests, Indian reservations, recreation areas, and urban areas.

Land ownership in the Powder River Basin is controlled at present by four major classes of owners: (1) the Federal Government, (2) State government, (3) private sector, and (4) the Crow and Northern Cheyenne Indian Tribes. Nearly 60 percent of the land surface in the Powder River Basin is privately owned, according to estimates using Bureau of Land Management (BLM) land ownership maps for the region (U.S. Bureau of Land Management, 1974-77). The Federal Government controls about 27.5 percent of the surface area, the State(s) have jurisdiction over 7.5 percent, and the Indian tribes own 5 percent of the surface rights in the basin. Coal ownership, on the other hand, is divided approximately as follows: 70 percent, Federal Government; 17.5 percent, private sector; 7.5 percent, State governments; and 5 percent, the Crow and Northern Cheyenne Indian Tribes. Until about 10 years ago, Federal coal land could be leased more or less on demand, but currently all Federal coal leasing is on the basis of competitive auctions. All the leased coal shown on the CRO/CDP map reports was leased before competitive auctions were required by law.

Before 1862, all land in the Powder River Basin was in the public domain, having been acquired by the United States as the result of the Louisiana Purchase in 1803. Congress passed several Homestead Acts (1862, 1909, and 1916) and other statutes in order to encourage settlement and convert much of this land to private ownership. Thus, millions of acres of public land were opened to entry and settlement for agricultural purposes. A homesteader retained the surface and mineral rights on his "patented land" if he acquired it before 1909. After certain "separation laws" were passed by Congress from 1907 to 1910, these rights were split, and the Federal Government retained the coal rights on lands sold thereafter. The Federal Government has emerged as the largest holder of coal (mineral) rights in the Powder River Basin (USGS, 1973).

Additional large acreages in the region termed "school lands" were transferred to State ownership. Specifically, sections 16 and 36 in every township were given to the State, with the stipulation that the income from these lands be used to support public education. The State controlled all surface and mineral rights in these areas.

Another significant land grant was given to the railroads in 1864 as an incentive to build railroads and to open the area to commerce. Under its provisions, title to all odd-numbered sections in an area 60 miles on each side of a railroad right-of-way was granted to the railroads traversing the area. Thus, Burlington Northern, Inc. (then Northern Pacific Railroad), shares the coal rights about equally with the Federal Government in part of the northern Powder River Basin around Colstrip, MT. The pattern of ownership commonly is referred to as "checkerboard," for obvious reasons.

Finally, the Crow and Northern Cheyenne Indian Tribes own both the surface and coal rights on their respective reservations in the northern Powder River Basin, and the Crow Tribe owns the coal under some land where they relinquished the surface rights.

Acknowledgments

I thank Nancy K. Teaford, a geologist with the USGS, who helped me tally the coal resources in the quadrangles.

GEOLOGIC SETTING

Stratigraphy

A thick sequence of sedimentary rocks, whose ages range from Cambrian to Quaternary, unconformably overlies the Precambrian crystalline basement complex in the Powder River Basin of Montana and Wyoming. As much as 18,000 ft of sedimentary rocks has been estimated to overlie the axial trough of the basin adjacent to the Bighorn and Laramie Mountains (McGregor, 1972, p. 269-270). The coal-bearing Cretaceous and Tertiary strata are among the youngest rocks in the basin. The outline of the Powder River Basin shown on maps A, B, and C of this report is at the boundary of the coal-bearing rocks in the basin or at the base of the Upper Cretaceous Mesaverde Formation (Glass, 1980, p. 99; Lewis and Hotchkiss, 1981). Many Tertiary coal beds are separated by different rock sequences--from thin shale beds on the one hand to strata hundreds of feet thick on the other--that range from coarse sandstone or conglomerate to siltstone, claystone, and shale. Cretaceous coal beds are interbedded in similar types of rock but are generally less than 10 ft thick and much less numerous. Because the Cretaceous coal beds are generally thin and for the most part lie very deep in the basin, they are unimportant from a resource standpoint. No estimates of Cretaceous coal resources are presented in the CRO/CDP study.

Cretaceous beds

The Upper Cretaceous Mesaverde Formation is a 500-ft-thick unit cropping out along the western and southern flanks of the Powder River Basin. It pinches out northward and eastward halfway across the basin and is believed to be equivalent to the lower part of the Upper Cretaceous Adaville Formation farther west in Wyoming (Glass, 1978, p. 4-5). The Mesaverde beds consist mostly of sandstone, siltstone, and shale that contain thin coal beds on the southern flank of the basin. These beds reportedly have been penetrated in oil and gas well tests in the subsurface of the southwestern part of the basin. Mesaverde Formation coal beds have been variously described as clean, dirty, or shaly beds generally less than 1 foot thick (Glass, 1980, p. 100-102).

The Upper Cretaceous Lewis Shale conformably overlies the Mesaverde Formation in the western Powder River Basin and is laterally equivalent to the uppermost Pierre Shale in the eastern part of the basin (Breckenridge and others, 1974). The marine Lewis or laterally equivalent part of the Pierre Shale consists mostly of (a) dark-brownish-gray, silty or sandy shale, (b) dark-gray or black shale (locally bentonitic), and (c) light-gray bentonitic shale with thin beds of bentonite and limestone. The exposed thickness of the Lewis or Pierre Shale is roughly 1,100 ft in the vicinity of Recluse, WY (Kent and Berlage, 1980). According to R. J. Weimer (1960, p. 17), the Lewis Shale correlates with the Bearpaw Shale in Montana and was deposited during the last transgression (eastward) of the Cretaceous sea. The Lewis or Pierre Shale is transitional into the overlying Fox Hills Sandstone or the continental strata of the Lance Formation.

The Upper Cretaceous Fox Hills Sandstone conformably overlies the Lewis or Pierre Shale in the Powder River Basin. Composed of brownish-gray sandstone, siltstone, and some thin beds of sandy shale, its exposed thickness is about 200 ft in the area of Recluse, WY (Kent and Berlage, 1980). Together with the Lance Formation, the Fox Hills Sandstone constitutes an important aquifer in the basin (Lewis and Hotchkiss, 1981). The Fox Hills Sandstone is usually classified as a barrier bar sand of a marginal marine facies that was deposited during the last regression of the Cretaceous sea.

The Upper Cretaceous Lance Formation is a 2,500 ft thick unit that overlies the Fox Hills Sandstone, and in turn the Lewis or Pierre Shale and the Mesaverde Formation. It crops out on the east and west flanks of the basin, and is covered to the south by Tertiary rocks. The Lance Formation is composed of carbonaceous and bentonitic sandy shale and siltstone; locally a fine- to medium-grained silty sandstone containing thin coal beds is the dominant lithology (Lewis and Hotchkiss, 1981). This formation thins northward and has no commercially valuable coal beds except in the southwestern part of the basin. Several coal beds near the base of the formation exceed 3 ft in thickness in the Glenrock-Big Muddy area, and in Coal Basin No. 1 of the Sussex coal field. The coal beds mined in the Glenrock area averaged about 6 ft thick. Coal beds mined near Big Muddy and Casper, WY were all less than 5 ft thick (Glass, 1980, p. 102-103).

Tertiary beds

The thickest and most valuable coal beds of the Powder River Basin are in the Paleocene Fort Union Formation and the Eocene Wasatch Formation. The Fort Union Formation is a most prolific coal-bearing rock unit that ranges from 2,000 to 3,000 ft in thickness (Glass, 1980, p. 104). The thickest and most widespread coal beds are in the Tongue River Member, which locally is as much as 2,100 ft thick. Typically, the Tongue River Member consists of sandstone, siltstone, mudstone and shale, carbonaceous shale, and thick beds of coal (Kent and Berlage, 1980). The middle and lower members of the Fort Union Formation are, respectively, the Lebo and the Tullock Members. The Lebo comprises sandstone, claystone and shale, carbonaceous shale, and thin beds of coal; the Tullock Member comprises sandstone and silty shale, carbonaceous shale, and thin beds of coal (Kent and Berlage, 1980). The coal beds in the two lower members are not thick or widespread enough to be considered as commercially valuable for coal resources (Glass, 1978, p. 20-21). Coals in the Tongue River Member are best developed in the northern and eastern parts of the Powder River Basin. Noteable are the 8 to 12 subbituminous coal beds cropping out along the Tongue River valley from Monarch, WY to Decker, MT (Law, Barnum, and Wollenzien, 1979) and in the Birney-Broadus coal field of Montana (Warren, 1959). Another thick coal bed was found by drilling along the Powder River midway between Buffalo and Gillette, WY. This deposit, which has a maximum thickness of about 205 ft, is termed "Big George" and results from the coalescing of thinner coal beds of the Fort Union Formation (oral commun., Bion H. Kent, USGS, 1982).

The Wasatch Formation, which has as many as eight thick widespread coal beds and is as much as 2,000 ft thick, overlies the Fort Union Formation. It crops out over the Buffalo-Lake DeSmet area and much of the central part of the Powder River Basin, mostly in Wyoming. East of Buffalo and Lake DeSmet, the Wasatch Formation consists of conformable continental deposits of sandstone, shale, and coal having no marked difference in lithology from the Tongue River Member (Olive, 1957, p. 15-16). To the west near the mountains in the Buffalo-Lake DeSmet area, though, an angular unconformity divides the Wasatch into two distinct conglomeratic members (Mapel, 1959, pp. 62-66). The angularity of the discordance between the two members diminishes abruptly eastward from the mountains and passes into a conformable sequence of more than 1,000 ft of sandstone, shale, subbituminous coal, and lignite. The predominant color of the Wasatch Formation is moderate yellowish brown. Locally, the coal beds that have burned underground have altered the overlying rocks to bright-red clinker; this material, being resistant to erosion, caps most divides and buttes in the eastern part of the area. The thickest Wasatch coal is at Lake DeSmet on the west side of the basin north of Buffalo, WY. There the Healy coal bed locally exceeds 225 ft in thickness in drill holes (Mapel, 1959, p. 84-85). It is the thickest coal bed described in Wyoming and probably in the United States. Generally, the Wasatch coals are thickest and most widespread in the western and central parts of the basin (Glass, 1978, p. 21).

Structure

The Powder River Basin is a broad asymetrical syncline whose axis trends north-northwest along its western side adjacent to the Bighorn Mountains (McGregor, 1972, p. 269-270). In Montana, the structural axis trends northward through the Strowd Creek quadrangle (No. 86), which is in the trough of the basin (Mapel, Martin, and Butler, 1978, p. 5). Most central and eastern parts of the Powder River Basin, including much of the area discussed in this report, are situated along the homoclinal east limb of the fold where most beds dip westward at less than 2° and commonly less than 1°. In general, the Cretaceous rocks on the flanks of the basin dip more steeply than the Tertiary strata, which are nearly flat-lying except along the west and south flanks where locally Paleocene beds dip as much as 25° (Glass, 1978, p. 20). Although normal faulting displaces outcropping rocks in many parts of the basin, faults are relatively rare, except along the western margin particularly in southern Johnson County. Most faults in the

Sussex area about 50 mi north of Casper, WY, trend northeastward, and have maximum apparent vertical displacements of 300 to 400 ft.

Economic geology
Oil and Gas

Large quantities of energy resources including oil and natural gas, uranium, and coal have been discovered and are being produced from the Powder River Basin (Keefer and Schmidt, 1973). Exceeded in size only by the Williston Basin in the Rocky Mountain structural province, the Powder River Basin ranked first in the province in petroleum production and exploration activity from 1957 to 1971. It has been an important source of oil and gas since the early 1900's and, by 1972, had yielded 1.3 billion barrels of oil (McGregor, 1972, p. 269-270). Production has been largely from Cretaceous sandstone reservoir stratigraphic traps. Several large oil accumulations have been discovered, including the Salt Creek, Bell Creek, Clareton, Glenrock, Lance Creek, Dead Horse Creek, and the Hilight fields. Nearly half the oil produced in Wyoming as of 1972 was from fields in the Powder River Basin. There are still many townships where potentially productive sand strata less than 10,000 ft below the surface have not been tested by drilling. Exploration activity in the Powder River Basin is also likely to increase markedly in the sparsely drilled deeper parts of the basin. The concept of the stratigraphic trap was first described in this basin and, after World War II, it became a widely accepted exploration tool. The Powder River Basin, in fact, is notable for its many different types of petroleum traps and has proved to be a veritable laboratory for the study and development of petroleum-exploration techniques (McGregor, 972, p. 269-270).

Almost the only geologic evidence used in compiling some CRO/CDP map reports in the more deeply buried parts of the Powder River coal basin was obtained from coal-bed thicknesses and depths determined during exploration drilling for oil and gas. After recognition of the importance of the drilling information provided by the petroleum industry, the designers of the CRO/CDP program determined that by annotating the CRO/CDP maps with the latest geologic information, the maps could be kept up-to-date and used as guides to further exploration. This use of the CRO/CDP map as a growing library of geologic data could help geologists to find new oil and gas fields in the Powder River Basin and expand knowledge about the coal resources.

Uranium

The uranium industry in Wyoming had expanded very rapidly, as of 1978, so that its production of uranium oxide (U_3O_8) was approaching that of New Mexico, the Nation's leading producer (USBM, 1979, p. 4). A significant part of this uranium production comes from two districts in the central part of the basin where uranium-bearing rocks were first discovered in the 1950's, and from the southern Powder River Basin district just north of Douglas, WY (Keefer and Schmidt, 1973). During the late 1950's, more than 40 companies were involved in planning, exploring, mining, and milling in Wyoming, whereas a few years earlier only 8 companies were operating. Most current mining operations are open-pit mines; however, owing to increased exploration activity and discovery of ore at greater depths, companies are planning to open more underground mines (USBM, 1979, p. 4).

Whether or not the uranium ores in the Powder River Basin are surface- or deep-mined, any associated coal should also be recoverable as a byproduct, depending upon the economics of fuels at that time.

Coal

In this study, the coal resources are the chief interest. The greatest long-term energy source in the Powder River Basin is its immense quantities of low-sulfur subbituminous coal. Coal production from the Powder River Basin leads all other basins in the western United States: it is the principal reason that Wyoming now ranks 3d and Montana 10th in the Nation after Kentucky (1) and West Virginia (2) in coal output (U.S. Department of Energy, 1983, p. 2). There are six coal-fired electric powerplants at four localities in the Powder River Basin that have a total generating capacity of about 1,870 megawatts (Shifflett, 1982). Most coal mined in the Powder River Basin is exported to other steampowered electric generating plants (Keefer and Schmidt, 1973) in the midwest and south-central United States (USBLM Draft EIS, 1974, v. 1, p. 35). Only a minor part of the basin's coal production is consumed in the Powder River Basin powerplants.

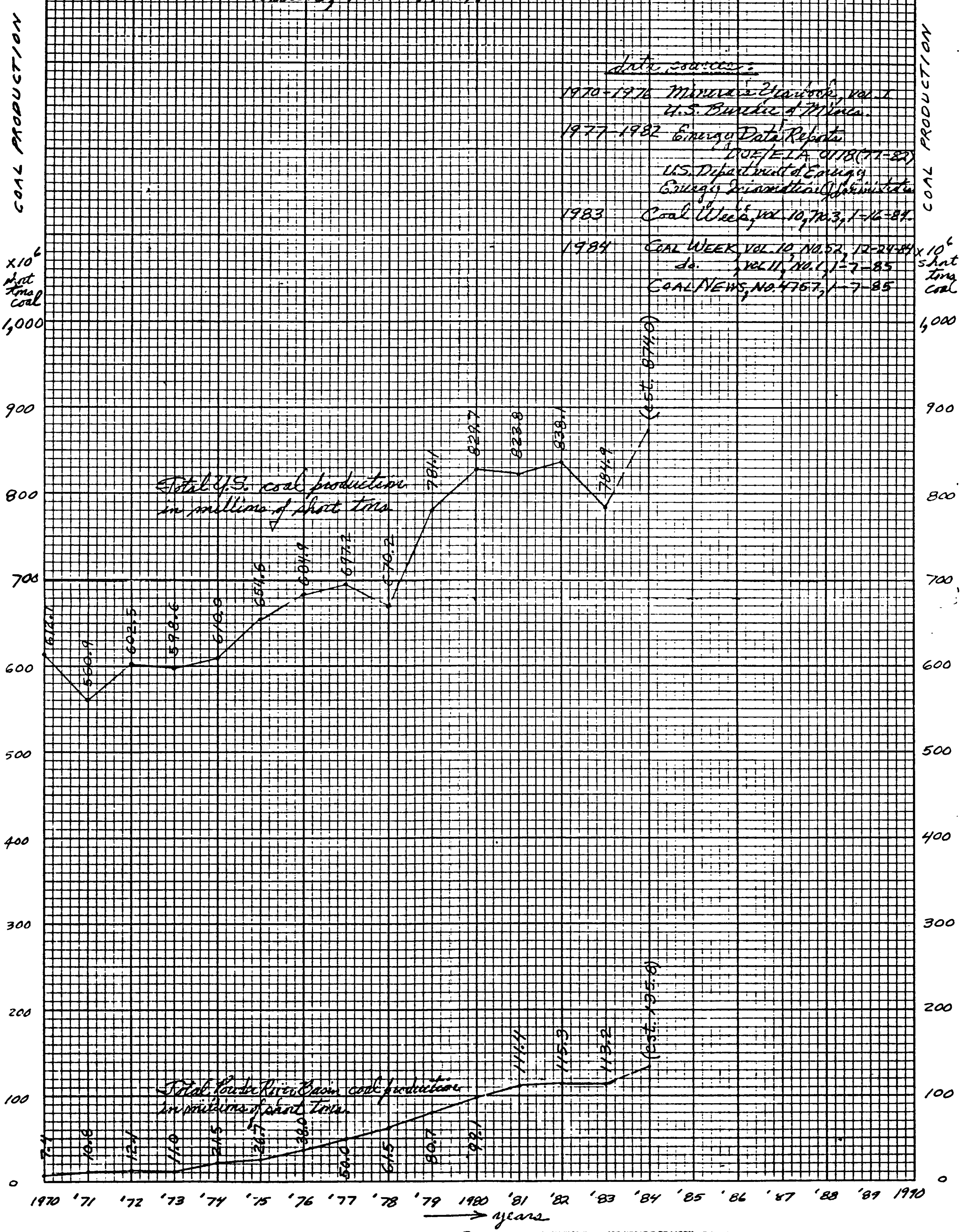
Coal production: -- Huge quantities of low-sulfur subbituminous coal have been identified in thick strippable beds in the Powder River Basin of Montana and Wyoming. Coal production from the basin has increased rapidly over the last several years--from 7.4 million short tons at 8 surface mines in 1970 to 115.3 million short tons from 22 surface mines in 1982, and an estimated 135.8 million short tons in 1984 (Coal Week, 1984, Vol. 10, No. 52, p. 1). The almost "steady-state" increase in Powder River Basin coal production beginning in 1973--the year of the OPEC petroleum embargo--is shown by figure 1. Powder River Basin coal production can be readily compared with increases in the total U.S. coal production through the same period of years; from 612.7 million short tons in 1970 to an estimated 874 million short tons in 1984 (Coal News, 1985, No. 4757, p. 1; fig. 1). Note that dips in the national coal production in 1971 and 1978 are not reflected in the Powder River Basin coal production curve. The percentage of the national coal output produced in the Powder River Basin has increased steadily from 1.2 percent in 1970 to 15.5 percent in 1984; an increasing proportion of the total United States coal production is coming from the Powder River Basin. Most of the nearly 19 million short tons increase from 1978 to 1979 came from one new mine and expanded production at the other operating mines near Gillette in Campbell County, WY.

An in-depth study of world coal supply and production has been made by A.M. Clarke, of the British National coal Board (written commun., unpubl. data, 1983). Briefly, his research suggests that in projecting coal output for very large coal basins over long-term time intervals (15-20 years), the rates of coal production have a momentum of their own. The coal-production rates continue on the same gradient regardless of fluctuations (blips) caused by ups and downs of the business cycle, wars, labor problems, or changes in technology. He also believes that coal is a unique commodity because even though it is being depleted worldwide, its long-term future price trend will be downward.

Future coal production from the Powder River Basin is projected to increase more slowly during the next few years because of a lessening of electric-power requirements and business activity. Using the long-term coal production trends shown by figure 1, I estimate that the total United States coal production will be about 1 billion short tons by 1990 and that about 230-250 million short tons/year of coal will be produced from the Powder River Basin in 1990. A more optimistic estimate has been published by Data Resources, Inc., an econometric forecasting service. Coal production from the Powder River Basin is projected by this firm to increase 14.4 percent in 1984 and in 1985, and they estimate that 409 million short tons of coal will be produced from the Powder River Basin in the year 2000 (Coal Week, 1984, p. 3).

Coal rank and quality: -- Most coal beds in the Powder River Basin are subbituminous in rank and low in sulfur. In spite of the relatively low heating values, the low-sulfur content has made Powder River coal a prized fuel because little or no cleaning is required to meet established emission standards. In general, most thick Powder River

Figure 1.- Total coal production in the United States and the Powder River Basin, 1970-1984.



coal beds contain less than 0.5 percent sulfur, have ash contents of 5 to 8 percent, and have relatively low heating values (all on an as-received basis).

Coal rank in the Powder River Basin of Montana ranges from lignite A along the eastern margin of the basin to subbituminous B, which predominates to the west (see table 13 for explanation of coal rank). Lignite underlies the northeastern part of the basin in a strip two to three quadrangles wide where the strata were less deeply buried along the edge of the basin. This rather limited area of lower rank coal is a southward extension of the Tertiary Fort Union lignite field in North Dakota and Montana (Trumbull, 1960). In the CRO/CDP reports, the coal resources in 14 quadrangles in Montana (see tables 4, 5, and 6) are designated as lignite in rank. Probably the coal in other nearby quadrangles also is lignite, but the necessary analytical data are lacking to document the rank. The approximate 8.7 billion short tons of lignite that underlies the 14 quadrangles constitutes only 1 percent of the total unleased "reserve base" coal in part of the Powder River Basin. With few exceptions, the coal beds in this part of the basin are low in sulfur (less than 1 percent) and have low to moderate ash contents. Heating values on an as-received basis determined from coal samples range from roughly 6,500 Btu/lb. along the eastern side of the basin to about 9,500 Btu/lb. in the vicinity of Decker, MT (Matson and Blumer, 1974, p. 13).

The rank of the thicker and more important coal beds in the Wyoming part of the Powder River Basin (Paleocene Fort Union Formation and Eocene Wasatch Formation coals) ranges from lignite A in the northeast to subbituminous C or B over much of the remaining basin area (Glass, 1978, p. 20). The subbituminous Tertiary coals have as-received moisture contents of 20 to 30 percent (mean value is 26.3 percent) and about equal percentages of volatile matter and fixed carbon. For the coal beds currently being mined in northeastern Wyoming, the sulfur content ranges from 0.45 to 0.6 percent, the mean value being 0.54 percent (Glass, 1978, p. 8). The ash content for coal samples from the Wyoming part of the basin ranges from 4.4 to 11.4 percent--the mean value is 7.9 percent. The heat-content values for coal samples from this part of the basin range from 7,550 to 8,700 Btu/lb., and the mean value is 8,300 Btu/lb. (all values were determined on an as-received basis) (Glass, 1978, p. 8). Generally, coal beds in the Northern Great Plains, including those in the Fort Union Formation of Montana and Wyoming, contain appreciably lesser amounts of most chemical elements of environmental concern than do coal beds in other areas of the United States (Hatch and Swanson, 1977, p. 147).

The only bituminous coal beds in the Powder River Basin are in some Cretaceous strata along the western and southwestern margins of the basin where folding is more pronounced. Studies have shown that coal from most beds in Wyoming can be washed to reduce its ash content to within suitable yield limits (Glass, 1978, p. 9); however, this is not done to Powder River Basin coal. Also, most Wyoming coal is non-agglomerating and may be carbonized in fluidized systems (Glass, 1978, p. 12-13), although the end product--a lump char--is relatively weak.

CRO/CDP PROGRAM SPECIFICATIONS AND PRODUCTS

The CRO/CDP map program was undertaken in order to locate the coal beds and furnish resource estimates on unleased Federally owned coal that would support future lease sales by the Department of the Interior in several western coal basins. They required that before leasing could begin, the unleased Federal coal resources must be classified into tonnage categories of surface-minable coal, deep-minable coal, and in situ gasification coal. Also, Congress required that further knowledge of the general rank and quality of the coal resources was to be determined. To help set priorities for the leasing, the relative development potentials were calculated for surface-mining and in situ gasification in order to serve as guides for land-use planning by the Bureau of Land Management (BLM). Because the congressional mandate was interpreted to mean that <u>all</u> unleased Federal coal had to be inventoried as soon as possible, the program was

Table 13.--Classification of coals by rank[A,1] (from Wood and others, 1983)

Class	Group	Fixed Carbon Limits, percent (Dry, Mineral-Matter-Free Basis) Equal or Greater Than	Fixed Carbon Less Than	Volatile Matter Limits, percent Dry, Mineral-Matter-Free Basis Greater Than	Volatile Matter Equal or Less Than	Calorific Value Limits BTU per pound (Moist,[B] Mineral-Matter-Free Basis) Equal or Greater Than	Calorific Value Less	Agglomerating Character
I. Anthracite*	1. Meta-anthracite	98	----	----	2	----------	-------	nonagglomerating
	2. Anthracite	92	98	2	8	----------	-------	
	3. Semianthracite[C]	86	92	8	14	----------	-------	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	----------	-------	commonly agglomerating[E]
	2. Medium volatile bituminous coal	69	78	22	31	----------	-------	
	3. High volatile *A* bituminous coal	----	69	31	----	14 000[D]	-------	
	4. High volatile *B* bituminous coal	----	----	----	----	13 000[D]	14 000	
	5. High volatile *C* bituminous coal	----	----	----	----	11 500	13 000	
		----	----	----	----	10 500	11 500	agglomerating
III. Subbituminous	1. Subbituminous *A* coal	----	----	----	----	10 500	11 500	nonagglomerating
	2. Subbituminous *B* coal	----	----	----	----	9 500	10 500	
	3. Subbituminous *C* coal	----	----	----	----	8 300	9 500	
IV. Lignite	1. Lignite *A*	----	----	----	----	6 300	8 300	
	2. Lignite *B*	----	----	----	----	----------	6 300	

[A]This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15 500 moist, mineral-matter-free British thermal units per pound.

[B]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[C]If agglomerating, classify in low-volatile group of the bituminous class.

[D]Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[E]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in the high-volatile *C* bituminous group.

[1]ASTM, 1981, p. 215.

*Modified from ASTM, 1981.

accorded a high-priority status. According to the original plan, nearly 1,400 quadrangle map reports at a scale of 1:24,000 would be required to encompass all known recoverable coal resource area(s)(KRCRA) in several Western U.S. coal basins. As of March 1980, 10 firms had undertaken CRO/CDP contracts; the Geologic Division of the USGS also was a contractor in the program. Contracts for 805 quadrangles were made through fiscal year 1979 (Wayland, 1981, p. 544). When the contracting program began, the Department of the Interior had not decided on the priority of areas for leasing. Later, the Powder River Basin and Green River-Hams Fork area of the Wyoming region, and the Uinta-southwestern Utah region were designated as priority areas for the initial resumption of general coal leasing.

Work on the CRO/CDP map program in the Powder River Basin was begun by USGS geologists in 13 quadrangles, most of which are in the Moorhead and Birney-Broadus coal fields, Montana. A total of 243 quadrangles in the Powder River Basin (108 in Montana and 135 in Wyoming) were evaluated under this program. Work in a significant number of 7 1/2 minute quadrangles, about 70 to 80, for the most part on the west and south sides of the basin, was never scheduled for completion in the CRO/CDP program. Most important, about 44 of these unevaluated quadrangles are in the western Powder River Basin where the Sheridan, Buffalo, and Lake DeSmet coal fields of Wyoming contain large quantities of coal. These quadrangles were not evaluated because of a lack of money and a shortage of time to prepare lease schedules; furthermore, several detailed coal-resource studies in these areas already completed by USGS geologists (see table 2) provide the data needed for leasing. Additional unevaluated quadrangles are in the Sussex coal field along the southwestern margin of the Powder River Basin. The unevaluated quadrangles on the east side of the basin probably contain little or no reserve base coal. Because not much drilling information is available for most of these southwestern quadrangles, geologic data are insufficient and there is little basis upon which to offer these Federal lands for coal leasing (oral commun., Mr. Charles Wilkie, BLM, Casper, WY, 1983). Funds were not available for exploration coal drilling because of budget limitations for the completion of the designated quadrangles in the CRO/CDP program. Thus, the compiled coal resource information contains significant gaps because of the exclusion of these areas of the Powder River Basin.

Reserve base problem

Two USGS definitions for reserve base are used in this report. When the USGS geologists began work on the 13 quadrangles in Montana at the start of the CRO/CDP program, no formal contract specifications had been set. The program managers agreed that the reserve base should include identified subbituminous coal beds 60 in. or more thick to maximum depths of 1,000 ft, and that the stripping limit for surface-minable coal be 200 ft. These limits conform to the accepted definition and criteria for the reserve base in standard use at that time, USGS Bulletin 1450-B (USBM and USGS, 1976, p. B5). However, when the USGS contract specialists and monitors later wrote the CRO/CDP program specifications for the private contractors, they changed the limiting depth criteria for surface-minable coal to 500 ft, and the criteria for reserve base coal to a depth limit of 3,000 ft. Hereafter, the latter will be referred to as the "reserve base" (CRO definition) and the former as the standard reserve base. Therefore, the standard reserve base definition applies only to the 13 quadrangle reports in Montana that were mapped by the USGS (see map A), whereas the "reserve base" (CRO definition) is applicable for the remaining 230 CRO/CDP reports on the Powder River Basin.

Contract specifications

The coal resources inventoried in this program exist in a wide range of geologic conditions. So that the CRO/CDP maps and estimated resource figures would be consistent, terms and conditions had to be standardized before bids for the work could be requested. USGS field and headquarters personnel had to make many difficult choices, as is evident in this selected list:

5	ft minimum coal-bed thickness for all mining methods
3,000	ft maximum limit of depth of burial for conventional underground mining methods
200	ft stripping limit for a single coal bed less than 40 ft thick
500	ft stripping limit for thicker beds or multiple beds
0^{o}-15^{o}	dip for conventional underground mining methods
15^{o}-90^{o}	dip for in situ production, except in the Powder River Basin where almost all dips are very low.
85	percent recovery of coal tonnages for surface mining
50	percent recovery of coal tonnages for conventional underground mining methods, but only for a maximum thickness of coal beds of 12 ft

Distance from data points for --
measured coal - 1/4 mi.
indicated coal - 1/4 to 3/4 mi.
inferred coal - 3/4 to 3 mi.

Coal resource occurrence (CRO) maps

Each CRO/CDP report consists of a brief text and a group of maps (the average is about 20) of a particular quadrangle. For each quadrangle, a general description of the CRO/CDP program and a summary of the geology are given in the text. Included also, in addition to the classified coal-resource tonnages for the quadrangle(s), are all available quality data for coal beds underlying the quadrangle area and a discussion of the coal-development potential. The first part of the map segment (all maps have a planimetric township-and-range base) consists of three map plates: plate 1, the Coal Data Map, which shows basic geologic data including mapped coal beds with coal data points (coal-thickness measurements) plotted along with mines and prospects, drill holes, and areas of burned coal; plate 2, the Boundary and Coal Data Map, which shows the area underlain by recoverable coal, all non-Federal coal land and the leased coal areas; the total tonnages of "reserve base" coal are listed by section; and plate 3, the Coal Data Sheet, which has a generalized geologic columnar section for the quadrangle, and cross section(s) from drill holes and/or measured sections in which the coal beds are correlated where possible.

Then, two to five derivative coal bed maps were prepared for each coal bed thick enough to be part of the "reserve base" category (60 in. or more). The derivative maps include coal-bed isopachs, structure contours, and overburden isopach and mining-ratio maps; two additional bed maps also show the areal distribution of identified coal resources by section, and the total coal resources for each coal bed on a strippable and nonstrippable basis.

The coal resources could have been calculated for other areas of interest, such as previously leased Federal and State lands and privately owned coal lands, because the CRO maps show coal-thickness information for all categories of land ownership except Indian lands. However, in the present study, only the unleased Federal coal is estimated so that leasing could proceed in approved areas according to a schedule. Before the estimation of coal resources could begin, a USGS monitor met with the contractor to select an applicable stripping limit and a mining recovery factor for each quadrangle, and to decide on any other limiting conditions. Thereafter, the contractor was concerned only with unleased Federal coal in KRCRA boundaries within the quadrangle.

According to the coal classification system of the USBM and USGS (1976), all coal that lies within a radius of 1/4 mi. of a coal-data point (a site where the thickness of coal is measured as shown in fig. 2) is classified as measured coal. The area surrounding the data point within an arc radius of 3/4 mi. and beyond the measured coal area is classified as indicated coal. The area around the data point circumscribed by a 3 mi. arc radius and beyond the indicated coal is classified as inferred coal. All coal beyond the 3 mi. arc radius is classified as hypothetical. The contractor drew the arcs around the coal-data points, and the areas made by the intersection of these arcs with the known boundary of unleased Federal coal permitted the calculation of measured, indicated, inferred, and hypothetical coal. Then the tonnage of coal-in-place was calculated for each of these categories and plotted for each section of land. Separate tabulations were compiled for surface-minable and deep-minable coal.

Coal development potential (CDP) maps

The CDP maps were the final phase of the map compilation and may be the most important products of the CRO/CDP program. The CDP maps delineate coal-bearing areas that have the greatest potential for coal-mine development or coal gasification. A CDP map distinguishes areas in a quadrangle that have HIGH, MODERATE, and LOW coal-development potential. Arbitrary standards for measuring the relative development potential of unleased Federal coal in tracts as small as 40 acres were devised by USGS personnel and incorporated into the contracts. Land-use planners need to know whether the potential for coal development of each such tract is HIGH, MODERATE, LOW, unknown, or negative. As planned, only the tracts of HIGH and MODERATE development potential will be considered initially for leasing, and the determination is to be based on the CRO/CDP maps.

The CDP for surface-minable coal is based upon the coal-bed mining ratio value, MR = cubic yards of overburden/short tons recoverable coal; where MR = 0 to 10 the CDP is HIGH, if MR = 10 to 15 the CDP is MODERATE, and if MR is greater than 15 the CDP is LOW. The coal-development potential for surface mining is based <u>only</u> on a mining ratio applied to coal 5 ft or more thick to a depth of 500 ft (200 ft for the 13 quadrangles completed by the USGS geologists in Montana). The CDP classification for each tract of land is the highest classification of development potential for any one coal bed in the area.

The CDP for underground-minable coal in the Powder River Basin was not calculated; the area mining supervisors of the USGS Conservation Division decided that underground mining in the basin was not economically feasible because of excessively thick coal beds and dangerous roof conditions. Coal is not currently being mined underground in the basin; therefore, the mining recovery factors are unknown (oral commun., Mr. Charles Wilkie, BLM, Casper, WY, 1983). Because of this philosophy, all the coal resources in the basin that have underground minable potential were arbitrarily assigned a LOW CDP. Only subbituminous coal beds 5 ft or more in thickness, lying more than 500 ft but less than 3,000 ft below the surface, were considered to have development potential for underground mining. Another arbitrary limiting factor for conventional underground-minable coal is that the beds dip from 0° to 15°. The underground minable reserve base coal limits of the 13 quadrangles in Montana completed by USGS geologists are for subbituminous coal beds 5 ft or more thick and from 200 ft to 1,000 ft depth of overburden. CDP maps were not prepared by the contractors or the USGS for underground-minable coal in the Powder River Basin.

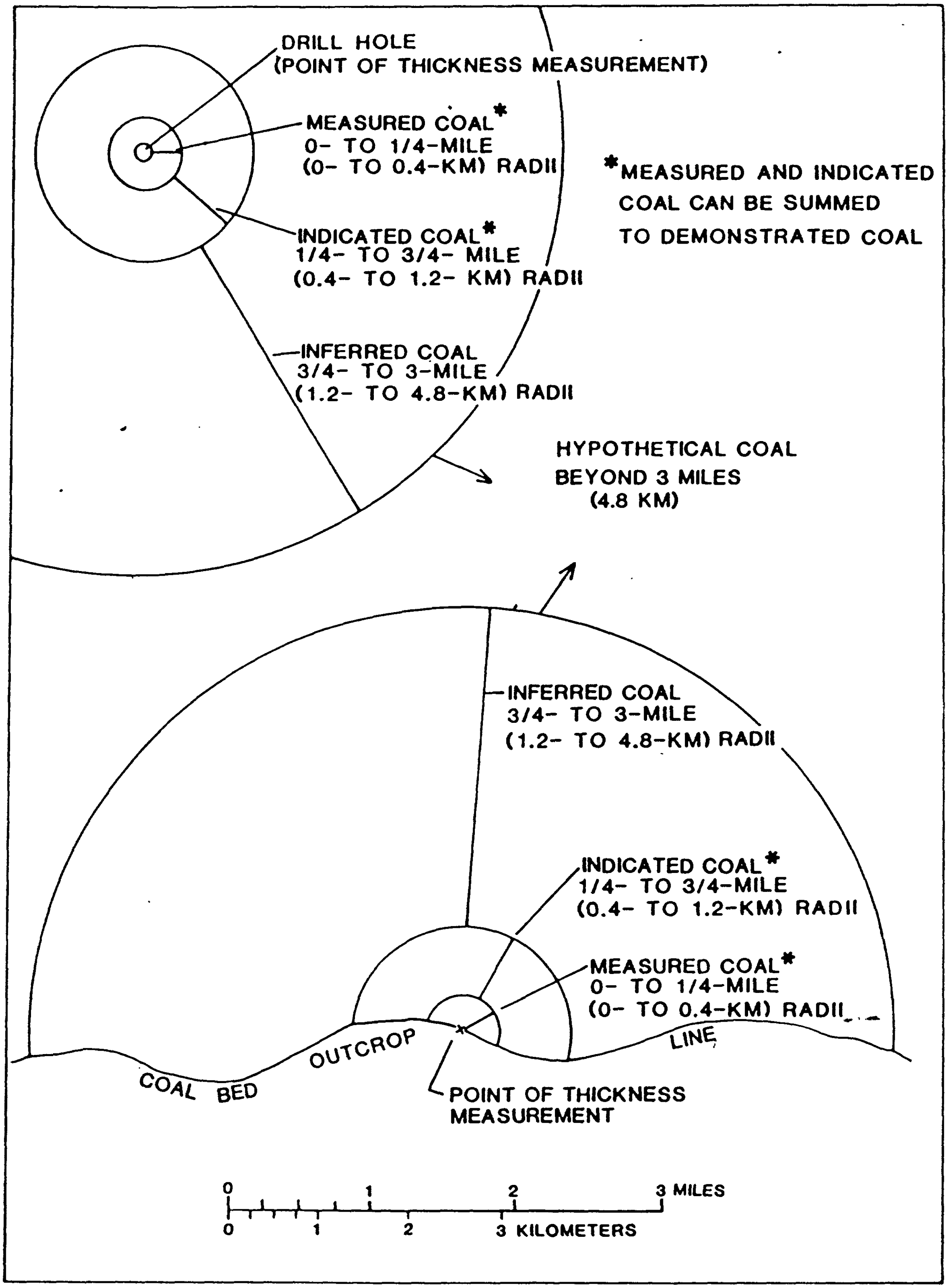


Figure 2.--Diagram showing reliability categories based solely on distance from points of measurement (from Wood and others, 1983).

The USGS monitors also set up the criteria for determining the CDP for in situ gasification of subsurface coal beds in the Wyoming part of the basin. The evaluation of subsurface coal deposits for in situ gasification development potential relates to the existence of coal beds more than 5 ft thick buried from 500 to 3,000 ft beneath the surface. This categorization is as follows:

1. LOW development potential relates to (a) a total coal section less than 100 ft thick that lies 1,000 ft to 3,000 ft beneath the surface, or (b) a coal bed or coal zone 5 ft or more thick that lies 500 ft to 1,000 ft beneath the surface; and to inclined beds whose dip is 15^{o} to 35^{o}.

2. MODERATE development potential is assigned to a total coal section from 100 to 200 ft thick and buried from 1,000 to 3,000 ft beneath the surface, and to inclined beds whose dip is 35^{o} to 90^{o}.

3. HIGH development potential involves 200 ft or more of total coal thickness buried from 1,000 to 3,000 ft; the degree of dip of inclined beds is not applicable.

Land-use planners, for whom the end products were designed, may find the data plates and derivative maps and reports generally instructive. The USGS will use the products as the starting point for further data collection and synthesis and for reinterpretation in light of new publicly available or proprietary information.

RESOURCE ESTIMATES OF UNLEASED FEDERAL COAL

A direct result of the CRO/CDP map program is that a modern new estimate of unleased federally owned coal resources for part of the Powder River Basin is now available. The grand total of these estimated "reserve base" (CRO definition) coal resources (down to 3,000 ft depth for beds 5 ft thick or greater) in part of the Powder River Basin is approximately 775 billion short tons, of which more than 98 percent is subbituminous coal (table 12). Most of these coal resources, an estimated 633 billion short tons, are in Wyoming where the coal basin is deeper, coal beds are more numerous, and many of the coal beds are thicker than those in Montana.

The geologic assurance or degree of reliability of the quadrangle coal-resource estimates, as suggested by the categories of measured, indicated, and inferred coal, is available for the 108 quadrangles in Montana. On the basis of the arithmetic means of the reliability measurements, 5 percent of the coal tonnages are measured, 25 percent are indicated, and 70 percent are inferred. I believe that the mean reliability measurements for the 135 quadrangles in Wyoming would approximate these results. This information may have been compiled by the contractor, IntraSearch Inc., but it was not presented in the quadrangle reports.

Estimated mean percent of quadrangles evaluated

The percentage results shown in table 14 help to clarify what proportions of the 243 quadrangles were excluded from the estimates of unleased Federal coal resources. For each of the 243 quadrangle reports, two visual estimates were made: (1) on the Property Boundary map, where I estimated the percentage of the quadrangle area that was not assessed (non-Federal coal land, NFCL) (column 1), and the other (2) on the CDP map, where I estimated the percentage of nonleased Federal coal land (FCL) having a HIGH CDP for surface mining (column 2). The percentage area estimate in column 2 was adjusted to a <u>quadrangle-area basis</u> in column 3 by the use of this equation: (column 2 x (100-column 1) x 100) = column 3. Then the arithmetic means (X) were calculated for

Table 14. - Comparison of percentages of (1) quadrangle areas not evaluated for unleased Federal coal, and of percentages of (2 and 3) quadrangle(s) areas underlain by unleased Federal coal with a HIGH CDP for surface mining, in part of the Powder River Basin, Montana and Wyoming, evaluated by the CRO/CDP program.

[Arthimetic mean $\overline{X} = \frac{X_1 + X_2 + X_3 + \ldots\ldots X_n}{n}$]

Coal Resource Area by State [total number of quadrangles in parentheses]		1 Estimated mean percentage of quadrangles' area <u>not evaluated</u> for unleased <u>Federal coal</u> greater than (>) 5 ft thick--non-Federal coal land, NFCL.	2 Estimated mean percentage of the area of unleased Federal coal land (FCL) that is underlain by coal (> 5 ft thick) with a HIGH CDP for surface mining.	3 Calculated mean percentage of the quadrangles' area underlain by unleased Federal coal with a HIGH CDP for surface mining.
Northern Powder River Basin, Montana				
Area 1 (24)		24 $\overline{X}$ = 21	24 $\overline{X}$ = 79	24 $\overline{X}$ = 63
Area 2 (17)		17 $\overline{X}$ = 5	17 $\overline{X}$ = 71	17 $\overline{X}$ = 68
Area 3 (17)		17 $\overline{X}$ = 40	17 $\overline{X}$ = 70	17 $\overline{X}$ = 42
Area 4 (23)		23 $\overline{X}$ = 58	23 $\overline{X}$ = 44	23 $\overline{X}$ = 17
Area 5 (27)		27 $\overline{X}$ = 81	27 $\overline{X}$ = 47	27 $\overline{X}$ = 10
Subtotal -- (108)	Subgrand Mean	108 $\overline{X}$ = 44	108 $\overline{X}$ = 61	108 $\overline{X}$ = 38
Southern Powder River Basin, Wyoming				
Area 6 (31)		31 $\overline{X}$ = 28	31 $\overline{X}$ = 57	31 $\overline{X}$ = 44
Area 7 (13)		13 $\overline{X}$ = 23	13 $\overline{X}$ = 23	13 $\overline{X}$ = 18
Area 8 (41)		41 $\overline{X}$ = 12	41 $\overline{X}$ = 25	41 $\overline{X}$ = 22
Area 9 (50)		50 $\overline{X}$ = 16	50 $\overline{X}$ = 8	50 $\overline{X}$ = 7
Subtotal -- (135)	Subgrand Mean	135 $\overline{X}$ = 20	135 $\overline{X}$ = 28	135 $\overline{X}$ = 24
Powder River Basin				
Grand Total (243)	Grand Mean	243 $\overline{X}$ = 32	243 $\overline{X}$ = 45	243 $\overline{X}$ = 31

each group (areas 1-9) of estimated percentages (column nos. 1, 2, and 3 in table 14). To demonstrate how these values change across different parts of the Powder River Basin, I gave the arithmetic means of the three estimated percentages for the nine coal resource areas, for Montana, for Wyoming, and a grand mean for the evaluated part of the basin. Other areas not evaluated include Federal coal lands either already leased or not underlain by coal 5 ft or more thick, and Indian lands. The results in table 14 suggest that 32 percent or about one-third of each quadrangle, on the average, was not evaluated for unleased Federal coal (greater than 5 ft thick). Roughly one-third or 31 percent of the area of each quadrangle (on the average) evaluated in the CRO/CDP program is underlain by unleased Federal coal (greater than 5 ft thick) with a HIGH CDP for surface mining. Coal-resource areas 1 and 2 of Montana for example have 63 and 68 percent average, respectively, of the quadrangle's area underlain by unleased Federal coal (greater than 5 ft thick) with a HIGH CDP for surface mining.

Reserve base coal estimates

The contractors were instructed by the USGS to classify all identified coal more than 5 ft thick to a depth of 3,000 ft. This did not follow the definition of the term reserve base in USGS Bulletin 1450-B (1976). Only the results presented in the 13 quadrangles in Montana by USGS geologists are in accord with the formal USGS definition of (standard) reserve base--that is, all identified coals 60 in. or more thick (for subbituminous coal) that occur to a depth of 1,000 ft. As discussed previously, in all other quadrangles (230 quadrangles), all coal thicker than 60 inches to a depth of 3,000 ft is classified in the "reserve base" (CRO definition) category. Also, about 70 to 80 quadrangles most of which are on the west and south sides of the basin, may have significant reserve base coal in the Tertiary beds, which were not evaluated. Of these, 44 quadrangles in the Sheridan, Buffalo, and Lake DeSmet coal fields of Wyoming almost certainly have large coal resources (see table 2). Table 12 shows an estimated quantity of nearly 200 billion short tons of nonleased Federal stripping coal alone in the evaluated part of the Powder River Basin. The amount of strippable coal in each quadrangle is shown on map B and tables 3-11.

COAL DEVELOPMENT POTENTIAL

Perhaps the most important products of the CRO/CDP program in the Powder River Basin are the quadrangle CDP maps. CDP depends on measurements of coal-bed thickness and depth of overburden, computation of mining recovery factors, and the quality of the coal. A CDP map shows the parts or areas (as small as 40 acres) of that quadrangle that have HIGH, MODERATE, or LOW CDP. The development potential of three classes of coal resources are characterized in terms of coal tonnages and location in the CRO/CDP program. These are shown in the main headings of the tables of resources in this report (tables 3-12). They are (1) surface-minable or strippable coal; (2) underground-minable coal resources, and (3) in situ gasification coal resources. The estimated coal resources for the first and third class are categorized areally (where applicable) into HIGH, MODERATE, and LOW CDP tracts of land in the quadrangles. The CDP rating for any section or tract of land is the highest CDP assigned to any one coal bed lying within it. Because all underground-minable coal was judged by the area mining supervisors of USGS to have LOW coal development potential, no maps of this class of coal resources were compiled.

The best of the "reserve base" coal resources in the evaluated part of the Powder River Basin is the strippable coal and in situ gasification coal of HIGH and MODERATE development potentials. Therefore, in this report, I show by quadrangle the location and tonnages of these two classes of unleased Federal coal resources on maps B and C and tables 3-12.

Surface-Minable (Strippable) Coal Resources

Coal-Resource Area 6

The largest quantity of Federal strippable coal of HIGH and MODERATE development potential is in coal-resource area 6 of Wyoming. As shown by map B and table 8, approximately 58 billion short tons of nonleased Federal strippable subbituminous coal underlies area 6 of the southern Powder River Basin. Nearly 44 billion short tons of these estimated coal resources are classified as having HIGH and MODERATE CDP.

Coal-Resource Area 8

The second most prolific source area of nonleased Federal coal resources in the evaluated part of the Powder River Basin is in coal resource area 8 of Wyoming. There, south of Gillette, are 12 quadrangles, each of which has an estimated 1 billion short tons or more of HIGH and MODERATE development potential strippable subbituminous coal resources (map B and table 10). Area 8 contains an estimated tonnage of 39 billion short tons of unleased Federal strippable subbituminous coal resources that include about 30 billion short tons of HIGH and MODERATE development potential coal.

Coal-Resource Area 1

The western part of coal-resource area 1 in the northern Powder River Basin of Montana holds the third largest amount of nonleased strippable Federal coal in the evaluated part of the basin. Much of this coal underlies a group of quadrangles north of and adjacent to Decker, MT. An estimated tonnage of nearly 32 billion short tons of unleased strippable Federal subbituminous coal is in coal-resource area 1, including nearly 25 billion tons of HIGH and MODERATE development potential coal (map B and table 3). Three large coal mines near Decker are producing coal (1983), and construction is scheduled to begin on another mine along the Tongue River.

Coal-Resource Areas 1 and 2

The fourth most important area spans the boundary of coal-resource areas 1 and 2 between the Tongue and Powder Rivers in the Moorhead and Birney-Broadus coal fields of Montana. Several quadrangles situated along the headwaters of Otter Creek have an estimated tonnage from 500 million short tons to 1 billion short tons of unleased strippable Federal subbituminous coal of HIGH and MODERATE development potential (map B). Also, quadrangle nos. 87, 90, and 103 each have more than an estimated tonnage of 1 billion short tons of nonleased Federal coal of HIGH and MODERATE development potential (map B and tables 3 and 4). In 1983, BLM was studying two tracts in coal-resource area 1 for lease sale; each tract has an area of roughly 1/4 township (oral commun., Mr. Charles Wilkie, BLM, Casper, WY, 1983). One tract, named Mud Springs, is in quadrangle no. 88 in T. 8 S., R. 45 E., and the other is the Hanging Woman tract in quadrangle nos. 100 and 101 in T. 9 S., R. 43 and 44 E.

Coal-Resource Area 3

Another area of importance lies near the Tongue River in coal-resource area 3 and includes several quadrangles along Otter Creek east and southeast of Ashland, MT. Quadrangles nos. 52, 53, and 63 each have an estimated tonnage of more than 1 billion short tons of unleased strippable Federal subbituminous coal resources of HIGH and MODERATE development potential (map B and table 5). Several nearby quadrangles (nos. 61, 62, 64, and 65) also with HIGH and MODERATE development potentials have nonleased strippable Federal subbituminous coal resources estimated at 500 million to 1 billion short tons. A tract of about 1/2 township along the southwest side of Otter Creek might be opened, if selected for the next competitive coal lease sale, according to Charles Wilkie, BLM, Casper, Wyoming District Office (oral commun., 1983). The proposed tract, named Otter Creek NW, is in quadrangles nos. 62 and 75, T. 4 and 5 S., R.45 E.

Coal-Resource Areas 5 and 9

Four quadrangles in coal-resource area 9 centered around Teckla, WY contain much unleased Federal coal. Quadrangle nos. 90, 91, and 98 each have an estimated 1 billion short tons or more of unleased strippable Federal subbituminous coal of HIGH and MODERATE development potential, and quadrangle no. 99 has an estimated tonnage from 500 million short tons to 1 billion short tons of unleased strippable coal resources (map B and table 11). According to the BLM District Office (oral commun., Charles Wilkie, 1983) three tracts of land in the vicinity of Teckla, WY, in southern Campbell County were being studied by the BLM in 1983 for possible lease sale. They are (1) Ridge Runner, an area of about 1/4 township; (2) Porcupine, about 400 to 500 acres; and (3) Thunder Cloud, approximately 3,000 acres. Two inoperative coal mines are nearby—the Rochelle Mine in coal-resource area 8 and the Antelope Mine. Furthermore, two tracts of land, named North and South Antelope, in the vicinity of Teckla, WY, are included in a formal lease application termed a "preference right lease application." These two tracts of land are now (1983) in the Environmental Impact Statement (EIS) phase of the lease application for the next competitive lease sale of Federal coal. Thus, much past and present interest in the coal resources is evident in this part of the southern Powder River Basin.

Two large important coal- and power-producing locations in the Powder River Basin are not obvious on map B. The first is Colstrip, MT, in the central part of coal-resource area 5, quadrangle no. 15. It is the site of two large producing surface-coal mines, the Colstrip and Big Sky Mines, both mining the Rosebud coal bed. Two operating mine-mouth powerplants at Colstrip are generating 716.7 megawatts (Shifflett, 1982, p. 12) of electricity and two additional powerplants are being built (1983). Farther west in area 5 is the large Absoloka coal mine in the Wolf School quadrangle (no. 25), Big Horn and Treasure Counties, MT. Because most of the Federal coal has long been leased there, nearly all the quadrangles in this area are each estimated to contain tonnage of less than 0.5 billion short tons of unleased strippable Federal subbituminous coal resources (map B and table 7). Much of the coal in this area is owned by the Burlington Northern Railroad, Inc. Similarly, another large coal mine and powerplant are now (1983) in operation in the southwest part of coal-resource area 9 of Wyoming. They are the Dave Johnson Mine, which is about 10 mi. north of Glenrock, and a 750.3 megawatt powerplant, (Shifflett, 1982, p. 22) which is nearby at Clayton. Map B indicates that most of the quadrangles in area 9 have an estimated tonnage from 1 million to 500 million short tons or less of unleased strippable Federal coal resources (table 11). Most of the strippable coal resources in the vicinity of the Dave Johnson Mine have been leased. Application has been made to lease several large tracts of land bordering the mine, according to the Regional Activity EIS map (U.S. Bureau of Land Management, 1981).

The previous paragraphs emphasize the principal areas of surface-minable coal having HIGH and MODERATE CDP. The fact that the areas of current (1983) intense coal development in the Powder River Basin are not conspicuous or apparent on the map of nonleased Federal strippable coal (map B) indicates that very large amounts of leased Federal coal resources or private coal are being developed and mined in the basin. The specific locations of the nonleased Federal coal resources may be found in the tabulated resources on a quadrangle basis (maps A and B, tables 3-11). Furthermore, map B shows the areal distribution of the primary nonleased strippable Federal coal resources in the evaluated part of the basin.

Underground-Minable Coal Resources

An estimated tonnage of nearly 575 billion short tons of unleased Federal underground-minable "reserve base" coal resources is in the Powder River Basin, most of which, roughly 548 billion short tons, is of LOW CDP because of arbitrary classification standards (table 12). The remainder, 27 billion short tons of Federal coal resources in resource-area 1 in Montana, has not been classified. Coal is not currently (1983) mined underground in the Powder River Basin; therefore, mining recovery factors have not been established, and all such coal is classified as having LOW development potential. Furthermore, all economic analyses suggest that underground mining probably will not take place in the near future. I am not stating that coal will never be mined underground in the Powder River Basin--rather I am stating that, when the right situation exists in terms of economics and engineering, some deep coal mining could develop. Underground coal mining is underway in the Hanna Basin of Wyoming; however, there is enough coal to be mined in the Powder River Basin by means of the less expensive methods and the more productive techniques of surface mining.

In situ Gasification Coal Resources

The following information was taken from a draft Environmental Impact Statement (EIS) for eastern Powder River Basin of Wyoming (U.S. Bureau of Land Management, 1974, v. 1, p. I-94):

Coal gasification

"Test projects for different gasification methods are currently underway by both private industry and the Federal government. All known full-scale commercial projects now being planned or constructed in the United States are based on variations of a German process called the Lurgi process. The Lurgi process has been used for many years on a small scale as a means of producing low Btu gas, commonly referred to as town gas. By adding a methanation process, this gas can be upgraded to pipeline quality comparable to natural gas.

Other gasification processes are being extensively tested and are showing promise, but none have been proved on a commercial scale. Table 1 lists the tests and their present status.

In addition to the various gasification methods for mined coal, the U.S. Bureau of Mines is working on an in situ gasification project near Hanna, Wyoming. Although still in experimental stages, this process shows potential, especially under certain circumstances. In situ gasification has the following advantages:

(1) Coal which cannot be economically mined can be gasified (coal seam too deep, thin, etc.).

(2) No open pit or underground mining is required.

(3) Water needs are minimal.

(4) Employment needs are low.

In situ should probably be considered as an additional method for only certain circumstances rather than an alternative to gasification."

Some in situ gasification projects in the Powder River Basin have been discontinued according to Charles Wilkie, BLM, Casper, WY (oral commun., 1983) because gasoline is now selling for $1.12 per gallon. As long as this relatively low price stays in effect, energy companies will be reluctant to invest the large sums of money necessary to build and put such costly plants into production. Therefore, on the basis of present (1983) economic conditions, the potential for the development of in situ gasification projects in the Powder River Basin is believed to be low.

Coal Resource-Areas 6, 7, and 8

The development potential of coal in Wyoming for in situ gasification was evaluated according to the guidelines previously mentioned. The tables of nonleased Federal coal resources shows a HIGH and MODERATE CDP for in situ gasification in three coal-resource areas of the southern Powder River Basin. The coal resources are plotted on map C in Wyoming coal-resource areas 6, 7, and 8. Coal resource area 8 has the largest estimated combined tonnage of nonleased Federal subbituminous coal resources of HIGH and MODERATE development potential, nearly 160 billion short tons, for in situ gasification (table 10). Also, very large quantities of unleased Federal subbituminous coal of HIGH and MODERATE development potential for in situ gasification are in coal-resource areas 6 and 7 (map C and tables 8 and 9). Table 12 shows an estimated tonnage of nearly 507 billion short tons of unleased Federal in situ gasification coal in the basin, and roughly 265 billion short tons of this total is classified as HIGH and MODERATE development potential. These resources are distributed through the evaluated part of the basin as shown on map C. This region, west of area 6 in the trough of the syncline, is generally where the thick coal section is buried most deeply in the basin. Some of the quadrangles that have the greatest quantities of nonleased Federal in situ gasification coal straddle the upper reaches of the Powder River in northeastern Johnson county west of Gillette, WY. This area of coal resources for in situ gasification is compact and symmetrical. It is in west-central Campbell County, and in the two tiers of quadrangles that bridge the Powder River in northeast Johnson County, WY. Each of the quadrangles shown in solid pattern on map C has an estimated 5 billion short tons or more of unleased Federal subbituminous coal resources of HIGH and MODERATE development potential for in situ gasification.

RELIABILITY JUDGMENTS OF CRO/CDP COAL RESOURCE ESTIMATES

I evaluated the reliability of the estimates of unleased Federal coal resources and coal-bed correlations while reviewing the CRO/CDP quadrangle map reports. I did this subjectively by comparing quadrangle reports with previously examined quadrangles that were adjacent or nearby. Other factors considered were the quantity of data available in a quadrangle, the manner in which those data were treated, and perhaps some geologic intuition. I assigned each quadrangle report a number from 1 to 10, 1 being the highest reliability and 10 the lowest. The average results were in the 4 to 6 range. Because I began my quadrangle reviews with the 13 quadrangles completed by USGS geologists in the Birney-Broadus coal field area of Montana, they were necessarily a beginning benchmark or standard against which the other 230 quadrangles were judged.

Coal correlations and coal-resource estimates in this study are judged on the whole to be of average reliability. The reliability rating is generally higher in quadrangles where great amounts of coal data are available and lower where data are sparse. Although I had no field experience in the area of these coal beds, and had no first-hand experience working on the stratigraphic section, I was assigned this task as part of my quadrangle-review duties. An experienced worker in the area informed me that some CRO/CDP coal correlations and resource estimates are good, some are bad, and some are ridiculous. My judgement was not quite as severe.

The coal-resource data presented in the CRO/CDP reports are judged acceptable, and can be used for future planning, in part because the structural geology of the Powder River Basin is not complex. The reliability of the coal-resource estimates is also enhanced because the estimates were completed on a 7 1/2-minute quadrangle basis and specific coal-data points were used. On the other hand, the subsurface stratigraphy is locally very complex, and poses some problems because of local abrupt changes in coal-bed thicknesses and the associated facies changes of the enclosing sedimentary rocks. Some coal-resource estimates were based in part on different types of well logs that had different accuracies; this also affected, in my opinion, the validity of some coal-resource calculations. However, no quadrangles were found to lack the data sheets and maps required by the contract specifications.

Only a part of the 775 billion short tons of non-leased Federal coal resources estimated in this analysis is standard reserve base coal; the rest is subeconomic. The end result of this is that coal deeper than 1,000 ft in 13 quadrangles in the vicinity of the Birney-Broadus coal field was not included in the CRO/CDP coal resource estimates. Also, the coal that has an overburden of between 200 and 500 ft is not classified as strippable coal as it was in the other 230 quadrangles in the basin. In summary, the 775 billion short tons of nonleased Federal coal was termed "reserve base" by the CRO/CDP program under instructions from the area mining supervisors of the USGS, but the part where overburden is between 1,000 to 3,000 ft should be classed as subeconomic coal. The thin coal beds from 30 to 60 inches thick that were omitted in the CRO/ CDP "reserve base" estimates for 230 quadrangles should be included in estimates of the standard resources for these quadrangles.

The final assessment is that the CRO/CDP maps were compiled on a sound technical basis and, more important, these maps can be used by other workers to (1) add new exploration data to that already on hand, (2) make new interpretations of geologic phenomena, and (3) permit more accurate coal-resource assessments and coal environment reconstructions. Only minor discrepancies were noted in the proper labeling of coal beds or of thickness measurements in drill sections compared with those in the drill logs. National Forest boundaries usually were not included on the coal-data maps, nor were the county boundaries. Locations of some drill holes were omitted from the coal-data map even though they were in the stratigraphic profile sections. I found no obvious errors in coal-bed correlations.

CONCLUSIONS

My review of the CRO/CDP map reports shows that a vast tonnage of good quality subbituminous coal with a variety of potential for development is in the Powder River Basin. When the classified coal resources are tabulated, the coal that has HIGH and MODERATE development potentials is readily identified and set apart from the subeconomic coal resources. That is what this report is all about--locating within the Powder River Basin the unleased Federal coal resources that have the greatest potential for development. Thus, because coal beds with the highest probabilities for development are clearly identified in this study, Government, industry, and other interested parties are saved much time and effort in compiling the information.

Total nonleased estimated Federal coal resources in part of the Powder River Basin of Montana and Wyoming are approximately 775 billion short tons of "reserve base" (CRO-definition) coal resources. Most of the "reserve base" coal resources, 633 billion short tons, are in Wyoming where the coal basin is deeper and the coal beds are thicker and more numerous. The coal tonnages in the 243 7 1/2-minute quadrangles that cover the eastern and northern parts of the basin were tallied from the CRO/CDP map series initiated by the USGS. Several types of coal resources were omitted from this nonleased Federal coal-resource estimate (CRO/CDP); if these coal resources were added to the "reserve base" estimate, the total original coal resources of the Powder River Basin probably will exceed an estimated 1 trillion short tons.

The premium coal resource in the basin is the surface-minable coal, or that coal which is 5 ft or more thick and not more than 500 ft deep. The estimated tonnage is approximately 74 billion short tons of strippable coal in Montana and 125 billion short tons of strippable coal in Wyoming. The largest estimated tonnage of strippable coal is in coal-resource area 6--roughly 58 billion short tons; the second largest is coal-resource area 8--approximately 39 billion short tons; and the third-largest is coal-resource area 1--approximately 32 billion short tons (see table 12). The classification of this coal into categories of HIGH, MODERATE, and LOW development potential is based upon strip-mining ratios (the cubic yards of overburden per estimated ton of recoverable coal). The best of the premium coal resources in the Powder River Basin is an estimated 100 billion short tons of surface-minable, HIGH development potential subbituminous coal, of which about 62 billion short tons is in Wyoming. The areas containing the greatest amounts of HIGH development potential strippable coal are 6, 8, and 1, in that order (see table 12). These coal-resource areas are shown on map B. All the underground-minable nonleased estimated Federal coal resources, roughly 67 billion short tons in Montana and 509 billion short tons in Wyoming, have LOW potential for development at present. Approximately 75 billion short tons of the underground-minable nonleased Federal coal resources in Wyoming is estimated to have a HIGH potential for coal development for in situ gasification; these coal resources are in areas 6, 7, and 8 (map C). Currently (1984), a selling cost of $1.12 per gallon for gasoline appears to preclude beginning any in situ gasification projects in the Powder River Basin. The bulk of the coal in the Powder River Basin is low in sulfur (less than 1 percent) and of subbituminous rank; however, more than 9 billion short tons of lignite is estimated to be along the eastern margins of the basin.

An average of 32 percent of the area of each of the 243 quadrangles examined was eliminated from the estimate because it was non-Federal or leased coal land or contained thin coal. For all 243 quadrangles (on the average), the mean percentage of quadrangle area that has a HIGH potential of coal development for surface mining is 31 percent (table 14).

The principal benefit of this study is the summation of strippable and in situ gasification coal-resource data from 243 separate reports and the location of the highest development potential coal resources by 7 1/2-minute quadrangle on small-scale maps of the Powder River Basin. This was done for strippable coal resources and for in situ gasification coal resources where present in Wyoming. A more complete coal-resource assessment for the Powder River Basin will be possible after all the coal-bearing quadrangles omitted from this inventory are mapped, especially the 44 quadrangles in the Sheridan, Buffalo, and Lake DeSmet coal fields of Wyoming.

REFERENCES CITED

Averitt, Paul, 1975, Coal resources of the United States, January 1, 1974: U.S. Geological Survey Bulletin 1412, 131 p.

American Society for Testing and Materials, 1981, Annual book of ASTM standards; part 26, gaseous fuels; coal and coke; atmosphere analysis: Philadelphia, Pennsylvania, p. 181-399.

Baker, A.A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 806-B, p. 15-67.

Bohor, B.F., Kent, B.H., and Haddock, D.R., 1979, Geologic map and coal sections of the Twentymile Butte quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1073, scale 1:24,000.

Breckenridge, R.M., Glass, G.B., Root, F.K., and Wendell, W.G., 1974, Geologic map atlas and summary of land, water, and mineral resources of Campbell County, Wyoming: Geological Survey of Wyoming, County Resource Series No. 3 (CRS-3), 9 plates.

Coal News, 1985, (Estimates of 1984 U.S. coal production): Coal News, No. 4757 (1/7/85), p. 1.
Coal Week, 1984a, (Estimates of 1983 U.S. coal production): Coal Week, v. 10, no. 3, p. 3.
_____1984b, (Estimates of 1984 U.S. coal production): Coal Week, v. 10, no. 52, p. 1.
Culbertson, William C., 1975, Preliminary geologic map and coal sections of the Wyarno quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-723, scale 1:24,000, 2 sheets.
Culbertson, William C., and Klett, Mark C., 1975a, Preliminary geologic map and coal sections of the Jones Draw quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-726, scale 1:24,000, 2 sheets.
_____1975b, Preliminary geologic map and coal sections of the SR Springs quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-727, scale 1:24,000, (2 sheets).
Culbertson, W.C., and Klett, M.C., 1976, Geologic map and coal sections of the Browns Mountain quadrangle, Rosebud county, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-814 (2 sheets), scale 1:24,000.
Culbertson, W.C., Mapel, W.J., and Klett, M.C., 1976a, Geologic map and coal sections of the Strowd Creek quadrangle, Rosebud and Big Horn Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-822, scale 1:24,000, (2 sheets).
Culbertson, W.C., Hatch, J.R., and Affolter, R.H., 1978, Geology and coal resources of the Hanging Woman Creek study area, Big Horn and Powder River Counties, Montana: U.S. Geological Survey Open-File Report 78-506.
Culbertson, W.C., Kent, B.H., and Mapel, W.J., 1979, Preliminary diagrams showing correlations of coal beds in the Fort Union and Wasatch Formations across the northern Powder River Basin, northeastern Wyoming and southeastern Montana: U.S. Geological Survey Open-File Report 79-1201, 11 p., 2 pls.
Culbertson, W.C., and Klett, M.C., 1979a, Geologic map and coal sections of the Forks Ranch quadrangle, Big Horn County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1086, scale 1:24,000.
Culbertson, W.C., and Klett, M.C., 1979b, Geologic map and coal sections of the Quietus quadrangle, Big Horn and Powder River Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1087, scale 1:24,000.
Denson, N.M., Dover, J.H., and Osmonson, L.M., 1978a, Lower Tertiary coal bed distribution and coal resources of the Reno Junction-Antelope Creek area, Campbell, Converse, Niobrara, and Weston Counties, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-960, scale 1:250,000.
Denson, N.M., Dover, J.H., and Osmonson, L.M., 1978b, Structure contour and isopach maps of the Wyodak-Anderson coal bed in the Reno Junction-Antelope Creek area, Campbell and Converse Counties, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-961, scale 1:125,000.
_____1980, Lower Tertiary coal bed distribution and coal resources of the Reno Junction-Antelope Creek area, Campbell, Converse, Niobrara, and Weston Counties, Wyoming: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1201, scale 1:125,000.
Dobbin, C.E., and Barnett, V.H., 1927, The Gillette coal field, northeastern Wyoming, with a chapter on the Minturn district and the northwestern part of the Gillette field by W.T. Thom, Jr.: U.S. Geological Survey Bulletin 796-A, p. 1-64.
Doelger, N.E., and Fahy, J.W., 1980, Preliminary geologic map and coal resources of the Holmes Ranch quadrangle, Big Horn County, Montana: U.S. Geological Survey Open-File Report 80-212, 1 map, scale 1:24,000, 18 coal sections, 2 tables.
Galyardt, G.L., 1980a, Preliminary geologic map and coal deposits of the Appel Butte quadrangle, Campbell County, Wyoming: U.S. Geological Survey Open-File Report 80-053, 1 map, scale 1:24,000.

_____1980b, Geologic map and coal deposits of the Four Bar J Ranch quadrangle, Campbell County, Wyoming: U.S. Geological Survey Open-File Report 80-648, 1 map, scale 1:24,000.

Galyardt, G.L., and Murray, F.N., 1981, Geologic map and coal sections of the Pearl School quadrangle and the easternmost part of the Bar V Ranch quadrangle, Big Horn County, Montana: U.S. Geological Survey Open-File Report 81-870, 1 map, scale 1:24,000, well logs, and tables.

Glass, G.B., 1978, Wyoming Coal Fields, 1978: Geological Survey of Wyoming, Public Information Circular No. 9, 91 p.

_____1980, Coal resources of the Powder River Basin, in Glass, G.B., ed., Guidebook to the Coal Geology of the Powder River Coal Basin, Wyoming: Wyoming Geological Survey Public Information Circular 14, p. 97-131.

Grazis, S. L., 1977, Geologic map and coal resources of the Saddle Horse Butte quadrangle, Campbell County, Wyoming: U.S. Geological Survey Coal Investigations Map C-79, scale 1:24,000 (3 sheets).

Hatch, J.R., and Swanson, V.E., 1977, Trace elements in Rocky Mountain coals, in Proceedings of the 1976 symposium, Geology of Rocky Mountain Coal, 1977: Colorado Geological Survey Resource Series 1, p. 143-163.

IntraSearch, Inc., 1980, Coal resource occurrence and coal development potential maps of the Lariat quadrangle, Sheridan, Johnson, and Campbell Counties, Wyoming: U.S. Geological Survey Open-File Report 79-169, 27 p., 55 pls., scale 1:24,000.

Keefer, W.R., and Schmidt, P.W., 1973, Energy resources map of the Powder River Basin, Wyoming and Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-847-A, scale 1:500,000.

Kent, B.H., 1976, Geologic map and coal sections of the Wildcat quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-735, scale 1:24,000.

Kent, B.H., Haddock, D.R., and Bohor, B.F., 1977, Geologic map and coal sections of the Truman Draw quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-917, scale 1:24,000.

Kent,B.H., and Munson, B.E., 1978a, Structure contour map of the Canyon and associated coal beds in western half of the Recluse $1^{o}x1/2^{o}$ quadrangle, Campbell County, Wyoming: U.S. Geological Survey Coal Investigations Map C-81-A, 2 maps, scale 1:100,000.

_____1978b, Isopach maps of the Canyon and associated coal beds, western half of the Recluse $1^{o}x1/2^{o}$ quadrangle, Campbell County, Wyoming: U.S. Geological Survey Coal Investigations Map C-81-B, 2 maps, scale 1:100,000.

_____1978c, Preliminary geologic map of the principal coal beds in the western part of the Recluse $1^{o}x1/2^{o}$ quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1045, scale 1:100,000.

Kent, B.H., and Berlage, L.J., 1980a, Geologic map of the Recluse $1^{o}x1/2^{o}$ quadrangle, Campbell and Crook Counties, Wyoming: U.S. Geological Survey Coal Investigations Map C-81-D, scale 1:100,000.

Kent, B.H., Berlage, L.J., and Boucher, E.M., 1980b, Stratigraphic framework of coal beds underlying the western part of the Recluse $1^{o}x1/2^{o}$ quadrangle, Campbell County, Wyoming: U.S. Geological Survey Coal Investigations Map C-81-C, scale 1:100,000.

Kent, B.H., and Berlage, L.J., 1981, Geologic map and coal sections of the Reservoir Creek quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1336, scale 1:24,000.

Law, B.E., 1978, Geologic map and coal deposits of the Gillette West quadrangle, Campbell County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-974, scale 1:24,000.

Law, B.E., Barnum, B.E., and Wollenzien, T.P., 1979(1980), Coal bed correlations in the Tongue River member of the Fort Union Formation, Monarch, Wyoming and Decker, Montana, areas: U.S. Geological Survey Miscellaneous Investigations Map I-1128.

Lewis, D.B., and Hotchkiss, W.R., 1981, Thickness, percent sand, and configuration of shallow hydrogeologic units in the Powder River Basin, Montana and Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-1317, scale 1:1,000,000.

Mapel, W.J., 1954 (1955), Geology and coal resources of the Lake DeSmet area, Johnson County, Wyoming: U.S. Geological Survey Coal Investigations Map C-23, scale 1:48,000.

_____1959, Geology and coal resources of the Buffalo-Lake DeSmet area, Johnson and Sheridan Counties, Wyoming: U.S. Geological Survey Bulletin 1078, 148 p.

_____1976a, Geologic map and coal sections of the Bar N Draw quadrangle, Wyoming and Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-763, scale 1:24,000, 2 sheets.

_____1976b, Geologic map and coal sections of the Birney quadrangle, Rosebud County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-813, scale 1:24,000.

Mapel, W.J., 1978a, Geologic map and coal sections of the.Pine Butte School quadrangle, Big Horn County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1014, scale 1:24,000, 2 sheets.

_____1978b, Geologic map and coal sections of the northern part of the Ucross quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Open-File Report 78-455, 2 sheets, 1:24,000.

_____1978c, Geologic map and coal sections of northern part of Horse Hill quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Open-File Report 78-793, 1 map, scale 1:24,000.

Mapel, W. J., and Dean, B. W., 1976, Geologic map and coal sections of the Verona quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-762, scale 1:24,000, 2 sheets.

Mapel, W.J., and Malahy, M.D., 1976, Geologic map and coal sections of the Buffalo Run Creek quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-792, scale 1:24,000, 1 sheet.

Mapel, W.J., Martin, B.K., and Butler, B.A., 1978, Coal resource occurrence and coal development potential map of the Strowd Creek quadrangle, Rosebud and Big Horn Counties, Montana: U.S. Geological Survey Open-File Report 78-038, 33 p., 54 pls., scale 1:24,000.

Mapel, W.J., and Griffith, J.K., 1981, Geologic map and coal resources of the Thompson Creek area, Big Horn County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1312, scale 1:24,000.

Matson, R.E., and Blumer, J.W., 1974, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p.

McGregor, A.A., 1972, The Powder River Basin, in Geologic atlas of the Rocky Mountain region: Denver, Rocky Mountain Association of Geologists, 331 p.

McKay, E.J., 1976a, Preliminary geologic map and coal sections of the Willow Crossing quadrangle, Rosebud and Powder River Conties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-802, scale 1:24,000, 1 sheet.

_____1976b, Preliminary geologic map and coal sections of the Fort Howes quadrangle, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-807, scale 1:24,000, 1 sheet.

McKay, E.J., 1976c, Preliminary geologic map and coal sections of the King Mountain quadrangle, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-817, scale 1:24,000, 2 sheets.

McLellan, Marguerite, 1981a, Geologic map and coal resources of the Box Elder Creek quadrangle, Powder River County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1297, scale 1:24,000.

_____1981b, Geologic map and coal resources of the Leslie Creek quadrangle, Powder River County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1296, scale 1:24,000.

Olive, W.W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U.S. Geological Survey Bulletin 1050, 83 p.

Sarnecki, J.C., 1977, Geologic map and coal sections of the Lacey Gulch quadrangle, Big Horn and Rosebud Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-832, scale 1:24,000, 2 sheets.

Shifflett, C.M., 1982, Map showing utility and industrial power sources in the conterminous United States: U.S. Geological Survey Miscellaneous Field Studies Map MF-1392, scale 1:2,500,000, 2 sheets, and accompanying State list (pamphlet), 22 p.

Stone, R.W., and Lupton, C.T., 1910, The Powder River coal field, Wyoming, adjacent to the Burlington Railroad: U.S. Geological Survey Bulletin 381-B, p. 115-136.

Trumbull, J.V.A., 1960, Coal fields of the United States, Sheet 1 (the U.S.A. exclusive of Alaska): Washington, D.C., U.S. Geological Survey, scale 1:5,000,000.

U.S. Bureau of Land Management, 1974-77, Surface-Minerals Management Quadrangle: U.S. Bureau of Land Management, Surface-Minerals Management Quadrangle nos. 1-110, scale 1:126,720.

_____1974, Draft Environmental Impact Statement-Eastern Powder River Basin of Wyoming: Cheyenne, WY., 5 Volumes.

_____1981, Powder River, Final Environmental Impact Statement, Coal: Cheyenne, WY., 88 p., Appendices A-H.

U.S. Bureau of Mines, 1972-78, Minerals Yearbook, Vol. I (1970-76): Washington, D.C., U.S. Government Printing Office.

_____1979, Minerals in the economy of Wyoming: U.S. Bureau of Mines, State Mineral Profiles, 17 p.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and the U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-B, 7 p.

U.S. Department of Energy, Energy Information Administration, 1979, Bituminous coal and Lignite production and mine operations - 1977: U.S. Department of Energy, Energy Information Administration, Energy Data Report DOE/EIA-0118(77), 78 p., 21 figs, 39 tables.

_____1980, Bituminous coal and lignite production and mine operations, 1978: U.S. Department of Energy, Energy Information Administration, Energy Data Reports, DOE/EIA 0118(78), 90 p., 20 figs., 39 tables.

_____1981, Coal production, 1979: U.S. Department of Energy, Energy Information Administration, Energy Data Report DOE/EIA 0118(79), 98 p., 17 figs., 63 tables.

_____1982a, Coal production--1980: U.S. Department of Energy, Energy Information Administration, Energy Data Report DOE/EIA-0118(80), 93 p., 14 figs., 63 tables.

U.S. Department of Energy, Energy Information Administration, 1982b, Coal production--1981: U.S. Department of Energy, Energy Information Administration, Report No. DOE/EIA-0118(81), 104 p., 13 figs., 63 tables.

_____1983, Coal production--1982: U.S. Department of Energy, Energy Information Administration, Report No. DOE/EIA-0118(82), 118 p., 13 figs., 61 tables, appendices.

U.S. Geological Survey, compiler, 1973, Land and coal ownership in the Gillette area, Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-848-B, scale 1:125,000, 1 sheet.

Warren, W.C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Bulletin 1072-J, p. 561-585.
Wayland, R.G., 1981, New maps of Federal Coal: Geological Society of America Bulletin, V. 92, p. 542-550, 14 figures, 3 tables.
Weimer, R.J.,1960, Upper Cretaceous stratigraphy, Rocky Mountain area: American Association of Petroleum Geologists Bulletin, v. 44, no. 1, p. 1-20.
Wood, G.H., Jr., Kehn, T.M., Carter, M.D., and Culbertson, W.C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p., 31 figs., 7 tables.