Wyoming Geo-notes

Number 55

Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
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PHONE: (307) 766-2286
FAX: (307) 766-2605
E-MAIL: wsgs@wsgs.uwyo.edu

WYOMING GEO-NOTES
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Cover: Rio Algom's Smith Ranch in-situ uranium recovery facility in the Powder River Basin. Solute injection began in mid-June. Uranium recovery started in early July.

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MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

The forecasts of energy and mineral production in this issue of *Wyoming Geo-notes* are the same as those in the last issue with the exception of uranium production (**Tables 1** and **2**; **Figures 1**, **2**, and **3**). Production of in-situ uranium in 1996 was 2.4 million pounds, rather than the estimated 2.0 million. Uranium production estimates for 1997 and later years have also been increased (**Table 1**). Monthly coal deliveries now reflect the first quarter of 1997 (**Figures 4** and **5**; **Table 3**).

The forecasts of energy and mineral prices are unchanged from the last issue of *Wyoming Geo-notes* (**Tables 4** and **5**; **Figures 6**, **8**, and **10**). In regard to 1997 prices, the average oil price slipped to $15.90 a barrel in June for a six-month average of $18.43 (**Figure 7**). The spot sale methane price at Opal was $1.35 in June for a six-month average of $2.03 (**Figure 9**). These six-month averages, however, are bolstered by the relatively high prices received for both oil and natural gas in the first quarter of the year.

In June, Barrett Resources announced plans to drill an ultra-deep test of the Madison at Waltman Field. This is a 21,150-foot test. And Louisiana Land & Exploration recovered 44 million cubic feet of gas per day in production tests

Table 1. Wyoming mineral production (1985-1996) with forecasts to 2003[1].

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	*73.4	*1,031.3	*142.6	*1.07	278.4	17.5	2.4	*1.20
1997	69.0	1,045.1	142.6	1.07	289.5	21.1	2.9	1.20
1998	65.2	1,072.4	142.6	1.07	304.0	21.1	3.5	1.20
1999	61.6	1,100.4	142.6	1.07	322.2	21.1	3.5	1.20
2000	58.2	1,129.0	142.6	1.07	344.5	22.6	3.5	1.20
2001	55.0	1,167.2	142.6	1.07	351.4	22.6	3.5	1.20
2002	52.0	1,206.5	142.6	1.07	355.0	24.4	3.5	1.20
2003	49.1	1,247.0	142.6	1.07	358.6	24.4	3.5	1.20

*Estimated until official figures are available.
[1]Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2003, July, 1997; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1985-1995; [4] Billions of cubic feet; [5]Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; [6]Millions of short tons (Wyoming State Inspector of Mines, 1985-1996); [7]Wyoming State Inspector of Mines, 1985-1996; [8]Millions of pounds of yellowcake (not available [N/A] for 1985 and previous years because it was only reported as taxable value); [9]Millions of short tons.

Table 2. Wyoming coal production by county (in millions of tons), from 1993 to 1996 with forecasts to 2003.

	1993	1994	1995	1996	1997[1]	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]
Campbell County	181.9	205.2	232.4	245.3	258.2	272.0	289.9	312.2	319.1	322.7	326.3
Converse County	10.2	11.7	14.1	15.8	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	4.7	3.8	4.0	4.0	4.0	4.0	4.0	4.0
Sweetwater County	9.2	11.2	9.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.1	4.3	4.5	4.4	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Hot Springs County	M	M	0	0	0	0	0	0	0	0	0
Total Wyoming	209.9	236.9	263.9	278.4	289.5	304.0	322.2	344.5	351.4	355.0	358.6
Annual Change	10.8%	12.9%	11.4%	5.5%	3.5%	5.0%	6.0%	6.9%	2.0%	1.0%	1.0%
Higher-priced coal[2]	36%	33%	26%	24%	22%	17%	13%	9%	6%	4%	4%

[1]County estimates by Wyoming State Geological Survey, April, 1997; [2]Estimated percentage of Powder River Basin coal production that is sold at prices above $5.00 [older long-term contracts that have not yet expired]. M means minor tonnage (less than 0.1 million tons).

Table 3. Monthly coal deliveries from Wyoming's mines in short tons (1994-1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	19,326,770	19,326,770	21,586,303	21,586,303	21,793,387	21,793,387	25,165,405	25,165,405
FEB	17,171,910	36,498,680	20,839,926	42,426,229	20,374,055	42,167,442	20,743,224	45,908,629
MAR	19,178,990	55,677,670	21,707,422	64,133,651	22,507,800	64,675,242	22,566,012	68,474,641
APR	17,839,110	73,516,780	20,066,616	84,200,267	22,579,959	87,255,201		
MAY	18,652,290	92,169,070	21,509,916	105,710,183	22,216,016	109,471,217		
JUN	17,741,480	109,910,550	18,602,505	124,312,688	20,698,814	130,170,031		
JUL	18,213,540	128,124,090	21,334,608	145,647,296	24,842,971	155,013,002		
AUG	20,572,120	148,696,210	21,356,870	167,004,166	24,421,537	179,434,539		
SEP	19,129,450	167,825,660	21,355,730	188,359,896	23,339,792	202,774,331		
OCT	18,189,260	186,014,920	21,178,610	209,538,506	22,615,721	225,390,052		
NOV	18,595,500	204,610,420	21,042,260	230,580,766	21,421,085	246,811,137		
DEC	20,866,710	225,477,130	22,032,910	252,613,676	22,105,530	268,916,667		
Total Tonnage Reported[1]		**225,477,130**		**252,613,676**		**268,916,667**		
Total Tonnage Not Reported[2]		**11,430,937**		**11,324,347**		**9,508,289**		
Total Tonnage Produced[3]		**236,908,067**		**263,938,023**		**278,424,956**		

[1] COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities (1994-1995); From bulletin board of the Federal Energy Regulatory Commission in 1996 and 1997.
[2] Includes estimates 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, July, 1997.

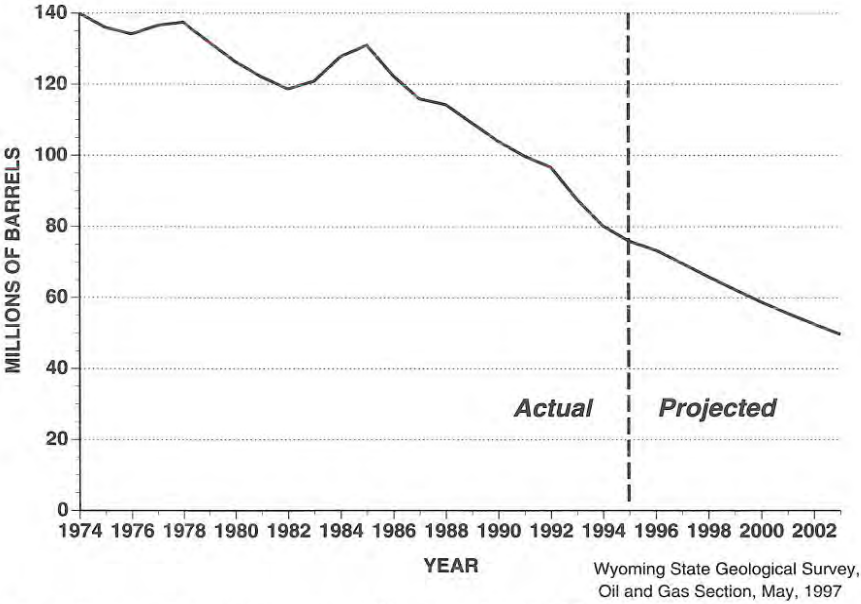


Figure 1. Annual oil production from Wyoming (1974 to 1995) with forecasts to 2003.

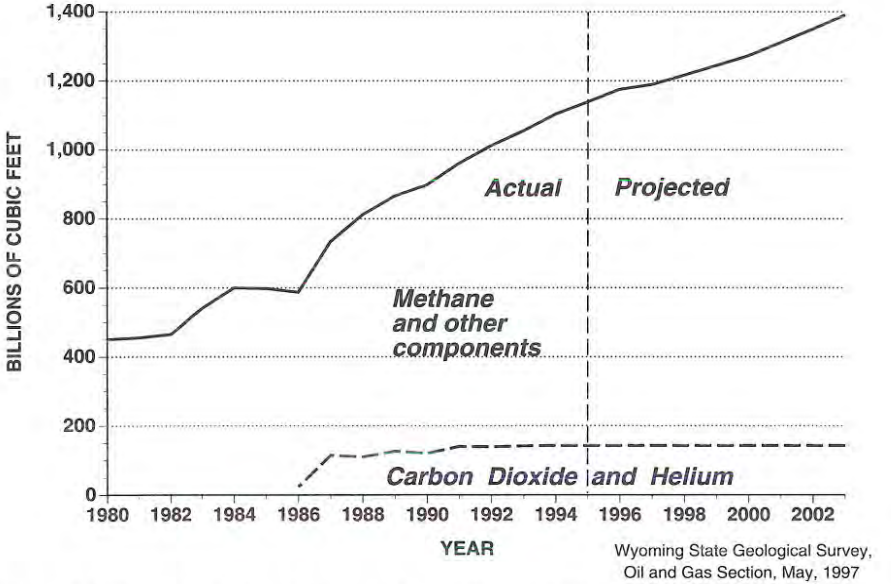


Figure 2. Annual natural gas production from Wyoming (1980 to 1995) with forecasts to 2003.

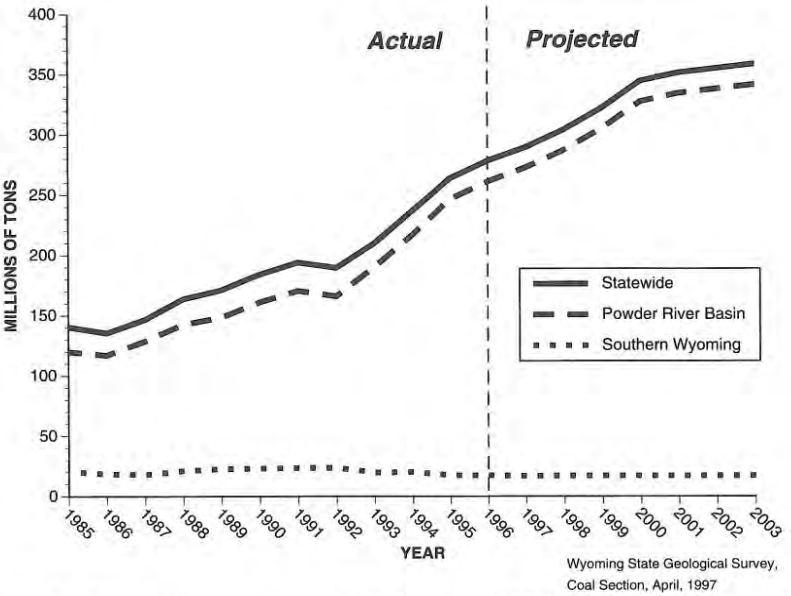


Figure 3. Annual coal production from Wyoming (1985-1996) with forecasts to 2003. Data from Wyoming State Inspector of Mines (1985-1996) and Wyoming Consensus Estimating Group (1997-2003).

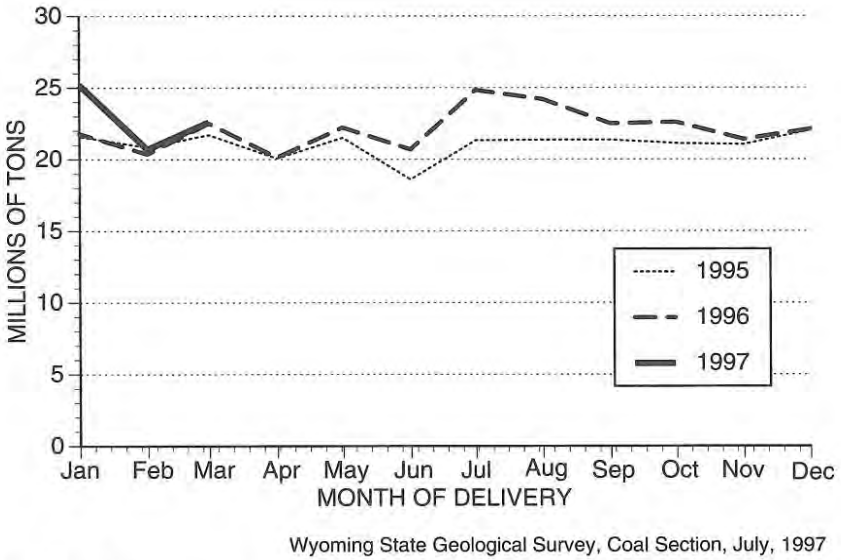
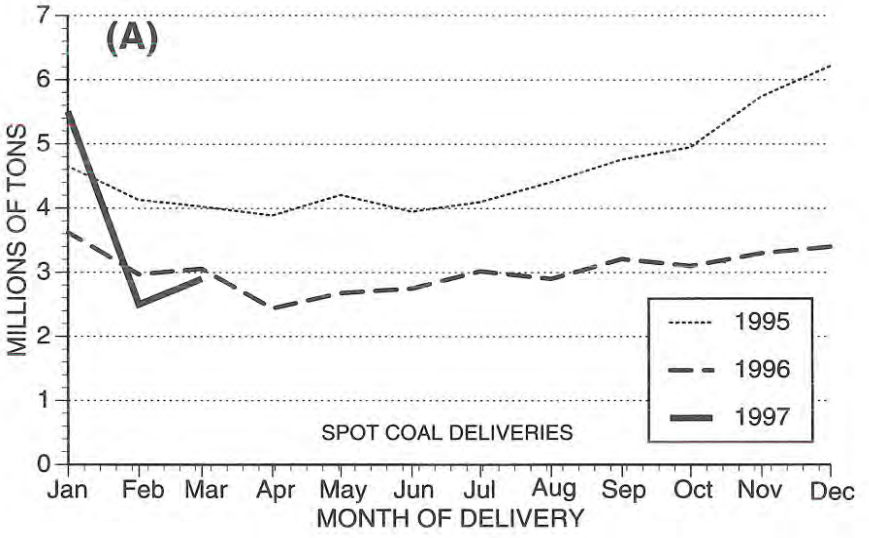


Figure 4. Reported monthly deliveries from Wyoming coal mines (1995 through 1997). From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997.



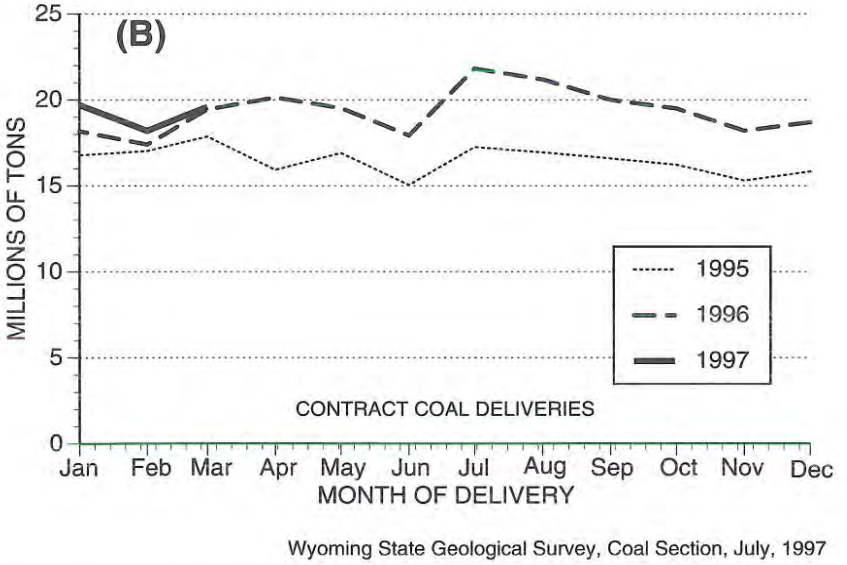


Figure 5. Monthly coal deliveries from Wyoming (1995 through 1997). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997).

Table 4. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1995) with forecasts to 2003[1].

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	1.60	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] Modified from CREG, Wyoming State Government Revenue Forecast FY97-FY2003, April, 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 Investment 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.

Table 5. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1995) with forecasts to 2003[1].

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

[1]Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1995 are derived from Wyoming Department of Revenue information; estimates for 1996-2003 are from the Consensus Revenue Estimating Group's report of April, 1997; and all regional breakdowns are estimated by the Wyoming State Geological Survey.

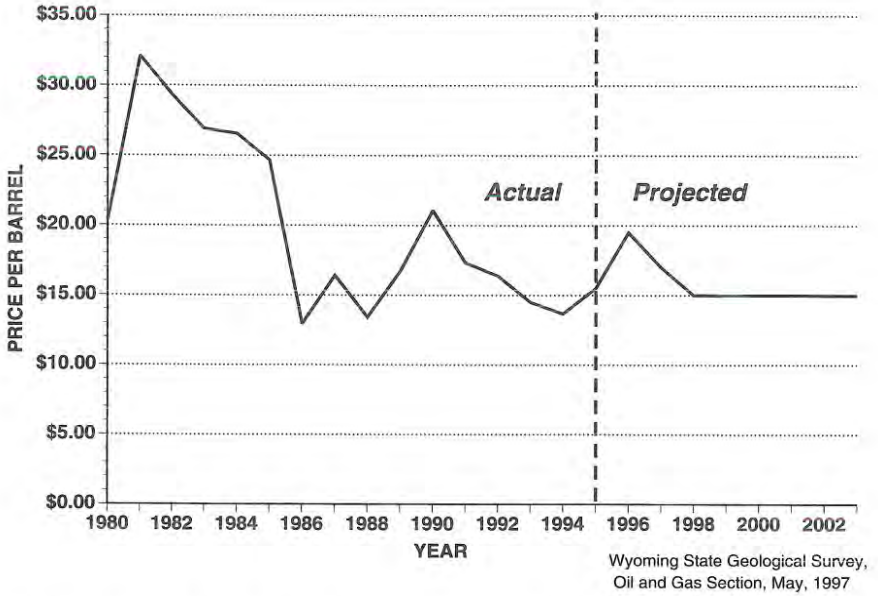


Figure 6. Average prices paid for Wyoming oil (1980-1995) with forecasts to 2003.

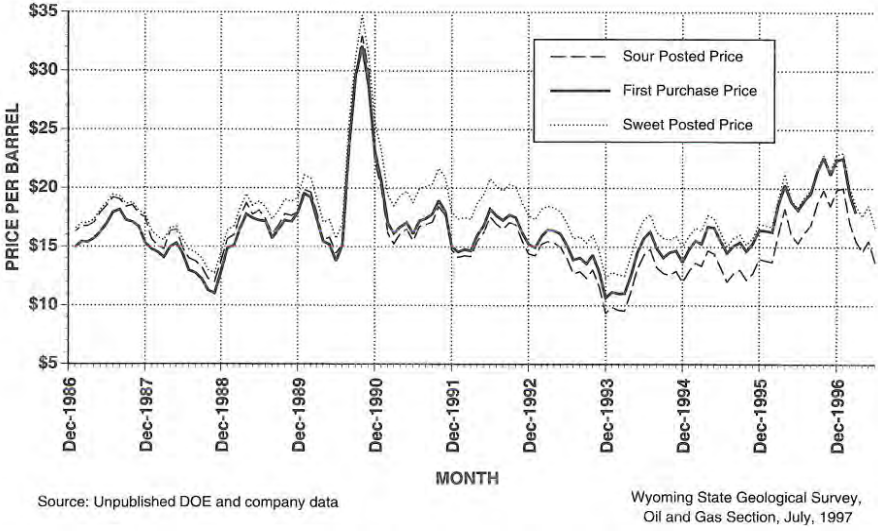


Figure 7. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

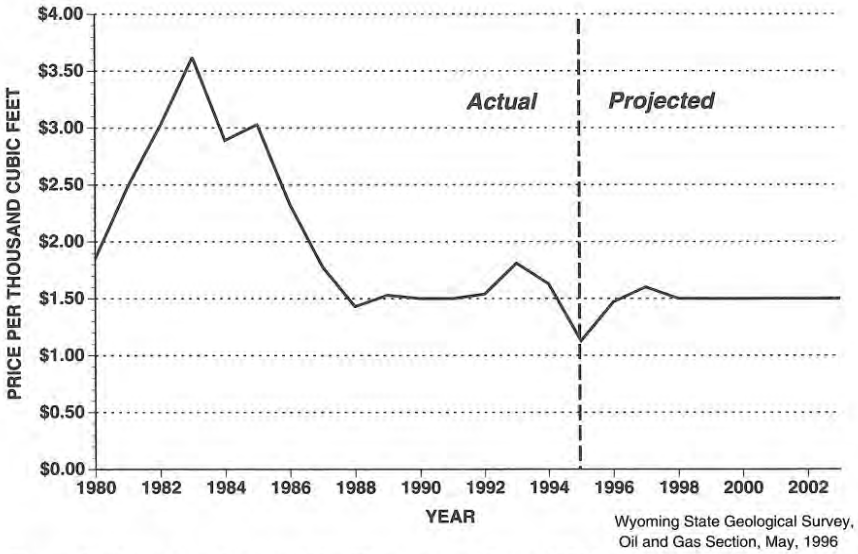


Figure 8. Average prices paid for Wyoming methane (1980 to 1995) with forecasts to 2003.

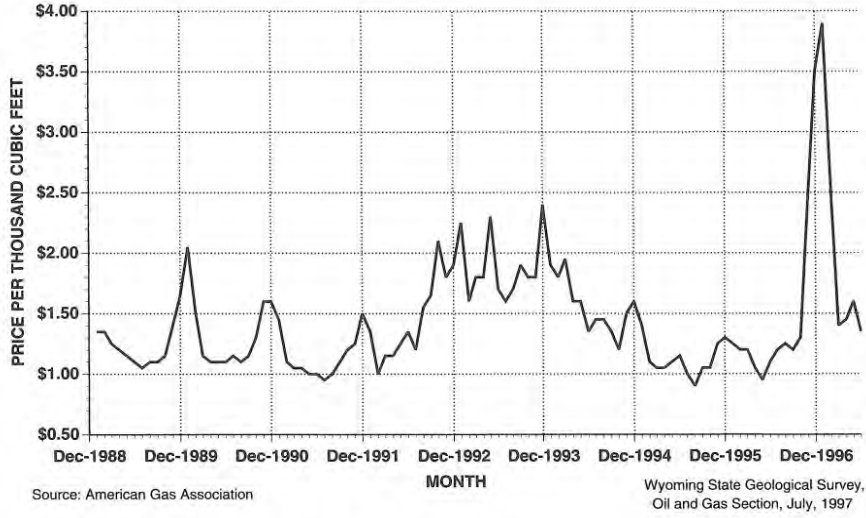


Figure 9. Spot sale price for methane at Opal, Wyoming, averaged by month (1989 to present).

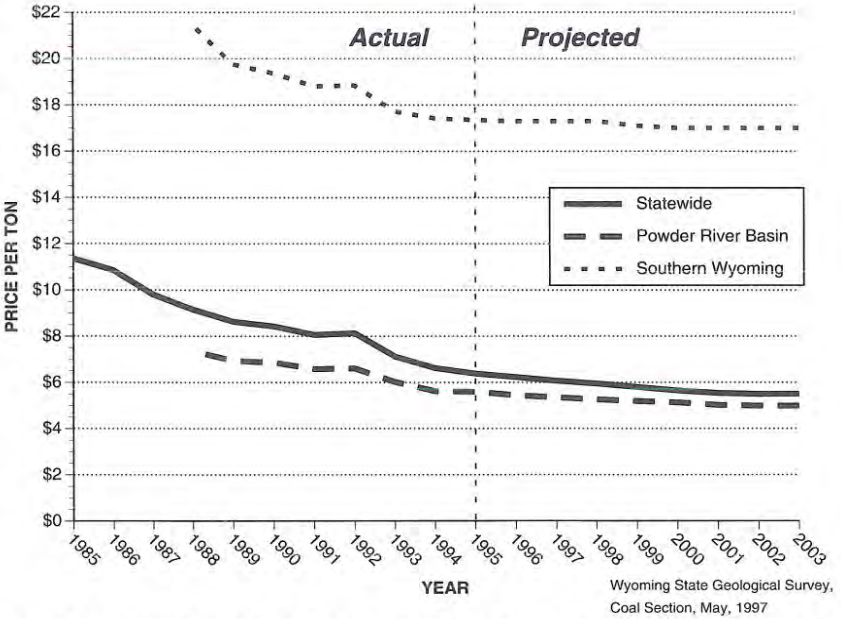


Figure 10. Average prices paid for Wyoming coal (1985 to 1995) with estimates to 2003. Source: U.S. Energy Information Administration (1985-1990); derived from the Wyoming Department of Revenue (1991-1995); and the Consensus Revenue Estimating Group (1996-2003).

of its new ultra-deep Madison well (24,107 feet) at Madden Field. These and other oil and gas activities are discussed in the **Oil and Gas Update** in this issue.

By the end of the second quarter, estimated spot sale coal prices were up slightly from the first quarter. This put 8,800-Btu/lb. coal at about $4.10 a ton and 8,400-Btu/lb. coal at about $3.05. The average first quarter price for 8,800-Btu/lb. coal was $3.95 per ton and $3.00 per ton for 8,400-Btu/lb. coal. Coal marketing newsletters were noting that some producers in the Powder River Basin were already sold out of 8,800-Btu/lb. coal for 1997, but that most producers of 8400-Btu/lb. coal still had coal available.

A noteworthy item in the second quarter, was Dakota, Minnesota, and Eastern Railway Corporation's (DM&E's) announced plans to build a third railroad into the Powder River Coal Field of northeastern Wyoming. This proposed railroad is designed to compete with the Union Pacific/Southern Pacific and Burlington Northern/Santa Fe railroads. DM&E hopes to begin coal haulage by early 2002 (see the **Coal Update** in this issue).

While uranium prices continued to soften with a quoted July price of only $9.75 a pound, Rio Algom's new in-situ recovery operation has come on line in the Powder River Basin. This and other uranium activities are discussed on p. 38-39 of this issue.

This issue also includes the second part of an overview of the historical seismicity in western Wyoming (p. 43-52).

OIL AND GAS UPDATE

Rodney H. De Bruin
Staff Geologist-Oil and Gas, Wyoming State Geological Survey

Prices paid to Wyoming oil producers during the second quarter of 1997 averaged an estimated $16.87 per barrel. The average price for the first half of 1997 is higher than the first half in any of the last five years, however, the average price has declined every month except for May (**Table 6**). This downward trend is contrary to fairly stable or increasing prices during the first half of recent years (**Figure 7**).

Oil production in Wyoming for the first quarter of 1997 was an estimated 17.3 million barrels (**Table 7**), according to preliminary figures from Petroleum Information Inc. This production is a drop of about 4% from last year's first quarter oil production.

Spot prices for natural gas at Opal, Wyoming, averaged $1.47 during the second quarter of 1997 (**Figure 9**). This is the highest second quarter average price since 1994. The price for the first six months of 1997 has averaged $2.03 (**Table 8**).

Natural gas production in Wyoming for the first quarter of 1997 was an estimated 274.6 billion cubic feet, according to preliminary production figures from Petroleum Information Inc. (**Table 9**). Production is about 15 billion cubic feet low because of a reporting omission by a major gas producer. Even with an added 15 billion cubic feet of production, the total for the first quarter is lower than for the first quarter of 1996. Production should increase later in the year when pipeline capacity out of the State increases.

The Federal Energy Regulatory Commission approved KN Energy's Pony Express pipeline in June. The 900-mile line will transport natural gas from Wyoming to the Kansas City area. The pipeline will deliver 230 million cubic feet of gas per day when construction is completed in approximately four months. KN Energy will take 100 million cubic feet of gas from the Waltman/Cave Gulch Field in the Wind River Basin.

Table 6. Monthly average price of a barrel of oil produced in Wyoming (1994 to present).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	$ 11.15	$ 11.15	$ 14.77	$ 14.77	$16.38	$16.38	$22.56	$22.56
FEB	$ 11.01	$ 11.08	$ 15.55	$ 15.16	$16.28	$16.33	$19.45	$21.01
MAR	$ 11.04	$ 11.07	$ 15.26	$ 15.19	$18.63	$17.09	$17.94	$19.98
APR	$ 12.59	$ 11.45	$ 16.73	$ 15.58	$20.29	$17.90	**$16.90**	**$19.21**
MAY	$ 14.53	$ 12.07	$ 16.65	$ 15.79	$18.85	$18.08	**$17.80**	**$18.93**
JUN	$ 15.73	$ 12.68	$ 15.52	$ 15.75	$18.15	$18.10	**$15.90**	**$18.43**
JUL	$ 16.31	$ 13.20	$ 14.50	$ 15.57	$18.98	$18.22		
AUG	$ 14.89	$ 13.41	$ 15.09	$ 15.51	$19.59	$18.39		
SEP	$ 14.10	$ 13.49	$ 15.41	$ 15.50	$21.48	$18.74		
OCT	$ 14.53	$ 13.59	$ 14.67	$ 15.42	$22.63	$19.13		
NOV	$ 14.68	$ 13.67	$ 15.32	$ 15.41	$21.19	$19.31		
DEC	$ 13.71	$ 13.67	$ 16.43	$ 15.50	$22.42	$19.56		
Average yearly price		**$ 13.67**		**$ 15.50**		**$19.56**		

Source: All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 1997 are estimated from various unpublished bulletins listing posted prices.

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

Table 7. Monthly oil production from Wyoming in barrels (1994 to present).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	7,115,472	7,115,472	6,700,000	6,700,000	6,153,037	6,153,037	5,945,693	5,945,693
FEB	6,387,147	13,502,619	6,100,000	12,800,000	5,693,084	11,846,121	5,428,432	11,374,125
MAR	6,984,248	20,486,867	6,300,000	19,100,000	6,176,805	18,022,926	5,918,631	17,292,756
APR	6,672,207	27,159,074	6,200,000	25,300,000	5,977,362	24,000,288		
MAY	6,847,709	34,006,783	6,300,000	31,600,000	6,035,505	30,035,793		
JUN	6,594,914	40,601,697	6,200,000	37,800,000	5,916,019	35,951,812		
JUL	6,773,956	47,375,653	6,300,000	44,100,000	6,076,992	42,028,804		
AUG	6,685,423	54,061,076	6,100,000	50,200,000	6,414,850	48,443,654		
SEP	6,446,719	60,507,795	6,100,000	56,300,000	6,180,180	54,623,834		
OCT	6,525,817	67,033,612	6,300,000	62,600,000	6,186,019	60,809,853		
NOV	6,257,924	73,291,536	6,100,000	68,700.000	6,221,912	67,031,765		
DEC	6,236,204	79,527,740	6,300,000	75,000,000	6,330,701	73,362,466		
Total Barrels Reported[1]		**79,527,740**		**75,000,000**		**73,362,466**		
Total Barrels Not Reported[2]		**651,400**		**554,113**				
Total Barrels Produced[3]		**80,179,140**		**75,554,113**				

[1]Monthly 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, July, 1997.

Table 8. Monthly average spot sale price for one thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1994 to present).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	$ 1.90	$ 1.90	$ 1.40	$ 1.40	$1.25	$1.25	$3.90	$3.90
FEB	$ 1.80	$ 1.85	$ 1.10	$ 1.25	$1.20	$1.23	$2.50	$3.20
MAR	$ 1.95	$ 1.88	$ 1.05	$ 1.18	$1.20	$1.22	$1.40	$2.60
APR	$ 1.60	$ 1.81	$ 1.05	$ 1.15	$1.05	$1.18	$1.45	$2.31
MAY	$ 1.60	$ 1.77	$ 1.10	$ 1.14	$0.95	$1.13	$1.60	$2.17
JUN	$ 1.35	$ 1.70	$ 1.15	$ 1.14	$1.10	$1.13	$1.35	$2.03
JUL	$ 1.45	$ 1.66	$ 1.00	$ 1.12	$1.20	$1.14		
AUG	$ 1.45	$ 1.64	$ 0.90	$ 1.09	$1.25	$1.15		
SEP	$ 1.35	$ 1.61	$ 1.05	$ 1.09	$1.20	$1.16		
OCT	$ 1.20	$ 1.57	$ 1.05	$ 1.09	$1.30	$1.17		
NOV	$ 1.50	$ 1.56	$ 1.25	$ 1.10	$2.45	$1.29		
DEC	$ 1.60	$ 1.57	$ 1.30	$ 1.12	$3.50	$1.47		
Average yearly price		**$ 1.57**		**$ 1.12**		**$1.47**		

Source: American Gas Association's monthly reports

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

Table 9. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1994 to present).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	93,146,775	93,146,775	100,224,249	100,224,249	101,359,648	101,359,648	99,298,948	99,298,948
FEB	85,623,666	178,770,441	86,691,577	186,915,826	96,303,300	197,662,948	73,258,011	172,556,959
MAR	94,388,052	273,158,493	94,344,991	281,260,817	103,541,127	301,204,075	102,009,092	274,566,051
APR	92,362,726	365,521,219	93,929,323	375,190,140	99,479,609	400,683,684		
MAY	93,886,923	459,408,142	95,791,327	470,981,467	97,900,863	498,584,547		
JUN	81,764,661	541,172,803	92,140,614	563,122,081	87,069,612	585,654,159		
JUL	94,998,414	636,171,217	92,796,301	655,918,382	100,219,275	685,873,434		
AUG	93,743,790	729,915,007	90,393,416	746,311,798	99,874,019	785,747,453		
SEP	88,476,703	818,391,710	92,589,092	838,900,890	93,510,551	879,258,004		
OCT	95,232,646	913,624,356	98,386,458	937,287,348	95,441,022	974,699,026		
NOV	95,312,491	1,008,936,847	94,939,660	1,032,227,008	94,015,007	1,068,714,033		
DEC	87,115,084	1,096,051,931	99,314,617	1,131,541,625	99,141,298	1,167,855,331		
Total MCF Reported[1]		**1,096,051,931**		**1,131,541,625**		**1,167,855,331**		
Total MCF Not Reported[2]		**6,879,705**		**6,448,396**				
Total MCF Produced[3]		**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.

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Coastal Corporation's subsidiaries, Colorado Interstate Gas and Wyoming Interstate, began construction on the expansion of their pipeline systems in Wyoming. The new facilities will increase Wyoming Interstate's capacity by 193 million cubic feet of gas per day and Colorado Interstate Gas' capacity by 68 million cubic feet per day. Both expansions should be completed later this year.

The U.S. Bureau of Land Management (BLM) combined its analysis of two natural gas development projects in Carbon and Sweetwater counties. While the Wamsutter II project involves up to 750 wells, the Continental Divide project could be as large as 3,000 wells. Well density will be from one well to eight wells per section. Both projects have grown larger than when they were first proposed about two years ago.

Union Pacific Resources will invest $60 million in two gas processing facilities and a connecting pipeline in Sweetwater County. The Patrick Draw plant will be replaced by a new plant that will process 120 million cubic feet of gas per day. The Brady plant will be rebuilt and converted to a gas sweetening plant that will remove hydrogen sulfide and produce 37 million cubic feet of sweet gas per day. The gas from the Brady plant will be shipped to the new Patrick Draw plant through a new 8-inch, 20-mile pipeline. Construction on the new facilities should be completed by November.

If TransCanada Pipeline's pipeline expansion is approved, Wyoming gas producers will have increased competition for gas markets in the U.S. Midwest. Plans call for expansion of capacity by 456 million cubic feet of gas per day by November, 1998, and additional expansion in 1999. This is in addition to 300 million cubic feet per day of new capacity that TransCanada will be adding by November, 1997. The company serves Canadian markets as well as U.S. Northeastern and Midwest markets.

Amoco Corp. plans to sell its major oil fields in Wyoming. The company's interests in Elk Basin Field in the Bighorn Basin, Salt Creek Field in the Powder River Basin, and Beaver Creek Field in the Wind River Basin are all for sale. The company will keep its natural gas fields in the Overthrust Belt and in the Greater Green River Basin.

Alberta Energy and Husky, two Canadian companies, plan to build a 343-mile oil pipeline that would transport oil from northeastern Alberta, Canada, to the Express Pipeline that carries Canadian crude oil to the Rocky Mountain region and to the U.S. Midwest. The new pipeline would also transport crude oil to the Interprovincial Pipeline that transports Canadian crude oil to eastern Canada and to the U.S. Midwest.

In the second quarter of 1997, there were four lease sales. Leasing activity at the April U.S. Bureau of Land Management (BLM) sale was concentrated in the Powder River Basin (**Figure 11**). The high per-acre bid was $400 by Maurice Brown for a 79.12-acre parcel covering parts of section 1, T53N, R69W (**Table 10**; location A, **Figure11**). The lease is less than a mile west of Muddy

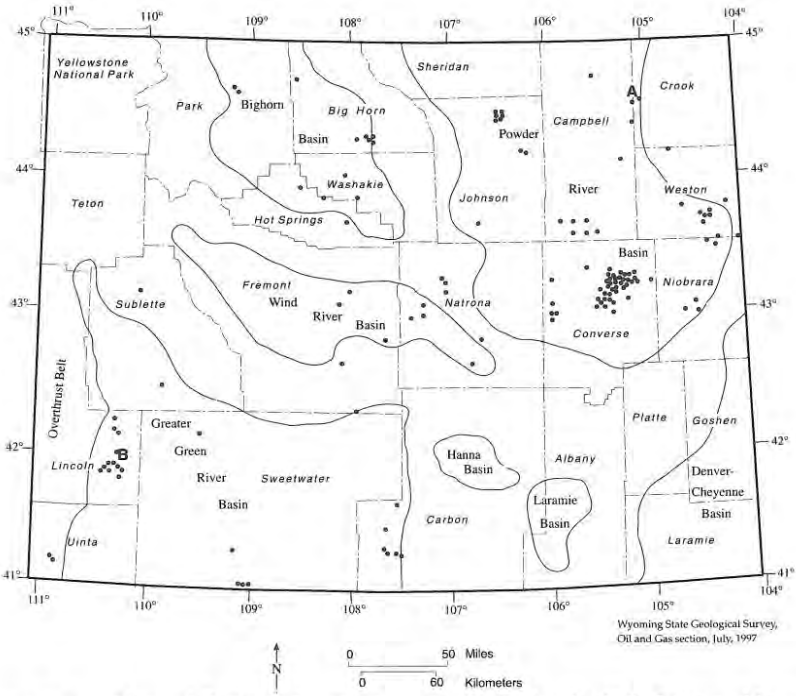

Figure 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the April, 1997, sale.

Sandstone oil production at Prairie Creek Field. The second high per-acre bid was $320 by High Plains Associates for a 640-acre lease that covers parts of sections 28 and 30 , T23N, R113W (location B, **Figure 11**). The lease is about three miles west of Frontier and Dakota gas production in Shute Creek Field.

Leasing activity at the Wyoming State Land and Investment Office's April sale was also concentrated in the Powder River Basin (**Figure 12**). The high per-acre bid was $170 by Intoil Inc. for a 2.8-acre lease that covers part of section 16, T50N, R95W (**Table 10**; location A, **Figure 12**). The lease is in Fritz Field where oil and gas have been produced from the Frontier, Muddy, and Cloverly. The second high per-acre bid was $110 by Shadco for a 640-acre parcel that covers all of section 16, T38N, R90W (location B, **Figure 12**). The lease is about a mile south of production at Madden/Lost Cabin Field and includes a non-commercial well that tested gas from the Mesaverde and the Shannon.

Leasing activity at the BLM's June sale was concentrated in the Powder River, Greater Green River, and Bighorn basins (**Figure 13**). The high per-acre bid was $310 by Marathon for a 330.39-acre lease that covers part of section 22, T12N, R100W (**Table 10**; location A, **Figure 13**). The lease is about two miles north of Wasatch, Fort Union, Lance, Lewis, and Mesaverde gas

Table 10. Federal and State competitive oil and gas lease sales in Wyoming.

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)

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							
TOTAL	$12,942,008	2,769	1,469	2,065,942	995,344	$13.00	$400.00
1994							
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.00
1995							
February	$3,252,668	533	332	473,177	290,046	$11.21	$425.00
April	$1,591,709	531	206	483,626	189,003	$8.42	$160.00
June	$3,499,604	393	246	384,746	238,863	$14.65	$660.00
August	$1,105,381	488	165	420,189	149,025	$7.41	$160.00
October	$2,761,689	477	227	384,683	174,453	$15.83	$1,100.00
December	$836,195	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
1996							
February	$1,635,668	455	192	358,478	137,901	$11.86	$220.00
June	$1,438,325	460	282	337,440	181,338	$ 7.93	$210.00
August	$2,021,488	289	182	261,321	118,267	$17.09	$145.00
October	$3,058,248	363	255	280,434	163,054	$18.76	$270.00
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
1997							
February	$2,463,137	267	210	222,486	148,148	$16.63	$250.00
April	$2,612,013	145	137	98,865	90,948	$28.72	$400.00
June	$4,642,113	285	249	313,519	262,682	$17.67	$310.00

STATE SALES (STATE LAND AND INVESTMENT 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
1993							
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
1994							
TOTAL	$3,304,152	800	607	331,779	255,152	$12.95	$205.00
1995							
March	$524,165	199	131	89,371	57,702	$9.08	$130.00
May	$452,747	200	125	75,633	49,735	$9.10	$78.00
September	$421,454	200	134	78,032	53,527	$7.87	$65.00
November	$257,852	200	102	80,851	41,744	$6.18	$52.00
TOTAL	$1,656,218	799	492	323,887	202,708	$8.17	$130.00
1996							
March	$308,927	199	96	85,369	41,909	$7.37	$108.00
June	$656,177	250	114	103,621	48,638	$13.49	$206.00
October	$663,241	300	134	115,495	54,538	$12.16	$175.00
December	$697,152	300	164	113,626	61,729	$11.29	$86.00
TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
1997							
April	$719,005	300	189	119,436	80,548	$8.93	$170.00
June	$1,008,470	300	185	108,470	62,447	$16.16	$162.00

Sources: Wyoming State Land and Investment Office, Petroleum Information Corporation - Rock Mountain Region Report, and U.S. Bureau of Land Mangement.

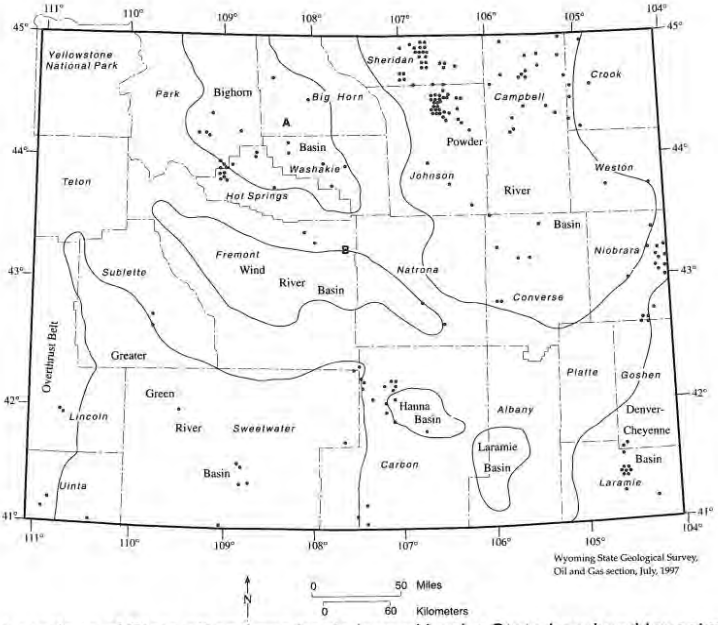

Figure 12. Locations of State oil and gas tracts leased by the State Land and Investment Office at the April, 1997, sale.

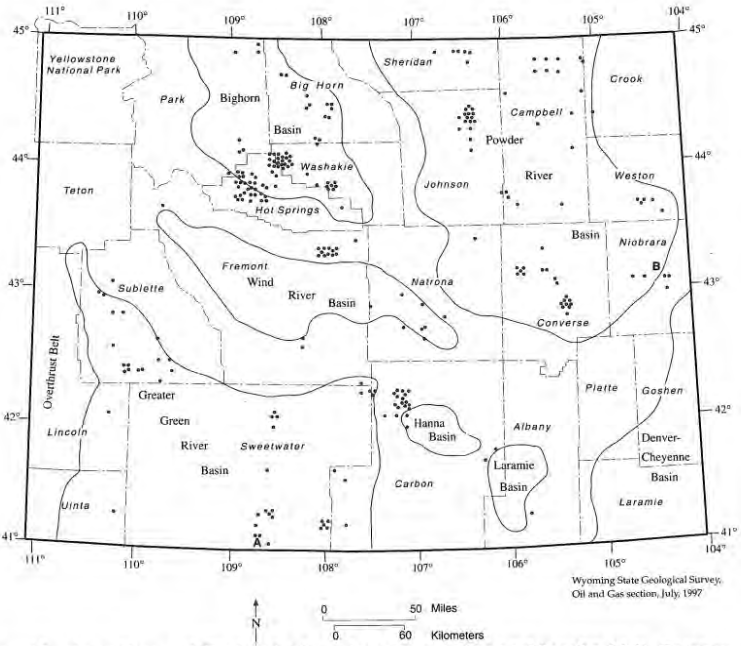

Figure 13. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the June, 1997, sale.

production at Hiawatha West Field in Colorado. The second high per-acre bid was $302 by Marathon for a 961.48-acre parcel that includes parts of section 17, 20, and 21, T12N, R100W (location A, **Figure 13**). This lease is also about two miles north of Hiawatha West Field. The third high per-acre bid was $270 by John E. Lucken for a 40-acre parcel that covers NE NW section 24, T37N, R63W (location B, **Figure 13**). The lease is between Newcastle and Dakota oil production at Ant Hills Field and Dakota and Minnelusa oil production at Ant Hills North Field.

Leasing activity at the Wyoming State Land and Investment Office's June sale was fairly evenly distributed throughout the State (**Figure 14**). The high per-acre bid was $162 by Devon Energy for a 400-acre parcel that takes in part of section 16, T43N, R71W (**Table 10**; location A, **Figure 14**). The lease is about one and a half miles west of Dakota gas and condensate production at Hilight Field and about two miles northeast of Sussex oil production at House Creek Field. The sale's second high per-acre bid was $157 by Devon Energy for a 39.70-acre lease that takes in part of section 6, T49N, R71W (location B, **Figure 14**). The parcel is about one and a half miles southwest of Minnelusa oil production at AG Farm Field.

There were 727 Applications for Permit to Drill (APDs) in the first half of 1997 (**Table 11**). APDs for the first half are at a pace that should bring the total in 1997 higher than in 1996, when APDs were at a five-year high. Over 40% of the permits were issued for Campbell County, and a large percentage of those permits were for shallow coalbed methane tests. The number of seismic projects permitted by the Wyoming Oil and Gas Conservation Commission was 33 in the first half of 1997 (**Table 12**). The seismic projects and miles permitted in the first half of 1997 were concentrated in counties in the Powder River Basin.

The average rig count for the second quarter of 1997 averaged 35, which is the highest average count for a quarter since the fourth quarter of 1994. The average rig count of 42 for June is the highest average for a month since January of 1994 (**Figure 15**). The rig count is currently on the upswing and has increased every month from February through June.

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 second quarter of 1997. The numbers preceding discussions below refer to locations on **Figure 16**.

1. Chevron USA completed a horizontally-drilled Nugget well in Painter Reservoir Field. The 33-1D well was drilled from a surface location in NW SE section 1, T15N, R120W to a true vertical depth of 10,463 feet. The well flowed 3.4 million cubic feet of gas, 196 barrels of condensate, and 1,037 barrels of water per day.

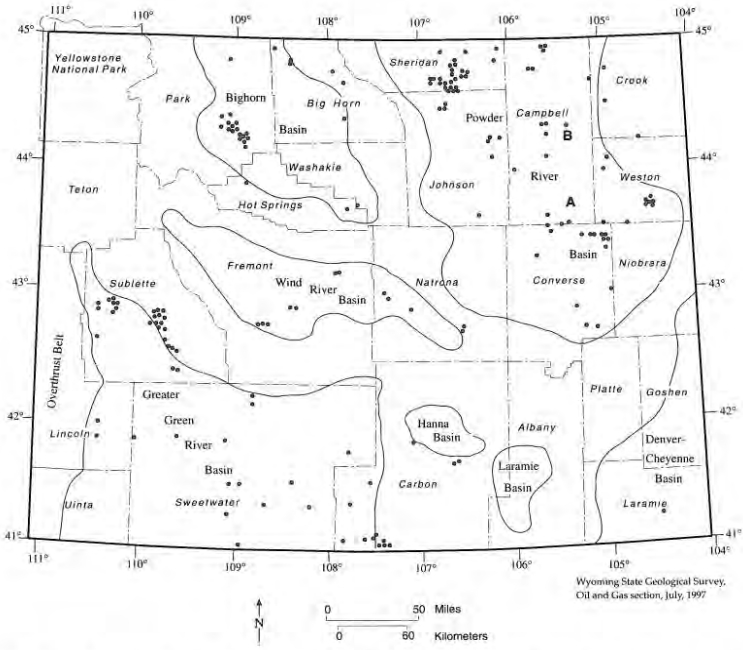

Figure 14. Locations of State oil and gas tracts leased by the State Land and Investment Office at the June, 1997, sale.

2. Texaco Exploration & Production completed a new discovery about a mile southwest of Cow Hollow Field. The 24-2 Ham's Fork-Federal well in NW SW section 24, T22N, R113W flowed 3.0 million cubic feet of gas and 31 barrels of water per day from the Frontier and Dakota between 10,896 and 11,877 feet. Texaco also completed the 14-1 Ham's Fork-Federal well in SW NE section 14, T22N, R113W. The well flowed 1.8 million cubic feet of gas and 186 barrels of water per day from the Frontier between 10,927 and 10,973 feet and from the Dakota between 11,873 and 11,882 feet. Texaco's 23-1 Ham's Fork-Federal well in NE NE section 23, T22N, R113W produced 1.4 million cubic feet of gas and seven barrels of condensate per day during its first day of production. The well is producing from an undisclosed interval in the Frontier and Dakota.

3. Four new wells were completed in Jonah Field. McMurray Oil completed its 11-33 Stud Horse Butte well in NE SW section 33, T29N, R108W. The well produced an average of 1.4 million cubic feet of gas and 22 barrels of condensate per day from an undisclosed interval in the Mesaverde during its first seven days on line. McMurray also completed its 1-35 Stud Horse

Table 11. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1993 to present).

County	1993 APDs	1994 APDs	1995 APDs	1996 APDs	1997 APDs
Albany	0	0	1	1	0
Big Horn	17	3	16	53	22
Campbell	126	105	151	554	306
Carbon	35	135	50	77	33
Converse	34	74	29	20	1
Crook	29	9	15	37	13
Fremont	16	46	30	26	32
Goshen	0	0	0	0	0
Hot Springs	12	4	13	24	21
Johnson	18	16	6	16	5
Laramie	33	15	10	2	2
Lincoln	135	103	64	55	45
Natrona	36	63	80	74	21
Niobrara	5	4	4	7	2
Park	22	18	20	30	18
Platte	0	2	0	0	0
Sheridan	7	3	0	0	0
Sublette	80	113	61	118	77
Sweetwater	156	204	153	136	96
Teton	0	0	0	0	0
Uinta	48	11	11	10	7
Washakie	17	12	31	30	24
Weston	23	6	10	10	2
TOTALS	**849**	**946**	**755**	**1280**	**727**

Source: All data are from the Wyoming Oil and Gas Conservation Commission (1997 data are through June 23, 1997).

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

Butte well in NE NE section 35, T29N, R108W. The well produced an average of 3.0 million cubic feet of gas and 27 barrels of condensate from an undisclosed interval in the Lance during its first seven days on line. Mc Murray completed its 3-4 Jonah-Federal in NW NE section 4, T28N, R108W. The well flowed 10.7 million cubic feet of gas and 163 barrels of condensate per day from an undisclosed interval in the Lance. Snyder Oil completed its 15-26 Stud Horse Butte well in SW SE section 26, T29N, R108W. The well produced an average of 764,000 cubic feet of gas per day from an undisclosed interval in the Lance during its first four days on line.

4. Wexpro completed a development well in Brady Field. The 5 Jackknife Spring Unit well in NW SE section 10, T16N, R101W flowed 7.7 million

Table 12. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1994 to present).

	1994			1995			1996			1997		
County	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	1	18	0	0	0	0
Big Horn	5	24	4	1	16	0	2	3	66	2	0	45
Campbell	13	17	50	12	24	43	32	56	220	12	25	48
Carbon	11	117	86	1	0	16	2	5	18	0	0	0
Converse	0	0	0	4	39	20	1	4	0	0	0	0
Crook	3	3	2	1	0	5	5	3	20	5	5	17
Fremont	6	12	104	6	32	56	2	5	15	3	0	66
Goshen	0	0	0	0	0	0	0	0	0	2	227	0
Hot Springs	1	9	0	2	70	9	4	17	29	0	0	0
Johnson	0	0	0	1	4	0	0	0	0	1	0	17
Laramie	3	57	0	0	0	0	0	0	0	0	0	0
Lincoln	0	0	0	2	18	110	0	0	0	3	7	116
Natrona	1	0	17	3	27	3	0	0	0	2	8	0
Niobrara	1	0	11	0	0	0	2	0	23	0	0	0
Park	1	0	7	0	0	0	6	20	82	2	4	43
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	0	0	0	1	5	0	0	0	0
Sublette	5	4	145	2	0	162	2	21	52	0	0	0
Sweetwater	4	59	0	9	17	497	8	17	670	0	0	0
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	2	0	89	0	0	0	1	0	40	0	0	0
Washakie	0	0	0	0	0	0	0	0	0	0	0	0
Weston	0	0	0	1	13	0	1	0	16	1	0	17
TOTALS	**56**	**302**	**515**	**45**	**260**	**921**	**70**	**174**	**1251**	**33**	**276**	**369**

Source: All data are from the Wyoming Oil and Gas Conservation Commission (1997 data are through June, 1997).

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

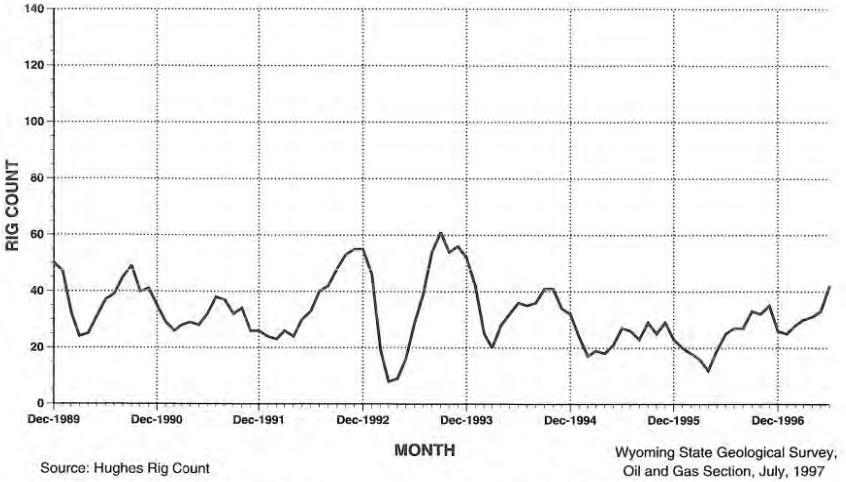

Figure 15. Wyoming daily rig count averaged by month (1990 to present).

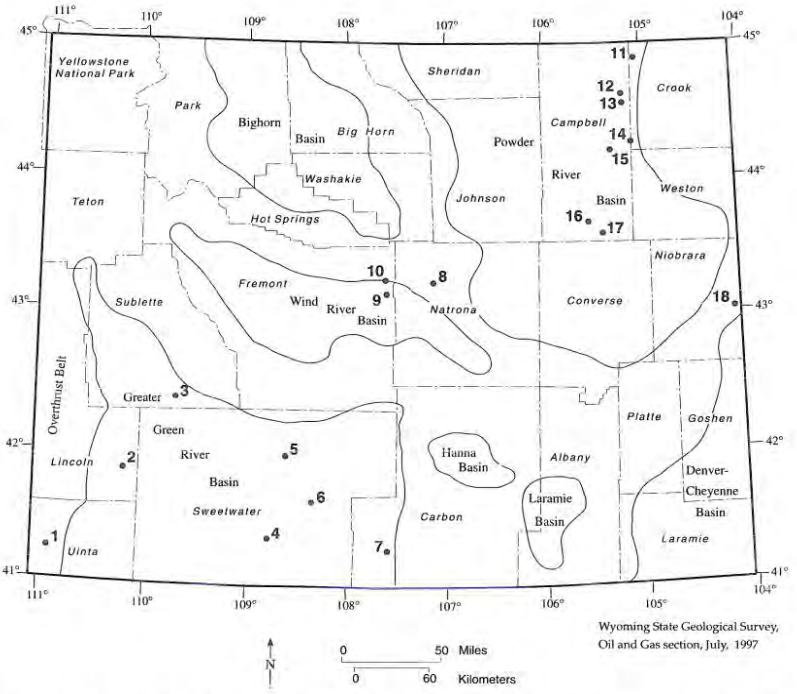

Figure 16. Oil and gas exploration and development activities in Wyoming during the second quarter of 1997 (exclusive of coalbed methane activities).

cubic feet of gas, 107 barrels of condensate, and 20 barrels of water per day from between 6,507 and 6,560 feet in the Blair Formation.

5. Yates established a new pay in Sinkhole Field. Its 1-3 Charlotte-Federal well in SW NW section 3, T23N, R99W averaged 358,000 cubic feet of gas, one barrel of condensate, and 16 barrels of water per day during the first 29 days of production. The well is producing from an undisclosed interval in the Almond. All other Sinkhole Field production is from the Lewis.

6. Texaco completed a discovery in the Nugget Sandstone. Its 4 Government-Union well in NW SW section 8, T19N, R97W flowed 1.9 million cubic feet of gas, 21 barrels of condensate, and 30 barrels of water per day from between 15,750 and 16,118 feet.

7. Vessels Oil & Gas discovered a new pay in Cherokee Creek Field. Its 10-14 Wild Cow Creek Unit well flowed 450,000 cubic feet of gas and 60 barrels of water per day from the Cow Creek sand in the Mesaverde between 3,222 and 3,230 feet. Cherokee Creek Field also produces gas and condensate from the Mesaverde Deep Creek sand, Shannon, and Frontier.

8. Cave Gulch/Waltman Field produced nearly four billion cubic feet of gas and over 17,000 barrels of condensate during March. The field gained six new producers in January and February of this year as Chevron completed four new wells, Barrett completed one new well, and Marathon completed one new well. KN Energy entered into a long term agreement to process 100 million cubic feet of gas per day from the Cave Gulch/Waltman Field area. In June, Barrett Resources announced plans to drill a 21,150-foot well to test the Madison at Waltman Field. They plan to spud the well in September. Barrett expects it will take about 195 days to complete the drilling with another 45 days for testing.

9. Delta Petroleum signed an agreement with KCS Mountain Resources to develop the Moneta Hills project, which covers 28,000 acres.

10. Louisiana Land & Exploration (LL&E) completed a new producer in Madden Field. The 23 Madden Deep Unit well in NW NE section 4, T38N, R90W flowed 3.5 million cubic feet of gas and 57 barrels of water per day from between 9,812 and 10,697 feet in the Fort Union Formation. LL&E also recovered 44 million cubic feet of gas per day during production tests of the Madison Limestone below 24,107 feet at its 4-36 Bighorn well in SW NE section 36, T39N, R91W. LL&E reported that the well's calculated absolute open flow potential is 240 million cubic feet of gas per day. The two other Madison wells in the field are currently producing a combined 52 million cubic feet of gas per day, but they are each capable of producing 40 million cubic feet of gas per day.

11. Cam West LP plans to horizontally drill two Minnelusa tests in Rocky Point Field. The 1H Federal-Bunten will be drilled from a surface location in SE NE section 34, T56.5N, R69W to a measured depth of 6,474 feet. The 3H

Federal-McMillan will be drilled from a surface location in SW NW section 35, T57N, R69W to a measured depth of 6,360 feet.

12. Fancher Oil discovered oil in the Minnelusa at its 33-4 Federal well in NW NW section 33, T54N, R70W. The well pumped 72 barrels of oil per day from between 7,372 and 7,395 feet.

13. Lario Oil & Gas discovered oil at its 1 Sagebrush-Federal well in NW SW section 14, T53N, R70W. The well is producing an average of 210 barrels of oil per day from the Minnelusa at about 7,440 feet.

14. Barrett Resources discovered oil at its 13-31 Hoffman et. al. well in NW SW section 31, T50N, R69W. The well is producing 1,200 barrels of oil per day from the Minnelusa at approximately 8,600 feet.

15. Conley P. Smith Operating recovered 51 barrels of highly gas-cut oil and 17 barrels of oil- and gas-cut water at its 8-9 Renee-Federal wildcat well in NE SE section 8, T49N, R71W during a drillstem test of an undisclosed interval in the Muddy.

16. Yates Petroleum discovered oil and gas at its 1 Groves well in NW NW section 9, T43N, R73W. The well produced 51 barrels of oil, 10,000 cubic feet of gas, and 17 barrels of water per day from an undisclosed interval in the Dakota.

17. Prima Oil & Gas discovered gas at its 1-39 P.R.E. Lanahan well in SE NE section 11, T42N, 72W. the well produced an average of 456,000 cubic feet of gas, two barrels of condensate, and nine barrels of water per day from an undisclosed interval in the Turner.

18. Ensearch Exploration completed its 2 Charles-Federal 14-33 well in SE SW section 33, T36N, R60W. The well pumped an average of 67 barrels of oil and 64 barrels of water per day from an undisclosed interval in the Leo. The well is within a half mile of a Leo discovery completed by the company last year.

COAL UPDATE

Alan J. Ver Ploeg, Interim Head-Coal Section and Gary B. Glass, State Geologist, Wyoming State Geological Survey

Coal production figures recently released by the U.S. Department of Energy's Energy Information Administration (EIA, 1997) indicate that coal production from the western states totaled about 439.4 million tons, which is 2.3% more than in 1995. Production from Wyoming, however, increased 5.5%, and represents 26.3% of the 1,056.7 million tons of coal produced in the nation last year. This compares with Wyoming's 25.5% market share in 1995. While pro-

duction from Appalachian coal fields (445.1 million tons) also increased by 2.3%, production from Interior coal fields (172.2 million tons) increased by 2.2%. Overall, U.S. coal production increased by 2.3% in 1996.

In 1996, Wyoming was again the nation's largest coal-producing state with 278.4 million tons (Stauffenberg, 1997). Wyoming was followed by West Virginia with 165.7 million tons and Kentucky with 150.1 million (EIA, 1997).

Developments in the Powder River Basin

The Land Quality Division (LQD) of the Wyoming Department of Environmental Quality recently explained how it determines what constitutes an adequate cash bond for the reclamation of a mine. The LQD indicated it is requiring bonds equal to 90% of the nationwide average cost for heavy equipment used to accomplish reclamation of strip mines. This figure is up from the 75% required a few years ago. The LQD noted that 90% was adequate in Wyoming because the cost of fuel, labor, and equipment is significantly lower than the national average.

The Union Pacific/Southern Pacific Railroad is moving coal from the Powder River Basin (PRB) mines more quickly, fast approaching their goal of 30 trains per day. With increased locomotive horsepower, they are now moving 27 to 29 trains per day with the train size increasing to 135 cars. This is up from 114 cars.

By the end of the year, Kerr-McGee Coal Corp. should complete the expansion of its coal preparation facilities at the Jacobs Ranch mine. With this expansion, mine capacity will increase to 39 million tons per year. The mine's current capacity is 25 million tons per year. The Jacobs Ranch mine produced 24.5 million tons of coal in 1996, which is slightly less than the 24.6 million tons it produced in 1995 (**Table 13**). The mine reportedly has recoverable reserves of 245 million tons.

Montana Power hopes it can complete the permitting process for its proposed Rocky Butte coal mine by the end of 1997. The Federal leasehold, which is southeast of Gillette, has an estimated 684 million tons of proven and probable reserves. To comply with "due diligence" requirements on Federal coal leases, the mine must be in production by 2002. If Montana Power does not make that deadline and wants to keep the lease, they will likely have to begin pre-paying production royalties.

Plant officials indicate the existing KFx plant will not go into full production until the third quarter of this year. Problems with the coal-feed system as well as effects of a December, 1996, fire have apparently caused the delay. The KFx plant, which reduces the moisture content of coal, currently has the capacity to turn 700,000 tons of coal per year into 500,000 tons of a product called K-fuel. KFx Inc. is building a second plant as well as expanding the capacity of the current plant. When completed, the two plants will have a combined ca-

Table 13. Wyoming coal production and employment by coal field and mine, 1995 and 1996.

Company	Mine Name		1995 Employees	1995 Production(tons)	1996 Employees	1996 Production(tons)	Production Difference 1995-1996	Percentage Increase/ Decrease
	POWDER RIVER COAL FIELD							
Kennecott Energy, Inc.	Antelope Coal Co.	(surface)	128	10,866,880	152	12,047,801	1,180,921	10.87
Cyprus-AMAX Coal Co.	Belle Ayr	(surface)	224	18,771,977	261	19,970,300	1,198,323	6.38
Big Horn Coal Co.	Big Horn	(surface)	17	37,472	18	15,129	-22,343	-59.63
Thunder Basin Coal Co.	Black Thunder	(surface)	449	36,149,282	486	39,174,599	3,025,317	8.37
Triton Coal Co.	Buckskin	(surface)	146	11,600,000	148	11,951,798	351,798	3.03
Powder River Coal Co.	Caballo	(surface)	232	18,357,087	237	22,003,064	3,645,977	19.86
Drummond Coal Co.	Caballo Rojo	(surface)	186	16,808,549	183	15,082,891	-1,725,658	-10.27
Kerr-McGee Coal Corp.	Clovis Point	(surface)	5	408,994	14	199,825	-209,169	-51.14
Thunder Basin Coal Co.	Coal Creek	(surface)	64	4,199,587	78	5,804,419	1,604,832	38.21
Kennecott Energy, Inc.	Cordero	(surface)	210	14,607,000	184	13,071,242	-1,535,758	-10.51
Glenrock Coal Co.	Dave Johnston	(surface)	183	3,268,961	185	3,792,706	523,745	16.02
Phillips/Western Fuels	Dry Fork	(surface)	47	3,603,453	39	2,945,662	-657,791	-18.25
Cyprus-AMAX Coal Co.	Eagle Butte	(surface)	180	16,942,000	184	15,642,744	-1,299,256	-7.67
Drummond Coal Co.	Fort Union	(surface)	6	450	14	1,004,887	1,004,437	2,232.08
Kerr-McGee Coal Corp.	Jacobs Ranch	(surface)	381	24,645,109	373	24,522,960	-122,149	-0.49
Powder River Coal Co.	North Antelope	(surface)	241	21,248,991	247	28,623,177	7,374,186	34.70
Triton Coal Co.	North Rochelle	(surface)	2	677,409	1	830,521	153,112	22.60
Powder River Coal Co.	Rawhide	(surface)	168	15,355,000	166	15,068,358	-286,642	-1.87
Powder River Coal Co.	Rochelle	(surface)	276	26,035,555	271	26,248,241	212,686	0.82
Wyodak Resources	Wyodak	(surface)	51	2,984,000	47	3,198,544	214,544	7.19
TOTAL			3,196	246,567,756	3,288	261,198,868	14,631,112	5.93%
	HANNA COAL FIELD							
Arch of Wyoming	Medicine Bow	(surface)	68	1,699,106	73	1,791,046	91,940	5.41
Rosebud Coal Sales Co.	Rosebud	(surface)	16	Reclamation	16	Reclamation	0	0.00
Arch of Wyoming	Seminoe No. 2	(surface)	8	113,991	13	224,368	110,377	96.83
Cyprus Shoshone Coal Co.	Shoshone No. 1	(deep)	141	1,990,114	138	2,640,912	650,798	32.70
TOTAL			233	3,803,211	240	4,656,326	853,115	22.43%

Table 13. Wyoming coal production and employment by coal field and mine, 1995 and 1996 *(continued).*

Company	Mine Name		1995 Employees	1995 Production(tons)	1996 Employees	1996 Production(tons)	Production Difference 1995-1996	Percentage Increase/ Decrease
	BIGHORN COAL FIELD							
Northwestern Resources Co.	Grass Creek	(surface)	0	0	0	0	0	0
TOTAL			0	0	0	0	0	0%
	HAMS FORK COAL FIELD							
Pittsburg & Midway	Kemmerer	(surface)	311	3,624,328	297	3,650,865	26,537	0.73
FMC Wyoming Corp.	Skull Point	(surface)	74	820,000	69	768,580	-51,420	-6.27
TOTAL			385	4,444,328	366	4,419,445	-24,883	-0.56%
	GREEN RIVER COAL FIELD							
Black Butte Coal Co.	Black Butte	(surface)	182	2,155,632	109	1,857,145	-298,487	-13.85
Bridger Coal Co.	Jim Bridger	(surface)	375	6,967,096	390	6,293,172	-673,924	-9.67
Union Pacific Resources	Pilot Butte	(deep)	3	0	1	0	0	0.00
TOTAL			560	9,122,728	500	8,150,317	-972,411	-10.66%
TOTAL UNDERGROUND			144	1,990,114	139	2,640,912	650,798	32.70%
TOTAL SURFACE			4,230	261,947,909	4,255	275,784,044	13,836,135	5.28%
GRAND TOTAL			4,374	263,938,023	4,394	278,424,956	14,486,933	5.49%

Modified from Annual Reports of the Wyoming State Inspector of Mines.
Wyoming State Geological Survey, Coal Section, July, 1997.

pacity of 1.26 million tons of K-fuel per year. KFx hopes to complete its expansion of the first plant as well as the construction of the second plant by July of 1998.

The existing KFx plant is located at the site of Kennecott Energy's newly acquired Fort Union mine. This mine along with the Caballo Rojo mine were recently purchased from Drummond Coal Co. The Caballo Rojo and Cordero mines have been combined into what has been called the Cordero-Rojo Complex.

In late May, ARCO's Black Thunder mine lost an estimated one million tons of production due to flooding of its three pits and the loop track area. Flooding followed an especially severe thunderstorm. The mine was idle for 10 days while 250 million gallons of water were pumped from the pits. Despite this setback, the mine is still expected to produce more than 40 millions tons of coal in 1997.

Dakota, Minnesota, and Eastern Railway Corporation (DM&E) announced plans to build approximately 250 miles of new trackage in Wyoming. The actual route of the new rail line from Gillette to South Dakota is still not determined. The company is considering three possible routes. In July, DM&E started holding public meetings in communities located along the possible routes. The new track and 650 miles of upgraded existing track will provide another transportation option for the mines to ship PRB coal to the Midwest. At an estimated cost of $1.2 billion, the project will create 1,220 jobs during the two-year construction phase. If line usage reaches 100 million tons per year by 2007, as the company projects, Wyoming operations will require 180 directly-involved jobs as well as another 190 indirectly-involved jobs. If the project is approved by the U.S. Surface Transportation Board, construction could begin in two years, with the first coal shipment in early 2002.

PacifiCorp reportedly will acquire Energy Group, an energy company that includes Peabody, the nation's largest coal producer. Peabody owns four coal mines in the PRB, the North Antelope, Rochelle, Rawhide, and Caballo mines. These mines employ nearly 1,000 people and produced 89.4 million tons of coal in 1996 (**Table 13**). PacifiCorp already owns Glenrock Coal Co.'s Dave Johnston mine in Converse County and Bridger Coal Co.'s Jim Bridger mine at Point of Rocks in Sweetwater County.

ARCO Coal has postponed adding a fourth dragline at their Black Thunder mine. The 160-cubic-yard dragline may be added by 2000 or 2001. With the addition of a new dragline, production capacity would increase to 55 million tons per year or 15 million more tons than its present capacity of 40 million tons. ARCO's recent announcement regarding the possible divestiture of its coal mining operations may have played a part in this decision (*Wyoming Geo-notes No. 54*, p. 27).

The U.S. Bureau of Land Management (BLM) recently set a date for the sale of the North Rochelle Tract, which is their next competitive coal lease. The sale is July 29, 1997. The North Rochelle tract includes an estimated 157,610,000 tons in two minable coal beds within the Wyodak coal zone. While the overburden above the uppermost bed (called the "rider seam") is 100-200 feet thick, the overburden above the Wyodak bed is 175-250 feet. The "rider seam" averages seven feet thick; the Wyodak bed averages 57 feet. The average stripping ratio for the tract is 2.91:1. The North Rochelle tract is adjacent to both Triton Coal Co.'s North Rochelle mine and ARCO's Black Thunder mine. The tract was nominated by Bluegrass Coal Development Company, a subsidiary of Zeigler Coal. Triton is also a subsidiary of Zeigler.

In a related note, the BLM plans to call for competitive bids on the Thundercloud lease in June of 1998. Kerr-McGee Coal applied for this 432-million-ton lease several years ago. It is located adjacent to their Jacobs Ranch mine, and could extend the life of that mine an additional six years at a production rate of 39 million tons per year. However, the size and quantity of these reserves may also draw a bid from ARCO's Thunder Basin Coal Co. since its Black Thunder mine is also adjacent to this lease.

Developments in southern Wyoming

A recent article in *Paydirt* magazine (May, 1997) captures the significance of Pittsburg and Midway Coal Co.'s Kemmerer mine. The article notes that this is the nation's largest open pit coal mine. The pit, which was begun in 1971, is nearly a mile long (5,000 feet), over a half mile wide (3,600 feet), and 1,000 feet deep. Trucks must travel six miles to get from the top to the bottom of the pit.

The mine produced its 106 millionth ton of subbituminous coal in 1996, and has reserves that should last it an estimated 200 years. Production in 1996 was about 3.7 million tons (**Table 13**). In regard to markets in 1996, 2.5 million tons went by conveyor belt to Utah Power and Light Co.'s nearby Naughton power plant. Another 470,000 tons were trucked to General Chemical Co.'s soda ash refinery near Green River, Wyoming. Three hundred thousand tons went to Tg Soda Ash's refinery also at Green River, and about 380,000 tons went by rail to Amalgamated Sugar Co.'s plants in Idaho and Oregon. With the recent purchase of FMC's Skull Point coal mine, Pittsburg and Midway has an additional 850,000-ton-per-year market at FMC's coke plant near Kemmerer, Wyoming, and FMC's soda ash facility near Green River.

Paydirt magazine (May, 1997) also had an interesting article on the Black Butte coal mine. Following the buy-out of a major contract, Black Butte's production dropped from 2.2 million tons in 1995 to 1.9 million tons in 1996 (**Table 13**). Its work force was also reduced substantially. The remaining employees adapted to the change and even created a new product for the mine. Black Butte now markets bags of lump coal and stoker coal for home use. Employ-

ees pitch in and bag the coal during slack times. Two hundred tons of the new product were sold in 1996, with a strong demand from the Gillette area.

Black Butte's main customer remains PacifiCorp's Jim Bridger power plant. Black Butte mines coals from three different pits to meet quality specifications required by its different customers. The mine also plans to be active on spot market solicitations to increase its customer base.

Power plants

Dominion Energy is initiating efforts to upgrade the boilers and fuel handling facilities at its newly acquired 1,108-Megawatt (MW) Kincaid power plant. This plant was purchased from Commonwealth Edison. Dominion's efforts are geared to making it possible to burn low-sulfur Powder River Basin (PRB) coal in this power plant.

Commonwealth Edison also sold their 490-MW State Line plant to a subsidiary of Southern Company. This plant, which has burned PRB coal for years, will continue using PRB coal.

North American Power Group (NAPG) cleared the first hurdle in its plans to build a $295 million coal-fired power plant adjacent to ARCO's Black Thunder mine. The Wyoming Industrial Siting Council approved NAPG's application for a construction permit. Construction of the air-cooled, Two Elk power plant will begin later in 1997, with completion expected by late 1999. For fuel, the 250-MW plant will initially use waste coal from the nearby Black Thunder mine. The plant's air quality permit is still pending before the Air Quality Division of the Wyoming Department of Environmental Quality. In a related note, NAPG is looking for a market for the electricity it will generate. The company is accepting bids for blocks of power as small as 5-MW and contract terms from one to 20 years.

In an extended test, Toledo Edison will switch all units in their 631-MW Bay Shore power plant to PRB coal. Last year, various units of the plant were testing low-sulfur coal supplied by Kennecott Energy's Antelope mine. Currently, coal supplies are coming from Cyprus-Amax's Belle Ayr mine. This contract extends through 1998.

The Tennessee Valley Authority (TVA) is currently burning a 50/50 blend of PRB and Utah coal in its Allen plant. It is also testing a 30% PRB blend in additional plants, beginning with the Paradise and Shawnee plants. The PRB coal comes from ARCO's Black Thunder mine; the Utah coal is coming from mines operated by White Oak Mining and Construction. TVA has indicated that they will buy more PRB coal, possibly up to 10 million tons per year.

Northern Indiana Public Service (NIPSCO) will increase its burn of blended PRB coal in the 480-MW Bailly plant to 50% by June of 1997. This compares with the 20% PRB blend used in April. NIPSCO is increasing the PRB coal blend to reduce sulfur emissions from the plant.

Texas Municipal Power Agency (TMPA) is continuing its tests of PRB coal in the Gibbons Creek power plant. The company is fine tuning the boiler and pulverizers using coal from the Black Thunder mine. When this testing phase is completed, the plant will test 200,000 tons of coal from each of the following PRB mines: Black Thunder, Cordero, and Caballo.

New coal contracts, tests, and solicitations

Table 14 is a tabulation of some of the contracts, tests, and solicitations for Wyoming coal announced during the second quarter of 1997.

References cited

Energy Information Administration (EIA), 1997, Quarterly coal report, October-December 1996: U.S. Department of Energy DOE/EIA-0121(96/4Q), 148 p.

Stauffenberg, Donald G., 1997, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 1996: Office of the State Inspector of Mines, Rock Springs, Wyoming, 68 p.

Table 14. Marketing activities for Wyoming coal producers during the second quarter of 1997[1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	American Electric Power Co.	Clifty City Rockport	Antelope mine Cordero-Rojo mine Black Thunder mine	C C	300,000 t 1.7 million t	Supplied over a 15-month period. Cordero-Rojo will supply 1.3 million t over 13 months and Black Thunder will supply 400,000 t over 15 months.
2.	Arkansas Power and Light	White Bluff and Independence	Powder River Basin	So	2.5 million t	Delivery in 1998.
3.	Colorado Springs Public Utilities	Nixon	Kennecott-PRB or Colowyo	C	200,000 t/y	Delivery over the next two years.
4.	Consumers Energy Co.	Campbell	Powder River Basin	So	1.0 million t/y	Bids on 8,500- and 8,650-Btu/lb coal with contract terms of one, two, five, or ten years.
5.	Detroit Edison	Various power plants	Antelope mine	C	250,000 t	Delivery in 1997 with an option to purchase another 250,000 t.
6.	Houston Lighting and Power Co.	Limestone	Powder River Basin	T	20,000-30,000 t	Testing to see effects on boiler.
7.	Lansing Board of Water and Light	Eckert No. 6	Antelope mine	T	Up to 70,000 t	Testing 100% PRB coal; previous tests were 30% PRB coal.
8.	Mississippi Power	Watson	Powder River Basin	So	275,000 t	Volumes up to 40,000 tons/month.
9.	Northern States Power Co.	Unspecified plant	Jacobs Ranch, Black Thunder, and North Antelope/Rochelle mines	C	3.0 million t	Up to 750,000 t from Jacobs Ranch and the remainder from Black Thunder and N. Antelope/Rochelle.
10.	Sierra Pacific Power Co.	North Valmy	Hanna Basin, Colorado, and/or Utah	So	140,000-600,000 t or 300,000-1.2 million t or 450,000-1.2 million t	Request proposals in three categories: over 7, 19, or 31 months.

Table 14 . Marketing activities for Wyoming coal producers during the second quarter of 1997[1] (*continued*).

	Utility	*Power Plant*	*Coal Mine/Region*	*Activity*	*Tonnage*	*Comments*
11.	Southwestern Public Service	Harrington Harrington	Powder River Basin Powder River Basin	Sp C	1.0-1.5 million t 2.0-2.5 million t	Delivery in 1998. Delivery over a three-year period.
12.	Union Electric	Unspecified plant	Powder River Basin	So	1.0 million t	Delivery in second half of 1997.
13.	Western Farmers Electric	Hugo	Black Thunder mine	C	Up to 1.7 million t	
14.	Western Fuels Assn.	Sikeston	Powder River Basin	T	100,000 t	If successful, will need 800,000 t/y over five years.
15.	Wisconsin Electric Power Co.	Presque Island	Powder River Basin	C	0.5-1.0 million t/y	Delivery in 1998 and extending for five years.

[1]Data 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; t/y =short tons per year; t/wk =tons per week; PRB =Powder River Basin
Wyoming State Geological Survey, Coal Section, June, 1997.

INDUSTRIAL MINERALS AND URANIUM UPDATE

Ray E. Harris
Staff Geologist - Industrial Minerals and Uranium, Wyoming State Geological Survey

General

The U.S. Geological Survey (USGS) released a statistical summary of nonfuel mineral production in the U.S. for 1995 (Smith, 1997). Nonfuel minerals include metals, precious stones, industrial minerals, and construction materials. The figures tabulated in this report show that Wyoming produced $973,000,000 worth of nonfuel minerals in 1995. Wyoming ranked 13th among states in total value of nonfuel production and 2nd among states after Nevada in the per capita value of nonfuel mineral production. Wyoming's principal nonfuel mineral products in order of descending value were soda ash (from mined trona), clays (bentonite and common clay) helium, cement (manufactured from limestone, gypsum, shale, and other mined materials), and construction aggregate. There was also production of decorative aggregate, dimensional stone, feldspar, gypsum, leonardite, sodium sulfate, and sulfur (listed alphabetically). Sulfur recovered from the refining of natural gas is not included in the USGS' nonfuel mineral calculations. Wyoming is second in the nation in the production of recovered sulfur. In addition to these products mined in Wyoming, a plant near Frannie in the Bighorn Basin produced lime from limestone mined in Montana, a plant east of Rock Springs produced soil conditioners from phosphate rock mined in Utah and sulfur from the refining of natural gas in Wyoming, and a plant west of Green River produced perlite expanded from rhyolite mined in Arizona and Nevada.

Bentonite

Bentonite production in Wyoming increased almost 130,000 short tons in 1996 over that of 1995. Total production for 1996 was 4,356,269 short tons. The1996 production figure was the third highest on record, after 1981 and 1979, and twice the production recorded in 1986. Bentonite is a clay mineral that is used in a variety of products including foundry molds, environmental cleanup, kitty litter, oil well drilling mud, and many other products.

Construction Aggregate

The Wyoming Environmental Quality Council ruled that topsoil, as well as overburden, is included in the amount of material quarry operators are permitted to mine under the 10-acre permit regulations. The new ruling restricts owners of 10-acre permits to moving no more than 10,000 cubic yards of material per year. The ruling effectively decreases the amount of construction aggregate that can be removed, since any other material that must be moved to access the aggregate is included in the total. The ruling was in response to nearby residents' attempts to limit the production of material from an aggregate

operation east of Casper (*Wyoming Geo-notes No. 54*, p. 32). The ruling, which could have an adverse effect on some operators, may be appealed.

Gypsum

Gypsum is quarried in Wyoming at three localities. Two quarries in the Bighorn Basin (Cody and south of Lovell) produce gypsum for processing into wallboard at nearby plants. Mountain Cement quarries gypsum from a locality south of Laramie for use in Portland Cement. Wyoming gypsum production remained about constant with1995, at 554,000 tons in 1996.

Limestone

Limestone is quarried in Wyoming for construction aggregate by Pete Lien & Sons, Inc., (Lien) and subsidiaries at Sundance and north of Rawlins. Lien is in the process of opening a limestone quarry near Hartville. Mountain Cement quarries limestone south of Laramie for their cement plant and other purposes. Quality Construction quarries limestone from the Bass quarry north of Hartville, for use in emissions control by the Laramie River power plant near Wheatland. Overall, the production of limestone in Wyoming increased to 1.5 million tons in 1996.

Mountain Cement is seeking a permit from the Environmental Quality Council to expand its limestone quarry. Because of the company's long-standing expansion plans, Albany County had denied subdivision permits in the proposed mining area under the county's Land Use Management System, concerned that the subdivision was too close to future quarry development. The developer, however, opted to sell the land in 35-acre and larger tracts, avoiding the need for county approval as a subdivision. While the purchasers of these tracts were reportedly warned that the quarry was going to expand in their direction, the homeowners are now seeking to block the quarry's expansion. The Wyoming Environmental Quality Council is expected to rule on the permit in July.

Trona

Expansion projects announced by the major trona mining companies and sodium-product producers continue to move forward. Of note, during the second quarter of 1997, was the approval of OCI's $137 million processing plant expansion project by the Wyoming Industrial Siting Council. OCI also obtained a permit from the U.S. Bureau of Land Management (BLM) to construct part of its expansion on BLM land. Ground breaking for this project took place the first week in July.

Solvay Minerals continues to expand its processing plant. FMC and General Chemical recently completed expansion projects, and the fifth trona mining and refining company, Tg Soda Ash, is seeking permits to construct a new mine.

As noted in *Wyoming Geo-notes No. 54*, the amount of trona mined in 1996 was slightly lower than that of 1995 (**Table 1**).

International Soda Ash Conference

The First International Soda Ash Conference (ISAC) was held in Rock Springs, June 9 -12, 1997. Over 300 participants, representing 15 countries, attended conference sessions and field trips. The Wyoming State Geological Survey plans to publish the proceedings of the conference in two volumes; one containing papers with dated material this fall, and the remainder of the papers in the second part of the proceedings volume in 1998.

Zeolites

U. S. Zeolites, of Golden, Colorado, shipped zeolite-bearing rock from Wyoming to Western Clay Co. in Aurora, Utah, for refining and sale during the second quarter of 1997. Ninety percent of the rock is the mineral clinoptilolite, a naturally-occurring zeolite. The material came from a deposit in Sweetwater County, southeast of Bitter Creek. Zeolites have become yet another industrial mineral produced in Wyoming.

Zeolites are a naturally occurring group of minerals that act as ion-exchangers. They have the ability to adsorb metal ions, ammonia, and other materials, releasing nonhazardous soluble sodium or potassium ions. Synthetic zeolites are used in petroleum refining, water softening, deodorizers, and many environmental cleanup operations. According to Walter C. Clark of U.S. Zeolite, the demand for natural zeolites is increasing. Mined zeolites are replacing synthetic zeolites similar to the replacement of synthetic soda ash by soda ash refined from mined trona.

Uranium

The price of yellowcake dropped in the second quarter of 1997, continuing a decline that began in September, 1996. As reported by Bob Odell in the June edition of the *Rocky Mountain Scout*, the July 1 price of unrestricted uranium was $9.75 per pound, down from $12.00 per pound at the end of the first quarter and $15.50 per pound at the beginning of September, 1996.

The production of yellowcake from in-situ uranium mines in Wyoming reached a new record of 2.4 million pounds, up from 1.3 million pounds in 1995 (**Table 1**). Wyoming continues to lead the nation in uranium production. Although these figures do not rival the amount of uranium produced in Wyoming during the uranium boom of the late 1970s, the production increases offer hope for the continued revival of this industry in Wyoming.

A new in-situ production facility came on-line in 1997 with the startup of production at Rio Algom's Bill Smith operations in the southern Powder River Basin uranium mining area. Rio Algom began injecting the solvent into the

mine area on June 20. Rio Algom joins CAMECO, also in the southern Powder River Basin, and COMIN in the Pumpkin Buttes uranium mining area as a major uranium producer in Wyoming.

Plans to begin production and milling from the Jackpot underground mine on Green Mountain south of Jeffrey City continue to develop. Kennecott Uranium Co., one of the partners in the Green Mountain Mining Venture (GMMV), has applied to the U. S. Nuclear Regulatory Commission to change the status of the Sweetwater mill from standby to operational. The Sweetwater mill, located northwest of Rawlins in eastern Sweetwater County, was operated by Union Oil of California (UNOCAL) in the early 1980s, using ore from a nearby surface mine. The change in status is requested so that the mill can process ore from the Jackpot mine.

Reference cited

Smith, S. D., 1997, Statistical summary annual review 1995: U. S. Geological Survey Mineral Industry Surveys, 34 p.

METALS AND PRECIOUS STONES UPDATE

W. Dan Hausel
Senior Economic Geologist, Wyoming State Geological Survey

The Wyoming State Geological Survey (WSGS) initiated field investigations of the Leucite Hills along the northern flank of the Rock Springs uplift in southwestern Wyoming. Field work began in June. This district includes 22 known leucite- and olivine-lamproite volcanoes and plugs that have yielded age dates of 3.1 to 1.4 Ma (million years ago).

The WSGS began mapping the district and collecting samples from many of the lamproites for geochemical and mineralogical studies. Additionally, samples will be collected to test prospective lamproites for diamonds. Possibly, Carmichael (1967) was the first to recognize the diamond potential of this region when he noted similarities between some of the Leucite Hills lamproites and the diamondiferous olivine lamproites of Arkansas, as well as to some lamproites in Western Australia, where commercial amounts of diamonds were discovered in the 1980s. Carmichael also suggested that the Leucite Hills lamproites may have been derived by the fractionation of a kimberlitic liquid at depth.

Even with these similarities, the Leucite Hills district has only received minor exploration interest in the past. But recently, a few chromites recovered from one of the Leucite Hills lamproites yielded chemistry similar to diamond inclusion chromites (Robert Kirkwood, personal communication, 1997), suggesting that the Leucite Hills need to be examined in greater detail.

In addition to mapping the known exposures, the WSGS will search for the presence of hidden lamproites in the region. Hidden lamproites may have the greatest potential for diamonds. This is because olivine-rich lamproites (which are often diamondiferous) tend to erode rapidly due to serpentinization and merge into the surrounding topography where they are easily overlooked (Hausel and others, 1997).

Southwest of the Leucite Hills, a significant kimberlitic indicator mineral anomaly was identified several years ago (McCandless and others, 1995). A portion of this anomaly was derived from the erosion of some breccia pipes in the Cedar Mountain area near the Wyoming-Utah state line. However, numerous other mantle-derived pipes are necessary in order to explain the origin of this widespread 500- to 1,000-square-mile anomaly. Although this area is currently receiving some company interest, it is surprising that the region isn't receiving a greater amount of attention, particularly since there are three different reports of diamonds being found.

Diamond exploration activity also continued along the Colorado-Wyoming state line by Royal Gold and Redaurum Ltd. Redaurum Ltd continued to recover high-quality gemstones from their Kelsey Lake diamond mine in Colorado. In addition, the company expanded their interest in the region with the acquisition of the Maxwell kimberlite to the west of the Kelsey Lake kimberlites, and another property at an undisclosed location in Wyoming. To date, the Kelsey Lake mine has produced several high-quality gem diamonds in the range of 1 to 3 carats including a 6.2-carat diamond from Wyoming, and 9.4-, 10.5-, 14.2-, and 28.3-carat diamonds from Colorado.

In the South Pass greenstone belt along the southern tip of the Wind River Range, some company interest was reported for gold. However, within the same region, Newmont Gold reportedly dropped their interest in the Lewiston district along the northeastern edge of the greenstone belt. The decision to drop the property may have been related to company reorganization according to some claim holders in the region.

The South Pass greenstone belt encloses numerous gold anomalies in shear zones and in veins in metagreywacke, metabasalt, and tonalite. Additionally, the margins of the greenstone belt are overlain by auriferous paleoplacers, for which the gold source, or sources, has never been identified. Potentially, the source, or sources, may have been derived from hidden, world-class, gold deposits within the greenstone belt. For example, the Oregon Buttes paleoplacer along the southern margin of the belt, encloses an estimated 28.5 million ounces of gold (Love and others, 1978).

Some company activity was also reported in the Sierra Madre and Medicine Bow Mountains during the past quarter. Some of the activity was a follow-up to some recent gold and nickel discoveries made by the WSGS. Several claims were staked in both regions.

In the Laramie Mountains west of Cheyenne, Mountain Lake Resources continued to explore and drill a large tonnage, low-grade, Proterozoic-age, Au-Cu porphyry. The porphyry hosts a minimum of 35 million tons of low-grade gold and copper ore. Mountain Lake Resources was reportedly testing some geophysical and geochemical anomalies.

During the past quarter, the following papers and books by the Metals and Precious Stones Section were published:

Hausel, W.D., 1996, Pacific Coast diamonds-an unconventional source terrane *in* Coyner, A.R., and Fahey, P.L., eds., Geology and ore deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, p. 925-934.

Hausel, W.D., 1997, The geology of Wyoming's copper, lead, zinc, molybdenum, and associated metal deposits in Wyoming: Wyoming State Geological Survey Bulletin 70, 224 p.

Hausel, W.D., 1997, Geology of the Red Dwarf corundum (ruby-sapphire) deposit, Graham Ranch, western Granite Mountains, central Wyoming: Wyoming State Geological Survey Mineral Report MR97-1, 8 p.

Hausel, W.D., Kucera, R.E., McCandless, T.E., and Gregory, R.W., 1997, Diamond exploration possibilities in the Wyoming Craton, western United States: Wyoming State Geological Survey Mineral Report MR97-2, 59 p.

Harris, R.E., Hausel, W.D., VerPloeg, A.J., and Glass, G.B., 1997, Wyoming [Exploration in 1996]: Mining Engineering, v. 49., no. 5, p. 85-88.

References cited

Carmichael, I.S.E., 1967, The mineralogy and petrology of the volcanic rocks from the Leucite Hills, Wyoming: Contributions to Mineralogy and Petrology, v. 15, p. 24-66.

Hausel, W.D., Kucera, R.E., McCandless, T.E., and Gregory, R.W., 1997, Diamond exploration possibilities in the Wyoming Craton, western United States: Wyoming State Geological Survey Mineral Report MR97-2, 59 p.

Love, J.D., Antweiler, J.C., and Moiser, E.L., 1978, A new look at the origin and volume of the Dickie Springs-Oregon Gulch placer gold at the south end of the Wind River Mountains [sic]: Wyoming Geological Association 30th Annual Field Conference Guidebook, p. 379-391.

McCandless, T.E., Nash, W.P., and Hausel, W.D., 1995, Mantle indicator minerals in ant mounds and conglomerates of the southern Green River Basin, Wyoming *in* Jones, R.W., ed., Resources of southwestern Wyoming: Wyoming Geological Association 1995 Field Conference Guidebook, p. 153-163.

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: .605 billion barrels of oil and 4.15 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 feed
- Total ..... 96.1 trillion cubic feet

COAL

Remaining Resources (January 1, 1997)
- Identified and Hypothetical (Discovered) ..... 1,426.9 billion tons[4]
- Speculative (Undiscovered) ..... 31.5 billion tons[4]
- Total ..... 1,458.4 billion tons

Remaining Reserve Base (January 1, 1997)
- Demonstrated strippable (Measured and indicated reserve base) ..... 25.3 billion tons[5]
- Demonstrated underground-minable (Measured and indicated reserve base) ..... 42.5 billion tons[5]
- Total ..... 67.8 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_3O_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.
[5] Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 p.
[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.
[7] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.
[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.

PART 2: OVERVIEW OF HISTORICAL SEISMICITY IN WESTERN WYOMING

James C. Case
Staff Geologist- Geologic Hazards, Wyoming State Geological Survey

Western Wyoming is one of the more seismically active areas of the State, with a historic earthquake density ranking second to that found in Yellowstone National Park (YNP). For the purposes of this article, western Wyoming is defined by an area that includes Teton County (outside of YNP), the northern half of Lincoln County, most of Sublette County, and the northwestern tip of Fremont County. Part 1 of this overview, which was published in *Wyoming Geo-notes No. 54* (p. 53-62) only discussed Teton County. Part 2, which follows, discusses the other western counties mentioned above.

There have been a number of damaging earthquakes in western Wyoming. None of the historic earthquakes, however, have been as large as the maximum credible earthquake postulated for either the Teton Fault in Teton County or the Star Valley Fault in Lincoln County (**Figure 17**). Both of those fault systems are capable of generating magnitude 7.3-7.5 earthquakes.

Many earthquakes in western Wyoming have been poorly located, especially those that occurred prior to 1970. In fact, most earthquakes that occurred prior to 1960, were located solely on the basis of where an earthquake was felt and how people described what they felt. As a result, patterns of historic seismicity are difficult to interpret.

Figure 18 is a plot of historic earthquakes in western Wyoming, and includes all significant earthquakes from 1915 through December, 1996. In general, only earthquakes with magnitudes greater than 2.9 or with intensities of III or larger have been plotted. The thousands of earthquakes that have occurred in or near western Wyoming over the last eighty years, however, cannot all be shown on **Figure 18** or described in the discussions below.

Consequently, the following discussion includes most, but not all, of the earthquakes that have caused damage in western Wyoming. Since so few earthquakes have occurred in Sublette County and the northwestern tip of Fremont County, discussions of earthquakes in those areas are incorporated into those for Teton County and Lincoln County. In a few cases, earthquakes that occurred in one county, but were strongly felt in another county, are described in the narrative for each county.

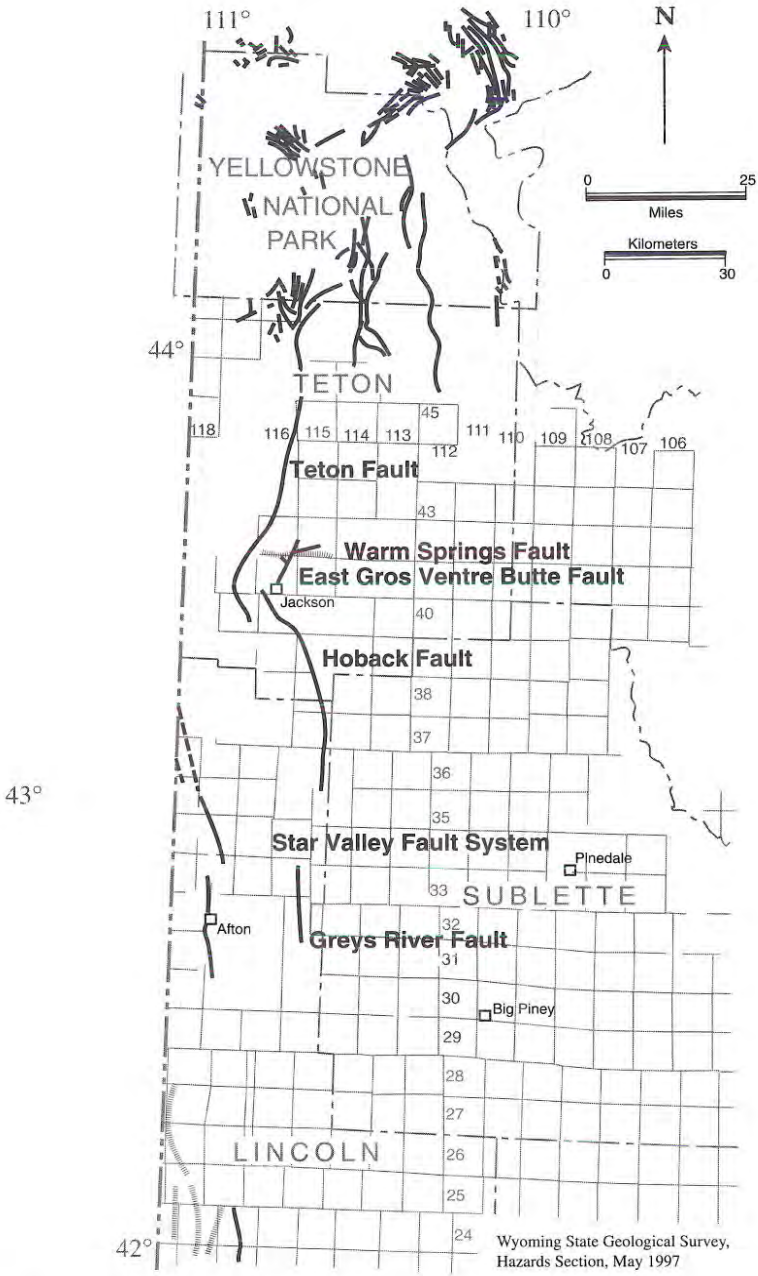

Figure 17. Known and suspected active faults in western Wyoming.

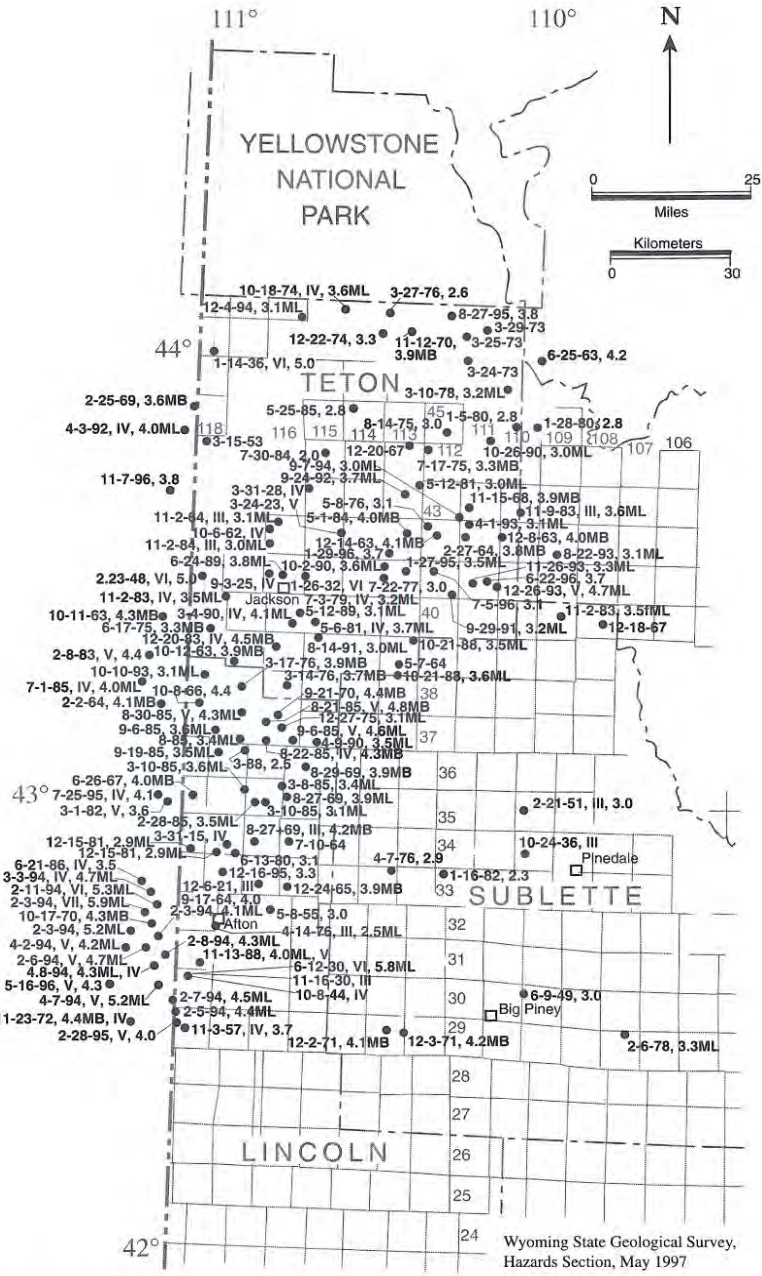

Figure 18. Select historic epicenters in western Wyoming.

OVERVIEW OF NORTHERN LINCOLN COUNTY EARTHQUAKES

On **Figure 17**, approximately sixty-five earthquakes are plotted in or near Lincoln County. The first earthquake recorded and plotted occurred in 1915, and the last earthquake plotted occurred in mid-1996. None of the plotted earthquakes are thought to be directly associated with active fault systems exposed at the surface, such as the Star Valley Fault.

Earthquakes from 1915 through the 1950s

The first earthquake recorded in northern Lincoln County occurred near Bedford in the Star Valley. On March 31, 1915, an intensity IV event shook buildings, with no significant damage reported (Humphreys, 1915). This event was followed by a non-damaging intensity III earthquake on December 6, 1921. The 1921 earthquake occurred approximately eight miles southeast of the 1915 event. No other earthquakes were recorded in Lincoln County in the 1920s.

The first recorded earthquake in the 1930s occurred on June 12, 1930. The intensity VI, magnitude 5.8 (estimated) earthquake caused damage in Grover, which is located north of Afton in the Star Valley. The earthquake, which was felt by most residents of the Star Valley, cracked one brick building in Grover, and cracked a swimming pool three miles northwest of Grover. Plaster was cracked in many Grover homes. Of interest is the fact that clocks on west walls were stopped by the event (Neumann and Bodle, 1932). Numerous aftershocks continued through June 16, 1930 (Reagor, Stover, and Algermissen, 1985). Even though most of the damage from the earthquake occurred in Grover, the U.S. Geological Survey located the event south of Afton. This earthquake was followed by an intensity III event at the same location on November 16, 1930. No damage was reported (Neumann and Bodle, 1932). On October 24, 1936, the Star Valley experienced two earthquakes, with each accompanied by a rumble (Neumann, 1938). Oddly enough, the earthquake epicenters have been placed near Pinedale in Sublette County (Reagor, Stover, and Algermissen, 1985).

Only one earthquake was recorded in northern Lincoln County in the 1940s, although a non-damaging earthquake did occur near Big Piney in Sublette County on June 9, 1949. The Lincoln County earthquake occurred on October 8, 1944, in the same vicinity as the 1930 earthquakes described above. The intensity IV earthquake was felt by several residents of Grover. The earthquake was described as having a trembling motion with an abrupt onset. Loose objects rattled and buildings creaked (Bodle, 1946).

Two earthquakes were recorded in northern Lincoln County in the 1950s. The first, a magnitude 3.0 event, located nine miles east-northeast of Afton, occurred on May 8, 1955. No damage was associated with that earthquake. The next earthquake occurred on November 3, 1957. The magnitude 3.7, intensity IV earthquake, which was located approximately eighteen miles south-

southwest of Afton, was felt by several residents of Geneva, Idaho (Brazee and Cloud, 1959).

Earthquakes of the 1960s and 1970s

Although a number of earthquakes occurred in northern Lincoln County in the 1960s and 1970s, none caused any significant damage. The first earthquake recorded near Lincoln County in the 1960s, occurred on February 2, 1964, approximately five miles west of Alpine. No damage was associated with the magnitude 4.1 earthquake. On September 17, 1964, a non-damaging magnitude 4.0 earthquake was recorded approximately ten miles northeast of Afton, and on October 8, 1966, a non-damaging magnitude 4.4 earthquake was recorded near Alpine. On August 27, 1969, a magnitude 4.2, intensity III earthquake was felt in Auburn, even though the epicenter was located just east of Bedford (von Hake and Cloud, 1971).

The largest earthquake recorded in northern Lincoln County in the 1970s occurred on September 21, 1970. The earthquake, which occurred near the Elbow Campground in the Snake River Canyon, was primarily felt in Teton and Sublette Counties. The Jackson Hole Guide (September 24, 1970) reported that the magnitude 4.4 earthquake was felt by residents from Jackson through the Hoback Canyon to Bondurant. Some residents in Jackson thought that the event was a sonic boom. At Camp Davis, a resident reported a figurine knocked off a television set and a "vibrating" staircase. Eleven miles south of Jackson, a resident reported rattling windows and a shaking bed. Near Bondurant, in Sublette County, a resident reported that windows rattled and her whole house shook. No other earthquakes in the 1970s caused any great concern.

A summary of earthquakes that are shown on **Figure 18**, and that occurred in or near northern Lincoln County in the 1960s and 1970s, is presented below. Earthquakes that did not originate in the county are flagged with an asterisk.

Date - 1960s	Magnitude/Intensity
February 2, 1964*	4.1
July 10, 1964	—
September 17, 1964	4.0
December 24, 1965	3.9
October 8, 1966	4.4
June 26, 1967	4.0
August 27, 1969	4.2, III
August 27, 1969	3.9
August 29, 1969	3.9

Date - 1970s	Magnitude/Intensity
September 21, 1979	4.4
October 17, 1970 *	4.3
December 2, 1971 *	4.1
December 3, 1971 *	4.2
November 23, 1972 *	4.4, IV
December 27, 1975	3.1
March 17, 1976	3.9
April 7, 1976 *	2.9
February 6, 1978*	3.3
April 14, 1978	2.5, III

Earthquakes in the 1980s

A number of earthquakes occurred in or near northern Lincoln County in the 1980s, with a few causing damage. The first earthquake recorded in Lincoln County in the 1980s occurred on June 13, 1980, and was located near Bedford. The magnitude 3.1 earthquake did not cause any damage or concern. On March 1, 1982, a magnitude 3.6, intensity V earthquake in eastern Idaho, just west of Freedom, Wyoming, was felt as an intensity IV event in Freedom, Etna, and Thayne. No damage was reported. On February 8, 1983, a magnitude 4.4, intensity V earthquake occurred in Idaho, approximately twelve miles northwest of Alpine, Wyoming. Although no damage was reported, the earthquake was felt as an intensity IV event at Etna (Star Valley) and at Teton Village (Teton County). The U.S. Forest Service reported that the event may have initiated snow avalanches in some areas (Casper Star-Tribune, February 9, 1983).

Most of the earthquakes in the 1980s that caused damage or concern in northern Lincoln County, occurred in 1985. On July 1, 1985, a magnitude 4.0, intensity IV earthquake occurred in Idaho, approximately ten miles northwest of Alpine. Although the earthquake was felt in Jackson Hole and Alpine, no damage was reported (Casper Star-Tribune, July 3, 1985). In August and September of 1985, four earthquakes occurred in northern Lincoln County. Three of those earthquakes were felt in Jackson. The first earthquake, a magnitude 4.8, intensity V event, occurred on August 21, 1985, approximately ten miles east of Alpine. It was felt as an intensity V event at Alpine, an intensity IV event at Wilson (Teton County), an intensity IV event at Lander (Fremont County), and was lightly felt in Jackson. No major damage was reported, although the Teton County Sheriff's Department reported that the earthquake caused a motorist to drive off the highway in the Snake River Canyon (Casper Star-Tribune, August 22, 1985). The second earthquake, a magnitude 4.3 event, occurred on August 22, 1985, approximately twelve miles southeast of Alpine. It was felt as an intensity IV event in Alpine, with no significant damage reported (Laramie Daily Boomerang, August 23, 1985). The third earthquake, a magnitude 4.3, intensity V event, occurred on August 30, 1985, approximately seven miles east of Alpine. It was felt as an intensity V event at Alpine, and was also felt in Jackson. No damage was reported (Laramie Daily Boomerang, August 31, 1985). The last earthquake, a magnitude 4.6, intensity V event, occurred on September 6, 1985, approximately fifteen miles east-southeast of Alpine. It was felt as an intensity V event at Alpine, and as an intensity IV event in Wilson. An earthquake-induced landslide temporarily closed a portion of U.S. Highway 89 in the Snake River Canyon (Casper Star-Tribune, September 8, 1985).

On June 21, 1986, a magnitude 3.5 earthquake occurred in Idaho, approximately thirteen miles northwest of Afton. The earthquake was felt as an intensity IV event at Auburn. On November 11, 1988, a magnitude 4.0, intensity V earthquake occurred near Smoot, south of Afton. The earthquake was felt as an intensity V event at Smoot, and an intensity IV event at Afton and Fairview. No significant damage was reported.

A summary of earthquakes that are shown on **Figure 18**, and that occurred in or near northern Lincoln County in the 1980s, is presented below. Earthquakes that did not originate in the county are flagged with an asterisk.

Date - 1980s	Magnitude/Intensity	Date - 1980s	Magnitude/Intensity
June 13, 1980	3.1	August 22, 1985	3.4
December 15, 1981	2.9	August 21, 1985	4.8, V
January 8, 1982 *	2.3	August 22, 1985	4.3, IV
March 1, 1982 *	3.6, V	August 30, 1985	4.3, V
February 8, 1983 *	4.4, V	September 6, 1985	4.6, V
February 28, 1985	3.5	September 6, 1985	3.6
March 8, 1985	3.4	September 19, 1985	3.5
March 10, 1985	3.6	June 21, 1986 *	3.5, IV
March 10, 1985	3.1	March, 1988	2.5
July 1, 1985 *	4.0, IV	November 13, 1988	4.0, V

Earthquakes from 1990 through 1996

The 1990s have been one of the most active periods on record for the area in and around northern Lincoln County. In large part this is due to the series of earthquakes that occurred in eastern Idaho and the western Star Valley in 1994. It is also due to the fact that the portable seismometers that were placed in the area in 1994 were able to detect very small events.

The first earthquake of significance recorded in northern Lincoln County in the 1990s was a magnitude 3.5 event that occurred on April 9, 1990. The earthquake, which was located approximately twenty miles east-southeast of Alpine, did not cause any damage. A series of earthquakes shook the Star Valley on November 10, 1992, but they are not shown on **Figure 18** because they are located well into Idaho. The first earthquake had a magnitude of 4.8, and was felt as an intensity V event at Alpine and Grover and as an intensity IV event in the rest of the Star Valley. This earthquake was quickly followed by a magnitude 4.7 earthquake that was felt as an intensity V event at Grover, an intensity IV event in the northern portion of Star Valley, and as an intensity III event in the more southern portion of Star Valley. The November 10, 1992, earthquakes did not cause any significant damage in Wyoming.

On January 30, 1994, a magnitude 3.3 earthquake occurred in eastern Idaho, west of Afton. No damage was associated with the event, which is not shown on **Figure 18**. This event was followed by a magnitude 3.4 earthquake on February 1, 1994, and a magnitude 4.0 earthquake on February 2, 1994. Neither of these earthquakes are shown on **Figure 18**. The magnitude 4.0 earthquake on February 2, 1994, was felt as an intensity V event at Afton and Freedom, and as an intensity III event at Grover. On February 3, 1994, a magnitude 4.7 earthquake occurred in the same area. This earthquake was soon followed by a magnitude 5.9, intensity VII earthquake that rocked the Star Valley. The earthquake epicenter was in the vicinity of Draney Peak in Idaho.

The most significant damage from the magnitude 5.9 event occurred at the Auburn Fish Hatchery, located just into Idaho, near Auburn, Wyoming. One wall separated from the roof of that facility. In addition, one home near Auburn had cracks in both the foundation and ceiling. The earthquake also shook dishes off shelves and clocks off walls in Afton and surrounding communities. In Wyoming, the magnitude 5.9 earthquake was felt as far away as Rock Springs. The earthquake was also felt in Salt Lake City, Utah, and Grand Junction, Colorado.

The magnitude 5.9 earthquake that occurred on February 3, 1994, was followed by thousands of aftershocks. The largest of the aftershocks are shown on **Figure 18**. The aftershocks include magnitude 5.2 and 4.1 earthquakes on February 3, 1994, a magnitude 4.4 earthquake on February 5, 1994, a magnitude 4.7 earthquake on February 6, 1994, a magnitude 4.5 earthquake on February 7, 1994, a magnitude 4.3 earthquake on February 8, 1994, a magnitude 4.4 earthquake on February 9, 1994, and a magnitude 5.3 earthquake on February 11, 1994. Large aftershocks continued into March and April, with a magnitude 4.7 earthquake on March 3, 1994, a magnitude 4.2 earthquake on April 2, 1994, a magnitude 5.2 earthquake on April 7, 1994, and a magnitude 4.3 earthquake on April 8, 1994.

The February 11, 1994, aftershock did cause some minor structural damage in the Star Valley. In Grover, a resident reported that his house had been damaged to the point where a front door would not close. There was also a report from Grover that a set of concrete steps had pulled away from a house. In Afton, cracks appeared in the walls of some homes. In Fairview, there were reports of lamps tipped over. No other significant damage was associated with what has been called the Draney Peak earthquake sequence.

A few earthquakes were felt in the Star Valley in 1995. On February 28, 1995, a magnitude 4.0, intensity V earthquake occurred seventeen miles south-southwest of Afton. The earthquake was felt as an intensity V event in Afton, and as an intensity IV event in Smoot. No significant damage was associated the earthquake. On July 25, 1995, two earthquakes occurred in Idaho, approximately six miles west of Etna, Wyoming. The first earthquake had a magnitude of 3.0, and was not widely felt. The second earthquake had a magnitude of 4.1, and was felt as an intensity IV event at Thayne. No damage was associated with the earthquake. On December 16, 1995, a magnitude 3.3 earthquake occurred near Bedford, Wyoming. The non-damaging earthquake occurred in the vicinity of the Star Valley fault (**Figure 17**), which is a system capable of generating magnitude 7.3-7.5 earthquakes. Due to a lack of seismic stations in the area, the epicenter could not be located accurately enough to determine if it had originated on the Star Valley fault.

In 1996, no significant earthquakes occurred in northern Lincoln County. On May 16, 1996, a magnitude 4.3, intensity V earthquake did occur northeast of Georgetown, Idaho, and twenty miles southwest of Afton, Wyoming. The non-damaging earthquake was felt as an intensity IV event at Afton, Wyoming,

and as an intensity III event in Auburn, Fairview, Freedom, Grover, and Smoot, Wyoming. This earthquake occurred in the same vicinity as those that caused damage and concern in the Star Valley in 1994.

A summary of earthquakes that are shown on **Figure 18**, and that occurred in or near northern Lincoln County in the 1990s, is presented below. Earthquakes that did not originate in the County are flagged with an asterisk. Earthquakes that were discussed in the text but not shown on **Figure 18** are flagged with two asterisks.

Date - 1990s	Magnitude/Intensity	Date - 1990s	Magnitude/Intensity
April 4, 1990	3.5	February 7, 1994	4.5
November 11, 1992 **	4.8, V	February 8, 1994 *	4.3
October 10, 1993	3.1	February 11, 1994 *	5.3, VI
January 30, 1994 **	3.3	March 3, 1994 *	4.7, IV
February 1, 1994**	3.4	April 2, 1994 *	4.2
February 2, 1994**	4.0, V	April 7, 1994 *	5.2, V
February 3, 1994**	4.7	April 8, 1994 *	4.3, IV
February 3, 1994*	5.9, VII	February 28, 1995	4.0, V
February 3, 1994*	5.2, IV	July 25, 1995 *	4.1, IV
February 3, 1994 *	4.1	December 16, 1995	3.3
February 5, 1994	4.4	May 16, 1996 *	4.3, V
February 6, 1994 *	4.7, V		

Summary

Earthquakes are a common occurrence in western Wyoming. None of the historic earthquakes described in this report, however, have been as large as the maximum credible earthquakes postulated for either the Teton Fault in Teton County or the Star Valley Fault in Lincoln County (**Figure 17**). Both of those fault systems are capable of generating magnitude 7.3-7.5 earthquakes. Expanded earthquake awareness and strengthened building codes are needed in western Wyoming if property destruction and loss of life are to be minimized in a major earthquake.

References Cited

Bodle, R.R., 1946, United States earthquakes 1944: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 682, 43 p.

Brazee, R.J., and Cloud, W.K., 1959, United States earthquakes 1957: U.S. Department of Commerce, Coast and Geodetic Survey, 108 p.

Humphreys, W.J., 1915, Seismological reports for March, 1915, *in* Abbe, C., editor, Monthly weather review: U.S. Department of Agriculture, Weather Bureau Monthly Weather Review, v. 43, no. 3, p. 142-145.

Neumann, F., 1938, United States earthquakes 1936: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 610, 45 p.

Neumann, F., and Bodle, R.R., 1932, United States earthquakes 1930: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 539, 25 p.

Reagor, B.G., Stover, C.W., and Algermissen, S.T., 1985, Seismicity map of the State of Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1709, scale 1:1,000,000.

von Hake, C.A., and Cloud, W.K., 1971, United States earthquakes 1969: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 80 p.

ROCK HOUND'S CORNER

W. Dan Hausel
Senior Economic Geologist, Wyoming State Geological Survey

The author recently led a field trip to a very interesting locality in Palmer Canyon, west of Wheatland in the Laramie Mountains. This particular locality, known as the Roff deposit, lies within a gneiss complex northeast of the Elmers Rock greenstone belt. The locality should be of interest not only to rock hounds, but also to geologists who study metamorphic rocks, as some of the pelitic gneisses and schists in this region contain a number of interesting porphyroblasts. For example, the Grizzly Creek prospect to the southwest of the Roff deposit, is reportedly underlain by schists with abundant kyanite and sillimanite.

There is an astonishing abundance and variety of porphyroblasts in the schists and gneisses in the area. Possibly of greatest interest, are samples of gneiss containing transparent, violet-blue, cordierite porphyroblasts up to 2 inches across. One sample collected by the author (sample PC2-96), contained as much as 15 to 20% cordierite.

Cordierite [$(Mg, Fe)_2Al_4(Si_5O_{18})$] is a silicate with a hardness of 7 to 7.5. The mineral has both cleavage and parting evident in many of the porphyroblasts. The cleavage and parting results in rectangular-shaped orthorhombic mineral grains. Although it appears much of the cordierite is gem-quality, the presence of the parting, often reduces the size of the cutable material. However, other samples (PC2-96A) do not appear to be as seriously flawed and include high-quality material of possibly a few carats in weight. Unfortunately, the extent of the cordierite schist appears to be restricted to the eastern edge of the property. But as far as the author is aware, this is the first report of gem-quality cordierite in this region, and the deposit and region is worthy of further investigation. The mineral was verified by XRD at the Wyoming State Geological Survey.

The Roff deposit also contains other interesting porphyroblasts. For example, near the cordierite gneiss along the eastern edge of the property, some fibrous, white, sillimanite (Al_2SiO_5) occurs in biotite schist. A few yards west of the sillimanite schist, near an old prospect pit dug for vermiculite, the same biotite schist contains some chlorite and is filled with large prisms of pale-blue, to dark-blue kyanite (Al_2SiO_5). Kyanite is a very interesting mineral in that it has two distinct hardnesses. For example, if you scratch the mineral prisms parallel to the c-axis (the longer dimension) with a pocket knife, it scratches rather easily as the hardness is only 4.5. However, if you scratch the mineral perpendicular to this direction, across the shorter dimension of the prism, it is more difficult to scratch except where the surface is weathered. This is because the mineral has a hardness of 6.5 to 7 in this direction, which is nearly the same as the pocket knife.

Another mineral found in abundance in the chlorite-biotite schist, particularly in the prospect pit, is corundum. The corundum (Al_2O_3) occurs as small hexagonal pink, red, purplish-red, and white mineral grains, typically of only about one-eighth of an inch across. All of the corundum examined by the author to date is opaque, and there is little evidence of gem-quality (ruby, sapphire) corundum. However, future studies by the WSGS will include a microscopic study of the corundum to determine the potential for any gem-quality ruby or sapphire in this area.

The Roff deposit lies on private land, and permission is required to visit the property.

NEW COAL GEOLOGIST

Robert M. Lyman has joined the Wyoming State Geological Survey as Head of the Coal Section. In 1973, he received his Master of Science degree in geology from the University of Iowa. Upon graduation, Bob joined the Paul Weir Company, in Chicago Illinois, and served as a coal project geologist until 1978, when he joined the Sun Energy Development Company as the senior coal geologist of their eastern coal acquisitions team. In 1981, Bob moved to Knoxville, Tennessee, with Sun Coal Company serving as the company's chief senior coal geologist where he had responsibilities in Sun's coal activities on a national scope, including Wyoming. After leaving Sun Coal in 1994, Bob started his own consulting business (Reserve Services), which served clients in coal matters throughout United States. In joining the Survey, Bob brings nearly 25 years of coal geology, consulting, and industry experience to the position.

NEW PUBLICATIONS OF THE WYOMING STATE GEOLOGICAL SURVEY

Sixty-third annual report of the Wyoming State Geological Survey for Fiscal Year 1996 (July 1, 1995, to June 30, 1996), by G.B. Glass and S.G. Bruhnke: Annual Report.-Free on request.

Copper, lead, zinc, molybdenum, and associated metal deposits of Wyoming, by W.D. Hausel: Bulletin 70.-$15.00.

*Subsurface correlation of selected Late Cretaceous and older formations along the eastern margin of the Great Divide and Washakie Basins, greater Green River Basin, Wyoming (Cross Section A-A'), by R.H. De Bruin: Geophysical Log Cross Section GLCS 97-1.-$5.50 (rolled blueline copy only).

*Subsurface correlation of selected Late Cretaceous and older formations along the Rock Springs uplift, greater Green River Basin, Wyoming (Cross Section B-B"), by R.H. De Bruin: Geophysical Log Cross Section GLCS 97-2.-$5.50 (rolled blueline copy only).

*Subsurface correlation of selected Late Cretaceous and older formations along the Moxa arch, greater Green River Basin, Wyoming (Cross Section C-C'), by R.H. De Bruin: Geophysical Log Cross Section GLCS 97-3.-$5.50 (rolled blueline copy only).

*Subsurface correlation of selected Late Cretaceous and older formations across the greater Green River Basin, Wyoming (Cross Section D-D'), by R.H. De Bruin: Geophysical Log Cross Section GLCS 97-4.-$5.50 (rolled blueline copy only).

*Geology of the Red Dwarf corundum (ruby-sapphire) deposit, Graham Ranch, western Granite Mountains, central Wyoming, by W.D. Hausel: Mineral Report MR97-1.-$1.05 (7 pages, xerox copy only).

*Diamond exploration targets in the Wyoming craton, western United States, by W.D. Hausel, R.E. Kucera, T.E. McCandless, and R.W. Gregory: Mineral Report MR97-2.-$9.15 (61 pages, xerox copy only).

Coal geology of Wyoming, by G. B. Glass: Reprint 63 (replaces Reprint 47).-$4.00.

Each geologic section of the Survey now releases some of its own numbered reports and maps. Note the GLCS reports (above) from the Oil and Gas Section and the MR reports (above) from the Metals and Precious Stones Section. Please contact the following Staff Geologists for coverage, availability, prices, or further information on specific commodities or topics [Phone: (307) 766-2286; FAX: (307) 766-2606; or use the E-Mail addresses included below]:

W. Dan Hausel - Metals and precious stones
(E-Mail: dan_hausel@wsgs.uwyo.edu)
James C. Case - Geologic hazards and environmental geology
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(E-Mail: rod_debruin@wsgs.uwyo.edu)
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Order these and other publications from: Wyoming State Geological Survey, P.O. Box 3008, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286; Fax (307) 766-2605; and E-Mail: sales@wsgs.uwyo.edu. An order form is also included in back of this issue of *Wyoming Geo-notes*. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming. A free list of publications is available on request.

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The meeting starts with golf on Saturday, September 20th; a Sunday afternoon (September 21st) roundtable discussion on carbon dioxide availability in Wyoming; a reception Sunday night; and an all day technical session on Monday, September 22nd. The fair will be held at the Snow King Resort in Jackson. Contact Don Basko at the Wyoming Oil and Gas Conservation Commission [(307) 234-7147] or any of the other sponsors if you need more information.

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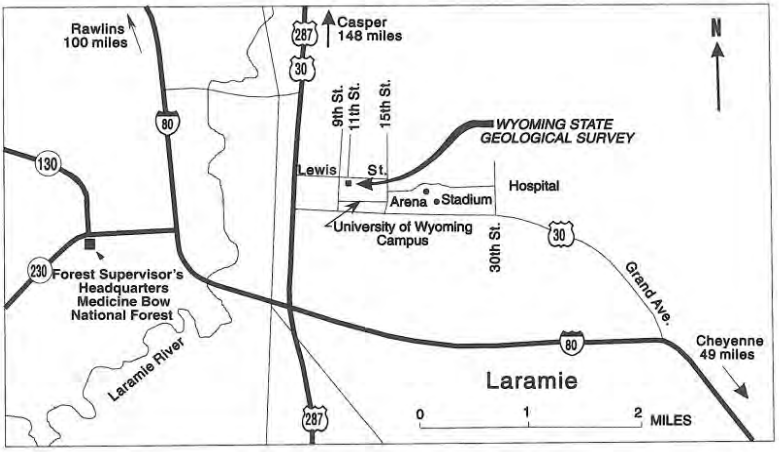

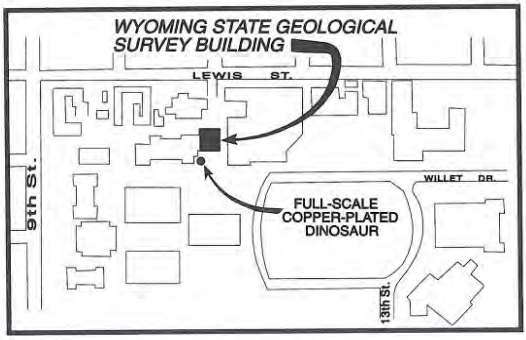

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