

Wyoming Geo-notes

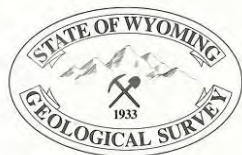
Number 53



Interstate 80 west of Pine Bluffs, Wyoming, follows the route of the Union Pacific Railroad (immediately to right of highway) across southern Wyoming. View is to southwest from atop cliffs capped by Miocene Ogallala Formation (Photograph courtesy of Wyoming Department of Transportation.)

Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
February, 1997



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WYOMING GEO-NOTES

This quarterly digest on the State's geology and mineral resources and activities of the Geological Survey is available by subscription (four issues for \$10.00) or as single copies at \$3.00 each. Two-year subscriptions are accepted.

People with disabilities who require an alternative form of communication in order to use this publication should contact the Editor, Wyoming State Geological Survey at (307) 766-2286. TDD Relay operator 1(800) 877-9975.



Printed on 50% recycled fiber paper. 500 copies printed by Pioneer Printing and Stationery Company, Cheyenne, Wyoming.

Cover: This is the cover photo on our new publication describing the geology and some of the history along Interstate 80 across southern Wyoming. Public Information Circular 37 is a 2'x3' full-color sheet, which is folded like a highway map of the State. The full title and ordering information are on p. 56 of this issue.

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MINERALS UPDATE

OVERVIEW

Gary B. Glass

State Geologist, Wyoming State Geological Survey

Although official production figures for oil, natural gas, and coal produced in Wyoming in 1996 will not be available until later this year, extrapolation from available preliminary figures indicate the production of all three of these fossil fuels will exceed the estimates made by the Consensus Revenue Estimating Group (CREG) back in October of 1996. In addition, the price received for Wyoming oil remained above \$21.00 a barrel through the last quarter of 1996 and into the new year. Natural gas prices more than doubled by the end of the year and have stayed over \$2.00 per thousand cubic feet (MCF) into 1997. Consequently, many of the production and price forecasts in **Tables 1 and 2** in this overview have been changed to reflect new estimates made by CREG or us in January of this year.

Oil production in 1996 is now estimated at 72.7 million barrels, which is one million barrels higher than CREG's earlier prediction (**Table 1; Figure 1**). As a result, the decline in oil production in 1996 slowed to about 4%, down from the average 5.5% decline seen over the previous ten years. In addition, estimates of oil production between 1997 and 2003 have been increased somewhat from October estimates. For 1997 and the ensuing years, the predicted rate of decline in production, is set at 5.5%, rather than 4%.

Table 1. Wyoming mineral production (1985-1995) with forecasts to 2003¹.

Calendar Year	Oil ^{2,3}	Natural Gas ^{3,4}	Carbon Dioxide ^{3,4}	Helium ^{4,5}	Coal ⁶	Trona ⁶	In-situ Uranium ^{7,8}	Sulfur ^{3,9}
1985	131.0	597.9	—	—	140.4	11.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	994.3	142.6	1.07	263.9	18.1	1.3	1.20
1996	*72.7	*1,031.3	*142.6	*1.07	*279.7	*18.8	*2.0	*1.20
1997	69.8	1,045.1	142.6	1.07	289.5	21.1	2.0	1.20
1998	66.0	1,072.4	142.6	1.07	304.0	21.1	2.5	1.20
1999	62.3	1,100.4	142.6	1.07	322.2	21.1	2.9	1.20
2000	58.9	1,129.0	142.6	1.07	344.5	22.6	2.9	1.20
2001	55.7	1,167.2	142.6	1.07	351.4	22.6	2.9	1.20
2002	52.6	1,206.5	142.6	1.07	355.0	24.4	2.9	1.20
2003	49.7	1,247.0	142.6	1.07	358.6	24.4	2.9	1.20

*Estimated until official figures are available.

¹Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2003, January, 1997; ²Millions of barrels; ³Wyoming Oil & Gas Conservation Commission, 1985-1995; ⁴ Billions of cubic feet; ⁵Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; ⁶Millions of short tons (Wyoming State Inspector of Mines, 1985-1995); ⁷Wyoming State Inspector of Mines, 1985-1995; ⁸Millions of pounds of yellowcake (not available [NA] for 1985 and previous years because it was only reported as taxable value); ⁹Millions of short tons.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1995) with forecasts to 2003¹.

Calendar				
Year	Oil ²	Methane ³	Coal ⁴	Trona ⁵
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	41.86
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	44.50
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	*19.50	*1.47	*6.23	*44.09
1997	17.00	1.89	6.07	44.49
1998	15.00	1.50	5.95	44.60
1999	15.00	1.50	5.80	44.97
2000	15.00	1.50	5.65	45.57
2001	15.00	1.50	5.54	45.96
2002	15.00	1.50	5.50	46.20
2003	15.00	1.50	5.50	46.44

* Estimated until official figures are available.
1. Adapted from CREG, Wyoming State Government Revenue Forecast FY97-FY2003, January, 1997; 2. First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1995; 3. Wellhead price in dollars per thousand cubic feet (MCF). Source: Wyoming State Land and Farm Loan Office, 1989-1995 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); 4. Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-1995; 5. Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1995.

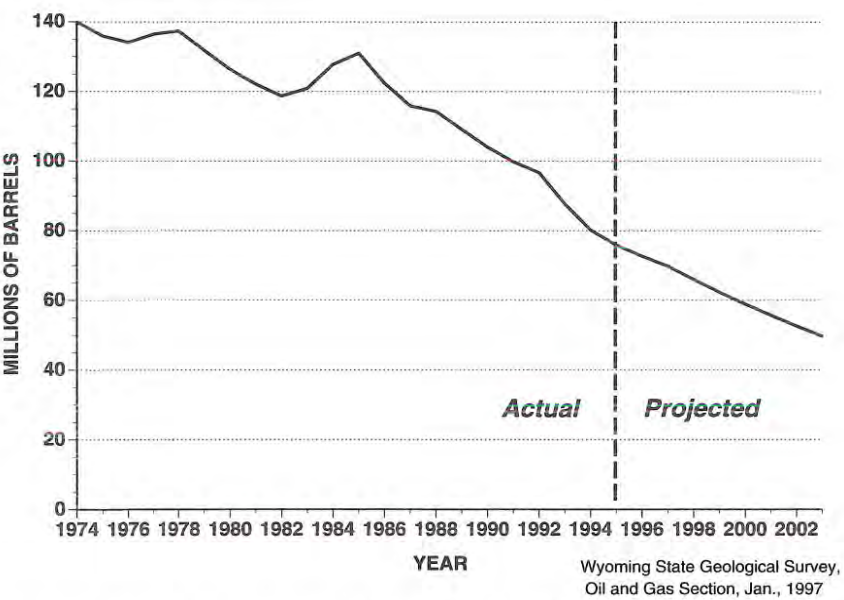


Figure 1. Annual oil production from Wyoming (1974 to 1995) with forecasts to 2003.

In regard to oil prices, CREG has estimated an average price of \$19.50 for 1996. This is the highest since 1990, when the Gulf war took it to \$21.08 (Table 2; Figures 2 and 3). It is also 90 cents higher than the October estimate. In the fourth quarter, oil prices mirrored a greater demand for Wyoming oil. The increase in demand was attributed to cold weather, coupled with the need to replace depleted storage capacity. Expecting demand and higher prices to at least continue into the first or second quarter of 1997, CREG increased its forecast price for 1997 to \$17.00, which is \$1.00 higher than its October estimate. Anticipating that price bonuses would be eliminated or reduced when Canadian oil starts flowing into Casper later this year, CREG stayed with their October estimate of \$15.00 a barrel for 1998 through 2003.

In mid-January, a survey by the Wyoming Independent Producers Association indicated a decline of 41 cents to \$2.00 a barrel in the price their members were getting. Many attribute these price declines to the nearly completed Express Pipeline, which will bring Canadian oil into the region, through Casper. While price reductions related to this pipeline were predicted some time ago, decreases prior to its operation were not.

We are now estimating natural gas production for 1996 at 1,175 billion cubic feet, or about 12 billion cubic feet above CREG's October estimate (Table 1; Figure 4). Because the increase in 1996 is attributed to demands related to cold weather, CREG did not change its estimates for 1997 through 2003.

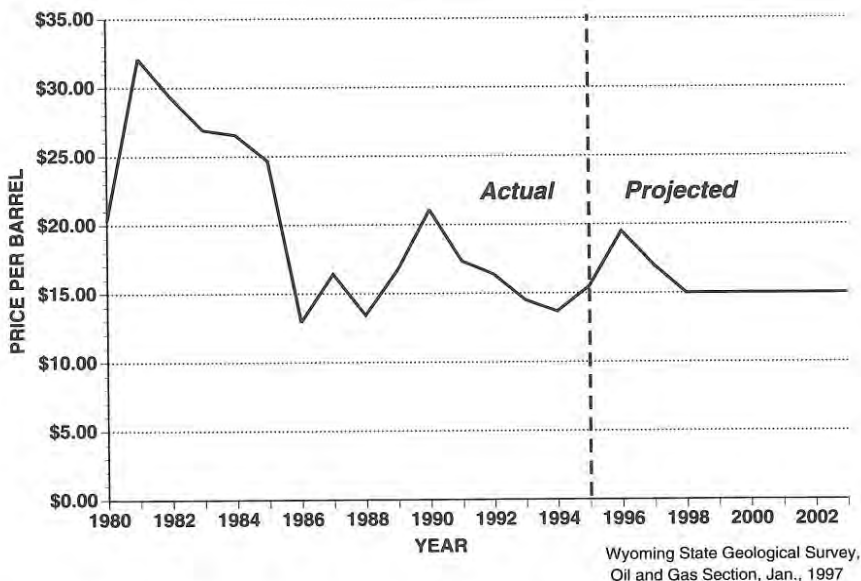
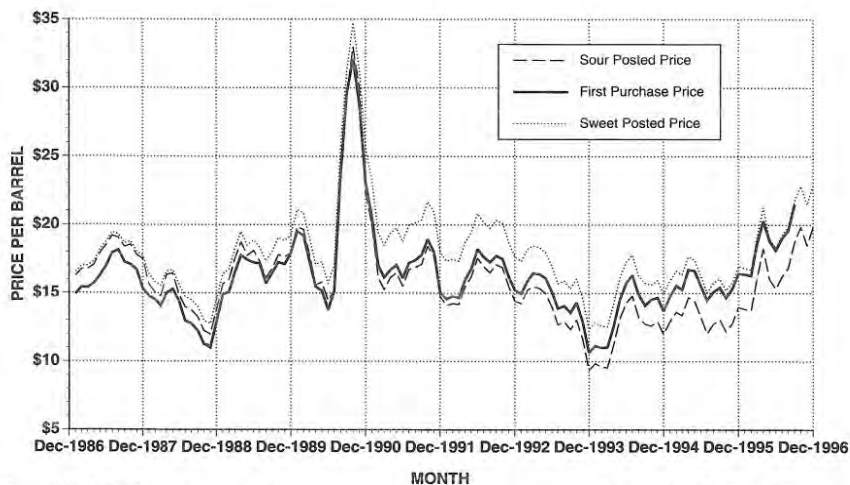


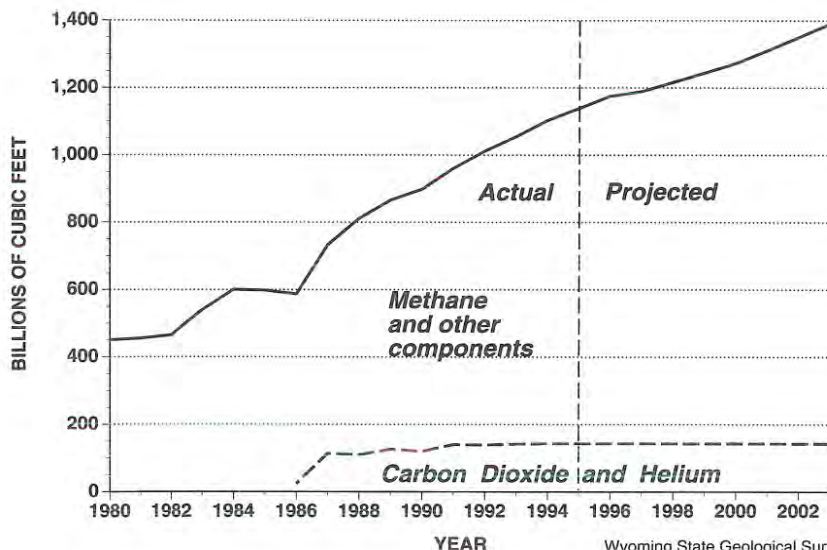
Figure 2. Average prices paid for Wyoming oil (1980 to 1995) with forecasts to 2003.



Source: Unpublished DOE and company data

Wyoming State Geological Survey,
Oil and Gas Section, Jan., 1997

Figure 3. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).



Wyoming State Geological Survey,
Oil and Gas Section, Jan., 1997

Figure 4. Annual natural gas production from Wyoming (1989 to 1995) with forecasts to 2003.

Natural gas prices, which averaged only \$1.17 an MCF through October, increased substantially in the last two months of 1996. For November and December, the spot price at Opal averaged \$2.45 and \$3.50, respectively. The prices have remained above \$2.00 into the new year. Our January estimate for the average natural gas price in 1996 is \$1.47, or 27 cents higher than CREG's October estimate (**Table 2, Figures 5 and 6**). Citing further cold weather demands and the need to replenish storage supplies, CREG increased its 1997 price forecast to \$1.89 an MCF. For the years 1998 through 2003, CREG now forecasts natural gas prices to average \$1.50. This average is 20 cents an MCF higher than CREG's October forecast.

Coal production also finished out the year higher than we estimated for CREG in October. We have increased our estimate of 1996 coal production to 279.7 million tons, an increase of 6% over 1995 production (**Tables 1, 3 and 4; Figures 7-9**). The six percent annual increase in production is approximately half of the annual increases of the previous three years, and about twice what we had expected after utilities met the 1995 deadline for compliance with Phase I of the amendments to the Clean Air Act of 1990. Our estimates of coal production for 1997 through 2003 have also been increased in light of what occurred in 1996. The rate of production gains, however, is expected to decline again in 1997, but increase to almost 7% by 2000, which is the Phase II deadline for compliance with the Clean Air Act (**Tables 2 and 3**).

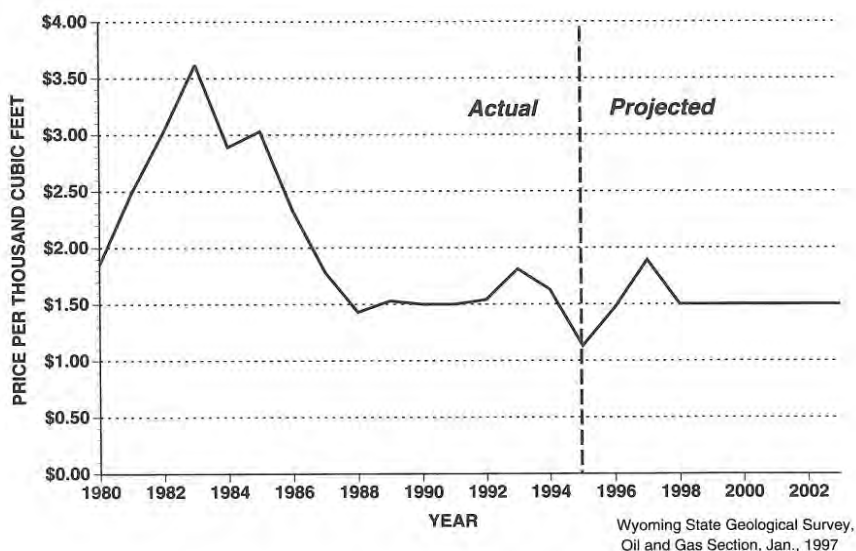


Figure 5. Average prices paid for Wyoming methane (1980 to 1995) with forecasts to 2003.

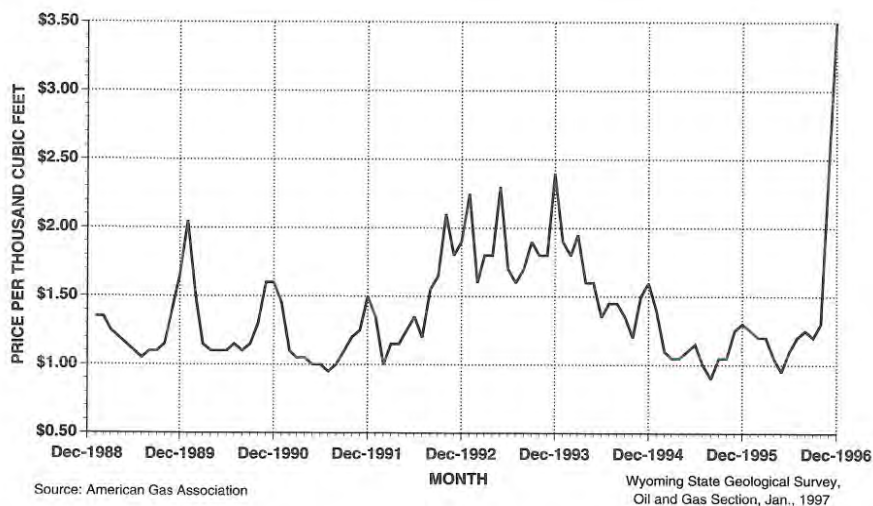


Figure 6. Spot sale prices for methane at Opal, Wyoming, averaged by month (1989 to present).

Coal prices in the Powder River Basin apparently softened even more in the last quarter of 1996. While the average price for 8,800-Btu/lb. coal was reportedly under \$4.00 a ton, the average price for 8,400-Btu/lb. coal was under \$3.20. Prices for higher-Btu coal from southern Wyoming, on the other hand, reportedly increased 14-53 cents a ton. These changes in current prices, however, did not warrant changing our forecast average price for Wyoming coal. Consequently, the price estimates for 1996 through 2003 in **Tables 2 and 5** and depicted in **Figure 10** are the same as those we made in October of 1996. These estimates remain above the currently quoted prices because they include older, long-term contracts signed at higher prices or increased by price-escalation clauses.

The continued low prices quoted for Powder River Basin coals appear to have had two effects on the markets or production of these coals. First, low prices probably account for the higher than expected demand for these coals in 1996 as utilities took advantage of bargain prices. Secondly, low prices likely had some part in the sale of two more mines and reserves from yet another. Early in 1997, Drummond Coal Co. sold its Caballo Rojo and Fort Union mines to Kennecott Energy. And Kerr-McGee sold the remaining reserves at its Clovis Point property to Western Fuels Association (WFA). These reserves are adjacent to WFA's Dry Fork mine. As mentioned last quarter, Kerr-McGee Coal recently sold its Clovis Point mine facilities and about 127 million tons of reserves on that property to Wyodak Resources; WFA idled production at its Dry Fork mine to about 800,000 tons a year and began buying spot coal from other producers; and Zeigler Coal Holding delayed the opening of its new North

Table 3. Wyoming coal production by county (in millions of tons), from 1993 to 1995 with forecasts to 2003.

	1993	1994	1995	1996 ¹	1997 ¹	1998 ¹	1999 ¹	2000 ¹	2001 ¹	2002 ¹	2003 ¹
Campbell County	181.9	205.2	232.4	247.6	258.2	272.0	289.9	312.2	319.1	322.7	326.3
Converse County	10.2	11.7	14.1	14.3	14.5	15.0	15.3	15.3	15.3	15.3	15.3
Sheridan County	0.1	0.1	M	M	M	M	M	M	M	M	M
Carbon County	4.4	4.4	3.8	4.1	3.8	4.0	4.0	4.0	4.0	4.0	4.0
Sweetwater County	9.2	11.2	9.1	9.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.1	4.3	4.5	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming	209.9	236.9	263.9	279.7	289.5	304.0	322.2	344.5	351.4	355.0	358.6
Annual Change	10.8%	12.9%	11.4%	6.0%	3.5%	5.0%	6.0%	6.9%	2.0%	1.0%	1.0%
Low-priced coal ²	64%	67%	74%	76%	78%	83%	87%	91%	94%	96%	96%

¹County estimates by Wyoming State Geological Survey, February, 1997; ²Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under \$5.00. M means minor tonnage (less than 0.1 million tons).

Table 4. Monthly coal deliveries from Wyoming's mines in short tons (1993-1996).

	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	15,931,150	15,931,150	19,326,770	19,326,770	21,586,303	21,586,303	21,793,387	21,793,387
FEB	14,646,090	30,577,240	17,171,910	36,498,680	20,839,926	42,426,229	20,374,055	42,167,442
MAR	17,112,970	47,690,210	19,178,990	55,677,670	21,707,422	64,133,651	22,507,800	64,675,242
APR	16,259,770	63,949,980	17,839,110	73,516,780	20,066,616	84,200,267	22,579,959	87,255,201
MAY	16,085,470	80,035,450	18,652,290	92,169,070	21,509,916	105,710,183	22,216,016	109,471,217
JUN	16,473,920	96,509,370	17,741,480	109,910,550	18,602,505	124,312,688	20,698,814	130,170,031
JUL	15,296,480	111,805,850	18,213,540	128,124,090	21,334,608	145,647,296	24,842,971	155,013,002
AUG	16,682,090	128,487,940	20,572,120	148,696,210	21,356,870	167,004,166	24,421,537	179,434,539
SEP	17,310,330	145,798,270	19,129,450	167,825,660	21,355,730	188,359,896	23,339,792	202,774,331
OCT	18,300,070	164,098,340	18,189,260	186,014,920	21,178,610	209,538,506		
NOV	18,007,970	182,106,310	18,595,500	204,610,420	21,042,260	230,580,766		
DEC	19,034,530	201,140,840	20,866,710	225,477,130	22,032,910	252,613,676		
Total Tonnage Reported¹	201,140,840		225,477,130			252,613,676		
Total Tonnage Not Reported²	8,784,986		11,430,937			11,324,347		
Total Tonnage Produced³	209,925,826		236,908,067			263,938,023		

¹ COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities (1993-1995); From bulletin board of the Federal Energy Regulatory Commission in 1996.

² Includes estimated of residential, industrial, and exported coal, plus tonnages not reported on FERC's 423 forms.

³ Wyoming State Mine Inspector's Annual Reports.

Wyoming State Geological Survey, Coal Section, October, 1996.

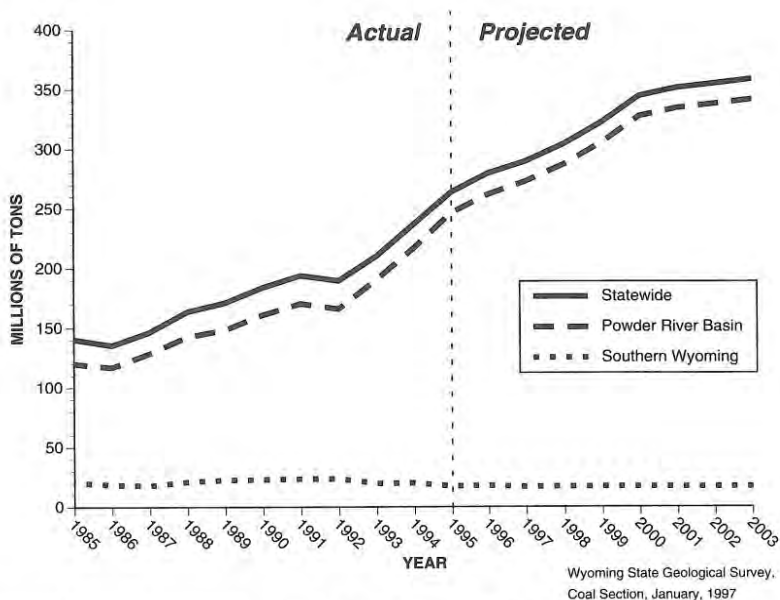
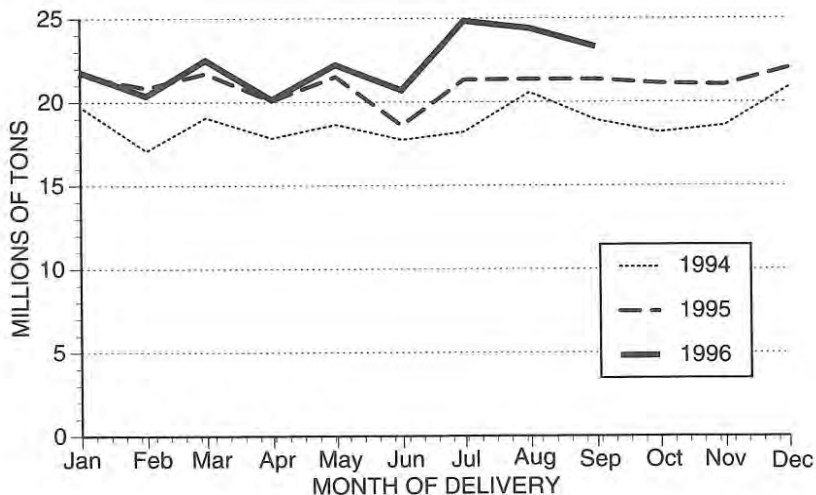


Figure 7. Annual coal production from Wyoming (1970-1995) with forecasts to 2003. Data from Wyoming State Inspector of Mines (1970-1995) and Wyoming Consensus Revenue Estimating Group (1996-2003).



Wyoming State Geological Survey, Coal Section, January, 1997

Figure 8. Reported monthly deliveries from Wyoming coal mines (1994 through September, 1996). From COALDAT Marketing Report by Resource Data International, Inc., (1994 and 1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996.

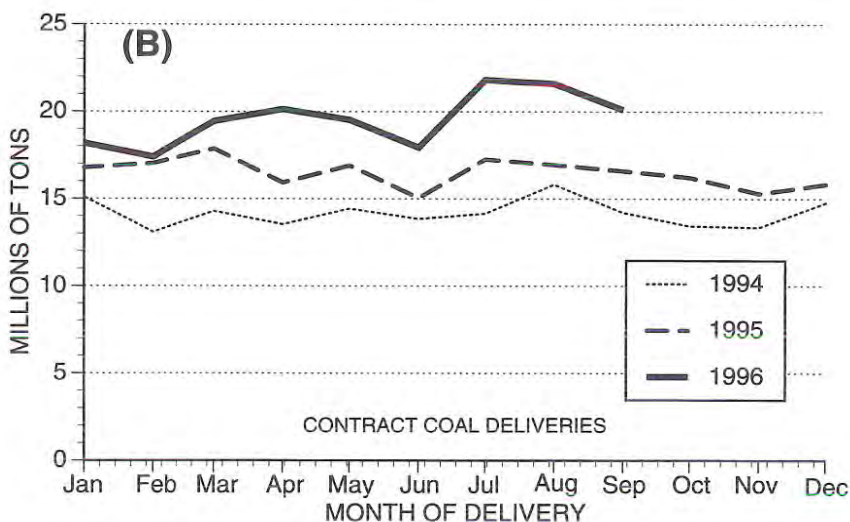
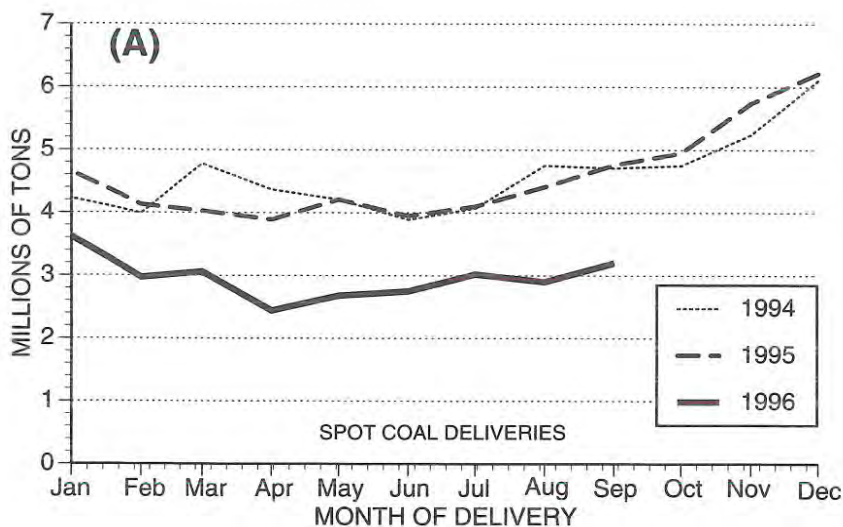


Figure 9. Monthly coal deliveries from Wyoming (1994 through September, 1996). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data Internation, Inc. (1994-1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996).

Table 5. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1995) with forecasts to 2003¹.

Year	Northeastern	Southern	Statewide
1988	\$7.35	\$21.45	\$9.16
1989	\$6.94	\$19.76	\$8.63
1990	\$6.86	\$19.36	\$8.43
1991	\$6.58	\$18.81	\$8.06
1992	\$6.61	\$18.84	\$8.13
1993	\$6.02	\$17.72	\$7.12
1994	\$5.62	\$17.42	\$6.62
1995	\$5.60	\$17.35	\$6.38
1996	\$5.44	\$17.30	\$6.23
1997	\$5.35	\$17.30	\$6.07
1998	\$5.26	\$17.30	\$5.95
1999	\$5.19	\$17.10	\$5.80
2000	\$5.13	\$17.00	\$5.65
2001	\$5.02	\$17.00	\$5.54
2002	\$4.99	\$17.00	\$5.50
2003	\$4.99	\$17.00	\$5.50

¹Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1994 are derived from Wyoming Department of Revenue information; estimates for 1996-2003 are from the Consensus Revenue Estimating Group's report of October, 1996; and all regional breakdowns are estimated by the Wyoming State Geological Survey.

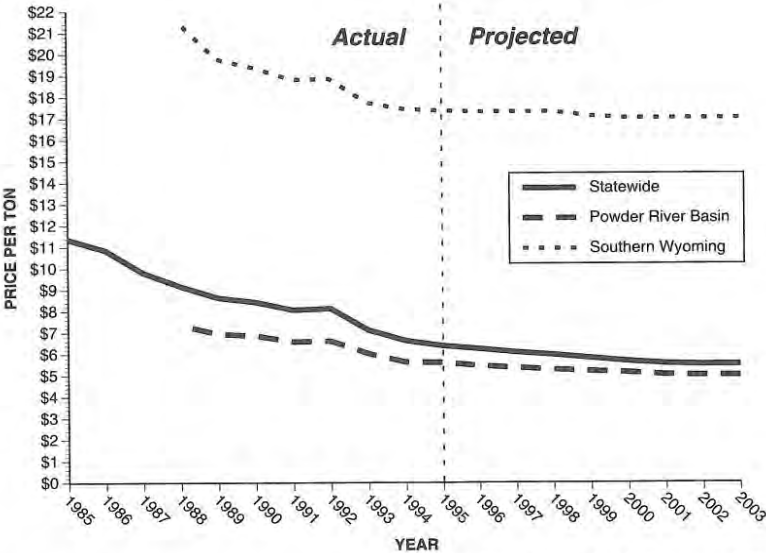


Figure 10. Average prices paid for Wyoming coal (1970 to 1995) with estimates to 2003. Source: U.S. Energy Information Administration (1970-1990); derived from the Wyoming Department of Revenue (1991-1995); and the Consensus Revenue Estimating Group (1996-2003).

Rochelle mine at least in part because of low coal prices. Meanwhile there are enough mines increasing their productive capacity to pick up the slack (see **Coal Update** in this issue).

Although the spot market price for uranium declined to \$13.90 by the end of the year, interest in Wyoming uranium continues with the sale of Power Resources, Inc. to Cameco, a large uranium mining and producing company based in Saskatchewan (p. 41). In late-March, Riverton will be the site of a uranium and nuclear conference in Wyoming, sponsored by the Riverton Ranger.

In addition to discussions of Tg Soda Ash's announced plans for a new trona mine, Solvay Minerals' planned expansion project, and plans for an International Soda Ash Conference in June, the **Industrial Minerals and Uranium Update** also notes there was interest in dimensional stone, limestone, silica sand, and a glass plant in the fourth quarter of 1996. And in early February, OCI Chemical Corp. announced it also would be applying for permits to expand its plant capacity to as much as 3.3 million tons of soda ash a year.

In December, a 5.39-carat diamond from the Colorado side of the Colorado-Wyoming State Line diamond district was sold to an anonymous buyer for \$89,000. The diamond was cut from a 28.3-carat stone found in September.

The **Metals and Precious Stones Update** includes a discussion of recent diamond exploration in Wyoming. It also describes some anomalous precious and base metal samples collected during the Wyoming State Geological Survey's field work in the Encampment mining district in 1996.

In a continuing series of articles on historical seismicity in Wyoming, this issue also contains a summary of the earthquakes that have been felt in the central portion of the State. Previous issues have highlighted historical earthquakes in northeastern and east-central Wyoming, as well as those in Yellowstone National Park.

OIL AND GAS UPDATE

Rodney H. De Bruin

Staff Geologist-Oil and Gas, Wyoming State Geological Survey

While the prices paid to Wyoming oil producers during 1996 averaged an estimated \$19.50 per barrel (**Table 6**), the average price in the fourth quarter was about \$22.08 per barrel. Oil prices haven't averaged this high since 1990 (**Figure 2, Table 2**) when the average price was \$21.08 per barrel.

Table 6. Monthly average price of a barrel of oil produced in Wyoming (1993 to present).

	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	\$ 15.08	\$ 15.08	\$ 11.15	\$ 11.15	\$ 14.77	\$ 14.77	\$ 16.38	\$ 16.38
FEB	\$ 16.00	\$ 15.54	\$ 11.01	\$ 11.08	\$ 15.55	\$ 15.16	\$ 16.28	\$ 16.33
MAR	\$ 16.47	\$ 15.85	\$ 11.04	\$ 11.07	\$ 15.26	\$ 15.19	\$ 18.63	\$ 17.09
APR	\$ 16.41	\$ 15.99	\$ 12.59	\$ 11.45	\$ 16.73	\$ 15.58	\$ 20.29	\$ 17.90
MAY	\$ 16.11	\$ 16.01	\$ 14.53	\$ 12.07	\$ 16.65	\$ 15.79	\$ 18.85	\$ 18.08
JUN	\$ 15.11	\$ 15.86	\$ 15.73	\$ 12.68	\$ 15.52	\$ 15.75	\$ 18.15	\$ 18.10
JUL	\$ 13.91	\$ 15.58	\$ 16.31	\$ 13.20	\$ 14.50	\$ 15.57	\$ 18.98	\$ 18.22
AUG	\$ 14.08	\$ 15.39	\$ 14.89	\$ 13.41	\$ 15.09	\$ 15.51	\$ 19.59	\$ 18.39
SEP	\$ 13.57	\$ 15.19	\$ 14.10	\$ 13.49	\$ 15.41	\$ 15.50	\$ 21.51	\$ 18.74
OCT	\$ 14.23	\$ 15.09	\$ 14.53	\$ 13.59	\$ 14.67	\$ 15.42	\$22.50	\$19.12
NOV	\$ 12.92	\$ 14.89	\$ 14.68	\$ 13.67	\$ 15.32	\$ 15.41	\$21.25	\$19.31
DEC	\$ 10.66	\$ 14.54	\$ 13.71	\$ 13.67	\$ 16.43	\$ 15.50	\$22.50	\$19.50
Average yearly price		\$ 14.54		\$ 13.67		\$ 15.50		\$19.50

Source: All averages are derived from unpublished monthly reports by the Energy Information Administration, except that averages in bold print in 1996 are estimated from various unpublished bulletins listing posted prices.

Wyoming State Geological Survey, Oil and Gas Section, January, 1997

Based on preliminary figures published by Petroleum Information, Inc., oil production for the first nine months of 1996 was 54.3 million barrels (**Table 7**). Year-end oil production for 1996 is now an estimated 72.7 million barrels.

Average spot sale prices for natural gas at Opal, Wyoming, were also higher during the fourth quarter of 1996 than for any quarter in the last several years (**Table 8** and **Figure 6**). The average spot price for the fourth quarter was \$2.42 per thousand cubic feet (MCF). The overall average price for 1996 was an estimated \$1.47 per MCF (**Table 2**). The higher fourth-quarter price this year is attributed to increased demand for filling storage, which was depleted by last winter's harsh weather, and colder than average temperatures so far this winter. The \$3.50 spot price in December is currently the highest on record for Wyoming gas in the 11 years that spot prices have been recorded.

Natural gas production in Wyoming during the first nine months of 1996 was a reported 878.4 billion cubic feet according to preliminary production figures from Petroleum Information, Inc. This production is the State's highest total for the first nine months of any year (**Table 9**). Year-end natural gas production for 1996 is now estimated at 1,175 billion cubic feet. Natural gas production from Wyoming has increased every year since 1986 (**Figure 4**).

KN Energy has announced firm transportation contracts for a total of 230 million cubic feet of gas per day for its new Pony Express natural gas pipeline, which will serve the Kansas City area. The contracts are with Western Resources and Missouri Gas Energy, the two largest natural gas distributing companies serving that area. Both of the contracts are for approximately 20 years. The pipeline should begin shipping gas in the second quarter of 1997.

The average daily rig count for the fourth quarter of 1996 averaged 30, which is the highest average count in a fourth quarter since 1994 (**Figure 11**). The average for all of 1996, however, was just 24, which is the same as last year (**Figure 12**).

Louisiana Land & Exploration plans to join Tom Brown, Inc. in an exploration alliance that covers 500,000 acres on the Wind River Indian Reservation.

Coastal Field Services and Snyder Oil have formed Great Divide Gas Services, a joint-venture, limited liability company. Coastal Field Services owns 73% of the new company, with Snyder Oil owning the remaining 27%. The assets of these two companies include more than 600 miles of field pipelines connecting 650 gas wells that produce an aggregate 165 million cubic feet of gas per day. Many of these holdings are in the Washakie, Wind River, Green River, and Bighorn Basins of Wyoming. Great Divide will oversee the operation and expansion of these gas pipelines as well as the development of new facilities within six areas of mutual interest to Coastal Field Services and Snyder Oil.

A recent report by the U.S. Department of the Interior (1996) shows that Wyoming received more Federal mineral royalties in fiscal year 1995 than any

Table 7. Monthly oil production from Wyoming in barrels (1993 to present).

	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	7,616,208	7,616,208	7,115,472	7,115,472	6,700,000	6,700,000	6,145,017	6,145,017
FEB	6,583,954	14,200,162	6,387,147	13,502,619	6,100,000	12,800,000	5,681,352	11,826,369
MAR	7,690,771	21,890,933	6,984,248	20,486,867	6,300,000	19,100,000	6,167,126	17,993,495
APR	7,355,334	29,246,267	6,672,207	27,159,074	6,200,000	25,300,000	5,956,261	23,949,756
MAY	7,533,207	36,779,474	6,847,709	34,006,783	6,300,000	31,600,000	6,004,480	29,954,236
JUN	7,307,445	44,086,919	6,594,914	40,601,697	6,200,000	37,800,000	5,884,800	35,839,036
JUL	7,572,346	51,659,265	6,773,956	47,375,653	6,300,000	44,100,000	6,002,613	41,841,649
AUG	7,370,091	59,029,356	6,685,423	54,061,076	6,100,000	50,200,000	6,326,016	48,167,665
SEP	7,162,224	66,191,580	6,446,719	60,507,795	6,100,000	56,300,000	6,125,368	54,293,033
OCT	7,374,889	73,566,469	6,525,817	67,033,612	6,300,000	62,600,000		
NOV	6,897,568	80,464,037	6,257,924	73,291,536	6,100,000	68,700,000		
DEC	7,203,163	87,667,200	6,236,204	79,527,740	6,300,000	75,000,000		
Total Barrels Reported¹		87,667,200		79,527,740		75,000,000		54,293,033
Total Barrels Not Reported²		1,233,006		651,400		554,113		
Total Barrels Produced³		88,960,236		80,179,140		75,554,113		

¹Monthly production reports from Petroleum Information, except for 1995 which is estimated by the Wyoming State Geological Survey.

² (Total barrels produced) minus (total barrels reported by Petroleum Information).

³ Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, January, 1997.

Table 8. Monthly average spot sale price of a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1993 to present).

	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	\$ 2.25	\$ 2.25	\$ 1.90	\$ 1.90	\$ 1.40	\$ 1.40	\$1.25	\$1.25
FEB	\$ 1.60	\$ 1.93	\$ 1.80	\$ 1.85	\$ 1.10	\$ 1.25	\$1.20	\$1.23
MAR	\$ 1.80	\$ 1.89	\$ 1.95	\$ 1.88	\$ 1.05	\$ 1.18	\$1.20	\$1.22
APR	\$ 1.80	\$ 1.87	\$ 1.60	\$ 1.81	\$ 1.05	\$ 1.15	\$1.05	\$1.18
MAY	\$ 2.30	\$ 1.96	\$ 1.60	\$ 1.77	\$ 1.10	\$ 1.14	\$0.95	\$1.13
JUN	\$ 1.70	\$ 1.91	\$ 1.35	\$ 1.70	\$ 1.15	\$ 1.14	\$1.10	\$1.13
JUL	\$ 1.60	\$ 1.87	\$ 1.45	\$ 1.66	\$ 1.00	\$ 1.12	\$1.20	\$1.14
AUG	\$ 1.70	\$ 1.85	\$ 1.45	\$ 1.64	\$ 0.90	\$ 1.09	\$1.25	\$1.15
SEP	\$ 1.90	\$ 1.85	\$ 1.35	\$ 1.61	\$ 1.05	\$ 1.09	\$1.20	\$1.16
OCT	\$ 1.80	\$ 1.84	\$ 1.20	\$ 1.57	\$ 1.05	\$ 1.09	\$1.30	\$1.17
NOV	\$ 1.80	\$ 1.84	\$ 1.50	\$ 1.56	\$ 1.25	\$ 1.10	\$2.45	\$1.29
DEC	\$ 2.40	\$ 1.89	\$ 1.60	\$ 1.57	\$ 1.30	\$ 1.12	\$3.50	\$1.47
Average yearly price		\$ 1.89		\$ 1.57		\$ 1.12		\$1.47

Source: American Gas Association's monthly reports

Wyoming State Geological Survey, Oil and Gas Section, January, 1997

Table 9. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1993 to present).

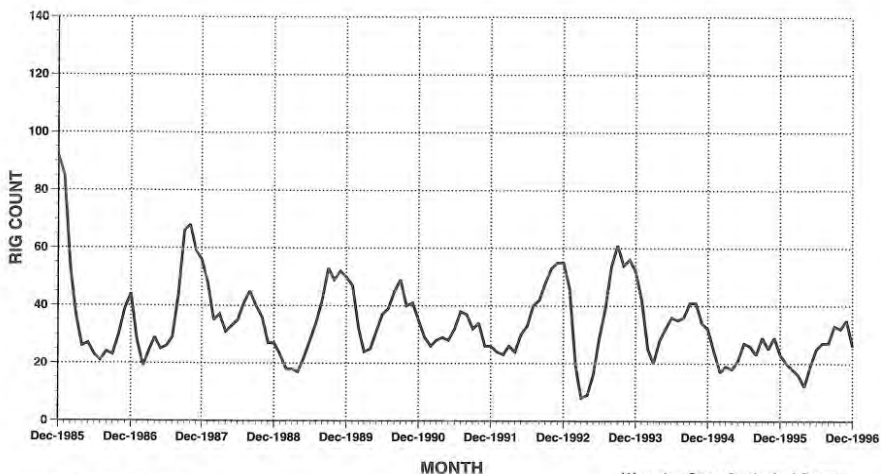
	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	88,172,339	88,172,339	93,146,775	93,146,775	100,224,249	100,224,249	101,315,119	101,315,119
FEB	80,726,687	168,899,026	85,623,666	178,770,441	86,691,577	186,915,826	96,268,679	197,583,798
MAR	88,920,212	257,819,238	94,388,052	273,158,493	94,344,991	281,260,817	103,594,144	301,177,942
APR	86,208,224	344,027,462	92,362,726	365,521,219	93,929,323	375,190,140	99,461,156	400,639,098
MAY	87,857,947	431,885,409	93,886,923	459,408,142	95,791,327	470,981,467	97,844,457	498,483,555
JUN	74,555,764	506,441,173	81,764,661	541,172,803	92,140,614	563,122,081	86,967,598	585,451,153
JUL	91,832,536	598,273,709	94,998,414	636,171,217	92,796,301	655,918,382	100,004,406	685,455,559
AUG	91,562,051	689,835,760	93,743,790	729,915,007	90,393,416	746,311,798	99,668,550	785,124,109
SEP	90,580,094	780,415,854	88,476,703	818,391,710	92,589,092	838,900,890	93,322,076	878,446,185
OCT	93,388,208	873,804,062	95,232,646	913,624,356	98,386,458	937,287,348		
NOV	88,046,821	961,850,883	95,312,491	1,008,936,847	94,939,660	1,032,227,008		
DEC	90,133,281	1,051,984,164	87,115,084	1,096,051,931	99,314,617	1,131,541,625		
Total MCF Reported¹		1,051,984,164		1,096,051,931		1,131,541,625		878,446,185
Total MCF Not Reported²		2,715,623		6,879,705		6,448,396		
Total MCF Produced³		1,054,699,787		1,102,931,636		1,137,990,021		

¹ Monthly production reports from Petroleum Information, Inc.

² (Total MCF produced) minus (total MCF reported by Petroleum Information).

³ Wyoming Oil and Gas Conservation Commission.

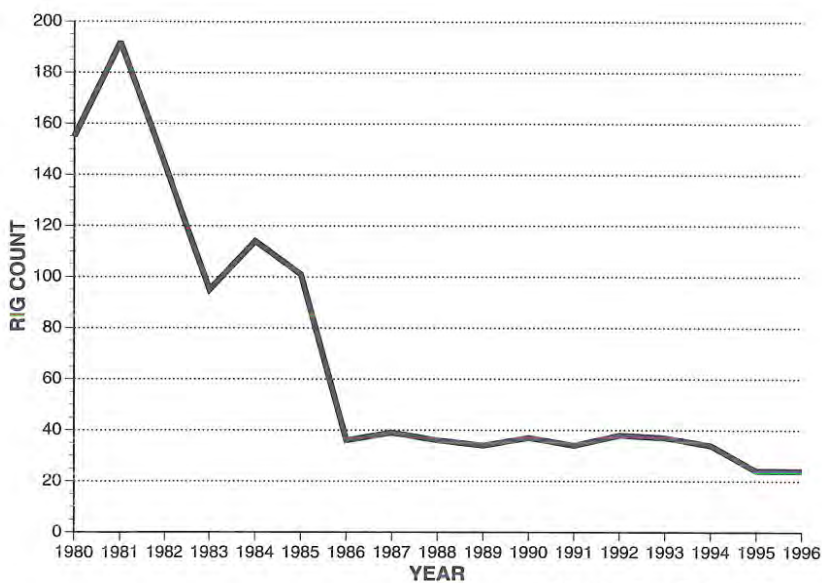
Wyoming State Geological Survey, Oil and Gas Section, January, 1997



Source: Hughes Rig Count

Wyoming State Geological Survey,
Oil and Gas Section, Jan., 1997

Figure 11. Wyoming daily rig count averaged by month (1986 to present).



Wyoming State Geological Survey,
Oil & Gas Section, Jan., 1997

Figure 12. Wyoming daily rig count averaged by year (1980 to present).

other State. Wyoming received \$214.2 million as its share (\$212 million in the State's fiscal year), or nearly 45% of all distributions from Federal onshore mineral leases. This total is lower than the \$242.1 million distribution in fiscal year 1994, but is still the second highest total in the last ten years. The lower prices for both gas and oil in 1995 as well as declining oil production accounted for this decline in royalty collections. Wyoming was the leading producer of coal, oil, and sodium from Federal onshore mineral leases, and was second to New Mexico in natural gas production. Royalties from these four commodities, bonus bids at lease sales, and rents on oil and gas leases made up most of the Federal mineral revenues paid to Wyoming. Wyoming accounted for 75.1% of all sodium royalties, 58.7% of all coal royalties, 37.3% of all oil royalties, and 27.2% of all natural gas royalties from onshore Federal leases. As a consequence of relatively low prices in the first three-quarters of the year, low bonus bids on leases, and declining oil production, the State expects to receive about \$197.6 million in royalty distribution in fiscal year 1996.

The U.S. Department of Energy (1996) has released its new reserve estimates for crude oil and natural gas. **Table 10** shows Wyoming's relative ranking among the top ten states in proved reserves of natural gas and crude oil. At the end of 1995, Wyoming ranked fourth in natural gas reserves and sixth in crude oil reserves. **Table 11** shows that Wyoming's natural gas reserves increased in 1995 to their highest level ever, despite record production, and its crude oil reserves increased for the first time in several years. Most of these increases are attributed to reserves delineated by either in-fill drilling or field extensions, rather than wildcat discoveries.

In the fourth quarter of 1996, there were four oil and gas lease sales. Although leasing activity at the Wyoming State Land and Farm Loan Office's October sale was fairly scattered throughout the State, the Bighorn Basin had more leasing activity than usual (**Figure 13**). The majority of leases issued at the State Land and Farm Loan Office's December sale were in the Greater Green River and Powder River Basins (**Figure 14**). In the October and December lease sales by the U.S. Bureau of Land Management (BLM) most of the

Table 10. Wyoming's 1995 ranking in proved reserves of crude oil (billions of barrels) and dry natural gas (trillions of cubic feet).

State	Crude Oil	State	Dry Natural Gas
Texas	5.743	Texas	36.542
Alaska	5.580	New Mexico	17.491
California	3.462	Oklahoma	13.438
New Mexico	0.732	Wyoming	12.166
Louisiana	0.637	Alaska	9.497
Wyoming	0.605	Louisiana	9.274
Kansas	0.275	Kansas	8.571
Colorado	0.252	Colorado	7.256
North Dakota	0.233	Alabama	4.868
Utah	0.216	West Virginia	2.499

Source: U.S. Department of Energy, 1996.

Table 11. Comparison of Wyoming's proved reserves of crude oil (billions of barrels), dry natural gas (trillions of cubic feet), and condensate and natural gas liquids (billions of barrels) for the years 1980 through 1995.

Year	Crude Oil	Dry Natural Gas	Condensate and Natural Gas Liquids ¹
1980	0.928	9.100	0.239
1981	0.840	9.307	0.269
1982	0.856	9.758	0.477
1983	0.957	10.227	0.552
1984	0.954	10.482	0.602
1985	0.951	10.617	0.664
1986	0.849	9.756	0.665
1987	0.854	10.023	0.647
1988	0.825	10.308	0.808
1989	0.815	10.744	0.627
1990	0.794	9.944	0.568
1991	0.757	9.941	0.524
1992	0.689	10.826	0.462
1993	0.624	10.933	0.420
1994	0.565	10.789	0.395
1995	0.605	12.166	0.415

Source: U.S. Department of Energy, 1996.
¹Estimated from U.S. Department of Energy figures.

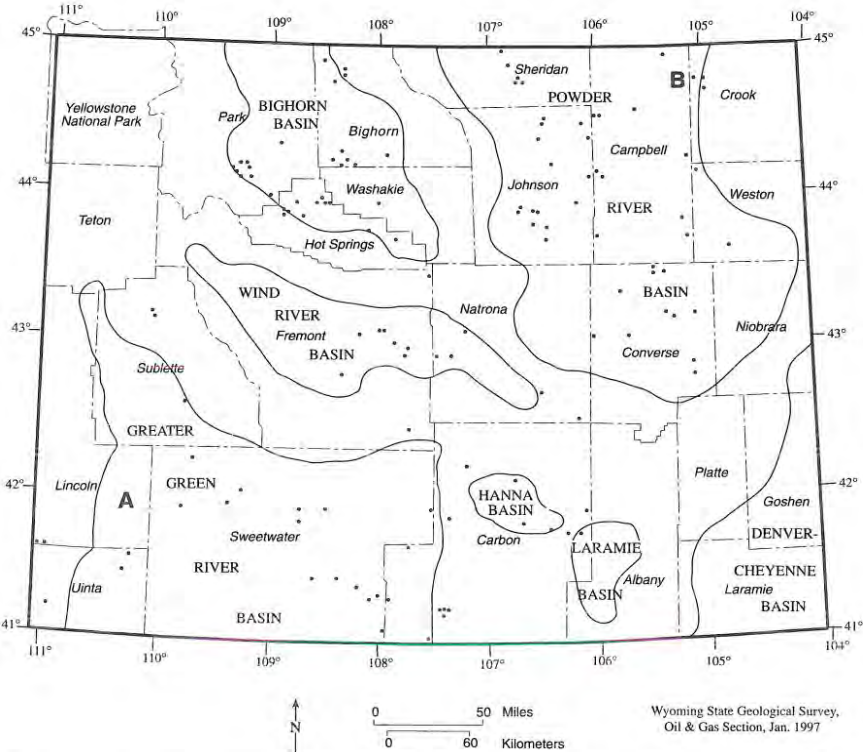


Figure 13. Locations of State oil and gas tracts leased by the State Land and Farm Loan Office at the October, 1996, sale.

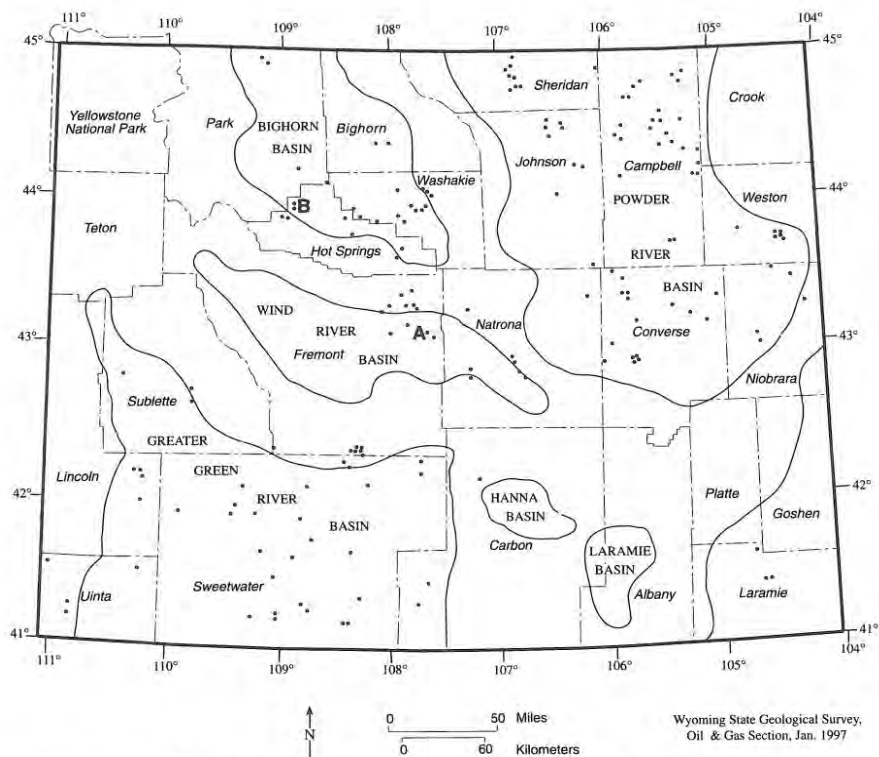


Figure 14. Locations of State oil and gas tracts leased by the State Land and Farm Loan Office at the December, 1996, sale.

issued leases were in the Bighorn and Powder River Basins (**Figures 15 and 16**). The total revenue for these sales was an improvement over earlier sales in 1996 and most sales in 1995. Total revenue for the year, however, was still slightly behind total revenue in 1995, partly because the BLM held one less sale in 1996 than in 1995 (**Table 12**). The high per-acre bid at the October BLM sale was \$270 by Richard Pardon for a 137.37-acre lease in section 14, T50N, R93W. The lease is adjacent to the northwestern edge of Manderson Field (location A, **Figure 15**). The second high per-acre bid was \$230 by Marathon Oil for an 80-acre parcel that covers S/2 SW section 26, T23N, R113W (location B, **Figure 15**). The lease is just west of Frontier and Dakota gas production at Shute Creek Field. In all, 42 leases received bids of \$50 or more per acre at this sale.

The high per-acre bid at the Wyoming State Land and Farm Loan Office's October sale was \$175 by Celsius Energy for a 637.72-acre lease that covers all of section 36, T22N, R113W (location A, **Figure 13**). The lease is about two miles west of Frontier gas production at Cow Hollow Field. The sale's second highest per-acre bid was \$123 by Maurice W. Brown for a 265.85-acre lease in

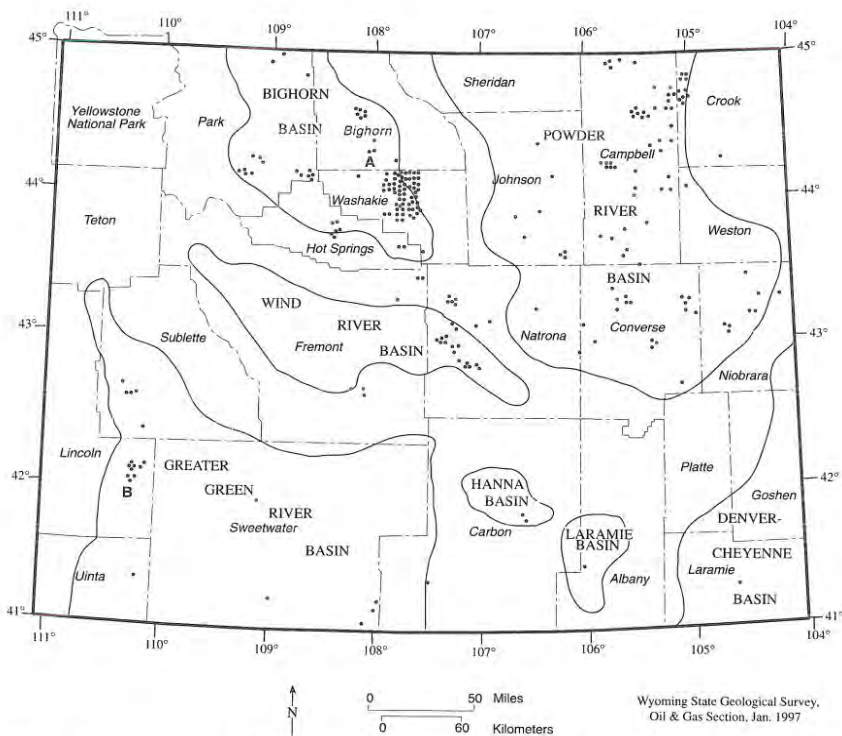


Figure 15. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the October, 1996, sale.

section 6, T55N, R70W (location B, **Figure 13**). The lease is about two miles north of abandoned Minnelusa oil production at Little Field. Nine leases received bids of \$50 or more per acre at this sale.

The high per-acre bid at the BLM's December sale was \$1,450 by Hanson & Strahn for an 18.39-acre parcel in section 14, T50N, R93W (location A, **Figure 16**). The lease is adjacent to the northwestern edge of Manderson Field. The sale's second highest per-acre bid was \$1,000, also by Hanson & Strahn, for a 40-acre parcel that covers SE NE section 14, T50N, R93W (location B, **Figure 16**). This lease is also near Manderson Field. There were several other leases in the vicinity of Manderson Field that were bid at fairly high values. In all, 43 parcels were leased for \$50 or more per acre.

The high per-acre bid at the Wyoming State Land and Farm Loan Office's December sale was \$86 by Yates Petroleum for a 640-acre lease that covers section 16, T36N, R91W (location A, **Figure 14**). The lease is near the Deer Creek II Field discovery in section 15, which produced gas from the Lance. The sale's second highest per-acre bid was \$75 by Marathon Oil for a 360-acre

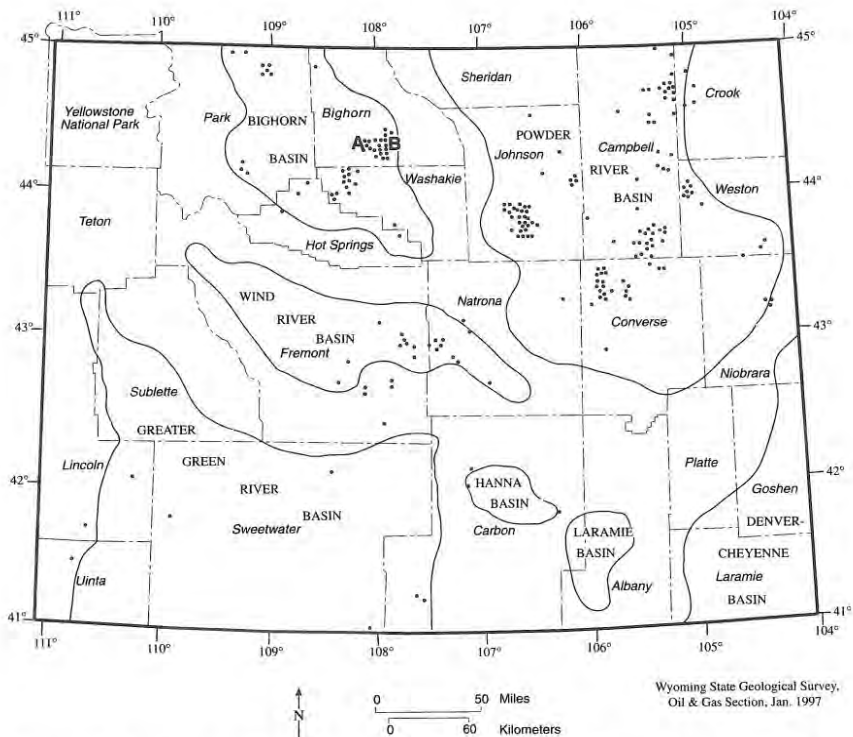


Figure 16. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the December, 1996, sale.

lease in parts of sections 20 and 21, T46N, R100W (location B, **Figure 14**). The parcel is about three miles west of Frontier, Curtis, and Phosphoria production at Enos Creek Field. There were nine leases that received bids of \$50 or more per acre at this sale.

According to the Wyoming Oil and Gas Conservation Commission (WOGCC), Applications for Permit to Drill (APDs) in the fourth quarter increased from the low levels in the first two quarters of 1996, finishing the year at 1,280 (**Table 13**). APDs for 1996 exceeded the number issued in each of the previous four years.

The number of seismic projects permitted by the WOGCC had been dropping steadily since 1992 (**Table 14**) even though the total number of miles shot has remained fairly stable. Permits issued in 1996, however, surpassed the number of permits issued in 1995 and 1994 and fell only four short of the number issued in 1993. The number of 3-D square miles permitted in 1996 set a new record. Once again the seismic projects and miles permitted in 1996

Table 12. Federal and State competitive oil and gas lease sales in Wyoming.

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)							STATE SALES (STATE LAND AND FARM LOAN OFFICE)								
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1993							1993								
TOTAL	\$12,942,008	2,769	1,469	2,065,942	995,344	\$13.00	\$400.00	TOTAL	\$1,980,017	800	562	311,273	222,139	\$8.91	\$400.00
1994							1994								
February	\$3,909,085	442	290	374,989	237,761	\$16.44	\$160.00	March	\$917,380	200	169	84,571	73,061	\$12.56	\$170.00
April	\$4,248,182	498	278	369,657	201,690	\$21.06	\$275.00	May	\$802,688	200	141	75,523	54,199	\$14.81	\$205.00
June	\$3,759,282	480	270	417,447	233,664	\$16.09	\$325.00	September	\$566,083	200	149	83,143	61,675	\$9.50	\$190.00
August	\$5,100,550	439	294	323,410	217,157	\$23.49	\$255.00	November	\$998,001	200	148	88,542	66,217	\$15.07	\$142.00
October	\$4,703,706	492	341	411,117	269,003	\$17.49	\$11,200.00								
December	\$5,386,789	617	367	479,930	290,384	\$18.55	\$390.00								
TOTAL	\$27,107,594	2,968	1,840	2,376,530	1,449,659	\$18.70	\$11,200.00	TOTAL	\$3,304,152	800	607	331,779	255,152	\$12.95	\$205.00
1995							1995								
February	\$3,252,668	533	332	473,177	290,046	\$11.21	\$425.00	March	\$524,165	199	131	89,371	57,702	\$9.08	\$130.00
April	\$1,591,709	531	206	483,826	189,003	\$8.42	\$160.00	May	\$452,747	200	125	75,633	49,735	\$9.10	\$78.00
June	\$3,499,804	393	246	384,746	238,893	\$14.65	\$660.00	September	\$421,454	200	134	78,032	53,527	\$7.87	\$65.00
August	\$1,105,381	488	165	420,189	149,025	\$7.41	\$160.00	November	\$257,852	200	102	80,851	41,744	\$6.18	\$52.00
October	\$2,761,689	477	227	384,683	174,453	\$15.83	\$1,100.00								
December	\$636,195	205	88	180,367	68,321	\$12.24	\$316.00								
TOTAL	\$13,047,246	2,649	1,264	2,326,988	1,109,711	\$11.76	\$1,100.00	TOTAL	\$1,656,218	799	492	323,887	202,708	\$8.17	\$130.00
1996							1996								
February	\$1,635,668	455	192	358,478	137,901	\$11.86	\$220.00	March	\$308,927	199	96	85,369	41,909	\$7.37	\$108.00
June	\$1,438,325	460	282	337,440	181,338	\$7.93	\$210.00	June	\$656,177	250	114	103,621	48,638	\$13.49	\$206.00
August	\$2,021,488	389	182	261,321	118,267	\$17.09	\$145.00	October	\$663,241	300	134	115,495	54,538	\$12.16	\$175.00
October	\$3,058,248	383	255	280,434	163,054	\$18.76	\$270.00	December	\$897,152	300	164	113,626	61,729	\$11.29	\$86.00
December	\$3,333,838	261	214	165,771	138,945	\$23.99	\$1,450.00								
TOTAL	\$11,487,567	1,828	1,125	1,403,444	739,505	\$15.53	\$1,450.00	TOTAL	\$2,325,497	1049	508	418,111	206,814	\$11.24	\$206.00

Sources: Wyoming State Land and Farm Loan Office, Petroleum Information Corporation - Rocky Mountain Region Report, and U.S. Bureau of Land Management.

Table 13. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1993 to present).

	1993	1994	1995	1996 ¹
County	APDs	APDs	APDs	APDs
Albany	0	0	1	1
Big Horn	17	3	16	53
Campbell	126	105	151	554
Carbon	35	135	50	77
Converse	34	74	29	20
Crook	29	9	15	37
Fremont	16	46	30	26
Goshen	0	0	0	0
Hot Springs	12	4	13	24
Johnson	18	16	6	16
Laramie	33	15	10	2
Lincoln	135	103	64	55
Natrona	36	63	80	74
Niobrara	5	4	4	7
Park	22	18	20	30
Platte	0	2	0	0
Sheridan	7	3	0	0
Sublette	80	113	61	118
Sweetwater	156	204	153	136
Teton	0	0	0	0
Uinta	48	11	11	10
Washakie	17	12	31	30
Weston	23	6	10	10
TOTALS	849	946	755	1280

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, February, 1997.*

were concentrated in counties in the Powder River and Greater Green River Basins.

Exploration and Development

Company data, news releases, and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the fourth quarter of 1996. The numbers preceding discussions below refer to locations on **Figure 17**.

1. Chevron USA completed a new horizontal well in the Nugget Sandstone in Painter Reservoir East Field. The 41-18A well was horizontally drilled from

Table 14. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1993 to present).

County	1993				1994				1995				1996 ¹			
	Permits	Conven- tional Miles	3-D Square Miles	Permits	Conven- tional Miles	3-D Square Miles	Permits	Conven- tional Miles	Permits	Conven- tional Miles	3-D Square Miles	Permits	Conven- tional Miles	Permits	Conven- tional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	0	0	0	0	0	1	18	0	0	0
Big Horn	0	0	0	5	24	4	1	16	0	0	0	2	3	66	0	0
Campbell	24	134	29	13	17	50	12	24	43	220	32	32	56	220	220	220
Carbon	8	115	0	11	117	86	1	0	16	18	2	2	5	18	18	18
Converse	4	26	0	0	0	0	4	39	20	4	0	1	4	0	0	0
Crook	5	21	0	3	3	2	1	0	5	3	20	5	3	20	20	20
Fremont	6	38	62	6	12	104	6	32	56	15	5	2	5	15	15	15
Goshen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	1	0	2	1	9	0	2	70	9	4	17	4	17	29	29	29
Johnson	1	20	0	0	0	0	1	4	0	0	0	0	0	0	0	0
Laramie	1	67	0	3	57	0	0	0	0	0	0	0	0	0	0	0
Lincoln	3	27	50	0	0	0	2	18	110	0	0	0	0	0	0	0
Natrona	3	20	0	1	0	17	3	27	3	0	0	0	0	0	0	0
Niobrara	0	0	0	1	0	11	0	0	0	0	0	2	0	23	23	23
Park	5	54	55	1	0	7	0	0	0	0	0	6	20	82	82	82
Platte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0
Sublette	0	0	0	5	4	145	2	0	162	21	52	2	21	52	52	52
Sweetwater	9	117	187	4	59	0	9	17	497	8	670	8	17	670	670	670
Teton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	0	0	0	2	0	89	0	0	0	0	0	1	0	40	40	40
Washakie	4	17	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Weston	0	0	0	0	0	0	1	13	0	0	0	1	0	16	16	16
TOTALS	74	656	391	56	302	515	45	260	921	70	174	70	174	1251	1251	1251

Source: All data are from the Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, February, 1997.

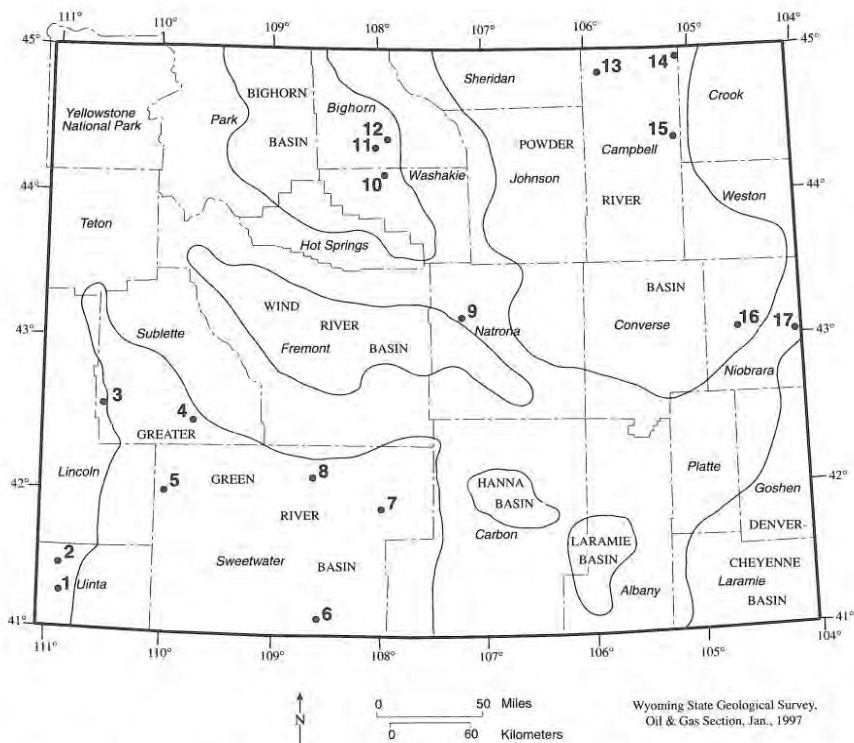


Figure 17. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 1996 (exclusive of coalbed methane activities).

- a surface location in SE SW section 7, T15N, R119W to a true vertical depth of 12,058 feet. The well produced 9.5 million cubic feet of gas and 1,481 barrels of condensate during its first day on line.
2. Amoco Production completed a well in the Darby Formation in Whitney Canyon-Carter Creek Field. The Champlin 457-A # 4 well in SE NE section 7, T17N, R119W flowed 31.9 million cubic feet of gas and 322 barrels of condensate per day from an undisclosed interval in the Darby.
3. Griggs Oil discovered gas at its 1-35 North Riley Ridge Federal Unit well in SW NE section 35, T30N, R115W. The well flowed 3.6 million cubic feet of gas per day from 48 net feet of pay in the Frontier Formation at approximately 8,300 feet. The well also encountered 42 feet of net pay in the Baxter Shale. The new discovery is about two miles northwest of the inactive Riley Ridge Field.
4. McMurray Oil completed three new wells in the Mesaverde Formation at Jonah Field. The 2-4 Jonah-Federal well in SW SW section 4, T28N, R108W

flowed an average of 7.6 million cubic feet of gas and 102 barrels of condensate per day during its first 12 days on line. The 13-34 Stud Horse Butte well in SW SW section 34, T29N, R108W flowed an average of 3.2 million cubic feet of gas and 38 barrels of condensate during its first 18 days on line. The 1-33 Stud Horse Butte well in NE NE section 33, T29N, R108W flowed 1.8 million cubic feet of gas and 18 barrels of condensate per day during its first three days on line. All three wells were drilled to approximately 11,000 feet and are producing from undisclosed intervals in the Mesaverde Formation.

5. Cabot Oil & Gas completed its 40-12 Horseshoe Unit well in SE SW section 12, T23N, R111W in the Frontier. The well flowed 406 barrels of oil and 690,000 cubic feet of gas per day through perforations between: 10,462-10,494 feet and 10,672-10,692 feet. The new well is on the southern edge of Mesa Field.
6. Celsius Energy completed a new discovery well in the Wasatch Formation in Kinney Field. The 8-2 Big Drop well in SW SW section 8, T13N, R99W flowed 2.0 million cubic feet of gas per day through perforations between 1,380-1,410 feet and 1,768-1,787 feet. The field produces from the Mesaverde and Dakota and has produced from the Frontier and Nugget.
7. In Siberia Ridge Field, Abraxas Petroleum worked over a well that was originally completed in the Mesaverde, recompleting it in the Lewis Shale. The 3-24A Federal well in C SW section 24, T22N, R94W flowed 5.4 million cubic feet of gas and 340 barrels of condensate per day from between 10,780 and 10,818 feet.
8. Yates Petroleum discovered gas at its 1 Highline 9412-JV-P well in SW NE section 9, T24N, R99W. The well is reportedly capable of producing commercial amounts of gas from about 8,700 feet in the Almond Formation. No details on flow rate or producing interval have been released.
9. Activity continues in Waltman Field. Chevron USA completed its 37 Bullfrog well in NE NW section 31, T37N, R86 W. The well flowed 8.5 million cubic feet of gas and 113 barrels of condensate per day from an undisclosed interval in the Lance.
10. Devon Energy completed two new Tensleep Sandstone producers in Worland Field. The 11-T Worland Unit well in NE SW section 28, T48N, R92W pumped 213 barrels of oil and 29 barrels of water per day through perforations between 10,232 and 10,342 feet. During its first month of production, the 71-129 Worland Unit well in NE SE section 29, T48N, R92W produced an average of 10 barrels of oil per day from an undisclosed interval.
11. KCS Energy completed another Phosphoria well in Manderson Field. The 22-12P Manderson Unit well in SE NW section 12, T50N, R93W flowed 881 barrels of oil and 3.7 million cubic feet of gas from an unreported interval. The company believes that Manderson Field is substantially longer than the

nine miles it originally estimated. KCS controls about 14,000 acres in the field and plans to drill additional wells which they hope will allow for production of 10,000 barrels of oil per day from Manderson Field.

12. Laser Exploration and W. E. Sauer Companies discovered oil in the Phosphoria at their 31-47 Sagebush-State well in NE SW section 36, T51N, R92W. The well is producing an average of 25 barrels of oil per day from an undisclosed interval in the Phosphoria.
13. Oedekoven Water & Hot Oil discovered oil in the Muddy Sandstone at its 1CKS well in NE NE section 14, T56N, R75W. The well pumped 78 barrels of oil and 25,000 cubic feet of gas per day from between 7,782 and 7,796 feet.
14. Cam West Limited Partnership completed its 1H Federal-McMillan horizontally-drilled well in SW SW section 35, T57N, R69W in Rocky Point Field. The well pumped 84 barrels of oil and 946 barrels of water per day from the Minnelusa Formation. True vertical depth of the well is 5,476 feet. The company also completed a second horizontally-drilled Minnelusa well, the 2H Federal-McMillan well in NW SW section 35, T57N, R69W. This well produced an average of 255 barrels of oil and 262 barrels of water per day during its first nine days on line. The well was drilled to a true vertical depth of 5,525 feet.
15. Conley P. Smith reported details on its Rockhopper oil field discovery at its 32-3 Charlotte well in NE NE section 32, T51N, R69W. The well flowed 186 barrels of oil and two barrels of water per day from the Minnelusa between 8,063 and 8,071 feet. The new discovery is about a half mile north of Minnelusa and Muddy production at Windmill Field.
16. OKT Petroleum extended Lance Creek Field with its 1-36 Finley-State well in SE NW section 36, T36N, R65W. The well pumped 39 barrels of oil, 100,000 cubic feet of gas, and three barrels of water per day through perforations between 3,862 and 3,878 feet in the Dakota.
17. Ensearch Exploration discovered oil at its 1 Charles-Federal 4-4 well in NW NW section 4, T35N, R60W. The well pumped 114 barrels of oil per day from perforations in the second Leo between 3,570 and 3,584 feet. The new discovery is about three miles southwest of the nearest previous production, which is an abandoned discovery in South Dakota.

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COAL UPDATE

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The National Mining Association (NMA) is concerned with the U.S. Bureau of Land Management's (BLM's) plans to publish new rules relating to the Federal Coal Management Program under the Mineral Leasing Act. The NMA is requesting time for comment by the public, industry, and the western states, which include much of the Federally-controlled coal reserves. The NMA notes that the new rules were proposed before deregulation of the electric utility industry and no opportunities for comment were given that industry or the steam coal industry. The NMA is concerned that the proposed rule changes could place unwarranted constraints and impose unnecessary regulations on coal operations on public lands in the West.

The U.S. Department of Energy's (DOE's) coal research budget for FY1997 is \$103.1 million, a 20% or \$18.2 million cut from FY1996. DOE plans a "business line" approach to its research efforts, organized under three major categories: (1) Advanced Power Systems, (2) Advanced Clean Fuels Research, and (3) Advanced Research and Technology Development.

Developments in the Powder River Basin

Kennecott Energy has bought Drummond Coal Co.'s Caballo Rojo and Fort Union mines in the PRB for \$99 million in cash. The sale of these two mine properties is subject to regulatory approvals and was not final in January. The Caballo Rojo mine produced about 15 million tons in 1996 and is located adjacent to Kennecott's Cordero mine. Kennecott also purchased the Fort Union mine apparently because Drummond made it a condition of the sale. Production from the Fort Union mine in 1996 and 1997 is reportedly only enough to satisfy "due diligence" requirements on its Federal coal lease. A Kennecott official said that after those requirements were met, the mine might be closed, expanded, sold, or idled.

The production capacity of Kennecott Energy's Antelope mine will increase to 24 million tons by the end of 1997. The Antelope mine produced about 12 million tons of coal in 1996. To increase its production, the mine's pit crusher and conveyor were upgraded late in 1996. In a related note, the U.S. Bureau of Land Management accepted Kennecott's 15 cents per ton bonus bid for a lease on 60.3 million tons of reserves bordering the Antelope mine. The new bid of \$9,054,600 was made in December. Kennecott's earlier bid of 11 cents per ton had been rejected in September as not meeting fair market value.

Zeigler Coal Holding budgeted \$12 million in capital expenditures in 1996 toward the development of its North Rochelle mine. As noted in the third quarter of 1996, Zeigler moved the completion of this mine back about six months,

to late 1998 or early 1999. The North Rochelle mine will be operated by Triton Coal Company, a subsidiary of Zeigler.

Powder River Coal Co. has become the first operator in the PRB to use contract switching to speed up movements of coal trains in and out of their loading facilities. They have contracted with Rail Link, Inc. to take control of Union Pacific-Southern Pacific trains as they cross Powder River's property lines. They are also negotiating with the Burlington Northern-Sante Fe to do the same with their trains. According to Powder River, it took an average of 2 hours and 15 minutes to run a train through one of their loadouts before contract switching. Rail Link has reduced that time to well below two hours.

Kerr-McGee Coal is constructing a new coal processing facility at its Jacobs Ranch mine. The new 2,200 tons per hour (tph) facility includes a truck-dump area, crushing unit, and coal conveyor system. When completed, production capacity will increase to 5,800 tph.

Western Fuels Association (WFA) is buying additional coal reserves for its Dry Fork mine. The reserves total 117 million tons and were part of Kerr-McGee's Clovis Point mine and property. This purchase will increase the reserves at the Dry Fork mine to about 370 million tons. Last quarter, WFA announced that it had idled its production at Dry Fork to about 0.8 million tons per year, at least through 2000 (*Wyoming Geo-notes No. 52*, p. 27). In the interim, it is buying less expensive coal from Triton Coal Co., primarily for the contract with Basin Electric's Laramie River plant at Wheatland, WY. Kerr-McGee earlier sold an additional 127 million tons of reserves as well as its mine facilities at Clovis Point to Wyodak Resources (*Wyoming Geo-notes No. 52*, p. 27).

Thunder Basin Coal Co. (a subsidiary of ARCO Coal) has announced plans to add a new 160-cubic-yard dragline at their Black Thunder mine. With the addition of this dragline, they expect to increase production capacity to 55 million tons per year, up from the current capacity of 40 million tons per year. While this new dragline will be the fourth in operation at Black Thunder, it may eventually replace a smaller 45-cubic-yard machine.

Based on a recent survey conducted by the Burlington Northern-Santa Fe railroad (BNSF), combined coal production from Montana and Wyoming portions of the PRB was about 300 million tons in 1996. The BNSF's survey also projected an increase of as much as 70 million more tons by 2000. As a result, BNSF has budgeted \$113 million for expansions and improvements aimed at increasing its carrying capacity from the PRB coal mines to eastern and mid-western markets.

Western Fuels Service Corp. (WFSC), a subsidiary of Western Fuels Association, has petitioned the Surface Transportation Board (STB) to require the BNSF railroad to make selected trackage and facilities available to WFSC. WFSC argued this was necessary to improving the competitiveness of coal produced from the Buckskin, Rawhide, Eagle Butte, Fort Union, and Dry Fork

mines. WFSC specifically requested access to the tracks between West Caballo and the terminal facility at each mine.

The U.S. Bureau of Land Management (BLM) recently set a tentative leasing schedule for three pending coal lease applications in the PRB. The bidding on Bluegrass Coal Development Co.'s North Rochelle Lease by Application (LBA) is set for July 15, 1997. This 1,440-acre tract has an estimated 144 million tons of reserves and is adjacent to Triton Coal Co.'s North Rochelle mine. Blue Grass and Triton are both subsidiaries of Zeigler Coal Holding. There may be some competition for this maintenance tract since it also adjoins Thunder Basin Coal Co.'s Black Thunder mine. The comment period on the draft Environmental Impact Statement (EIS) for this lease closed in January, and the BLM is now preparing the final EIS.

The North Antelope/Rochelle LBA is tentatively set for leasing sometime in March of 1998. This tract was nominated by Peabody Holding Co. and consists of 4,020 acres and 550 million tons of coal reserves. This tract is adjacent to the North Antelope and Rochelle mines.

Kerr-McGee's Thundercloud LBA is for 4,000 acres and 432 million tons of reserves. The sale for this tract, which is adjacent to its Jacobs Ranch mine, is tentatively set for July of 1998.

An LBA by Evergreen Resources for a 7,840-acre tract with an estimated 675 million tons of reserves is still pending before the BLM.

In January of this year, ENCOAL Corporation, a subsidiary of Zeigler Coal Holding, filed a permit amendment application with the Industrial Siting Division of the Wyoming Department of Environmental Quality for a \$740 million, 16,500-ton-per-day, ENCOAL Commercial LFC (liquids from coal) plant. The plant site is located about 55 miles southeast of Gillette at the North Rochelle mine. Construction could start as early as the second quarter of 1997, with initial operations beginning in the first or second quarter of 1999. Full plant capacity is not expected until 2001. According to ENCOAL's application, each ton of raw coal will produce one-half ton of a solid fuel called "process-derived fuel" (PDF), one-half barrel of "coal-derived liquid" (CDL), and 70% of the plant's process gas requirements. The LFC plant will consist of three 5,500-ton-per-day parallel modules with an associated 240-megawatt co-generation power plant. The power plant will burn coal fines from the LFC plant along with minor purge gas streams. It will produce more than enough electricity for the LFC plant and the North Rochelle mine, with the excess electricity available for external sale. ENCOAL lists electric utilities and steel companies as markets for the PDF and petroleum refineries as markets for the CDL.

A KF_x plant, designed to turn low-sulfur Wyoming coal into a low-moisture, high-energy fuel, is in the testing phase. The plant, which is located at the Fort Union mine, physically and chemically reduces the moisture content of coal. American Electric Power of Ohio has a contract to take most of the fuel

produced by this plant, which has the capacity to turn 700,000 tons of coal a year into 500,000 tons of K-fuel. In a related note, KFX has applied for permits to increase the capacity of this plant by 150,000 tons per year and to build another plant with a capacity of 650,000 tons per year, for a total combined annual output of 1.3 million tons of K-fuel. Kfx also indicated the December explosion and fire in the recently completed facility did only minor damage and the project is still on schedule. It is unclear what effect Kennecott Energy's recent purchase of Drummond Coal Co.'s Fort Union mine will have on the future of the Kfx plant.

Synfuel Technology (ST) has announced plans to begin construction of a "coal refinery" on a leased site by mid-1998. The site, which is called the North Ranchester tract, is near Sheridan, Wyoming. According to ST, it will mine coal on-site and process it into a number of products, including nut coke for use by the detergent manufacturing industry.

Officials of the State's Abandoned Mine Land Program (AML) announced in January that NuCor, Inc., of Riverton, had apparently submitted the low bid for reclamation work on abandoned underground coal workings at Glenrock, Wyoming. NuCor's bid was reportedly around \$2 million. The project, which is slated to start by March of 1997, will involve the pressure injection of about 20,000 cubic yards of grout into what was the Glenrock No. 1 and No. 2 mine workings. The Glenrock mines closed around 1910.

Developments in Southern Wyoming

The U.S. Bureau of Land Management (BLM) is evaluating Ark Land Company's 4,145-acre, Carbon Basin Lease by Application in Carbon County, Wyoming. The scoping process has been completed and the BLM has started preparing the draft EIS, which they hope to have completed for public review in mid-1997. At the earliest, a lease sale might be possible by November or December of 1998. The lease contains about 100 million tons of coal reserves.

Ark Land's proposed Carbon Basin mine is planned to come into full production around 2000. By that time, Ark Land's Medicine Bow and Seminoe No. 2 mines in the Hanna Basin will be closed or closing for lack of additional reserves. These latter two mines are operated by Arch of Wyoming, a subsidiary of Ark Land. The proposed mine, which would be comprised of Federal, State, and fee lands, is expected to strip mine 2-3 million tons per year by the year 2000, with an estimated 8- to 11-year life. Approximately 2,600 acres would be disturbed by the mining operation. Coal would be trucked approximately 14 miles to the load-out facility at the Seminoe No. 2 mine. Earlier this year, Ark Land purchased significant fee coal reserves in the Carbon Basin, allowing for mining to start even while the leasing process is in progress (*Wyoming Geo-notes No. 52*, p. 29).

Cyprus Shoshone Coal Co., a subsidiary of Cyprus-Amax Coal Co., has announced that its Shoshone No. 1 mine at Hanna, Wyoming, has signed a

new contract that will keep the mine in production for at least 10 years. Without this new contract, it looked like the mine might close as early as 1999. As a result of the new contract, an additional 20 employees may be added to the work force. This is the only active underground coal mine in Wyoming, and it has been producing about two million tons a year, using long-wall mining techniques.

Power Plants

The Burlington Northern-Santa Fe railroad sold 416 miles of track to North American Railnet, Inc. The major destination on this trackage is the Nebraska Public Power District's Gentleman power plant.

Muscatine Power and Water (MP&W) recently announced plans to convert its 80-MW, Muscatine No. 8 cyclone unit to Powder River Basin (PRB) coal in 1998. The plant, which is located in Muscatine, Iowa, will continue to burn Illinois Basin coal through 1997. Their Muscatine No. 9 cyclone unit is already converted to subbituminous coal, and in 1996, used about 600,000 tons of coal supplied by Triton Coal Co.'s Buckskin mine in the PRB. MP&W anticipates using 620,000 tons in 1997. After the No. 8 unit is converted, the two plants will together use up to one million tons per year. These plant conversions are part of MP&W's efforts to reduce sulfur emissions per an agreement with the U.S. Environmental Protection Agency and the Iowa Department of Natural Resources.

The Burlington Northern-Santa Fe railroad announced plans to supply GKE, a Dutch utility, with an undisclosed test volume of 8,800-Btu/lb coal from Powder River Coal Co.'s Rochelle mine. Arrangements will be made to export the coal, moving it by rail to Mobile, Alabama, and then by ship to the Netherlands. This is in response to GKE's challenge to suppliers to make PRB coal available to European utilities. In addition, it appears the Dutch utility wants to show Indonesian coal producers that it has an alternative source of low-sulfur coal.

Lower Colorado River Authority (LCRA) recently requested bids on 200,000 tons of PRB coal for the first quarter of 1997. LCRA has taken this approach to compare quarterly solicitations against their past practice of annual solicitations. Quarterly solicitations should offer them a chance at any discounted coal prices that occur during the course of the year.

Tennessee Valley Authority (TVA) recently called for offers on varying quantities of coal it will need for a dozen different power plants. They noted that PRB coal will be added to the solicitation, specifically for the Gallatin plant, which will have a 100,000-ton, first-quarter need. TVA is calling for 3-, 6-, and 12-month offers.

North American Power Group (NAPG) recently announced plans to build a \$260 million coal-fired power plant adjacent to Thunder Basin Coal Co.'s Black Thunder mine. The facility will be called the Two Elk plant, with construction

possibly beginning as early as 1997. NAPG has said the plant could be operational by late 1999. The 200- to 250-MW plant would be fired by non-commercial waste coal from the nearby Black Thunder mine as well as possibly other mines. NAPG is looking at Colorado and Utah as markets for the electricity. They have applied for State and Federal permits to include an application to the Federal Energy Regulatory Commission for wholesale generation status.

In a related issue, the Wyoming Board of Land Commissioners gave preliminary approval to a land exchange in which approximately 640 acres of State land valued at \$200,000 would be exchanged for about 1,900 acres of private land of equal value. Only the surface rights would be exchanged. This exchange would provide the site for NAPG's proposed power plant.

Other mine-mouth power projects are proposed in the PRB, including the Cogentrix Energy/Crow Tribe's 260-MW power plant in the Montana portion of the PRB, Zeigler Coal Holding's planned 240-MW co-generation plant near its North Rochelle mine (p. 32), and Calpine and Black Hills Corporations' planned 80-MW plant near Black Hills' Wyodak mine.

Zeigler Coal Holding indicates that a contract it has with Western Fuels Association apparently will be rejected in Cajun Electric's bankruptcy proceedings. The coal was to have been supplied from the Buckskin mine.

New Coal Contracts and Solicitations

Table 15 is a tabulation of some of the contracts, test burns, and solicitations for Wyoming coal announced in the fourth quarter of 1996 or early in 1997.

Coalbed Methane

The U.S. Bureau of Land Management (BLM) has initiated its environmental analysis of Federal lands within the Gillette North coalbed methane project near Gillette, Wyoming (*Wyoming Geo-notes No. 51*, p. 37-38). Redstone Resources, Inc. plans to develop a 250-well field north of Gillette, producing methane gas from the Wyodak-Anderson coal bed in the Tertiary Fort Union Formation. Approximately 40 wells have been drilled on private and State oil and gas leases, with another 30 wells pending approval before the Wyoming Oil and Gas Conservation Commission. The BLM estimates that of the 250 wells planned over a five-year time frame, 100 will produce methane off Federal leases. Production from individual wells is estimated at 50-700 thousand cubic feet (MCF) of gas per day once the wells achieve optimum production. The project will require at least five gas compressor stations, one for each grouping of 50 wells.

The BLM's environmental assessment of the project is a prerequisite to BLM giving approval to any Applications for Permits to Drill (APD) on Federal

Table 15. Marketing activities for Wyoming coal producers during the fourth quarter of 1996¹.

<i>Utility</i>	<i>Power Plant</i>	<i>Coal Mine/Region</i>	<i>Activity</i>	<i>Tonnage</i>	<i>Comments</i>
1. Basin Electric	Leland Olds plant	Undisclosed	T	60,000-70,000 t	For a 6- to 8-week period in January 1997; Leland Olds normally burns North Dakota lignite, but bad weather disrupted supplies.
2. Centerfor Energy	Bayshore plant	Powder River Basin	So	Up to 720,000 t	PRB coal will be blended with Appalachian coal for testing.
3. Central and South West Services	Colet Creek station	Cordero	T	200,000 t	Will conduct a similar sized test from another PRB mine.
4. Commonwealth Edison	Unspecified plants	Jacobs Ranch Caballo	C T	3 million t 100,000 t	Test burn will occur in 1997.
5. Consumers Power	Campbell, Karn, and Weadlock	Powder River Basin	C	325,000 t	Delivery in 1997.
6. Consumers Power	Cobb plant	Powder River Basin	C	850,000 t	Delivery in 1997.
7. GKE (a Dutch utility)	Unspecified plants	Rochelle	T	undisclosed	For delivery to Mobile, AL and then by ship to the Netherlands.
8. Hastings Utility Dept.	Unspecified plants	Caballo	Sp	50,000-200,000 t	Currently finalizing contract with Peabody.
9. IES Industries	Sutherland Prairie Creek and Burlington	Powder River Basin Powder River Basin	So So	0.4 million t 1.7 million t	
10. Illinois Power	Havana station	Medicine Bow/ Seminole II	Sp	120,000 t	Late 1996 delivery continuing into 1997.
11. Lower Colorado River Authority	Unspecified plants	Powder River Basin	So	200,000 t	First quarter of 1997.

Table 15. Marketing activities for Wyoming coal producers during the fourth quarter of 1996¹ (continued).

<i>Utility</i>	<i>Power Plant</i>	<i>Coal Mine/Region</i>	<i>Activity</i>	<i>Tonnage</i>	<i>Comments</i>
12. Nebraska Public Power District	Gentleman station Shelton station Gentleman station	Belle Ayr Rochelle Powder River Basin/BNSF	C C C	12 million t 3 million t 1.5 million ty	To be supplied over a four-year period beginning in 1997.
13. Nebraska Public Power District	Gentleman station	Rochelle	C	3 million t	To be supplied over a three-year period beginning in 1997.
14. Nebraska Public Power District	Gentleman station	Belle Ayr	C	600,000 t	Late 1996 delivery.
15. Nebraska Public Power District	Gentleman station	Thunder Basin Coal	C	500,000 t	For delivery in 1997.
16. Omaha Public Power District	North Omaha	Jacobs Ranch	C	2.0 million t	For 1996-1997; supplemental tonnage.
17. Southern Co./Mississippi Power	Watson plant	Jacobs Ranch	T	75,000 t	Test includes blend of 80% Illinois and 20% PRB coal-if successful, future test will increase % PRB coal.
18. SWEPCO	Welsh and Flint plants	Jacobs Ranch	C	500,000 t	A one-year arrangement for 1997.
19. Tennessee Valley Authority	Gallatin plant	Powder River Basin included	So	100,000 t	First quarter need.
20. TU Electric	Monticello plant	Jacobs Ranch Belle Ayr	C	Up to 1.7 million ty	For two years beginning Jan. 1, 1997.
21. TUCO Inc.	Tolk plant	Powder River Basin	So	50,000-500,000 t	Spot delivery for 1997.
22. West Texas Utilities	Oklahoma plant	Buckskin	C	800,000-1.2 million t	A one-year arrangement for 1997.
23. Western Fuels Association (WFA)	Laramie River Station	Buckskin Dry Fork	C C	2.0-5.0 million ty 0.8 million ty	1996 through 2000 (replaces coal from WFA's Dry Fork mine). Duration not disclosed.

¹Data obtained from: Coal Week® Coal Outlook®, trade journals, periodicals, FERC database, and personal contacts.
C = contract coal; Sp = spot coal; So = solicitation; T = test burn; t = short ton; ty = short tons per year; t/wk = tons per week; PRB = Powder River Basin
Wyoming State Geological Survey, Coal Section, January, 1997.

leases within the project area. In addition, the BLM requires an individual environmental assessment for each APD that is filed.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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Construction aggregate

Umetco, a uranium mining company, plans to quarry 500,000 cubic yards of aggregate to reclaim a former open pit uranium mine in the Gas Hills, east of Riverton. The aggregate will come from a granite outcrop located in the Rattlesnake Hills east of the mine (**Figure 18**). Umetco will crush the granite and spread it over the surface of the former open pit, which has been filled with tailings from an abandoned uranium mill south of Riverton. The aggregate will overlie a previously installed clay cover to help prevent the growth of vegetation. This reclamation procedure is designed to prevent the roots of plants from reaching the slightly radioactive tailings located below the clay cover. Umetco is awaiting a decision by the U.S. Bureau of Land Management regarding its quarrying plan. If the permit, which is opposed by some nearby residents, is denied, the next closest source of aggregate is 30 miles farther east. Transporting costs would increase substantially if the more distant site was developed.

Decorative and dimensional stone

Sunrise Stone, of Wheatland, Wyoming, has secured a second contract to provide a black granite, called Wyoming Raven, for Bill Gates' residence on the shore of Lake Washington in Seattle. Toby Ser Voss, of Sunrise Stone, reports that this contract represents eighteen months of production at the current rate of quarrying. Sunrise had previously supplied finished black granite products to Bill Gates' construction site. While the Wyoming Raven quarry is located in northern Albany County, Sunrise's fabricating plant is 25 miles southwest of Wheatland in Platte County (**Figure 18**).

In January, the Wyoming Economic Development and Stabilization Board awarded an \$11,000 planning-only grant to the town of Lusk for a study of the feasibility of quarrying a limestone deposit in Niobrara County south of Manville. This deposit was the subject of a 1987 study by the Wyoming State Geological Survey (Harris 1987). The earlier study concluded the limestone was suitable for use in the refining of sugar, in controlling power plant emissions, as a construction aggregate, and as a source of lime. The recently-awarded grant will study the suitability of the limestone for use as dimensional stone.

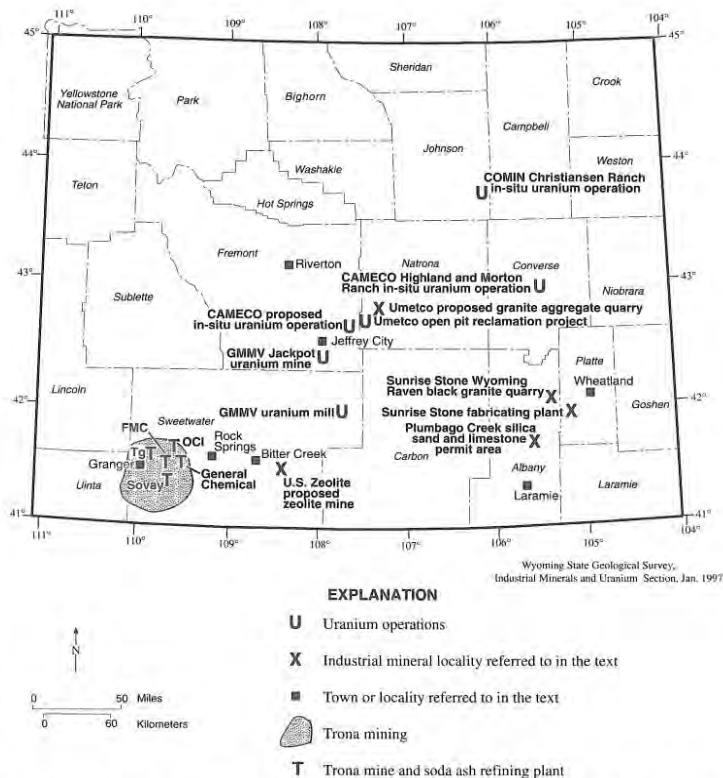


Figure 18. Industrial minerals and uranium activities in Wyoming the fourth quarter of 1996.

Dimensional limestone is a popular stone used in exterior construction and as decorative dimensional blocks, slabs, and tile for both exterior and interior use. It is relatively low cost compared to granite and marble and finds widespread uses in commercial buildings, shopping malls, and private residences. In the U.S., dimensional limestone is produced in Indiana, Kansas, Oklahoma, Wisconsin, Ohio, Alabama, Texas, Arkansas, California, Iowa, Minnesota, New Mexico, and Utah. Due to increasing demand for this product in developing countries of the Pacific Rim, exports of dimensional limestone are increasing.

Limestone & silica sand

V.A. Resources (VA), of Casper, Wyoming, has conducted exploration drilling on a limestone deposit at Plumbago Creek, 30 miles north of Laramie in Albany County (**Figure 18**). VA drilled eight core holes and constructed an access road to the site. Following the drilling, VA applied to the Wyoming Department of Environmental Quality (DEQ) for a permit to quarry limestone.

V.A. Resources also applied for a permit to quarry silica sand adjacent to the limestone at the Plumbago Creek site. This permit is currently under review by the DEQ. In addition to quarrying limestone and silica sand, VA is considering development of a plant for the manufacture of glass products. If the project proceeds as planned, glass will be manufactured from Wyoming silica sand, soda ash, and feldspar.

The Plumbago Creek sites were selected on the basis of a Wyoming State Geological Survey (WSGS) Report of Investigations (Harris, 1988). This publication was the final report for a study commissioned by Albany County, which had received funding through a block grant from the Wyoming Department of Commerce. The WSGS provided technical support for the county's study and then prepared a published evaluation of the silica sand resource at the site, noting also the limestone resources in the same general area.

Trona

A significant portion of the expanding world market for soda ash comes from the trona district in southwestern Wyoming (**Figure 18**). Five mines produced 18.2 million short tons of trona in 1995, and somewhat more in 1996. The trona mines are all underground mines, with mining 800 to 1,600 feet beneath the surface. One-third of the soda ash refined from this trona is exported. Other sodium-based products, such as baking soda and the sodium cyanide used in the extraction of gold from its ore, are manufactured from soda ash at some of the plants.

Tg Soda Ash, Inc. has applied for Federal permits to construct a new trona mine within a lease east of Granger, (**Figure 18**). The new mine would produce trona from bed 17. This is the same bed mined by FMC, General Chemical, and Solvay, which are other trona mining companies in the area. Tg's existing mine is in beds 24 and 25. No initial increase in annual production is projected as a result of the new mine. When the new mine comes on line in 2004, it will replace production from the old mine. Tg has not announced any plans to expand the capacity of its soda ash processing plant.

A major expansion project at Solvay Minerals, a Belgium-based company which operates a trona mine and soda ash processing plant west of Green River (**Figure 18**), was approved by the Wyoming Industrial Siting Council. This expansion will increase the plant capacity from 2.3 million short tons of soda ash per year to 3.5 million short tons. Solvay's planned capacity will make its plant the largest in Wyoming, surpassing the 3.4-million-short-ton capacity of FMC's plant. So far, FMC has been the largest producer for the entire fifty years of trona mining in Wyoming.

Solvay, however, is the world's largest soda ash producer. Throughout Europe and the near East, Solvay produces soda ash by a synthetic process, which is known as the Solvay Process. Eighty percent of the Wyoming operation is owned by Solvay, while the remaining 20% is owned by Asahi Glass of Japan.

International Soda Ash Conference

Plans are nearly complete for the first International Soda Ash Conference (ISAC). This conference is set for, June 10-12, 1997, in Rock Springs, Wyoming. Sponsors of the conference are the U.S. Geological Survey, the U.S. Bureau of Land Management, and the Wyoming State Geological Survey. The conference will feature papers on the geology, mining, processing, transportation, and marketing of sodium carbonate deposits. The Fiftieth Anniversary of trona mining in Wyoming will be highlighted, with emphasis on the Wyoming trona district. Speakers will also present papers on natural soda ash deposits elsewhere in the world. Two days of papers and poster sessions are planned, followed by a day of field trips to an underground mine, a surface processing plant, and to outcrops of the geologic units that host the trona deposits.

The Wyoming State Geological Survey will published the conference papers. For further information regarding ISAC, contact Ray Harris at (307) 766-2286, FAX (307) 766-2605, or by email: ray_harris@wsge.uwyo.edu.

Uranium

As reported by Bob Odell in the December issue of the *Rocky Mountain Scout*, the Uranium Exchange's unrestricted price of yellowcake on the spot market decreased from \$15.25 per pound on October 1, 1996, to \$13.90 per pound on January 2, 1997. This continues the retreat of spot market prices that began in September, 1996 (Figure 19). The high for the last several years was reached on September 3, 1996, at \$15.50 per pound. Wyoming's two existing producers, COMIN (Cogema Mining) and Power Resources (see Cameco discussion below), continue to operate under contracts, and are not significantly affected by short term changes in spot market prices.

This January, Power Resources, which produces uranium from the Highland and Morton Ranch properties in the southern Powder River Basin (Figure 18), was acquired by Cameco, a large uranium mining and producing company based in Saskatoon, Saskatchewan. Cameco Corporation acquired Power Resources, Inc. and Central Electricity Generating Board Exploration (Canada) Ltd. from a subsidiary of Magnox Electric plc, a United Kingdom entity, for \$106.5 million (US). According to a company press release, the purchase adds about one million pounds to Cameco's current annual production of more than 16 million pounds of uranium and increases its reserves by 37 million pounds and its resource base by another 85 million pounds. The company reports almost 400 million pounds of reserves and 300 million more pounds in the resource category. Not all of these reserves and resources are in Wyoming. Power Resources' operations represent Cameco's only Wyoming production at this time, although the company has other properties and reserves in Wyoming.

In December of 1996, U.S. Energy-Crested Corp. (USE-CC) announced that it intends to purchase Kennecott Energy's 50 percent share of the Green

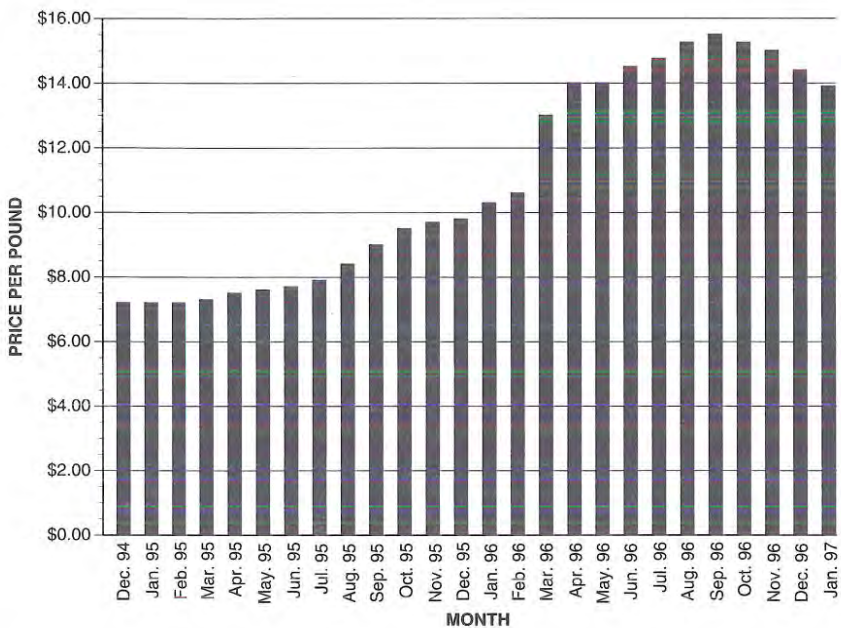


Figure 19. Recent changes in the spot sale price of yellowcake (Source: Uranium Exchange as quoted in the *Rocky Mountain Scout*).

Mountain Mining Venture (GMMV). The GMMV was formed in 1990 when Kennecott purchased a 50% interest in the Jackpot property from USE-CC. The Jackpot mine is located on Green Mountain south of Jeffrey City (**Figure 18**). It is being developed as an underground uranium mine. The GMMV later purchased Union Minerals' inactive uranium mill south of Green Mountain in the Red Desert (**Figure 18**). When USE-CC's purchase is completed, which is expected before the end of 1997, it will take over full ownership of the mine property and mill site.

Uranium production in Wyoming is expected to increase in 1997 as COMIN constructs additional capacity at its Christiansen Ranch property west of the Pumpkin Buttes in Johnson County. Power Resources' plans and permitting for a new in-situ mine in the Gas Hills east of Riverton will apparently continue under its new Cameco ownership.

Uranium Conference

There are plans underway to host a U.S. Uranium and Nuclear Conference (UNC) in Riverton, Wyoming, on March 20 and 21, 1997. Sponsored by the Riverton Ranger, the conference will highlight the resurgence of the uranium mining and milling industry in Wyoming and the nation, and it will include

discussions regarding the future of nuclear energy. For further information regarding this conference, contact State Senator Bob Peck at the Riverton Ranger, 421 East Main St., P.O. Box 993, Riverton, WY 82501; telephone: (307) 856-2244; or FAX: (307) 856-0189.

Zeolites

U.S. Zeolite's requested zoning change at Bitter Creek, southeast of Rock Springs in Sweetwater County (*Wyoming Geo-notes No. 52*, p. 37-38) is on hold (**Figure 18**). The company wants to construct a small, 37,000-ton-per-year zeolite processing plant at this locality. The County Commissioners have deferred the request pending resolution of a question involving the maintenance of the road from the mine east of Fort LaCledé to Bitter Creek. This is the road over which the zeolite-bearing rock would be hauled to the plant. U.S. Zeolite's request was set for discussion at the January 15th meeting of the Sweetwater County Commissioners.

Zeolite is the name of a group of minerals that act as natural ion exchangers. Zeolites have a wide variety of uses, from water purification and softening to deodorizers, absorbents, and as industrial chemicals, most of which are used in the refining of petroleum. Water softeners are synthetic zeolites. Zeolites are mined in a number of states, including Oregon, Nevada, and Arizona. For information about the zeolite resources of Wyoming, see Harris and King, (1990).

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Technically Recoverable Resources (January 1, 1997)	
Discovered (Includes oil, gas liquids, and condensate)	3.54 billion barrels ¹
Undiscovered	6.18 billion barrels ¹
Total	9.72 billion barrels

Remaining Reserve Base (January 1, 1997)	
Measured reserves (Proved reserves) (Includes: 0.605 billion barrels of oil and 0.415 billion barrels of gas liquids and condensate)	0.95 billion barrels ²
Indicated and inferred reserves (Reserve growth in conventional fields)	2.61 billion barrels ¹
Total	3.56 billion barrels

NATURAL GAS

Remaining Technically Recoverable Resources (January 1, 1997)	
Discovered (Includes 36.6 trillion cubic feet (TCF) of methane ¹ and 121.6 TCF of CO ₂ ³)	158.2 trillion cubic feet
Undiscovered (Includes 14.72 TCF of conventional methane ¹ ; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO ₂ ³)	170.6 trillion cubic feet
Total	328.8 trillion cubic feet
Remaining Reserve Base (January 1, 1997)	
Measured reserves (Proved reserves) (Includes 11.2 TCF of methane ² and 59.9 TCF of CO ₂ ³)	71.1 trillion cubic feet
Indicated and inferred reserves (Reserve growth in conventional fields)	25.0 trillion cubic feet
Total	96.1 trillion cubic feet

COAL

Remaining Resources (January 1, 1996)	
Identified and Hypothetical (Discovered)	1,427.2 billion tons ⁴
Speculative (Undiscovered)	31.5 billion tons ⁴
Total	1,458.7 billion tons
Remaining Reserve Base (January 1, 1996)	
Demonstrated stripable (Measured and indicated reserve base)	25.6 billion tons ⁵
Demonstrated underground-minable (Measured and indicated reserve base)	42.5 billion tons ⁵
Total	68.1 billion tons

TRONA

Original Resources	
Trona	76.0 billion tons ⁶
Mixed trona and halite	51.0 billion tons ⁶
Total	127.0 billion tons

URANIUM

Remaining Resource (December 31, 1989)	1.99 billion pounds U ₃ O ₈ ⁹
Remaining Reserve Base (December 31, 1989)	
Uranium oxide recoverable at \$30.00 per pound	66 million pounds ⁷

OIL SHALE

Original Resources (January 1, 1981)	
Identified (Discovered)	320 billion barrels of shale oil ⁸

¹ Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 1118, 20 p.

² Modified from Energy Information Administration, 1996, U.S. crude oil, natural gas, and natural gas liquids reserves: 1995 Annual Report, 151 p.

³ De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.

⁴ Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000-scale (color) and 44 p. pamphlet.

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⁶ Wiig, S.V., Grundy, W.D., and Dyni, J.R., 1995, Trona resources in the Green River Basin in southwest Wyoming: U.S. Geological Survey Open File Report 95-476, 88 p.

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⁸ Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

METALS AND PRECIOUS STONES UPDATE

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Wyoming State Geological Survey

Diamonds

During the fourth quarter of 1996, the Wyoming State Geological Survey (WSGS) and private companies continued field investigations and research related to diamond deposits in the Green River Basin of southwestern Wyoming. The WSGS completed some geophysical surveys on topographic anomalies in the basin and collected samples of 'kimberlitic indicator' minerals from ant hills for geochemical and petrographic studies.

In addition, the WSGS is currently gathering information on the Leucite Hills for field studies in 1997. The Leucite Hills, near Rock Springs, consist of several, 1 to 3 million-year-old lamproite volcanoes and flows. The project will include detailed geological mapping, mineralogical and geochemical studies, a search for buried olivine lamproite, and an appraisal of the diamond potential of the area.

The rocks which form the Leucite Hills consist of some of the rarest rock types on the surface of the earth. These include phlogopite lamproites and olivine lamproites known as wyomingite, madupite, orendite, and olivine orendite. These rock types are similar to barren and diamondiferous lamproites found elsewhere in the world. For example, some olivine lamproites found in Western Australia, India, and Arkansas, have yielded diamonds for many years. The Leucite Hills lie north of a 1,000-square-mile area that is currently the target of considerable diamond exploration.

Several miles south of the Leucite Hills, some exploration was reported by a company from Utah. The company identified several potential targets in the basin and collected samples for geochemical studies.

Guardian Enterprises Ltd., in a press release (Dec. 19, 1996), announced that the U.S. Bureau of Land Management was opening some Federal land for diamond exploration. The lands had been withdrawn in 1930 for the protection of oil shale resources. Following a two-year effort by Guardian, the block of land was opened for exploration on November 14, 1996.

Unfortunately, this block is not the entire region withdrawn by the Federal government. The total withdrawn area covers about 86,000 acres. Much of the remaining withdrawn lands have considerable potential for the discovery of kimberlite, lamproite, and lamprophyre pipes (and possibly diamonds). The State has asked the BLM to reevaluate the need for this withdrawal.

Following the opening of these lands, Guardian reported that they had acquired 70 claims on potentially diamondiferous properties. This increased

their interest to 115 claims, including five placer claims and seven State leases in the area.

Exploration by Guardian led to the discovery of 10 breccia pipes in 1995, and the reported recovery of 52 diamonds in 1996. According to a press release by the company, a 30-foot core sample recovered from one of the pipes in 1996 yielded three gem quality macro diamonds and one micro diamond. The Wyoming State Geological Survey along with the University of Arizona conducted geochemical analyses of mantle indicator minerals recovered from one of Guardian's pipes, the DK pipe (*Wyoming Geo-notes No. 52*, p. 40-42). The analyses documented a definite signature from the upper mantle. Because of the favorable geologic setting, the identification of upper mantle rocks, and the widespread occurrence of 'kimberlitic indicator' elements, the Green River Basin and adjacent Rock Springs uplift could contain dozens and possibly hundreds of undiscovered mafic, ultramafic, and possibly ultrabasic breccia pipes.

Metals

Studies of the Encampment district have continued to provide evidence that the Sierra Madre may be one of the better exploration targets in the western U.S. for base and associated precious metals. Over the past several decades, numerous copper, lead, zinc, gold, silver, and some nickel, cobalt, and platinum-group metal anomalies have been detected and identified in the district through efforts of the Wyoming State Geological Survey (WSGS), the University of Wyoming, and the U.S. Geological Survey. The relatively recent identification of copper-nickel-cobalt-platinum group metal anomalies by the WSGS has again attracted private industry to the region.

Some prospects examined by the WSGS in 1996 included a collapsed shaft sunk in metagabbro in S/2 section 10, T14N, R86W near Bridger Peak. Unfortunately, very little evidence of mineralization was found on the mine dump. However, sample BP196, comprised of quartz with uncommon pyrite, malachite, and tenorite, assayed 0.08% Cu, 45 ppb Au, and traces of silver, cobalt, nickel, zinc, and chromium.

Two samples, BP296 and BP396, were collected to the north in the NW section 10, T14N, R86W on the Bridger Peak Quadrangle. These were collected from the historic Island City-Creede prospect. The rocks consisted of massive pyrite and breccia rehealed by pyrite in greenschist and greenstone. These yielded disappointing results of only 10 and 41 ppb Au, respectively, with traces of nickel and cobalt and no detectable platinum or palladium.

To the east of the Island City-Creede prospect, in section 5, T14N, R86W samples were collected from the Jack Creek (Leighton-Gentry) mine. These samples (BP496 and BP596) were poorly mineralized mafic schists collected from mine dumps. The samples assayed only 4 and 5 ppb Au, respectively.

The lack of mineralization on this property is intriguing in that there appears to have been considerable historical development. The property included

a large steam boiler, the remains of a relatively large mill, and other improvements.

At the Doane-Rambler mine to the south, samples of mineralized quartzite and mafic schist were collected. These included sample BP696, collected from the main mine dump at the historic Doane-Rambler mine in NE section 25, T14N, R86W. This sample consisted of chalcopyrite, pyrite, malachite, cuprite, and specular hematite in quartz gangue in quartzite. The sample assayed 3.0% Cu, 1.1 ppm Au, and 5.7 ppm Ag.

Sample RM296 collected from the easternmost Rambler adit on Battle Creek consisted of quartz gangue with tawny limonite boxworks in mafic schist. The sample assayed only 8 ppb Au. Sample BP796 collected from the southwesternmost Rambler adit on Battle Creek consisted of cuprite in quartz stained by malachite and tenorite in mafic schist. The composite sample assayed 1.4% Cu, 676 ppb Au, and 363 ppb Ni.

North of the Doane-Rambler area, Sample BP896, was collected from an unnamed shaft in the SE section 1, T14N, R86W. The shaft was an estimated 200 feet deep and was sunk in bedded quartzite. A select sample of quartzite with minor pyrite, chalcopyrite, and bornite yielded 2.9% Cu and 498 ppb Au.

A sample (DP196) of quartz with boxworks and muscovite was collected from the Bridger mine in NW section 2, T15N, R87W on the Divide Peak Quadrangle. This appeared to be a very poor prospect developed in greenschist and gabbro. The sample yielded only 28 ppb Au.

Samples DP296 and DP396 were collected from a collapsed shaft in the NW section 11, T15N, R87W, to the south of the Bridger mine. The samples consisted of milky quartz with limonite boxworks with some chalcopyrite and galena in milky quartz, and milky quartz with chalcopyrite, sphalerite, and galena. The first composite sample assayed 106 ppb Au, <5 ppb Pt, 2 ppb Pd, >200 ppm Ag (12.6 opt), 0.17% Cu, >10,000 Pb (2.33%), 11 ppm Ni, and 0.38% Zn. The second sample assayed 151 ppb Au, <5 ppb Pt, 8 ppb Pd, >200 ppm Ag (12.7 opt), 0.22% Cu, 0.44% Pb, 37 ppm Ni, and 0.42% Zn.

A sample (DP496) of the host rock greenstone stained with malachite and containing traces of chalcopyrite was also assayed. This sample yielded 39 ppb Au, 6 ppb Pt, 18 ppb Pd, 1.1 ppm Ag, 962 ppm Cu, 32 ppm Pb, 58 ppm Ni, 43 ppm Zn, and 17 ppm Cr.

To the east, samples were collected from prospects on the Red Mountain Quadrangle. Sample RM196 was collected from a mine dump in the SE section 14, T14N, R85W. The sample of quartz with chalcopyrite, bornite, chalcopyrite, and malachite yielded 3.2% Cu, 389 ppm Pb, 659 ppm Zn, 406 ppb Au, and 15.7 ppm Ag.

At another prospect (W/2 section 2, T14N, R85W), hidden in the forest on the Red Mountain Quadrangle, samples of vein material and altered wallrock

were collected. Some historical trenching was done on the property in the search for gold.

Two samples were collected for assay. Sample RM396 was from a milky quartz vein, which contained considerable boxworks (after pyrite?). This sample assayed only 45 ppb Au. A second sample (RM496) was collected from the limonite-stained wallrock and yielded anomalous gold values. That sample contained 7.03 ppm (0.2 opt) Au. Further investigations of this property are anticipated as the gold values in the wallrock suggest a potential for large tonnages.

Following the WSGS' detection of anomalous gold values in 1995, more samples were collected from the Golden Clover mine (section 26, T14N, R82W) on the Barcus Peak Quadrangle. A grab sample of milky quartz collected from the property in 1995 yielded 0.323 ounce per ton gold and 14.9 ppm silver (0.43 ounce per ton).

The mine is located within the Big Creek district in the foothills of the Medicine Bow Mountains south of Encampment. The mine was developed by two, 100-foot-deep shafts on a 2,000-foot-long quartz vein in sheared quartzofeldspathic gneiss country rock. The vein is 6 inches to 6 feet wide and contains auriferous pyrite in quartz. The values reportedly increased where the vein pinches. Several assay certificates from the mine ranged from 0.2 to 20 ounces per ton gold (Ralph Platt, personal communication, 1995).

Samples collected in 1996 yielded anomalous gold and silver. These samples ranged from 3 ppb to 49.85 ppm Au (1.45 opt), < 0.02 to 37.4 ppm Ag (1.09 opt), 248 ppm to 1.8 % Cu, and a trace of lead and zinc. Further work is expected on this property as time permits in the 1997 field season.

In the Black Mountain region, west of the Rattlesnake Hills, samples of a spodumene - pegmatite were collected for future studies. In addition, a sample of cupriferous graphitic schist was collected from the King Solomon prospect (section 1, T32N, R89W). This rock yielded 43 ppb Au, 0.2 ppm Ag 4.397 ppm Cu, 149 ppm Pb, 3,435 ppm Zn, 527 ppm As, 1.5 ppm Sb, 2 ppm Mo, and 0.028 ppm Hg.

HISTORICAL SEISMICITY IN CENTRAL WYOMING

James C. Case

Staff Geologist-Geologic Hazards, Wyoming State Geological Survey

Central Wyoming is seismically active, with reported earthquakes dating back more than 100 years. A few of the historic earthquakes have caused damage, and future earthquakes will undoubtedly do the same. **Figure 20**

shows that earthquakes have been recorded throughout central Wyoming, although few have occurred in the eastern part of the Wind River Basin.

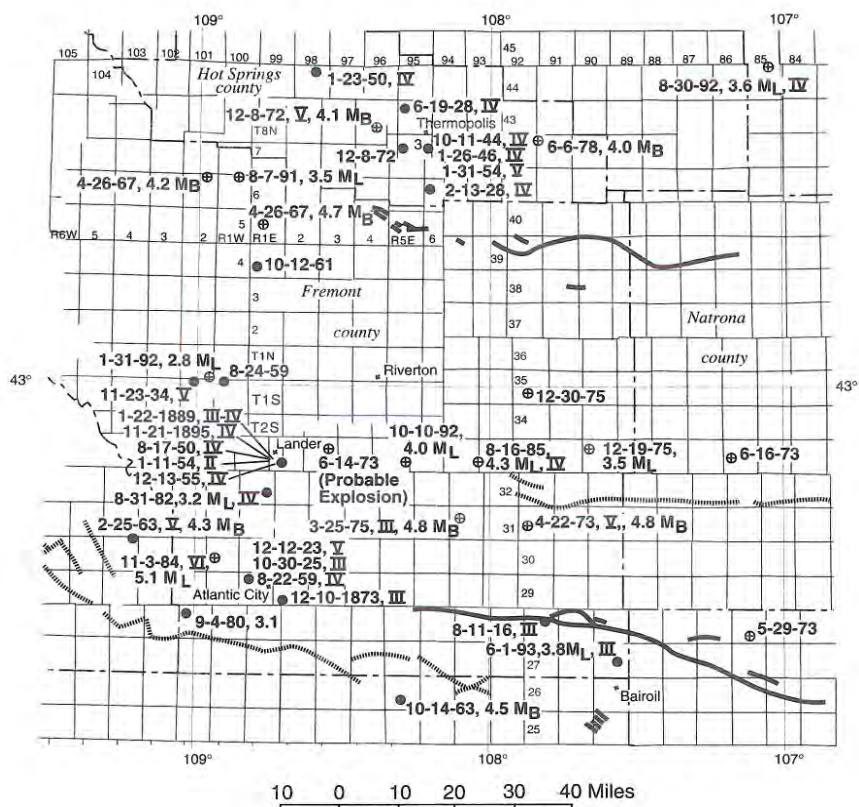
The area encompassed by this discussion includes the southern part of the Bighorn Basin and Bighorn Mountains, the Owl Creek Mountains, the Wind River Basin, a large portion of the Wind River Range, the Granite Mountains, and the northern part of the Great Divide Basin. The significant historic earthquakes described below are organized by the specific regions in which they occurred. These specific regions include the areas around Thermopolis, Pavillion/Maverick Springs Dome, Lander, Sand Draw/Gas Hills, and Atlantic City.

THERMOPOLIS AREA

The Thermopolis area has experienced a number of earthquakes, with a few causing minor damage. The first earthquake reported in the area occurred on February 13, 1928, approximately 10 miles south of Thermopolis. The intensity IV earthquake was felt as three shocks in Thermopolis, and was "felt sharply" in Worland, Owl Creek, Gebo, Crosby, and Kirby. It was also strongly felt at a mine in the Copper Mountain mining district, near Bonneville. Reports indicate that two men entered their mine when aftershocks were occurring and found that many of the mine props were so loose that they could be moved by hand (Heck and Bodle, 1930). On June 19, 1928, another intensity IV earthquake was reported in the area, with the epicenter placed approximately six miles northwest of Thermopolis (Heck and Bodle, 1930). In this case, a single shock was felt in Thermopolis, with sounds slightly preceding the earthquake.

An intensity IV earthquake, which caused damage, occurred in the Thermopolis area on October 11, 1944. Several landslides occurred as a result of the earthquake, and rocks fell onto the highway in Wind River Canyon. At Hot Springs State Park, there was a "caving of earth on the south rim of the large hot spring in the park" (Casper Tribune-Herald, October 13, 1944). On January 26, 1946, there was an intensity IV earthquake near Thermopolis that rattled windows and dishes. The earthquake, which was felt for approximately ten seconds, clouded the water in Hot Springs State Park for a few days (Laramie Republican-Boomerang, January 29, 1946). On January 23, 1950, an intensity V earthquake was felt near Hamilton Dome, approximately 22 miles northwest of Thermopolis. Houses shook and dishes rattled in the Hamilton Dome area, and the earthquake was felt in Thermopolis (Murphy and Ulrich, 1952). On January 31, 1954, an intensity V earthquake occurred in the Thermopolis area (Casper Tribune-Herald, February 2, 1954). No damage was associated with that earthquake.

One of the largest earthquakes recorded in the Thermopolis area occurred on December 8, 1972. The magnitude 4.1, intensity V earthquake was centered approximately eight miles west of Thermopolis. It caused two cracks in the ceiling of a new addition to a Thermopolis rest home (Laramie Daily Boomerang, December 9, 1972), and the floor in a local lumber yard sank a few



EXPLANATION

- ⊕ Location of determined epicenter to nearest 0.1° latitude and longitude.
- Number of events at location.
- *• Multiple events in vicinity.
- I-XII Intensities (degree of shaking) derived from Modified Mercalli Intensity Scale of 1931.
- 2.0-7.5 Magnitudes (instrumental readings of relative earthquake size).

M_L Local magnitude (Richter).

M_B Body wave magnitude.

 Faults with segments known or suspected to have been active in the Quaternary.

 Faults that have been recurrently active over the last 20 million years. Quaternary activity poorly defined or nonexistent. "Quaternary" Period, as used here, includes events as old as 2 million years before the present.



Wyoming State Geological Survey, Environmental Section, Jan., 1997

Figure 20. Earthquake epicenters and active faults with surficial expression in central Wyoming.

inches (Casper Star-Tribune, December 9, 1972). The earthquake was felt in Kinnear, Pavillion, and the Riverton area, and was reportedly felt as far away as Craig, Colorado. On June 6, 1978, a magnitude 4.0 earthquake was recorded approximately 20 miles east of Thermopolis (Reagor, Stover, and Algermissen, 1985). No damage was associated with that earthquake.

PAVILLION/MAVERICK SPRINGS DOME AREA

Beginning in the 1960s, and continuing into the 1990s, a series of earthquakes have been recorded in the area between Pavillion and Maverick Springs Dome, which is located approximately 23 miles northwest of Pavillion. On October 12, 1961, a small-magnitude earthquake was recorded approximately seven miles northwest of Pavillion (Reagor, Stover, and Algermissen, 1985). On April 26, 1967, two earthquakes were recorded in the area. A magnitude 4.7 earthquake occurred approximately 12 miles north of Pavillion, and a magnitude 4.2 earthquake occurred near Maverick Springs Dome (Reagor, Stover, and Algermissen, 1985). No damage was associated with either event. Most recently, on August 7, 1991, a magnitude 3.5 earthquake was recorded near Maverick Springs Dome (Case, 1994). This non-damaging earthquake was felt in Thermopolis.

LANDER AREA

A number of earthquakes have occurred in the Lander area. The first reported earthquake occurred on January 22, 1889, and had an intensity of III-IV (Case, 1993). This earthquake was followed by an intensity IV event on November 21, 1895, which resulted in the jarring of houses and the rattling of dishes (Case, 1993). On November 23, 1934, an intensity V earthquake was centered approximately 20 miles northwest of Lander. For a radius of 10 miles around Lander, residents reported that dishes were thrown from cupboards and pictures fell from walls. Cracks were found in buildings in two business blocks, and the brick chimney of the Fremont County Courthouse was moved two inches away from the building. The earthquake was felt at Rock Springs and Green River (Casper Tribune-Herald, November 25, 1934).

There were a series of earthquakes in the Lander area in the 1950s that caused little damage. On August 17, 1950, there was an intensity IV earthquake that caused loose objects to rattle and buildings to creak (Murphy and Ulrich, 1952). On January 11, 1954, there was an intensity II event (Reagor, Stover, and Algermissen, 1985), and on December 13, 1955, there was an intensity IV event near Lander (Murphy and Cloud, 1957), with no damage reported.

On June 14, 1973, a small earthquake was reported about eight miles east northeast of Lander. Recently, this earthquake has been interpreted as a probable explosion. On August 31, 1982, a magnitude 3.2, intensity IV earthquake occurred approximately 10 miles southwest of Lander. No significant damage was reported. On January 31, 1992, a non-damaging magnitude 2.8 earth-

quake occurred approximately 20 miles northwest of Lander (Case, 1994). This event was followed on October 10, 1992, by a magnitude 4.0, intensity III earthquake centered approximately 22 miles east of Lander (Case, 1994).

SAND DRAW/GAS HILLS AREA

The first earthquake reported in this area occurred on August 11, 1916, approximately six miles south of Jeffrey City (Reagor, Stover, and Algermissen, 1985). No damage was associated with the intensity III event. On April 22, 1973, a magnitude 4.8, intensity V earthquake was recorded approximately 12 miles north of Jeffrey City. Dishes were rattled and pictures on walls were disturbed in Jeffrey City (Casper Star-Tribune, April 24, 1973). On March 25, 1975, there was a magnitude 4.8, intensity III earthquake recorded approximately 18 miles northwest of Jeffrey City. A mobile home 35 miles southeast of Riverton was moved an inch off its foundation as a result of the earthquake (Laramie Daily Boomerang, March 26, 1975). On December 19, 1975, a non-damaging magnitude 3.5 earthquake was recorded approximately 25 miles northeast of Jeffrey City (Reagor, Stover, and Algermissen, 1985). On August 16, 1985, a magnitude 4.3, intensity IV earthquake was recorded approximately 25 miles northwest of Jeffrey City. No damage was reported. Most recently, on June 1, 1993, a non-damaging, magnitude 3.8, intensity III earthquake occurred near Bairoil, approximately 20 miles southeast of Jeffrey City (Case, 1994).

ATLANTIC CITY AREA

One of the first reported earthquakes in central Wyoming was near Atlantic City in southern Fremont County. The earthquake occurred on December 10, 1873, and was felt as an intensity III event at nearby Camp Stambaugh (Case, 1996). An intensity V earthquake was reported from Atlantic City on December 12, 1923, with no significant damage recorded (Humphreys, 1924). Non-damaging earthquakes were also reported in the area on October 30, 1925 (intensity III) and on August 22, 1959 (intensity IV).

On February 25, 1963, a magnitude 4.3, intensity V earthquake occurred approximately 25 miles west northwest of Atlantic City. The earthquake was felt for over a minute in Atlantic City, and for approximately six seconds in the Lander and Hudson areas (Casper Star-Tribune, February 26, 1963). Windows, doors, and dishes were rattled in Fort Washakie as a result of the earthquake (von Hake and Cloud, 1965). On October 14, 1963, a magnitude 4.5 earthquake was recorded approximately 30 miles southeast of Atlantic City, with no damage reported. On September 4, 1980, a magnitude 3.1 earthquake was recorded approximately 15 miles west southwest of Atlantic City, with no damage being reported. On November 3, 1984, a magnitude 5.1, intensity VI earthquake was recorded approximately 10 miles northwest of Atlantic City. The earthquake, which was felt in Dubois and Casper, was one of the strongest fault-related events recorded in the southwestern quarter of the State. A number of residents in Lander and Atlantic City reported cracked walls, foundations, and windows (Casper Star-Tribune, November 4, 1984).

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ROCK HOUND'S CORNER

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In a recent article published by the *International California Mining Journal*, Hausel (1996) discussed areas in which to search for gold nuggets and specimen-grade gold samples in Wyoming. The discussion on South Pass below was excerpted from that article.

Many lode gold deposits in the South Pass region are localized in shear zones in very old, complexly folded, Precambrian rock. Because of the style of deformation, the gold is often concentrated in ore shoots.

Typically, the shears contain anomalous, but very low gold concentrations along the entire strike length of the shear, with periodic ore shoots of high-grade gold. The shoots may be localized by a number of factors, most notable are steeply-plunging folds. Where enclosed by folds, the shoots continue down-plunge to unknown depths. Where exposed at the surface, these shoots are excellent places to search for specimen-grade samples with visible gold.

When the ore shoots are exposed to erosion or dissected by streams, very rich placers often develop immediately downstream. Gold nuggets, as well as specimen-grade samples, are typically found within the vicinity of the shoots.

One of the better regions to search for specimen-grade gold is the South Pass-Atlantic City district, itself. This area encloses several gold-bearing shear zones which were mapped by the Wyoming State Geological Survey (Hausel, 1991). Literally, thousands of feet of gold-bearing shears occur in this district.

In the Lewiston district along the eastern margin of the South Pass region, rich pockets of gold were found at Wilson Bar in 1878. A 500-foot strip of gravel mined at Wilson Bar in the late 1800s yielded 370 ounces of gold. The gold was traced upstream to the Burr lode.

In 1893, a pocket of ore intersected in the Burr mine reportedly yielded 3,000 ounces of gold. It was said some specimen-grade ore from this pocket contained as much as 1,690 ounces per ton of gold (opt Au)! According to the reports, the lode averaged 2 to 3.5 opt Au. To the northeast at the Hidden Hand mine, miners reportedly intersected a rich shoot in the 1930s that produced several sacks of specimen-grade ore containing 75 to 3,100 opt Au!

To the northeast at the Mint-Gold Leaf mine, some samples collected by the Wyoming State Geological Survey yielded 1.29 and 3.05 opt Au. But none of the mines in the district were developed to any great depth. Apparently, the miners did not recognize that the shoots continued down-plunge. But because of the rich shoots, the few placers in the district have been notable. Unfortunately, very few streams cut the area, and the few that do are very small with limited gravel.

One prospector, a few years ago, explored Strawberry Creek, which cuts most of the shears in the district. Near the mouth of the creek, about 25 ounces of gold were reportedly recovered with nuggets up to 1/2-inch in length. Other placers have apparently yielded some nice nuggets. For example, reports indicate that some nuggets (3 and 4.5 ounces) were recovered in Two Johns Gulch in 1905. In 1944, five 'good-size' nuggets were found in the Big Nugget placer. Possibly, these two placers are the same as Giblin Gulch, where in 1932, several nuggets were found, including nuggets weighing 5.2 and 5.3 ounces.

Giblin Gulch, which drains into Strawberry Creek, is essentially dry except during spring runoff. The drainage cuts across the western end of the Mint-Gold Leaf shear zone. Since the shear projects into the mouth of the gulch, it would have been interesting to know if all of the nuggets were found near the mouth, or farther uphill. At any rate, it appears at least one unexplored ore shoot lies under this drainage.

The South Pass-Atlantic City district to the west of Lewiston encloses several shear zones. Some mines in the district produced good, specimen-grade ore. For example, reports indicate that specimen-grade ore found in the Carissa mine in 1908, assayed as high as 260 opt Au. At the Duncan mine to the east, a one-foot composite chip sample was collected from a fold by the Wyoming State Geological Survey. This sample assayed 0.96 opt Au. At the Mary Ellen mine to the east, early reports indicated that pockets of ore, containing as much as 50 opt Au were intersected. Farther east, at the Miners Delight mine (one of the two principal producers in the district along with the Carissa mine) reports indicated that some rich pockets of gold were intersected in the mine.

Historical reports also indicate that miners pumped water from the Miners Delight shaft into Spring Gulch below the mine, to mine the drainage. Several 1- and 2-ounce nuggets were found in the gravels along with a 6-ounce nugget. In 1873, one lump of specimen-grade quartz was found that was as large as a water bucket. According to one witness, it looked as if it could contain a pound of gold. One company on Yankee Gulch to the northeast of the Miners Delight mine reportedly took out 8 to 15 ounces of gold per day, including one nugget that weighed nearly 5 ounces.

One of the principal placers in the South Pass region, known as Rock Creek, runs through the middle of the district. This placer apparently produced some impressive specimen-grade samples. One fist-size chunk of quartz found in the drainage was filled with an estimated 24 ounces of gold. A boulder found nearby, in 1905, contained an estimated 630 ounces of gold! From 1933 to 1941, the E.T. Fisher Company dredged six miles of Rock Creek, recovering as much as 30,000 ounces of gold, including nuggets up to 3.4 ounces in weight. It is interesting that Willow Creek, which lies a short distance to the west, cuts across the same rock units as Rock Creek, yet Willow Creek has seen only minor activity.

Paleoplacers have been identified at a few localities in the region. One of these, located along the southern flank of South Pass, was discovered in 1863 in the vicinity of Oregon Buttes. Dry placers in this area have been estimated to host 2.2 million ounces of gold, and the adjacent paleoplacers are estimated to contain about 28.5 million ounces. Even though the paleoplacers are very low-grade, a systematic search with a magnetometer might reveal some pay streaks. The source terrane for this deposit, and the McGraw Flats paleoplacer along the northern flank of South Pass, have yet to be discovered!

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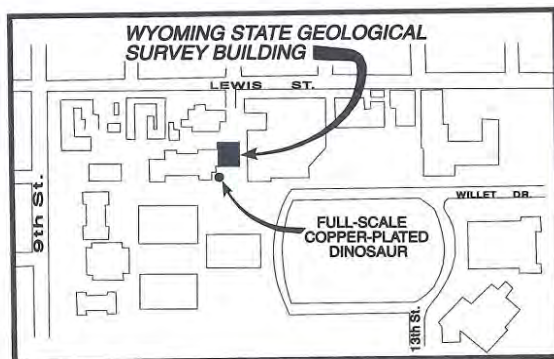
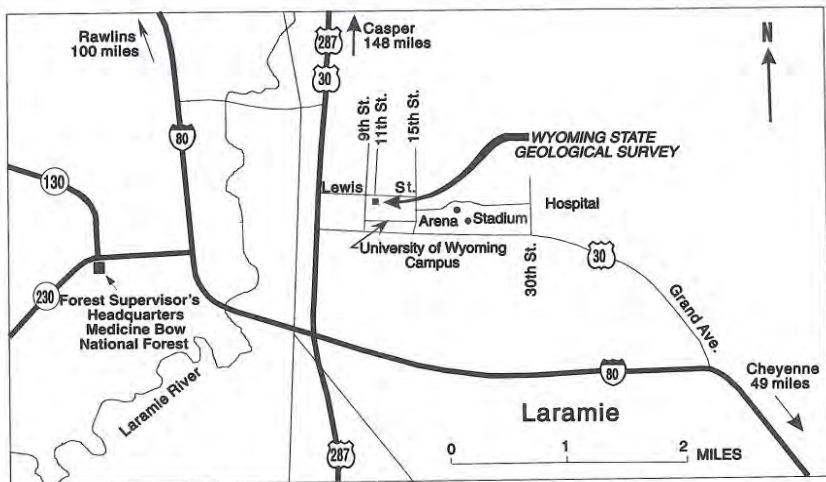
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