

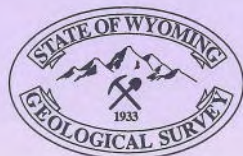
Wyoming Geo-notes

Number 54

WYOMING GEOLOGISTS PRACTICE ACT AMENDED IN 1997

Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
June, 1997



WYOMING STATE GEOLOGICAL SURVEY

Gary B. Glass, *State Geologist*

GEOLOGICAL SURVEY BOARD

Ex Officio

Jim Geringer, *Governor*
Philip L. Dubois, *President, University of Wyoming*
Donald B. Basko, *Oil and Gas Supervisor*
Gary B. Glass, *State Geologist*

Appointed

Nancy M. Doelger, *Casper* Charles M. Love, *Rock Springs*
Ronald A. Baugh, *Casper* Stephen L. Payne, *Casper*
Victor R. Hasfurther, *Laramie*

STAFF

Supportive Services Section

Susanne G. Bruhnke - *Office Manager*
Peggy Hopkins - *Administrative Secretary*

Publications Section

Richard W. Jones - *Editor*
Janet VanNuys - *Public Information Technician*
Kathy Hastreiter - *Sales Manager*
Fred H. Porter, III - *Cartographer*
Phyllis A. Ranz - *Cartographer*

Geologic Sections

W. Dan Hausel, *Senior Economic Geologist - Metals and Precious Stones*
James C. Case, *Staff Geologist - Geologic Hazards*
Rodney H. De Bruin, *Staff Geologist - Oil and Gas*
Ray E. Harris, *Staff Geologist - Industrial Minerals and Uranium*
Alan J. Ver Ploeg, *Staff Geologist - Geologic Mapping*
Vacant, *Staff Geologist - Coal*
Robert W. Gregory, *Laboratory Technician*

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

WYOMING GEO-NOTES

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

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



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

Cover: Page 63 of this issue summarizes the 1997 changes to this licensing act and provides an address for the licensing board, as well as its phone and fax numbers and its e-mail address.

Table of Contents

	<i>Page</i>
Minerals Update	1
Overview	1
Oil and Gas Update	11
Exploration and development	19
Reference cited	25
Coal Update	26
Developments in the Powder River Basin	26
Developments in southern Wyoming	28
Power plants	29
New coal contracts and solicitations	30
Coalbed methane	30
Industrial Minerals and Uranium Update	30
Construction aggregate	30
Decorative and dimensional stone	32
Limestone and silica sand	32
Salt	32
Trona	33
Uranium	33
References cited	34
Metals and Precious Stones Update	34
Mineral Resource and Reserve Base Estimates for Wyoming	37
Summary of 1996 Exploration for Coal, Oil, Gas, and Other Minerals in Wyoming	36
Coal	36
Diamond	39
State Line district	39
Eagle Rock area	40
Seminole Mountains	41
Green River Basin	41
Leucite Hills	43
Industrial Minerals and Construction Materials	43
Metals	44
Golden Clover mine	44
South Pass	45
Encampment district	45
Copper King property	46
Quaking Asp Mountain	46
Rattlesnake Hills	46
Oil and Gas	47

	<i>Page</i>
Drilling activities and well completions	47
Lease sales	49
Powder River Basin	51
Greater Green River Basin	51
Wind River Basin	51
Bighorn Basin	52
Overthrust Belt	52
Ruby and Sapphire	52
Uranium	52
Reference cited	53
Part 1: Overview of Historical Seismicity in Western Wyoming	53
Overview of earthquakes in Teton County, 1923-1996	55
Earthquakes from 1920 through the 1950s	55
Earthquakes in the 1960s and 1970s	58
Earthquakes in the 1980s	59
Earthquakes from 1990 through 1996	60
References cited	62
Rock Hound's Corner	62
Beryl	62
Licensure of Geologists in Wyoming Now Required	63
New publications of the Wyoming State Geological Survey	64
Recreational map purchasers!	64
Wyoming State Geological Survey location maps	66

MINERALS UPDATE

OVERVIEW

Gary B. Glass

State Geologist, Wyoming State Geological Survey

Because of the Special June Legislative Session on school financing, the Consensus Revenue Estimating Group (CREG) met again in April to review its mineral and other forecasts. In this regard, the CREG revised its forecast oil production slightly upward for 1996, but lowered its annual forecast for the years 1997-2003 (Table 1; Figure 1). Its forecast oil prices were not changed from those made in January (Table 2; Figure 2). Figure 3 now shows the posted prices for Sweet and Sour crude oil through the first quarter of the year. The three-month average was \$19.35 and reflected decreases in some bonuses that had been paid Wyoming producers. The bonuses started to decrease even before Express Pipeline brought its first Canadian crude into Casper.

In regard to natural gas, the CREG did not change its production forecast of January (Table 1; Figure 4). It did change its estimate of the average methane price for 1997 from \$1.89 down to \$1.60 (Table 2; Figure 5). The high

Table 1. Wyoming mineral production (1985-1996) with forecasts to 2003¹.

Calendar Year	Oil ^{2,3}	Natural Gas ^{3,4}	Carbon Dioxide ^{3,4}	Helium ^{4,5}	Coal ⁶	Trona ⁶	In-situ Uranium ^{7,8}	Sulfur ^{3,9}
1985	131.0	597.9	—	—	140.4	11.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	994.3	142.6	1.07	263.9	18.1	1.3	1.20
1996	*73.4	*1,031.3	*142.6	*1.07	278.4	*17.5	*2.0	*1.20
1997	69.0	1,045.1	142.6	1.07	289.5	21.1	2.0	1.20
1998	65.2	1,072.4	142.6	1.07	304.0	21.1	2.5	1.20
1999	61.6	1,100.4	142.6	1.07	322.2	21.1	2.9	1.20
2000	58.2	1,129.0	142.6	1.07	344.5	22.6	2.9	1.20
2001	55.0	1,167.2	142.6	1.07	351.4	22.6	2.9	1.20
2002	52.0	1,206.5	142.6	1.07	355.0	24.4	2.9	1.20
2003	49.1	1,247.0	142.6	1.07	358.6	24.4	2.9	1.20

*Estimated until official figures are available.

¹Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2003, April, 1997;

²Millions of barrels; ³Wyoming Oil & Gas Conservation Commission, 1985-1995; ⁴ Billions of cubic

feet; ⁵Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek

is 0.5%; ⁶Millions of short tons (Wyoming State Inspector of Mines, 1985-1996); ⁷Wyoming State

Inspector of Mines, 1985-1996; ⁸Millions of pounds of yellowcake (not available [N/A] for 1985 and

previous years because it was only reported as taxable value); ⁹Millions of short tons.

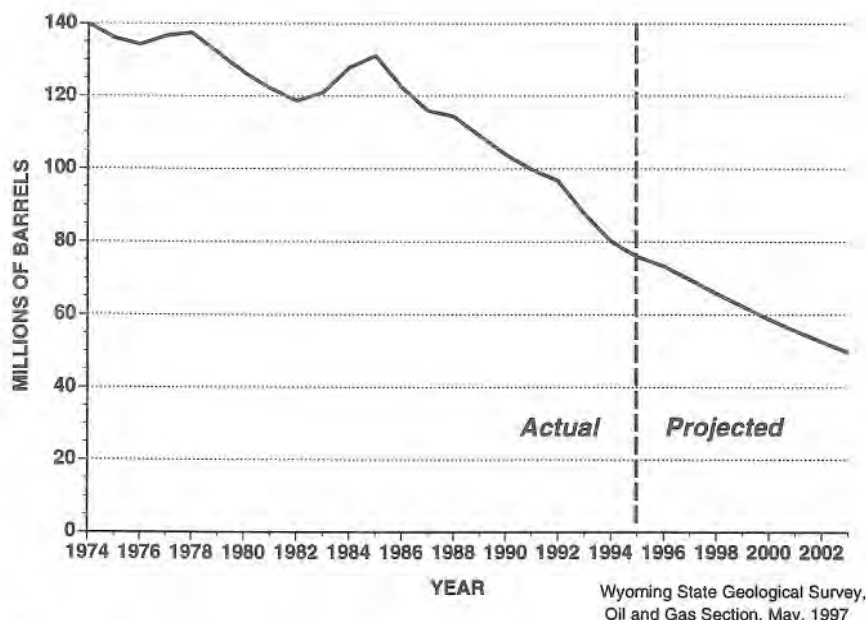


Figure 1. Annual oil production from Wyoming (1994 to 1995) with forecasts to 2003.

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

Calendar				
Year	Oil ²	Methane ³	Coal ⁴	Trona ⁵
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	41.86
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	44.50
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	*19.50	*1.47	*6.23	*44.09
1997	17.00	1.60	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 Farm Loan Office, 1989-1995 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); ⁴ Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-1995; ⁵ Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1995.

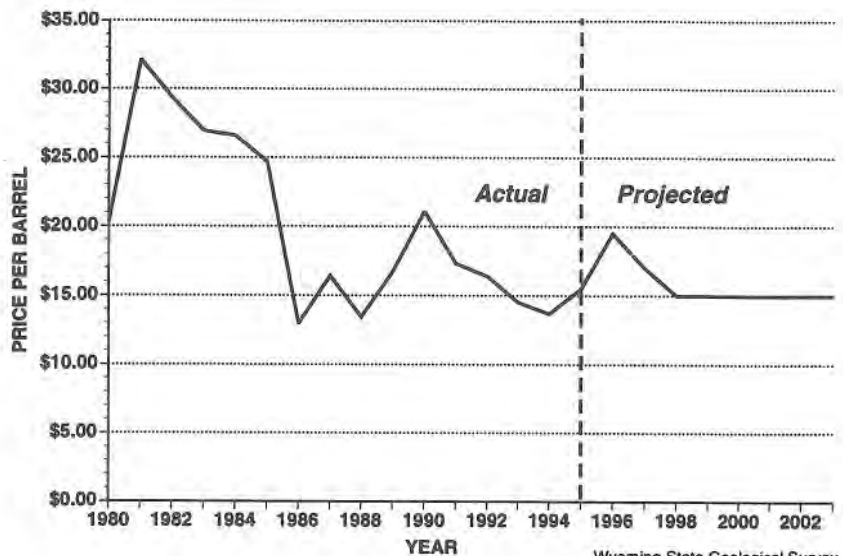


Figure 2. Average prices paid for Wyoming oil (1980-1995) with forecasts to 2003.

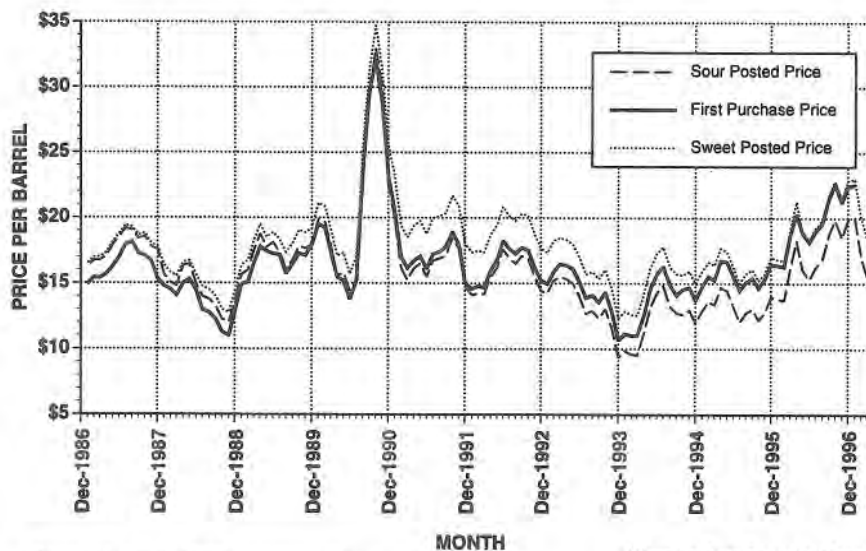


Figure 3. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

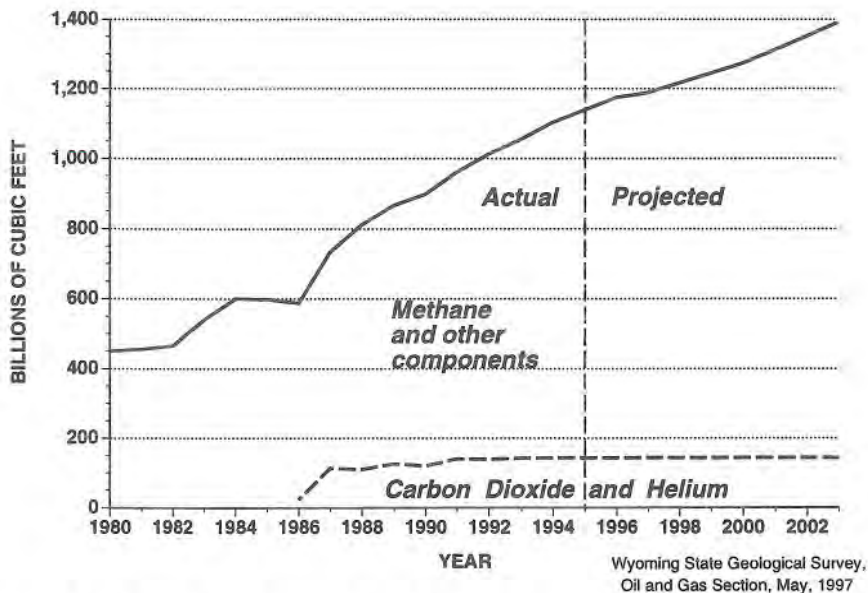


Figure 4. Annual natural gas production from Wyoming (1980 to 1995) with forecasts to 2003.

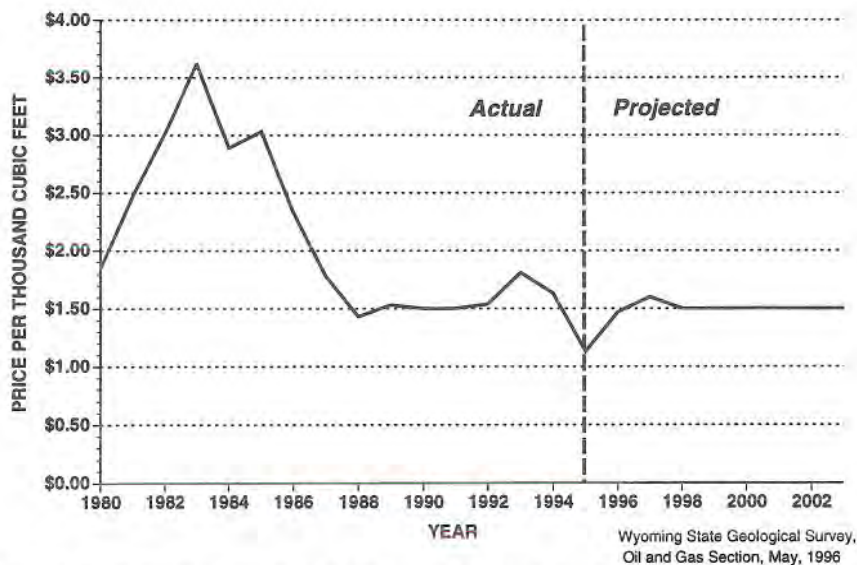


Figure 5. Average prices paid for Wyoming methane (1980 to 1995) with forecasts to 2003.

spot sale prices seen at the end of 1996 and early in 1997 disappeared much faster than expected (**Figure 6**). While the average spot sale price for the first quarter was \$2.60, methane prices had dropped from \$3.90 in January to \$1.40 by March. The \$3.90 spot price in January is the highest on record for Wyoming gas in the 11 years that spot prices have been recorded.

In regard to coal, the CREG only changed its 1996 production figure in April. The new production figure for 1996 is 278.4 million tons, which is 1.3 million tons less than the January forecast (**Tables 1, 3, and 4; Figure 7**). With this production, Wyoming coal accounted for about 26% of the nation's total production.

Table 3 was changed somewhat to better reflect the percentage of Powder River Basin coal that is or will be sold above \$5.00 a ton. This higher-priced coal reflects older long-term contracts that have not yet expired. **Figures 8 and 9** now reflect all the coal deliveries in 1996. The CREG's estimate of coal prices was not changed from January (**Tables 2 and 5; Figure 10**).

Only one change was made to the production and price forecasts for the other minerals shown in **Tables 1 and 2**. Trona production was reduced to 17.5 million tons.

This issue of *Wyoming Geo-notes* includes a summary of 1996 exploration for coal, oil and gas, and other minerals in Wyoming as well as Part 1 of a lengthy overview of seismic activity in western Wyoming. The second part of

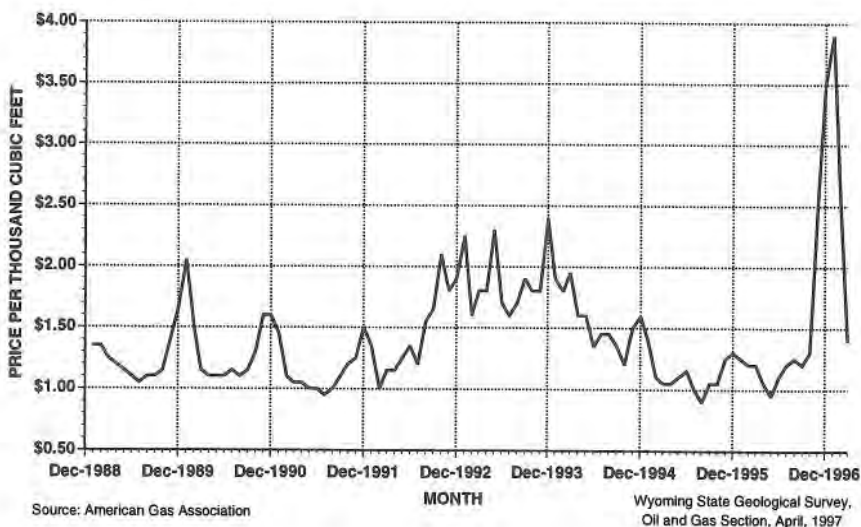


Figure 6. Spot sale price for methane at Opal, Wyoming, averaged by month (1989 to present).

Table 3. 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%

¹County estimates by Wyoming State Geological Survey, April, 1997; ²Estimated 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 4. Monthly coal deliveries from Wyoming's mines in short tons (1993-1996).

	1993		1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	15,931,150	15,931,150	19,326,770	19,326,770	21,586,303	21,586,303	21,793,387	21,793,387
FEB	14,646,090	30,577,240	17,171,910	36,498,680	20,839,926	42,426,229	20,374,055	42,167,442
MAR	17,112,970	47,690,210	19,178,990	55,677,670	21,707,422	64,133,651	22,507,800	64,675,242
APR	16,259,770	63,949,980	17,839,110	73,516,780	20,066,616	84,200,267	22,579,959	87,255,201
MAY	16,085,470	80,035,450	18,652,290	92,169,070	21,509,916	105,710,183	22,216,016	109,471,217
JUN	16,473,920	96,509,370	17,741,480	109,910,550	18,602,505	124,312,688	20,698,814	130,170,031
JUL	15,296,480	111,805,850	18,213,540	128,124,090	21,334,608	145,647,296	24,842,971	155,013,002
AUG	16,682,090	128,487,940	20,572,120	148,696,210	21,356,870	167,004,166	24,421,537	179,434,539
SEP	17,310,330	145,798,270	19,129,450	167,825,660	21,355,730	188,359,896	23,339,792	202,774,331
OCT	18,300,070	164,098,340	18,189,260	186,014,920	21,178,610	209,538,506	22,615,721	225,390,052
NOV	18,007,970	182,106,310	18,595,500	204,610,420	21,042,260	230,580,766	21,421,085	246,811,137
DEC	19,034,530	201,140,840	20,866,710	225,477,130	22,032,910	252,613,676	22,105,530	268,916,667
Total Tonnage Reported¹	201,140,840		225,477,130		252,613,676		268,916,667	
Total Tonnage Not Reported²	8,784,986		11,430,937		11,324,347		9,508,289	
Total Tonnage Produced³	209,925,826		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 (1993-1995); From bulletin board of the Federal Energy Regulatory Commission in 1996.

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, April, 1997.

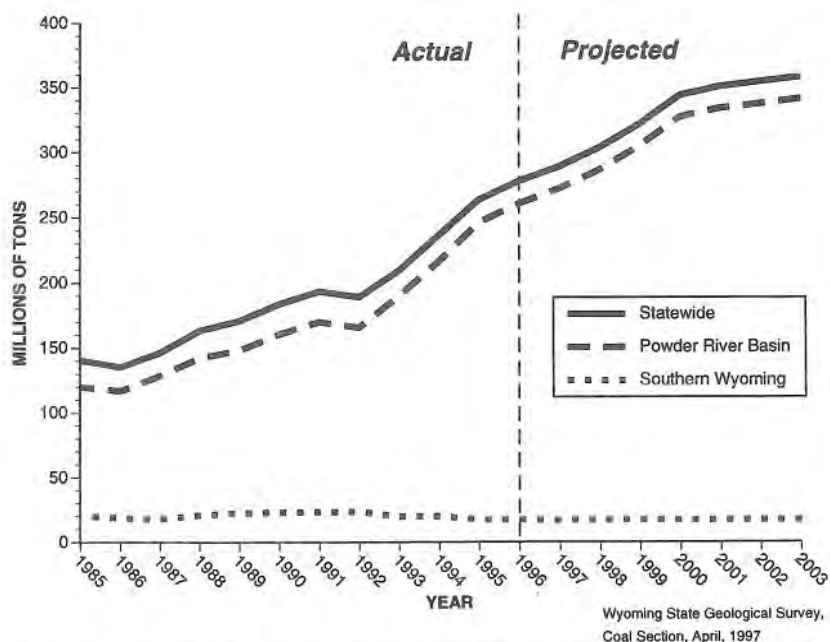
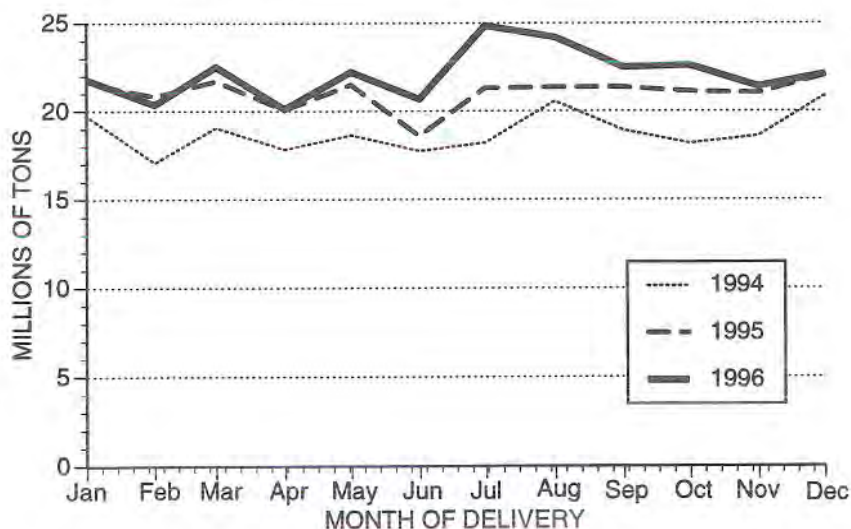
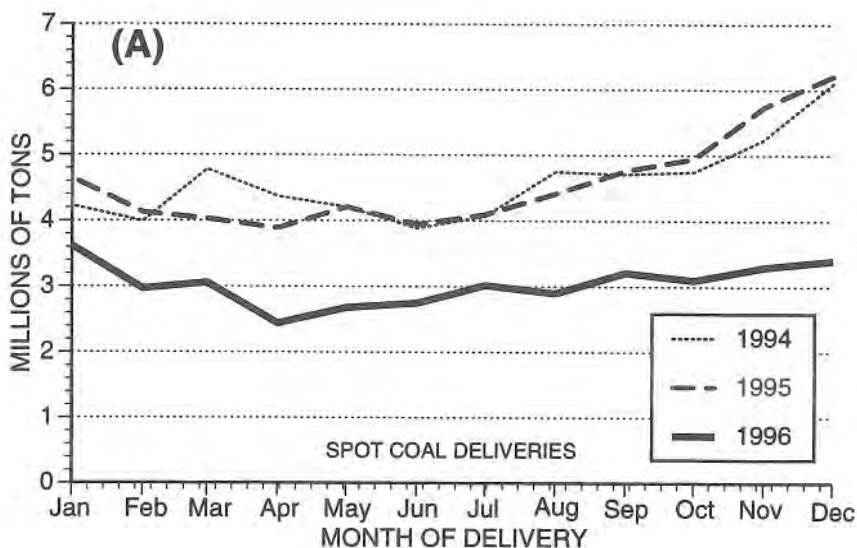


Figure 7. Annual coal production from Wyoming (1985-1996) with forecasts to 2003. Data from Wyoming State Inspector of Mines (1985-1996) and Wyoming Consensus Estimating Group (1997-2003).

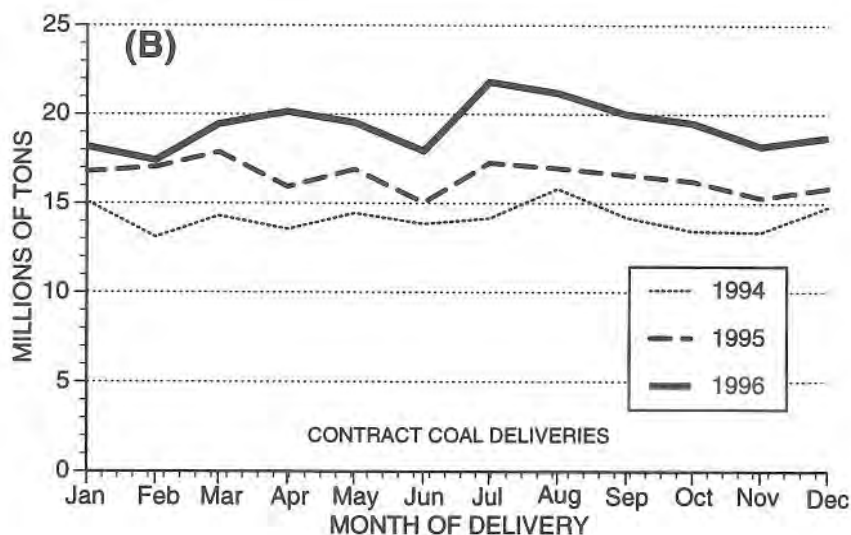


Wyoming State Geological Survey, Coal Section, April, 1997

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



Wyoming State Geological Survey, Coal Section, April, 1997



Wyoming State Geological Survey, Coal Section, April, 1997

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

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

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

¹Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1995 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.

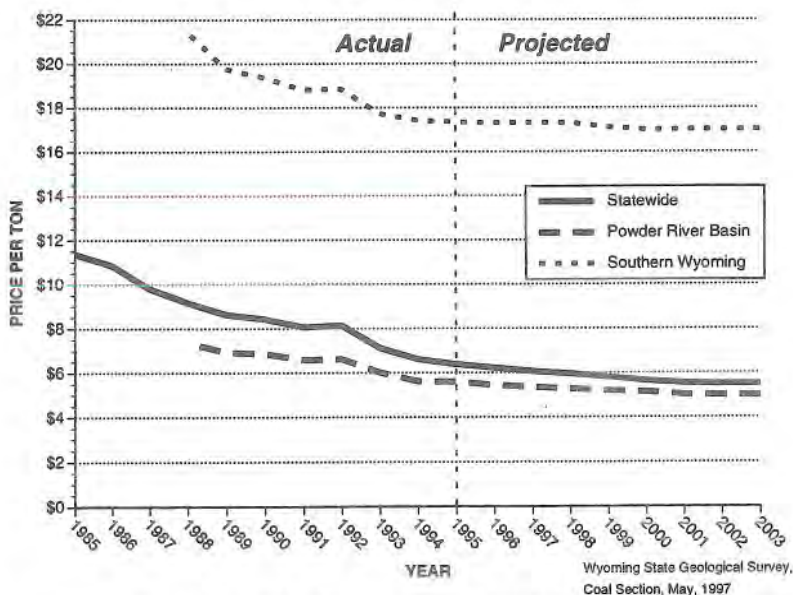


Figure 10. Average prices paid for Wyoming coal (1985 to 1996) with estimates to 2003. Source: U.S. Energy Information Administration (1985-1990); derived from the Wyoming Department of Revenue (1991-1995); and the Consensus Revenue Estimating Group (1996-2003).

this latter article will be published in the next issue. There is also a special notice about the new licensing act for geologists who want to practice before the public in Wyoming (p. 63).

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 first quarter of 1997 averaged an estimated \$19.35 per barrel. But during the first quarter, the average monthly price decreased from \$22.56 per barrel in January to \$17.00 per barrel by March (Table 6). This downward trend is contrary to fairly stable or increasing prices during the first quarter of recent years (Table 6).

Spot prices for natural gas at Opal, Wyoming, averaged higher in the first quarter of 1997 than in any other quarter over the last eight years (Table 7 and Figure 6). The average spot price for the first quarter was \$2.60 per thousand cubic feet (MCF). The average for all of 1996 was \$1.47 per MCF (Table 7).

According to preliminary figures from Petroleum Information, Inc., oil production in Wyoming was an estimated 73.4 million barrels in 1996 (Table 8). They also estimate that last year's natural gas production in Wyoming was 1,167.9 billion cubic feet (Table 9). Based on past years, the official production figures that will be provided by the Wyoming Oil and Gas Conservation Commission later this year will be slightly higher than these estimates.

Wyoming oil producers now have two new competitors. The Beartooth Pipeline is a crude oil pipeline that is bringing Canadian oil to refineries in Wyoming, Colorado, and Utah. This 76-mile-long, 18-million-barrel-per-year pipeline extends from Billings, Montana, to Elk Basin, Wyoming. It is a joint venture of Amoco and Conoco. In addition, the Express Pipeline brought its first Canadian crude oil into Casper in early April. Its annual capacity is about 63 million barrels.

The Wyoming Legislature passed, and the Governor signed, extensions to two tax relief measures for oil and gas producers. House Enrolled Act 52 (Chapter 72) will extend the 2% severance tax credit for incremental increases in tertiary production until March, 2001. The Wyoming Oil and Gas Conservation Commission will still have to certify a project as tertiary production before the State's Department of Revenue can authorize the credit. House Enrolled Act 111 (Chapter 171) grants producers 24 months of production with no severance tax on incremental production increases that are a result of workovers or recompletions. The tax break is subject to Wyoming Oil and Gas Conservation Commission rules and oversight. This credit was extended until January 1, 2001.

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

	1994	1994	1995	1995	1996	1996	1997	1997
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	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	\$18.50	\$20.53
MAR	\$ 11.04	\$ 11.07	\$ 15.26	\$ 15.19	\$ 18.63	\$ 17.09	\$17.00	\$19.35
APR	\$ 12.59	\$ 11.45	\$ 16.73	\$ 15.58	\$ 20.29	\$ 17.90		
MAY	\$ 14.53	\$ 12.07	\$ 16.65	\$ 15.79	\$ 18.85	\$ 18.08		
JUN	\$ 15.73	\$ 12.68	\$ 15.52	\$ 15.75	\$ 18.15	\$ 18.10		
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		\$19.50		

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, April, 1997

Table 7. Monthly average spot sale price of a thousand cubic feet (MCF) for natural gas at Opal, Wyoming (1994 to present).

	1994		1995		1996		1997	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	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		
MAY	\$ 1.60	\$ 1.77	\$ 1.10	\$ 1.14	\$0.95	\$1.13		
JUN	\$ 1.35	\$ 1.70	\$ 1.15	\$ 1.14	\$1.10	\$1.13		
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, April, 1997

Table 8. Monthly oil production from Wyoming in barrels (1994 to present).

	1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	7,115,472	7,115,472	6,700,000	6,700,000	6,153,037	6,153,037
FEB	6,387,147	13,502,619	6,100,000	12,800,000	5,693,084	11,846,121
MAR	6,984,248	20,486,867	6,300,000	19,100,000	6,176,805	18,022,926
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 Reported¹		79,527,740		75,000,000		73,362,466
Total Barrels Not Reported²		651,400		554,113		
Total Barrels Produced³		80,179,140		75,554,113		

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

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

³ Wyoming Oil and Gas Conservation Commission.

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

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

	1994		1995		1996	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
JAN	93,146,775	93,146,775	100,224,249	100,224,249	101,359,648	101,359,648
FEB	85,623,666	178,770,441	86,691,577	186,915,826	96,303,300	197,662,948
MAR	94,388,052	273,158,493	94,344,991	281,260,817	103,541,127	301,204,075
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 Reported¹	1,096,051,931			1,131,541,625		1,167,855,331
Total MCF Not Reported²		6,879,705			6,448,396	
Total MCF Produced³		1,102,931,636			1,137,990,021	

¹ Monthly production reports from Petroleum Information, Inc.

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

³ Wyoming Oil and Gas Conservation Commission.

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

The U.S. Bureau of Land Management (BLM) issued a Record of Decision (ROD) that allows up to 1,292 new wells in the Fontenelle area. The BLM also issued its ROD for the Expanded Moxa Arch Infill Drilling Project in southwestern Wyoming. This decision allows the drilling of up to 1,325 new wells in the next ten years.

True Oil acquired more than 40 wells in the Powder River, Green River, and Wind River Basins from Prenalta Corp. for an undisclosed amount. The properties reportedly have proved reserves of about 1.5 million barrels of oil and over four billion cubic feet of gas, with an additional 500,000 barrels of probable oil reserves.

BWAB, Inc. completed six acquisitions for a total of \$10.2 million. These purchases include 260 working interests and 465 royalty and overriding royalty interests in 15 states. The greatest number of interests are in Oklahoma, Texas, and Wyoming.

Marathon Oil purchased two oil fields in the Wind River Basin from Chevron USA. Both the Steamboat Butte and Pilot Butte fields are on the Wind River Indian Reservation and together produce about 940 barrels of oil and 700,000 cubic feet of gas per day from 34 wells.

Belco Oil & Gas formed two Areas of Mutual Interest (AMI) with partners in Wyoming. One oil and gas exploration agreement, which involves properties in the Green River and Wind River Basins, is with Andover Partners and Andex Partners. Belco will acquire a 50% undivided interest in about 553,000 gross mineral acres and will fund 100% of the planned \$20 million in exploration and development over the next five years. A second agreement is with Snyder Oil. Belco and Snyder have agreed on two joint development programs and AMIs in the Bighorn and Wind River Basins. The Bighorn Basin AMI covers 63,408 gross acres and the Wind River Basin AMI covers 30,692 acres.

Colorado Interstate Gas (CIG) has announced a \$40 million pipeline expansion to move Wyoming gas to Midwestern markets. The plan not only involves increased compression along its Trailblazer Pipeline System at Muddy Gap, Rawlins, Rock Springs, Laramie, and Cheyenne, but also a 68 million cubic feet per day expansion of its Wind River Lateral, which ties into CIG's Wyoming Interstate Company (WIC) pipeline at Rawlins. Work should be completed by August of 1997. Total expanded capacity of the Trailblazer/WIC System is about 193 million cubic feet per day. This will raise the overall capacity of the System to 700 million cubic feet a day. With additional compression, the System could be expanded to one billion cubic feet per day.

KN Energy will acquire the Bushton natural gas processing facility and other gas gathering assets, mainly in Kansas. These are currently owned by several subsidiaries of Enron Corp. The purchase will complement the \$160 million Pony Express Pipeline project, a 900-mile-long pipeline from Wyoming to Kansas City that will begin shipping gas in the second or third quarter of 1997.

In mid-April, KN Energy also announced plans to double the gas processing capacity of their Douglas plant to accommodate an estimated 100 million cubic feet per day input from the Cave Gulch discoveries. This would increase the present 85 million cubic feet per day capacity to 145 million cubic feet a day. The expansion should be completed by October of 1997. This gas will be shipped east to the Kansas City area on the new Pony Express pipeline project.

Williams Natural Gas has announced a pipeline expansion on the order of 40 million cubic feet per day. This gas is also headed to the Kansas City area.

A recent preliminary report by the U.S. Department of the Interior (1997) shows that Wyoming received more Federal mineral royalties in fiscal year 1996 than any other State. Wyoming received \$199.3 million as its share, or nearly 44% of all distributions from Federal onshore mineral leases. This total is lower than the \$214.2 million total in fiscal year 1995, but is still the fourth highest total in the last 11 years. New Mexico was second in disbursements with \$118.6 million. The report did not break out revenues by individual commodities.

In the first quarter of 1997, there was only one lease sale (Table 10). Leasing activity at the U.S. Bureau of Land Management's (BLM's) February sale was concentrated in the Powder River, Bighorn, and Greater Green River Basins (Figure 11). The high per-acre bid was \$250 by Maurice Brown for a 161.39-acre parcel covering parts of sections 7 and 9, T46N, R71W (location A, Figure 11). The lease is one to three miles northwest of Muddy Sandstone oil production at Hilight Field and about a mile south of Minnelusa oil production at Haight and Maysdorf South fields. The second high per-acre bid was \$180 by James Sullivan for a 234.34-acre lease that covers parts of sections 19 and 20, T54N, R69W (location B, Figure 11). The lease is just over one mile east of Muddy Sandstone oil production at Soda Well East Field. The third high per-acre bid was \$170 by Westech Energy for a 160-acre parcel that covers the NW section 32, T39N, R88W (location C, Figure 11). The tract is about four miles east of abandoned Lance gas production at Badwater Field. The fourth high per-acre bid was \$165 by Hanson & Strahn for a 120.64-acre tract that covers parts of section 25, T28N, R112W (location D, Figure 11). This lease is about three miles east of Baxter, Frontier, and Bear River gas production at Bird Canyon Field.

There were 298 Applications for Permit to Drill (APDs) in the first quarter of 1997 (Table 11). APDs for the first quarter are running at a pace that should bring the total in 1997 close to the total in 1996, when APDs were at a five-year high (Table 11). Over half 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 only 12 in the first quarter (Table 12), but that total should pick up later in the year. The seismic projects and miles permitted in the first quarter of 1997 were concentrated in counties in the Powder River Basin and in southwestern Wyoming.

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

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)							STATE SALES (STATE LAND AND FARM LOAN OFFICE)								
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1993								1993							
TOTAL	\$12,942,008	2,769	1,469	2,065,942	995,344	\$13.00	\$400.00	TOTAL	\$1,980,017	800	562	311,273	222,139	\$9.91	\$403.00
1994								1994							
TOTAL	\$27,107,594	2,968	1,840	2,376,530	1,449,659	\$18.70	\$11,200.00	TOTAL	\$3,304,152	800	607	331,779	255,152	\$12.95	\$205.00
1995								1995							
February	\$3,252,668	533	332	473,177	290,046	\$11.21	\$425.00	March	\$524,165	199	131	89,371	57,702	\$9.08	\$130.00
April	\$1,591,709	531	206	483,826	189,003	\$9.42	\$160.00	May	\$452,747	200	125	75,633	49,735	\$9.10	\$78.00
June	\$3,439,604	393	246	394,746	238,863	\$14.65	\$660.00	September	\$421,454	200	134	78,032	53,527	\$7.87	\$65.00
August	\$1,105,381	488	165	420,189	149,025	\$7.41	\$160.00	November	\$257,852	200	102	80,851	41,744	\$6.18	\$52.00
October	\$2,751,689	477	227	334,883	174,453	\$15.83	\$1,100.00	TOTAL	\$1,656,218	799	492	323,887	202,708	\$9.17	\$130.00
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								1996							
February	\$1,635,668	455	192	358,478	137,901	\$11.86	\$220.00	March	\$308,927	199	96	85,369	41,909	\$7.37	\$108.00
June	\$1,438,325	460	282	337,440	181,338	\$7.93	\$210.00	June	\$656,177	250	114	103,621	48,638	\$13.49	\$205.00
August	\$2,021,483	289	182	261,321	118,267	\$17.09	\$145.00	October	\$663,241	300	134	115,495	54,538	\$12.16	\$175.00
October	\$3,058,248	363	255	280,454	163,054	\$18.76	\$270.00	December	\$687,152	300	164	113,626	61,729	\$11.29	\$96.00
December	\$3,333,838	261	214	165,771	138,945	\$23.99	\$1,450.00	TOTAL	\$2,325,497	1049	508	418,111	206,814	\$11.24	\$206.00
TOTAL	\$11,487,567	1,828	1,125	1,403,444	739,505	\$15.53	\$1,450.00								
1997								1997							
February	\$2,463,137	267	210	222,466	148,148	\$16.63	\$250.00								

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

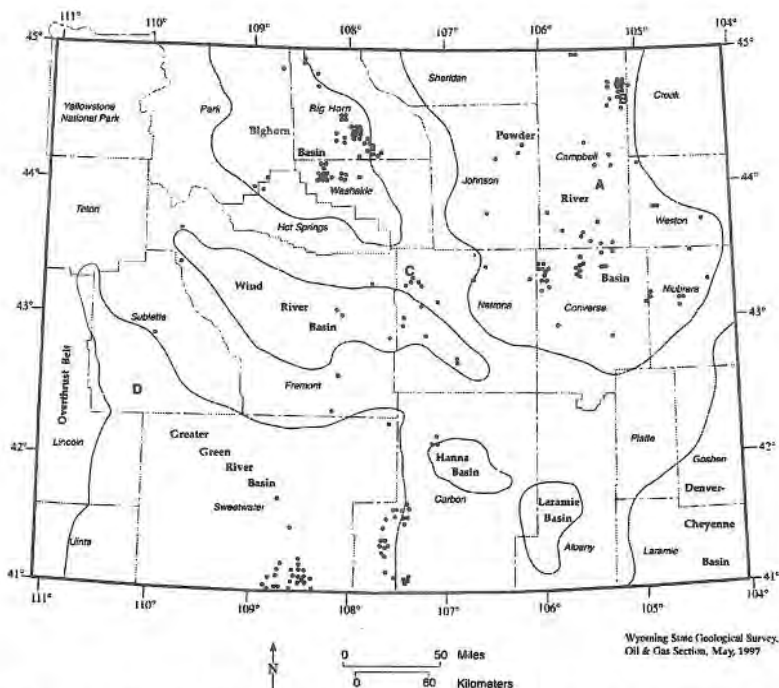


Figure 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the February, 1997, sale.

The daily rig count for the first quarter of 1997 averaged 28, which is the highest average count in a first quarter since 1994 (Figure 12). It is also atypical for the average daily rig count to rise in the first quarter of the year. Obviously, this boost in rig count was aided by the higher oil and gas prices at the end of 1996 and early in the first quarter of this year.

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 first quarter of 1997. The numbers preceding discussions below refer to locations on Figure 13.

1. Chevron USA plans to reenter a Nugget Sandstone producer in Painter Reservoir Field. The 23-6AH well will be horizontally drilled from a surface location in NE SW section 6, T15N, R119W to a true vertical depth of 10,675 feet. The well was originally completed in 1981 and had produced 21.7 billion cubic feet of gas and 525,500 barrels of oil.
2. American Methanol has announced plans to begin work on an \$80 million natural gas processing plant about fifteen miles west of Green River. The

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

	1993	1994	1995	1996	1997
County	APDs	APDs	APDs	APDs	APDs
Albany	0	0	1	1	0
Big Horn	17	3	16	53	10
Campbell	126	105	151	554	153
Carbon	35	135	50	77	10
Converse	34	74	29	20	0
Crook	29	9	15	37	4
Fremont	16	46	30	26	14
Goshen	0	0	0	0	0
Hot Springs	12	4	13	24	9
Johnson	18	16	6	16	0
Laramie	33	15	10	2	1
Lincoln	135	103	64	55	23
Natrona	36	63	80	74	16
Niobrara	5	4	4	7	0
Park	22	18	20	30	3
Platte	0	2	0	0	0
Sheridan	7	3	0	0	0
Sublette	80	113	61	118	15
Sweetwater	156	204	153	136	27
Teton	0	0	0	0	0
Uinta	48	11	11	10	2
Washakie	17	12	31	30	10
Weston	23	6	10	10	1
TOTALS	849	946	755	1280	*298

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

*Number of APDs issued in the first quarter of 1997.

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

plant would use about 20 million cubic feet of natural gas per day to produce about 69 million gallons of methanol per year. Construction could start in the second or third quarter of this year. The plant would employ an estimated 25 to 30 people when completed. Methanol is used in antifreeze, solvents, and to prevent the freezing of water produced in association with natural gas. The company estimates that over 30% of the methanol produced at the plant would be used by local producers of natural gas.

3. Petral Exploration completed a new wildcat well in SW SE section 35, T23N, R113W. The 40-35 Federal-Pascali well flowed 2.7 million cubic feet of gas, 96 barrels of condensate, and seven barrels of water per day from Muddy Sandstone perforations between 12,026 and 12,038 feet. There is no other Muddy production in the vicinity.

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

County	1994				1995				1996				1997			
	Permits	Conven- tional	3-D Square Miles	Permits	Conven- tional	3-D Square Miles	Permits	Conven- tional	Permits	Conven- tional	3-D Square Miles	Permits	Conven- tional	Permits	Conven- tional	3-D Square Miles
Albany	0	0	0	0	0	0	1	18	0	0	0	0	0	0	0	0
Big Horn	5	24	4	1	16	0	2	3	0	0	66	0	0	0	0	0
Campbell	13	17	50	12	24	43	32	56	3	16	220	3	16	0	0	0
Carbon	11	117	86	1	0	16	2	5	0	0	18	0	0	0	0	0
Converse	0	0	0	4	39	20	1	4	0	0	0	0	0	0	0	0
Crook	3	3	2	1	0	5	5	3	3	5	20	3	5	0	0	6
Fremont	6	12	104	6	32	56	2	5	15	1	15	1	0	0	20	0
Goshen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	1	9	0	2	70	9	4	17	29	0	0	0	0	0	0	0
Johnson	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0
Laramie	3	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lincoln	0	0	0	2	18	110	0	0	0	0	0	0	0	0	0	0
Natrona	1	0	17	3	27	3	0	0	0	0	0	3	7	116	0	0
Niobrara	1	0	11	0	0	0	2	0	23	0	0	1	4	0	0	0
Park	1	0	7	0	0	0	6	20	82	1	4	0	0	0	0	0
Platte	0	0	0	0	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	0	0	0	0
Sublette	5	4	145	2	0	162	2	21	52	0	0	0	0	0	0	0
Sweetwater	4	59	0	9	17	497	8	17	670	0	0	0	0	0	0	0
Teton	0	0	0	0	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	0	0	0	0
Washakie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weston	0	0	0	1	13	0	1	0	16	0	0	0	0	0	0	0
TOTALS	56	302	515	45	260	921	70	174	1251	*12	*36	*142				

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
*Number of seismic projects and miles permitted during the first quarter of 1997.

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

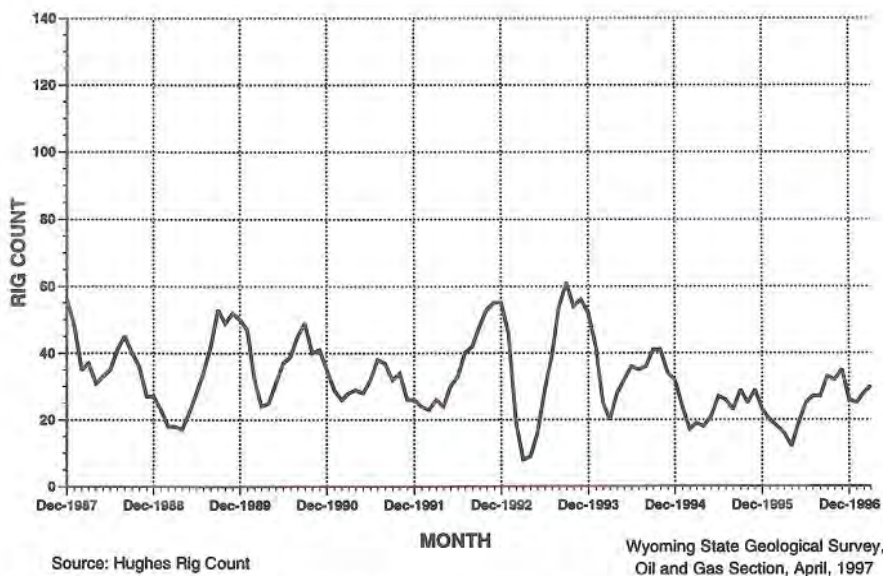


Figure 12. Wyoming daily rig count averaged by month (1988 to present).

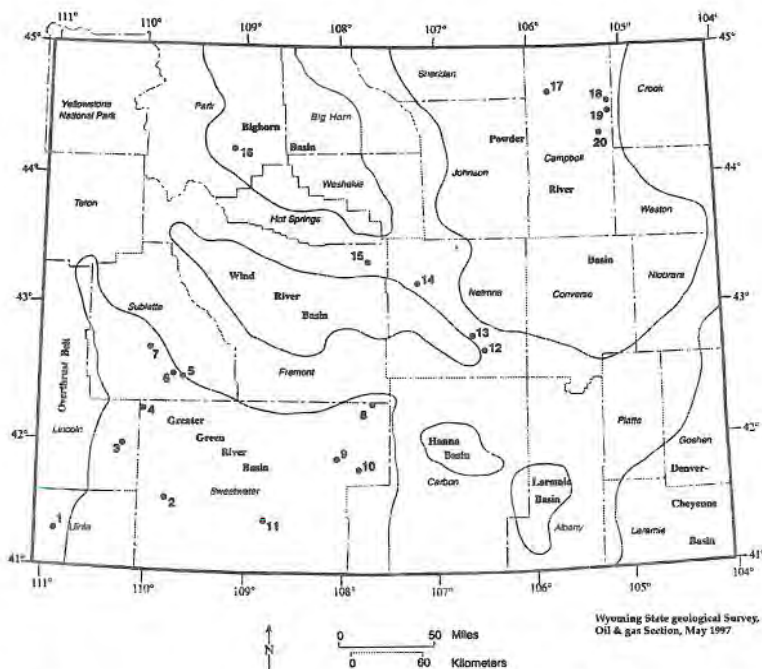


Figure 13. Oil and gas exploration and development activities in Wyoming during the first quarter of 1997 (exclusive of coalbed methane activities).

4. Bataa Oil completed a new Frontier producer in NW NW section 25, T26N, R111W. The 11-25 Bataa-Federal well flowed 858,000 cubic feet of gas and 11 barrels of water per day from between 9,412 and 9,437 feet in second Frontier. This well extends Bird Canyon Field about a mile to the southeast.
5. Snyder Oil completed a new Lance discovery in NW NW section 30, T29N, R107W. The 4-30 Cabrito-Federal Unit well flowed 1.4 million cubic feet of gas and 40 barrels of condensate per day from an undisclosed interval in the Lance. The well is about two miles east of Jonah Field.
6. McMurray Oil completed four new producing wells in Jonah Field. The 15-34 Stud Horse Butte well in SW SE section 34, T29N, R108W flowed 2.8 million cubic feet of gas and 37 barrels of condensate per day. The 9-28 Stud Horse Butte well in NE SE section 28, T29N, R108W produced an average of 2.0 million cubic feet of gas and 14 barrels of condensate per day in December, 1996. The 13-35 Stud Horse Butte well in SW SW section 35, T29N, R108W produced an average of 7.7 million cubic feet of gas and 123 barrels of condensate per day during its first 17 days of production in December, 1996. The 4-36 Stud Horse Butte well in NW NW section 36, T29N, R108W produced an average of 3.4 million cubic feet of gas and 20 barrels of condensate per day in December, 1996. All four wells are producing from undisclosed intervals in the Lance. Jonah Field produced over 1.4 billion cubic feet of gas and over 13,000 barrels of condensate from 25 wells in December, 1996.
7. Alpine Gas completed a new discovery in SE NW section 2, T31N, R110W. The 22-2 Mesa-Federal well flowed 238,000 cubic feet of gas, two barrels of condensate, and seven barrels of water per day from an undisclosed interval in the Lance. The new discovery is about six miles northwest of Pinedale Field.
8. Berco Resources discovered gas at its 1-3 Hadsell Spring-Federal well in NE SW section 3, T26N, R91W. The well flowed 559,000 cubic feet of gas and 344 barrels of water per day from the Lance between 6,541 and 6,665 feet. The well is about six miles west of Lost Soldier Field.
9. Abraxas Petroleum completed three new wells in Siberia Ridge Field. The 5-22 Siberia Ridge-Federal well in SE NW section 22, T22N, R94W flowed 6.6 million cubic feet of gas and 173 barrels of condensate per day. The well was completed in the Lewis between 10,787 and 10,810 feet and in the Almond between 11,260 and 11,282 feet. The 4-22 Siberia Ridge-Federal well in NE SE section 22, T22N, R94W flowed 4.6 million cubic feet of gas and 410 barrels of condensate per day. The well was also completed in the Lewis between 10,732 and 10,880 feet and in the Almond between 11,200 and 11,420 feet. The 4-24 Siberia Ridge-Federal well in SE SE section 24, T22N, R94W flowed 2.2 million cubic feet of gas and 200 barrels of condensate per day from the Lewis between 10,808 and 10,861 feet.

10. Burlington Resources completed a new exploration well in C SE section 20, T21N, R92W. The 20-1 Monument Lake-Federal well flowed 1.8 million cubic feet of gas, 111 barrels of condensate, and 17 barrels of water per day. The new well is about a mile and a half southeast of the Monument Lake Field discovery.
11. Union Pacific Resources plans to horizontally drill its 41P-H Brady Federal Unit well from a surface location in SE NW section 11, T16N, R101W. The well will test the Phosphoria Formation at a true vertical depth of approximately 13,400 feet.
12. C & S Operating reestablished production in Bates Creek Field with its 8-22 Federal well in SE NW section 8, T31N, R81W. The well is producing an average of 18 barrels of oil, 10,000 cubic feet of gas, and one barrel of water per day from the Frontier at approximately 1,850 feet. Bates Creek Field was abandoned in 1989.
13. Burr Oil & Gas completed an offset well to Canal Field. The 2-4 Burr-Federal well in NE NW section 4, T32N, R82W produced an average of 109 barrels of oil, and 54,500 cubic feet of gas per day during its first month of production. The well is producing from the Frontier at approximately 1,800 feet.
14. Barrett Resources completed three new wells on the Cave Gulch Unit and is setting production casing at a fourth well. The 15 Cave Gulch-Federal well in NE NE section 31, T37N, R86W flowed 1.2 million cubic feet of gas per day through perforations between 10,610 and 10,626 feet and between 10,726 and 10,754 feet in the Mesaverde. The 10 Cave Gulch-Federal Unit well in SE NW section 32, T37N, R86W averaged 4.6 million cubic feet of gas and five barrels of condensate per day during its first month of production. The 6 Cave Gulch-Federal Unit well in NE SE section 30, T37N, R86W averaged 4.0 million cubic feet of gas and 43 barrels of condensate per day during its first month of production. Both of these wells are producing from undisclosed intervals in the Lance. Barrett decided to set production casing to 19,106 feet at its 16 Cave Gulch Unit well in NE NW section 32, T37N, R86W. The company plans to evaluate the Frontier, Muddy, Lakota, Morrison, and Sundance formations.
15. Louisiana Land & Exploration (LL&E) penetrated a gas column of 260 gross feet in the Madison Limestone at its 4-36 Bighorn well in SW NE section 36, T39N, R91W. The 24,600-foot well was spudded in November, 1995, and was drilled approximately 1,000 feet downdip from the crest of Madden anticline, a mile and a half northwest of the 1-5 Bighorn and four miles northwest of the 2-3 Bighorn. The 1-5 Bighorn and the 2-3 Bighorn are currently producing gas from the Madison below 23,000 feet. Based on the estimated production capacity of these three wells, LL&E will likely have to expand its Lost Cabin plant to about 170 million cubic feet per day. The plant is currently limited to 50-67 million cubic feet a day. With additional

information from the 4-36 Bighorn well, LL&E increased its estimate of proved and probable recoverable gas reserves in the Madison Limestone at Madden to over one trillion cubic feet. This estimate seems conservative, considering that the 4-36 Bighorn well encountered no gas/water contact.

16. Texaco Exploration & Production completed a new well in Spring Creek Field. The 50 Spring Creek Unit well in SW NE section 11, T49N, R102W pumped 457 barrels of oil and 3,261 barrels of water per day. The well is producing from the Phosphoria between 3,610 and 3,634 feet and from the Tensleep between 3,752 and 3,814 feet.
17. Maxim Drilling & Exploration completed a wildcat well about a mile and a half northwest of Muddy production at Parnell Draw Field. The 43-31 Wild Horse-Federal well in NE SE section 31, T54N, R74W pumped 42 barrels of oil, 30,000 cubic feet of gas, and two barrels of water per day from the Muddy between 8,678 and 8,700 feet.
18. Lario Oil & Gas completed a wildcat in the Minnelusa about a mile southeast of shut-in Minnelusa production at Roehrs Field. The 1 Sagebrush-Federal in NW SW section 14, T53N, R69W recovered oil at the rate of 25 to 30 barrels per hour during swab tests of the Minnelusa at approximately 7,440 feet. This well is one of four new Minnelusa producers drilled as a result of a 31-square-mile, 3-D seismic program shot by Lario and GCRL Energy in early 1996.
19. Swift Energy also discovered oil in the Minnelusa at its 1 Rule Federal 21-11 well in NE NW section 11, T52N, R69W. The well pumped 241 barrels of oil per day from between 7,150 and 7,156 feet. The new discovery is about a mile and a half from production at three other Minnelusa fields.
20. Plains Petroleum ran production casing and is testing its horizontally drilled 23-12H Rozet Muddy Sand Unit well. The well was drilled from a surface location in NE SW section 12, T50N, R70W to an undisclosed true vertical depth in the Muddy Sandstone. This is the first horizontal test in Rozet Field.

Reference cited

- U.S. Department of the Interior, 1997, Statistical highlights fiscal year 1996: Royalty Management Program: Denver, CO, 29p.

COAL UPDATE

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

Based on preliminary production figures from the Wyoming State Inspector of Mines, coal production from Wyoming reached 278.4 million tons in 1996. This is an increase of 14.5 million tons (5.49%) over the 263.9 million tons produced in 1995 (Table 3). Coal production from the Powder River Basin also increased to record amounts. The 20 mines active in the basin combined to produce 261.2 million tons of coal in 1996 as compared to 246.6 million in 1995, a 5.93% increase. While this production gain is not as dramatic as the gains in each of the three previous years, it points toward a steady increase in demand fueled by utilities seeking low-cost, low-sulfur coal that meets clean-air standards.

Production from the three mines in the Hanna Basin totaled 4.7 million tons in 1996, an increase of 22.4% over the 3.8 million tons produced in 1995. The two active mines in the Green River Basin produced 8.2 million tons of coal in 1996, which was a 10.7% decline from the 9.1 million tons mined in 1995. The two mines in the Hams Fork Coal Field accounted for 4.4 million tons of coal in 1996, almost identical to 1995's production.

Developments in the Powder River Basin

The U.S. Bureau of Land Management's (BLM's) Powder River Basin Regional Coal Team (RCT) met in April to review the status of three pending coal lease applications (LBAs) and to consider three new LBAs. The pending LBAs are the North Rochelle, Powder River, and Thundercloud tracts. The new tracts are the New Keeline, Horse Creek, and Belle Ayr tracts.

The Final Environmental Impact Statement on the 149-million-ton North Rochelle LBA has been completed and it is out for review. The estimated date for this sale is July 15, 1997. The applicant on this tract is Bluegrass Coal, a subsidiary of Zeigler Coal Holding Co. This tract is adjacent to Triton Coal Co.'s North Rochelle mine. Triton is also a subsidiary of Zeigler Coal Holding Co.

The BLM decided to do a combined environmental impact statement for the Powder River and Thundercloud LBAs. The draft version of this impact statement is expected late in the summer of this year. The applicant on the 550-million-ton Powder River (North Antelope/Rochelle) LBA is Powder River Coal Co., a subsidiary of Peabody Coal Co. This LBA is adjacent to Powder River Coal's North Antelope and Rochelle mines. The applicant on the 432-million-ton Thundercloud LBA is Kerr-McGee Coal Co. This LBA is adjacent to Kerr-McGee's Jacobs Ranch mine. The tentative sale dates for these two tracts are March 3, 1998, and June 25, 1998, respectively.

The RCT voted not to accept the application of Evergreen Enterprises for its 635-million-ton New Keeline LBA. The denial does not prevent Evergreen from reapplying in the future. This large LBA was designed to allow for the start-up of a new mine at about 2015.

The Horse Creek LBA of Antelope Coal Co., a subsidiary of Kennecott Energy, Inc., was accepted by the RCT. This 177.5-million-ton LBA is adjacent to the Antelope mine and would add 7.5 years to the mine's life if it were made available. The company would like to begin mining this tract in 2001. By accepting the application, the BLM is able to move forward with its processing of the LBA.

The Belle Ayr LBA of Amax Land Co., a subsidiary of Cyprus-Amax Coal Co., was also accepted by the RCT. This 200-million-ton LBA is adjacent to Cyprus-Amax's Belle Ayr mine and would add about eight years to the mine's life if it were mined.

The RCT also noted that the accepted bonus bid at the most recent coal lease sale, the Antelope LBA held in December of 1996, had been 15 cents a ton. That bid by Powder River Coal Co. had been for a relatively small maintenance tract of 60.3 million tons, which was adjacent to their Antelope mine.

Atlantic Richfield Company (Arco) recently announced it is considering selling off its worldwide coal assets valued at \$1.75 billion. This would include the nation's largest coal mine, the 40-million-ton-per-year Black Thunder mine near Wright. In addition to Black Thunder, the company owns the Coal Creek mine, which is also in the Powder River Basin (PRB). Company officials indicated that coal was not really an area the company sees in its future as it shifts its emphasis more to oil and gas exploration and production.

In addition, Cyprus-Amax has also indicated it is looking at its future in coal mining. Besides many mines in other states, Cyprus-Amax has two large strip mines in the PRB (Belle Ayr and Eagle Butte) as well as an underground mine in the Hanna Basin (Shoshone No. 1).

Recent air quality applications submitted to the Wyoming Department of Environmental Quality, indicate three mines in the PRB are seeking to expand their production capacity. Kennecott wants to increase the capacity of its Cordero mine to 30 million tons per year, an increase of six million tons per year over its current permitted capacity. Cyprus-Amax has applied to increase the production capacity for its Eagle Butte mine to 35 million tons per year, a nine-million-ton-per-year increase. Kerr-McGee indicates it wants to open a third production facility at the Jacobs Ranch mine by the end of 1997 in order to increase its capacity to over 39 million tons per year.

Kennecott Energy's purchase of the Caballo Rojo mine from Drummond Coal is now completed (*Wyoming Geo-notes No. 53*, p. 32). This mine will be combined with the adjoining Cordero mine. The combined operation will be

referred to as the Cordero-Rojo Complex. One hundred eleven of the former Caballo Rojo's 175 employees were kept on after the purchase. Kennecott officials indicate that 41 of the other workers will be offered jobs at other area Kennecott mines and another 23 will be offered jobs at other Kennecott operations outside Wyoming.

The Wyoming Industrial Siting Council recently approved ENCOAL Corporation's permit application for a 16,500-ton-per-day, Liquids From Coal (LFC) plant in the Gillette area (*Wyoming Geo-notes No. 53*, p. 32). Construction could start during the second quarter of this year, with initial operations beginning in the first or second quarter of 1999. Full plant capacity is not expected until 2001. In a related note, Zeigler Coal Company announced that subsidiaries, ENCOAL Corporation and Americoal Development Company, have combined to form NuCoal LLC. NuCoal has signed contracts with Mitsubishi for construction of the \$460 million LFC plant.

There has been little additional information released on Synfuel Technology's (ST's) announced "coal refinery" in the Sheridan area. ST is based in Salt Lake City, Utah. The coal for their planned project is apparently located north of Ranchester, near the Montana-Wyoming border. The plant location has not been described.

Developments in southern Wyoming

For the first time, coal from the Hanna Basin has been moved by the Superior Midwest Energy Terminal, a shipping terminal on the western end of Lake Superior. A recent interconnect with the Union Pacific-Southern Pacific Railroad gives producers in both the Powder River Basin and the Hanna Basin access to this terminal. A test shipment of Hanna Basin coal from Arch Mineral went to an unnamed customer in late 1996, before the terminal shut down shipping for the winter. After the terminal reopens in early Spring, additional test shipments of coal from the Hanna Basin are expected.

Pittsburg and Midway Coal Mining Company (P&M) recently announced their purchase of FMC Corporation's Skull Point mine near Kemmerer, Wyoming. The Skull Point mine will be combined with P&M's larger Kemmerer mine. With this purchase, the total mine workforce will decline to 244, a loss of 43 jobs. P&M will supply the 850,000 tons of coal per year that Skull Point was to provide to FMC for use at its coke plant near Kemmerer and its soda ash facility near Green River. P&M expects its annual production to increase to at least 4.5 million tons of coal. The Kemmerer mine produced approximately 3.6 million tons of coal in 1995 and 1996. Skull Point produced 820,000 tons in 1995 and 768,580 tons in 1996.

Cyprus-Shoshone Coal Co., a subsidiary of Cyprus-Amax, recently signed a contract that adds an estimated 10 years to the life of their Shoshone No. 1 underground coal mine in the Hanna Basin. As a result of this contract, the company plans to add 20 new employees to its present workforce of 130. Central Illinois Public Service Co. (CIPSC) is using coal from the Shoshone No. 1

mine to replace higher-sulfur Illinois coal. CIPSC purchased nearly one-third of the 2.6 million tons produced from this mine in 1996.

Early in the second quarter, Ashland Coal, Inc. and Arch Mineral Corp. announced a merger agreement to form Arch Coal, Inc. The merger will require review by the Securities and Exchange Commission as well as ratification by Ashland Coal's shareholders. If consummated, the merger will create the nation's sixth largest coal company. Arch Mineral Corp. has two active strip mines in the Hanna Basin (Seminole No. 2 and Medicine Bow) and has proposed a new strip mine in the Carbon Basin, which is south of the Hanna Basin.

Power plants

In early March, the city of Colorado Springs began testing Powder River Basin (PRB) coal at its Nixon power plant with a trainload of coal from the Cordero mine. This is a single unit, 220-Megawatt (220-MW) plant, which currently uses coal from Cyprus-Amax's Twentymile mine in Colorado. The contract with the Twentymile mine expires in 2004. This test will last through early April of 1997 and is now a 30% blend of PRB coal. If testing continues to go well, the city could be using almost 200,000 tons of PRB coal by 1998. The city is looking at what coal supplier options it might have after 2004. And it is looking for available sources of spot coal in the meantime.

PRB coal has made its deepest incursion into the South. During the first quarter of 1997, Carolina Power and Light (CP&L) accepted its first unit train of PRB coal for testing at its Roxboro and Mayo plants, which are located in North Carolina. Using the Burlington Northern/Santa Fe Railroad, the coal came from Peabody's North Antelope mine. CP&L is blending the PRB coal with Appalachian coals at an 8:1 to 10:1 blend.

Mississippi Power is conducting additional testing of PRB coal at its Jack Watson plant. If the test is successful, some portion of the Watson plant's 300,000-ton spot coal requirement will be solicited from the PRB. Kerr-McGee's Jacobs Ranch mine supplied the coal for previous testing. The source of the latest shipment was not disclosed.

Centerior Energy recently announced that 1996 tests burns of PRB coal were successful and they are now committed to using 100% PRB coal in at least one of their Bay Shore units starting in the second quarter of 1996. Initially the PRB coal will be burned in one of the smaller units of the 631-MW Bay Shore plant. Although no official announcement has been made, the PRB coal will likely come through Venture Fuels, a joint venture of Kennecott Energy and Midwest Energy Services. The PRB coal supplied for the testing was a blend of Wyoming and Montana coal from Kennecott mines.

New coal contracts and solicitations

Table 13 is a tabulation of some of the contracts and solicitations for Wyoming coal announced during the first quarter of 1997.

Coalbed methane

A recent report in the *Oil and Gas Journal* indicates that coalbed methane production derived from the Wyodak-Anderson coal bed in the Powder River Basin could double as pipeline hookups are completed. Figures show production from this Tertiary-age, Fort Union Formation coal was 28 million cubic feet per day by the end of 1996. The identified shut-in gas that is awaiting pipeline connection totals another 35 million cubic feet a day. Presently there are 240 wells producing gas in the areas north and south of Gillette, with an exploration program beginning just across the border in Montana's Big Horn and Rosebud Counties. Western Gas Resources and Redstone Resources, owners of at least 80% of the leases in the area of the current methane play, estimate that production could reach 150 million cubic feet per day from the Powder River Basin of Montana and Wyoming with 600 to 1,000 new wells in the next five years.

Northport, a subsidiary of the Alabama-based River Gas Corporation, staked a 5,000-foot exploratory coalbed methane test on the north end of the Rock Springs uplift, 10 miles north-northeast of Superior. This well is located a mile northwest of an inactive, unnamed, gas discovery drilled by Triton Oil and Gas Corporation in 1991. That well produced 41,233,000 cubic feet of gas and 99,201 barrels of water from the Rock Springs Formation before being temporarily abandoned. This test will examine coal beds in the Upper Cretaceous Mesaverde Group.

INDUSTRIAL MINERALS AND URANIUM UPDATE

Ray E. Harris

*Staff Geologist - Industrial Minerals and Uranium, Wyoming State
Geological Survey*

Construction aggregate

As an interesting statistic, an Indiana University study notes that the annual production of construction aggregate in the U.S. equates to about 17,720 pounds of aggregate (sand and gravel and crushed stone) per person. Construction aggregate is the least expensive of all mined or quarried products, costing between \$0.80 and \$2.00 per ton at the quarry, while the cost of transporting it from the quarry to the point of use is the same as for most bulk prod-

Table 13. Marketing activities for Wyoming coal producers during the first quarter of 1997¹.

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1. American Electric Power Co.	Rockport	Powder River Basin	So	Unspecified amount	8,000 Blt/lb. coal to be delivered in the third quarter of 1997.
2. Central Louisiana Electric	Rodemacher	Powder River Basin	So	1.2 million ty	Three-year-term starting in 1999.
3. Commonwealth Edison	Unspecified plants	Rochelle Medicine Bow Medicine Bow Rochelle	Sp Sp Sp Sp	1.0 million t 120,000 t 100,000 t 1.5 million t	First quarter 1997 purchase. First quarter 1997 purchase. Second quarter 1997 purchase. Second quarter 1997 purchase.
4. Lower Colorado River Authority	Fayette Project	Powder River Basin	So	300,000-400,000 t	8,000 Blt/lb. coal to be delivered in the second quarter of 1997.
5. Ontario Hydro	Nanicoke	Antelope North Antelope	C C	210,000 t 150,000 t	For delivery to a Great Lakes port in 1997.
6. Southern Company Services	Big Cajun II	Powder River Basin	So	Up to 4 million t	
7. Southwestern Public Service	Tolk	Cordero	Sp	50,000-500,000 t	Amount and scheduling to be determined by pending power sales.
8. Southwestern Public Service	Harrington	Powder River Basin	So	3 million ty	For December; expiring contract with ARCO's Black Thunder mine.
	Harrington	Powder River Basin	So	1.3 million ty	For December; expiring contract with Peabody.
9. Tennessee Valley Authority	Gallatin or Allen	Powder River Basin	So	Up to 1 million ty	Six years beginning July 1, 1997; to be blended with midwestern coal.
10. Union Electric	Unspecified plant	Powder River Basin	So	1 million t	For delivery in 1997.
11. Western Farmers Electric	Unspecified plant	Powder River Basin	So	1.2 million t	For delivery in 1998.
12. Wisconsin Electric Power Co.	Presque Island	Powder River Basin	So	500,000-1 million t	For delivery in 1998.

¹Data obtained from: Coal Week®, Coal Outlook®, trade journals, periodicals, FERCO database, and personal contacts.

C=contract coal; Sp=Spot coal; So=solicitation; T=Test burn; t=short ton; ty=short tons per year; fwyk=tons per week; PRB=Powder River Basin
Wyoming State Geological Survey, Coal Section, April, 1997.

ucts, currently about \$1.10 to \$1.15 per ton-mile. Because of these transportation costs, construction aggregate operations must be located as close to their users as possible, or the prices become unreasonably high.

A controversy related to the mining of some aggregate deposits in Wyoming surfaced in the first quarter of this year. The Wyoming Environmental Quality Council (EQC) must determine if top soil is part of the allowable 10,000 cubic yards of material that can be moved each year in a 10-acre mining permit. This issue came up in regard to a sand and gravel pit near Casper. If top soil is considered part of the allowable 10,000 yards, less sand and gravel can be removed each year under these kinds of permits.

Decorative and dimensional stone

In January, 1997, the Wyoming Economic Development and Stabilization Board (EDSB) awarded a planning-only grant to the town of Lusk to study the feasibility of developing a dimensional limestone quarry at a site south of Manville in Niobrara County. Geotec, a company from Milan, Italy, began the study in March. Geotec is a company specializing in the design of quarries for the extraction of dimensional stone. The site was selected on the basis of a 1987 report by the Wyoming State Geological Survey (Harris, 1987). This report described a deposit of high-calcium limestone at the site.

Limestone and silica sand

In December, 1996, V. A. Resources (VA), of Casper, Wyoming, applied for a 10-acre permit to quarry limestone and silica sand on a site 30 miles north of Laramie at Plumbago Creek (*Wyoming Geo-notes No. 53*, p. 39-40). In early 1997, the Land Quality Division of the Wyoming Department of Environmental Quality (LQD) denied the 10-acre permit to quarry silica sand, but it was still reviewing the 10-acre permit to quarry just the limestone.

VA also applied for a Small Mining Permit (40 acres) to quarry silica sand at a site near Cassa, in Platte County. The Platte County Commissioners expressed their unanimous support for development of this site. The application will be reviewed by the LQD. The Cassa site was also chosen on the basis of a report published by the Wyoming State Geological Survey (Harris, 1988).

Salt

The U.S. Bureau of Land Management (BLM) approved an application to produce salt brine from a salt spring on Salt Creek between Smoot and Cokeville in Lincoln County. The operator plans to use some of the spring water for dust control on local roads and highways. This salt brine, which reportedly contains three pounds of salt (halite or NaCl) per gallon, would replace salt currently purchased from a producer in Salt Lake City. The operator also noted that future development might include the sale of livestock or culinary salt, derived from evaporation of the brine.

Trona

Preliminary figures indicate that 17.5 million tons of trona were mined in Wyoming in 1996, a decrease of 0.6 million tons from the record 18.1 million tons mined in 1995. Part of this decrease is due to temporary production cut-backs related to construction at some of the soda ash plants.

In February, OCI announced an expansion plan at its soda ash facility. In early April, the Wyoming Industrial Siting Council approved OCI's application to increase its production of soda ash from the current 2.3 million tons of soda ash per year to about 3.3 million tons per year. The construction, which will begin in the second quarter of this year, will be completed by late 1998.

Solvay Minerals is constructing a new shaft at their mine. Their raise-borer had reached the Tower Sandstone early in the second quarter of this year. This sandstone overlies the trona-bearing rocks.

Tg Soda Ash has announced plans to construct a new underground mine to supply their existing plant. The BLM's environmental assessment for the new mine should be out for public comment in September of this year. They are also reportedly considering an 800,000-ton-per-year expansion of their facility, although they apparently have not yet reached a decision in that regard.

Uranium

The unrestricted price of yellowcake on the spot market (Uranium Exchange) decreased from \$13.90 per pound on January 2, 1997, to \$12.00 by April 2nd (Rocky Mountain Scout, March [April], 1997). Although this continues the decrease in spot market prices that began in September of 1996, the current decline rate has flattened out to about half of what it was between November of last year and February of this year.

The United States Uranium and Nuclear Conference (UNC) was held in Riverton, Wyoming, on March 20 and 21, 1997. Sponsored by the Riverton Ranger, the conference highlighted the resurgence of uranium mining and milling in Wyoming and the nation and also focused on the future of nuclear energy. Speakers discussed ongoing uranium operations, new mine development, reclamation projects, regulatory problems, the recent fluctuations in uranium prices, uranium reserves, non-mined uranium sources, the status of storage sites for spent fuel and nuclear waste, and the world market for uranium fuel.

Speakers pointed out that the world's supply of uranium now comes from and is dependent upon new uranium from mined deposits, the use of reprocessed fuel, and the pace at which enriched weapons-grade uranium is converted into fuel-grade uranium suitable for use in nuclear power plants. If the rate of conversion by both the U.S. and Russia is not too fast, there will continue to be an expanding market for mined uranium, because reprocessed fuel cannot supply all the demand. However, this conversion rate is dependent

upon political realities, which may influence the market more than economics. Nevertheless, producers feel the near market for mined uranium is promising. While there is less optimism for the intermediate term (two to fifteen years away), the long-term future also looks good.

As a result of this optimism, Wyoming producers are expanding production, and new operators are planning new mines. The existing producers, COMIN and Power Resources (recently acquired by CAMECO), are planning increases in production at their in-situ recovery operations. In addition, Power Resources is applying for a permit to develop a new in-situ site in the Gas Hills. CAMECO is also developing properties near the Pumpkin Buttes in Campbell County and in the eastern Shirley Basin.

In May, Rio Algom Mining Corp. plans to begin in-situ production of yellowcake at their Bill Smith deposit northwest of Douglas. The Green Mountain Mining Venture continues to develop an underground mine on Green Mountain south of Jeffrey City. Twin declines will be completed soon, allowing truck access to the planned underground workings. Anaconda Uranium Corp., of Toronto, Ontario, is exploring with intention to develop the unconformity-related uranium deposit at the old Arrowhead property on Copper Mountain, north of Shoshoni.

References cited

- Harris, R. E., 1987, Geology and economic potential of a high-calcium limestone and dolomitic limestone deposit near Manville, Niobrara County, Wyoming: Wyoming State Geological Survey Report of Investigations 39, 16p.
- Harris, R. E., 1988, The Cassa silica rock deposit, Platte County, Wyoming: Wyoming State Geological Survey Report of Investigations 42, 38p.

METALS AND PRECIOUS STONES UPDATE

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

Exploration activities during the first quarter of the year were slow as always, because of inclement weather conditions. However, the Wyoming State Geological Survey (WSGS) was contacted by several companies and numerous gold prospectors seeking information on the State's precious stone and metal resources. The number of inquiries suggest that the State will again experience considerable exploration activity in the upcoming field season. In

addition to the company and prospector activity, the WSGS will conduct research projects related to diamonds as well as base, precious, and ferrous metal mineralization.

During the winter, WSGS staff reevaluated some areas they previously recognized as potentially diamond-bearing. Using aerial photography, several structurally controlled anomalies were selected for further investigation this summer.

Interest in the Colorado-Wyoming State Line district continued with at least one company (and possibly two) flying an airborne INPUT geophysical survey (conductivity and magnetics) over the district. The district is considered an important exploration target as approximately 40 diamondiferous kimberlites have been identified in the area. In an earlier INPUT survey flown over a small portion of the district in the 1980s, several possible 'blind' or buried diatremes were detected. None of the anomalies located within Wyoming were drilled, even though they lie within a diamond district, only three miles north of the Kelsey Lake diamond mine. The success of this early project attracted the attention of some companies who apparently expanded the INPUT coverage over the district this winter.

In early 1997, the Kelsey Lake diamond mine ran into legal complications when Union Pacific Land Resources (UPLR) named Redaurum Ltd., Diamond Company, and two landowners as defendants in a lawsuit that accuses the mine of reckless trespass (*International California Mining Journal*, March, 1997). Apparently, UPLR is challenging the company's right to the mine, claiming the historic mineral rights to the property still belong to the Union Pacific railroad (*Northern Miner*, 2/10/97). In spite of the lawsuit, Redaurum Ltd. expanded its exploration activities and acquired a property in Wyoming (*Canadian Corp. News*, 3/24/97).

In 1989, the WSGS discovered an anomaly with kimberlitic indicator minerals within a gold paleoplacer along the northern flank of the Seminoe Mountains. The anomaly was found during a regional study of the geology and mineralization associated with the Archean greenstone belt located in that area. The results of the study were described in the WSGS' Report of Investigations 50, "*Economic geology of the Seminoe Mountains mining district, Carbon County, Wyoming*". A sample from the paleoplacer yielded pebbles of banded iron formation similar to the iron formation found near Bradley Peak at the west end of the Seminoe Mountains. The sample also yielded some gold specs, as well as eight pyrope garnets and four chromian diopsides. As a follow-up, a more recent independent investigation of this region identified a circular depression of unknown origin (Woody Motten, personal communication, 1996). As a result of Motten's discovery, the WSGS conducted geophysical surveys over the cryptovolcanic structure in 1996. The surveys showed a strong EM and associated weak magnetic anomaly over the depression; however, no kimberlitic indicator minerals could be found in any drainage immediately adjacent to the structure. The origin of the depression remains unknown.

In southwestern Wyoming, Guardian Enterprises Ltd. continued expanding their holdings in the Green River Basin in the search for diamond deposits. The company increased their interest to 115 lode claims, 5 placer claims, and 7 State leases in a region where the company reportedly has recovered 52 diamonds. In addition to Guardian, five other companies had reported some exploration activity in the region during the past two years.

In regard to inquiries about metal occurrences, the WSGS has been contacted by several major and Canadian junior companies intending to continue or initiate projects to search for gold, iron, nickel, and zinc in the State. In one case, Mountain Lake Resources continued work throughout the winter and spring on a low-grade, Proterozoic-age, Au-Cu porphyry west of Cheyenne.

SUMMARY OF 1996 EXPLORATION FOR COAL, OIL, GAS, AND OTHER MINERALS IN WYOMING

*Rodney H. DeBruin, Ray E. Harris, W. Dan Hausel, Alan J. Ver Ploeg,
and Gary B. Glass, Wyoming State Geological Survey*

COAL

Coal production from Wyoming set another record in 1996 at 278.4 million tons. This was an increase of 14.5 million tons (5.5%) over 1995 production of 263.9 million tons. While the 1996 production gain was not as dramatic an increase as seen in each of the last three years, it showed continued growth in demand for Wyoming's low-sulfur coal as utilities strove to meet clean-air standards.

The Air Quality Division of the Wyoming Department of Environmental Quality approved Kennecott Energy's application to expand the capacity of its Antelope mine from its current 12 million tons/yr to 30 million tons/yr. They also approved Zeigler Coal Holding's application to expand the capacity of its North Rochelle mine from 8 million tons/yr to 20 million tons/yr. ARCO's application for its Black Thunder mine was still pending. ARCO wants to increase capacity from the current 44 million tons/yr to 55 million tons/yr. And Pittsburg and Midway Coal Mining Co. (P&M) applied for an air quality permit to produce 5.5 million tons/yr from its Kemmerer mine, up from the current capacity of 4.2 million tons/yr.

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 billionb barrels of oil	0.95 billion barrels ²
and 4.15 billion barrels of gas liquids and condensate)	
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 ₃ O ₈ ⁹
Remaining Reserve Base (December 31, 1989)	
Uranium oxide recoverable at \$30.00 per pound	66 million pounds ⁷

OIL SHALE

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

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

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

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

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

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-0476(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.

There were a number of property or mine sales that culminated or began in 1996. Lake DeSmet Energy Co. LC retained Energy Ventures to market a billion-ton-reserve of subbituminous coal in Johnson County. Texaco gave up its option on the property earlier in the year. The property, which includes the Lake DeSmet, Healy, Cameron, and other coal beds of the Wasatch Formation, is fee acreage rather than Federal leases. On portions of the property, the Healy, Cameron, and several other coal beds merge into the 250-foot-thick Lake DeSmet coal bed. Lake DeSmet Energy estimates the property contains 200 million tons of reserves at a mining ratio of 0.7:1.

In June of 1996, Commonwealth Edison sold its Carbon Basin coal property to Ark Land Company (Arch Minerals). These fee lands are located south and east of the Hanna Basin and just north of Interstate 80 in the vicinity of Elk Mountain. The property contains an estimated 100 million tons of reserves, a large percentage of which are too deep for surface mining. The major coals are the Finch and Johnson beds, which are up to 12 and 32 feet thick, respectively.

Kerr-McGee Coal sold 127 million tons of the coal reserves as well as the mining facilities at its Clovis Point mine to Wyodak Resources Development, the mining subsidiary of Black Hills Corporation. This property is immediately adjacent to Wyodak's mine in Campbell County. Kerr-McGee later sold the remaining 117 million tons of reserves on the Clovis Point property to Western Fuels Association (WFA). That tonnage was adjacent to WFA's Dry Fork mine.

Late in 1996, Kennecott Energy agreed to purchase Drummond Coal Co.'s Caballo Rojo and Fort Union mines in the Powder River Basin for an estimated \$99 million in cash. The sale of the properties was subject to regulatory approvals that were given in early 1997. The Caballo Rojo mine produced about 15 million tons in 1996 and is located next to Kennecott's Cordero mine. The future of the Fort Union mine is uncertain.

Similarly, Pittsburg and Midway Coal Mining Co. began negotiating a purchase of FMC Corporation's nearby Skull Point mine. That sale was completed early in 1997.

In Federal leasing activity, the U.S. Bureau of Land Management (BLM) accepted Kennecott Energy's 15 cents per ton bonus bid for a lease on 60.3 million tons of reserves bordering their Antelope mine. The new bid of \$9,054,600 was made in December. Kennecott's earlier bid of 11 cents per ton had been rejected by the BLM as not meeting fair market value.

The BLM also set a tentative leasing schedule for three pending lease applications in the Powder River Basin. The bidding on Bluegrass Coal Development Co.'s North Rochelle Lease by Application (LBA) is set for July 15, 1997. This 1,440-acre tract has an estimated 149 million tons of reserves and is adjacent to Triton Coal Co.'s North Rochelle mine. Blue Grass and Triton are both subsidiaries of Zeigler Coal Holding. The comment period on the

Draft Environmental Impact Statement (DEIS) for this lease closed in January, and the BLM was preparing the final EIS.

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

Kerr-McGee's Thundercloud LBA is for 4,000 acres and 432 million tons of reserves. The sale for this tract, which is adjacent to its Jacobs Ranch mine, is set for June of 1998. There may be some competition for this tract as it is also adjacent to Thunder Basin Coal Co.'s Black Thunder mine.

An LBA by Evergreen Resources for a 7,841-acre tract with an estimated 635 million tons of reserves was still pending with the BLM.

The BLM also began its evaluation of Ark Land Company's 4,145-acre, Carbon Basin LBA in Carbon County, Wyoming. The scoping process was completed and the BLM started preparation of the DEIS, which they hope to have completed for public review in mid-1997. At the earliest, a lease sale might be possible by November or December of 1998. The lease contains about 100 million tons of coal reserves.

Ark Land's proposed Carbon Basin mine is planned to come into full production around 2000. By that time, Ark Land's Medicine Bow and Seminole No. 2 mines in the Hanna Basin will be closed or closing for lack of additional reserves. These latter two mines are operated by Arch of Wyoming, a subsidiary of Ark Land. The proposed mine, which would be comprised of Federal, State, and fee lands, is expected to strip mine 2-3 million tons/yr by the year 2000, with an estimated 8-11 year life. Earlier in 1996, Ark Land Company purchased the adjacent fee coal reserves from Commonwealth Edison, allowing for some mining even while the leasing process continues.

DIAMOND

State Line district

Interest in diamonds was high in the Colorado-Wyoming State Line district following the commissioning of Redaurum Ltd.'s Kelsey Lake diamond mine in April, 1996. The mine and mill are located near the state line about 25 miles south of Laramie, at Kelsey Lake, Colorado. Nearly all of the production from the mine has been from Colorado, although Wyoming's State Land and Farm Loan Office noted that some of the diamonds had come from the Wyoming side of the district (Harold Kemp, personal communication, 1997).

According to *Ringold's* (2/14/96), the mine is expected to begin production at about 25,000 carats/yr and increase to 150,000 carats/yr in the future. With

an estimated operating life of about 12 years, the open pit should reach a maximum depth of 575 ft. Reserves are estimated to have a value of more than \$150 million (*Northern Miner*, 6/24/96).

Diamonds recovered from the property include a flawless, 14.2-carat, octahedron valued at \$250,000 (*Casper Star-Tribune*, 12/30/95), and a yellow, 28.3-carat diamond that was cut into a 5.39-carat gemstone that sold for \$87,000 (*Paydirt*, Nov., 1996). According to published information, the 28.3-carat diamond was the fifth largest verified diamond found in the U.S. Two other large stones recovered from Kelsey Lake weighed 6.2 and 9.4 carats.

Redaurum Ltd. also expanded their exploration activity and acquired another property in Wyoming. The property was described as a circular depression with an associated kimberlitic mineral anomaly (*Canadian Corporate News*, 3/24/97).

Some other companies, including Royal Gold, US Diamond Corp., Anvil Resources, and Fleck Resources explored the State Line district, which includes approximately 40 diamondiferous kimberlites. Royal Gold, reported the recovery of kimberlitic indicator minerals while exploring the Union Pacific land grant area near the Wyoming and Colorado state line. They felt there was a potential for the discovery of new diamond occurrences where kimberlites had not been previously identified. *USA Today* (9/23/96) reported that Royal Gold found kimberlitic indicator minerals in 17 of 73 stream-sediment samples.

US Diamond Corp. reportedly acquired several diamond properties in the district. According to a press release from the Hemisphere Group, US Diamond acquired the George Creek, Pearl Creek, and Sand Creek properties in Colorado (*Canadian Corporate News*, 9/15/96). The George Creek intrusives produced 86,000 diamonds in the past. The largest reported stone from the property was 2.14 carats.

Anvil Resources Ltd. reported the acquisition of four kimberlite 'blows' in the Chicken Park, Colorado, area. Past production from this property included 306 diamonds (the largest diamond weighed 2.5 carats) at an average grade of 6.67 carats/100 tonnes.

During the fall of 1996, some INPUT airborne geophysical surveys were flown over the district. The results of the surveys are unknown, but they could result in the discovery of 'blind' or buried diatremes.

Eagle Rock area

In 1994 and 1995, First Choice Exploration explored the Eagle Rock area, an anomalous region identified by the Wyoming State Geological Survey in the mid-1980s. The area lies north of the State Line district and east of Laramie in the Laramie Mountains. According to the *Northern Miner* (12/26/94), First Choice detected magnetic and resistivity anomalies in the Eagle Rock area, but was

unable to intersect kimberlite during drilling. The company had plans to continue stream-sediment sampling in the area to search for the source of the kimberlitic indicator minerals, but it is not known if they continued that exploration in 1996.

Seminole Mountains

In 1989, the Wyoming State Geological Survey (WSGS) discovered kimberlitic indicator minerals in a gold paleoplacer along the northern flank of the Seminole Mountains of central Wyoming. As a follow-up, an independent investigation identified a circular depression of unknown origin (Woody Motten, personal communication, 1996). Geophysical surveys over the cryptovolcanic structure by the WSGS identified strong EM and associated weak magnetic anomalies, although no kimberlitic indicator minerals were found adjacent to the structure. Exploration continued.

Green River Basin

In November of 1995, Guardian Enterprises Ltd. announced their discovery of a group of 10 kimberlitic diatremes and several associated dikes in southwestern Wyoming. This was the first report of mantle-derived pipes in this region, although kimberlitic indicator minerals have been known in the area for 20 years. The indicator minerals are found in ant hills, soils, and in an Oligocene conglomerate over a 500- to 1,000-mi² region in southwestern Wyoming, northwestern Colorado, and northeastern Utah. Based on the geology of the region, these pipes are probably Eocene in age (Richard Kucera, personal communication, 1995). In early 1996, Guardian reportedly found three diamonds associated with the pipes. Later in the year, Guardian (9/24/96) reported the discovery of 48 diamonds from an alluvial source at a different locality. While Guardian continued its work in a 240-mi² area of the basin, at least five other companies were also reportedly exploring the region.

The Wyoming State Geological Survey (WSGS) processed a 1.5-ton bulk sample from one of Guardian's pipes. Although no diamonds were recovered, hundreds of indicator minerals and some mini-xenoliths were extracted. Samples examined at the University of Arizona's microprobe laboratory were dominantly peridotitic garnets with G9 compositions, and eclogitic pyrope-almandine garnets with low sodium (≤ 0.06 wt.% Na₂O). All but one pyroxene yielded K₂O <0.07%. The exception was a calcic chromian diopside of peridotitic paragenesis, which yielded 0.10% K₂O, suggesting it originated within the diamond cogenetic field (T.E. McCandless, written communication, 8/27/96).

Ilmenites from the sample yielded 4.8-7.0 wt.% MgO and 0.0-4.5 wt.% Cr₂O₃ typical of kimberlitic ilmenites. The ilmenite compositions are favorable for the preservation of diamond (if originally present). The chrome spinels yielded 14.5-57.0 wt.% Cr₂O₃ and 0.0-19.7 wt.% MgO.

Thirteen garnet-bearing mini-xenoliths had a high almandine content suggesting a granulite (lower crustal) source. Four of the mini-xenoliths yielded magnesian pyrope-almandine garnets of probable eclogitic origin. None of the garnets contained elevated Na_2O , suggesting they did not originate within the diamond stability field (T.E. McCandless, written communication, 8/27/96). Although the data are not favorable for diamond, they support a definite signature from the upper mantle.

Petrographic studies at the WSGS showed the host breccia to be silicified and not typical of kimberlite. Back-scatter microprobe analysis completed at the University of Washington also showed the groundmass to be highly silicified, and no definite magmatic phases could be identified (Tony Irving, personal communication, 1996). Whole rock analyses yielded high silica and ranged from 67.66-44.08% SiO_2 , 0.47-0.27% TiO_2 , 9.86-5.25% Al_2O_3 , 5.13-2.82% Fe_2O_3 , 0.22-0.04% MnO , 14.95-4.29% MgO , 17.99-5.10% CaO , 1.75-0.57% Na_2O , 2.49-1.41% K_2O , 0.56-0.22% P_2O_5 , 17.77-6.6% LOI, 0.14-0.07% Cr_2O_3 , and 755-256 ppm Ni. One sample yielded 5.44% CO_2 .

The MgO content is low and the SiO_2 content is high compared to the average kimberlite. But samples yielded relatively high Ni and Cr suggestive of contribution from a mafic to ultramafic source magma. Samples examined by the WSGS are not kimberlite, and may have been produced by a gaseous disruption of the Bridger Formation from a mafic to ultramafic magma at shallow depth.

The WSGS conducted geophysical surveys over the cryptovolcanic structures. These survey's showed the breccia was relatively conductive, like some State Line kimberlites. The surrounding clay-rich Bridger Formation; however, yielded higher conductivity than the breccia, resulting in a relative conductivity low over the pipe. Magnetic surveys yielded only weak, positive anomalies.

Guardian also convinced the U.S. Bureau of Land Management (BLM) to allow diamond exploration and claim-staking on a small portion of an 86,000-acre mineral withdrawal. These lands had been withdrawn in 1930 to protect oil shale resources. On November 14, 1996, however, companies were allowed entry into the vacated portion of the withdrawal. Guardian acquired 70 claims in the area and increased their interest to 115 lode claims, 5 placer claims, and 7 State leases. Since then, the State and others have asked BLM to consider vacating the entire withdrawn area.

The Wyoming State Geological Survey investigated a group of circular anomalies in the Lonetree area west of Guardian's property. These anomalies had been identified by Gordon Marlatt (personal communication, 1995). The Lonetree anomalies lie along a line extending northeast to the Leucite Hills lamproites, and southwest to the Francis lamproites in Utah. Geophysical surveys over two of the structures produced weak conductors and weak magnetic anomalies.

Leucite Hills

In 1995 and 1996, exploration was reported in the Leucite Hills near Rock Springs. The Leucite Hills consist of 1- to 3-million-year-old (Ma) phlogopite lamproites and olivine lamproites. Although no results were reported, the Wyoming State Geological Survey plans to search the region for buried lamproites in 1997.

INDUSTRIAL MINERALS AND CONSTRUCTION MATERIALS

Industrial minerals produced in Wyoming in 1996 included bentonite, construction aggregate, feldspar (for ceramics), granite (for decorative aggregate, decorative stone, and railroad ballast), gypsum (for cement and wallboard), leonardite, limestone (for construction aggregate and for control of power plant emissions), marble (for decorative aggregate), scoria or clinker (baked and fused shale used for construction and decorative aggregate), siliceous shale (used in cement), sodium sulfate, and sulfur produced from the refining of natural gas.

Of these minerals and materials, there was significant exploration for bentonite, decorative aggregate, decorative stone, limestone, silica sand, and trona in 1996.

Wyoming remained the largest producer of bentonite in 1996, with the bentonite companies continuing exploration for minable deposits. In the Clay Spur bentonite district, American Colloid applied for mining permits from the U.S. Forest Service so they could open two new pits on the Thunder Basin National Grasslands of northeastern Wyoming.

Exploration for decorative aggregate and decorative stone continued, as it has for the past three years. A company from Milan, Italy, investigated a dimensional limestone property in Niobrara County and a granite property near Guernsey in Platte County. In January of 1997, they acquired a planning-only development grant from the Wyoming Economic Development and Stabilization Board to conduct exploratory activities on the limestone property.

V.A. Resources (VA), a Casper company, conducted exploration drilling on a property 30 miles north of Laramie for joint production of silica sand and limestone. The company acquired the property and conducted exploration based on a 1988 study and report by the Wyoming State Geological Survey.

Late in 1996, VA applied to the State for a 10-acre mining permit to mine both silica sand and chemical-grade limestone on the property. In early 1997, the silica sand portion of the 10-acre permit was denied, but the limestone portion of the permit remained under review. If the limestone portion of the permit is granted, V. A. Resources plans to quarry chemical-grade limestone

for the refining of sugar beets. VA also applied for a small mining permit to mine silica sand on a property at Cassa, 25 miles north of Wheatland in Platte County. The company acquired the property and conducted exploration based on a 1989 study and report by the Wyoming State Geological Survey.

In May of 1996, the Wyoming State Geological Survey hosted the 32nd Annual Industrial Minerals Forum in Laramie. Just over 200 industrial minerals geologists and producers attended this well-known international event, and over 150 participated in one of the field trips.

The U.S. Bureau of Land Management held two lease sales for trona in 1996. Both Solvay Minerals and General Chemical acquired additional reserves as a result of these sales. In addition, Church & Dwight and Rock Springs Realty Corporation, a subsidiary of Union Pacific Corporation, acquired trona leases.

While Wold Minerals continued with their plans for a new trona mine and refinery, Solvay Minerals and OCI announced plans to expand their processing facilities. And Tg announced plans to construct a new underground mine to supply their existing soda ash refinery.

Plans for the First International Soda Ash Conference (ISAC) began in 1996. The conference, which is co-hosted by the Wyoming State Geological Survey, the U.S. Geological Survey, and the U.S. Bureau of Land Management, was set for June 10-12, 1997, at Rock Springs, Wyoming. Two days of technical talks on the geology, refining, marketing, and future of soda ash production were planned, including a presentation on the bedded trona deposit at Beyparzi, Turkey. Plans were being made for field trips to an underground trona mine, to a surface processing plant, and to outcrops of the trona host rocks in the Green River Basin.

METALS

Golden Clover mine

The Wyoming State Geological Survey (WSGS) examined the Golden Clover mine in the Big Creek district in the foothills of the Medicine Bow Mountains of southeastern Wyoming. The property was developed by two shafts sunk on a 2,000-ft-long quartz vein in sheared quartzofeldspathic gneiss. The vein is 6 in. to 6 ft wide and contains free gold with auriferous pyrite. Gold values increase where the vein pinches, and some sheared wallrock reportedly yields anomalous gold. Assay certificates from the mine ranged from 0.2-20 ounces per ton gold (Ralph Platt, personal communication, 1995). Samples collected by the WSGS ranged from 3 ppb-49.85 ppm Au, <0.02-37.4 ppm Ag, 248 ppm-1.8% Cu, and a trace of Pb and Zn.

South Pass

South Pass continued to attract interest for gold, and a major U.S. mining company reportedly acquired some property there. This greenstone terrane is in the southern Wind River Range of western Wyoming. The South Pass district contains numerous gold-bearing shear zones that often yield significant anomalies.

Encampment district

Several companies explored the Encampment district in the Sierra Madre in southeastern Wyoming for Zn, Pb, Ni, Co, Cu, Au, and Pt. In addition, the Wyoming Department of Environmental Quality (DEQ) initiated work to reclaim the historic Ferris-Haggarty copper mine.

The Ferris-Haggarty mine was an important copper producer in the early 1900s. Records indicate the mine produced more than 21 million lbs of Cu with some Au and Ag from Proterozoic quartzite breccia along a contact with a hanging wall felsic schist. Ore shoots were reported to yield 6-8% Cu, and to average 20 ft thick with swells up to 65 ft. High grade ore yielded as much as 30-40% Cu.

In 1988, Exxon Minerals' sampling program in a portion of the mine identified significant mineralization, suggesting the property was not mined out. Samples yielded 0.10-21.3% Cu, 1.1 ppm-2.34 opt Ag, and 75 ppb-0.33 opt Au. Reserves reportedly include 928,500 tons of ore averaging 6.5% Cu containing 116,800 oz of Au.

Elsewhere in the district, several companies examined a significant Cu-Ni-Co-precious metal anomaly in the Puzzler Hill mafic complex. This anomaly was identified by the Wyoming State Geological Survey (WSGS) in 1994. Samples collected from the massif by the WSGS yielded 0.01-4.43% Cu, 66 ppm-3.72% Ni, 14 ppb-9.86 ppm Au, <5-828 ppb Pt, 5 ppb-4.04 ppm Pd, and <0.1-6.6 ppm Ag, 21 ppm-831 ppm Co, 64 ppm-294 ppm Cr, and a trace of Pb, and Zn.

In 1996, the WSGS examined other properties in the district, including the historic Doane-Rambler mine. Samples of mineralized quartzite and mafic schist from mine dumps yielded 1.4-3.0% Cu, 498 ppb-1.1 ppm Au, with 5.7 ppm Ag and 363 ppb Ni.

To the northwest of the Doane-Rambler mine, samples from a mine dump on the Divide Peak Quadrangle contained chalcopyrite, sphalerite, and galena in milky quartz. The composite samples assayed 106 and 151 ppb Au, <5 ppb Pt, 2 and 8 ppb Pd, 12.6 and 12.7 opt Ag, 0.17 and 0.22% Cu, 2.33 and 0.44% Pb, 11 and 37 ppm Ni, and 0.38 and 0.42% Zn.

At a mine dump on the Red Mountain Quadrangle (SE section 14, T14N, R85W), a sample yielded 3.2% Cu, 389 ppm Pb, 659 ppm Zn, 406 ppb Au, and 15.7 ppm Ag. In the same region, a prospect (W/2 section 2, T14N, R85W) contained milky quartz with considerable boxworks that assayed only 45 ppb Au. However, the limonite-stained wallrock yielded 7.03 ppm Au.

Copper King property

According to the *Northern Miner* (6/24/96), Mountain Lake Resources signed a letter of intent with Compass Minerals for a joint venture at the Copper King property, 18 miles west of Cheyenne. Compass Minerals identified proven and probable reserves of 25.7 million tons of 0.024 opt Au and 0.19% Cu within a larger untested resource.

The property has been described as a low-grade, Proterozoic-age, Au-Cu porphyry. Exploration and drilling by Compass Minerals extended the mineralized zone for more than a mile along strike (Paul Graff, personal communication, 1995). The U.S. Bureau of Mines drilled the property in the 1940s and identified a large-tonnage, low-grade deposit containing a minimum of 35 million tons averaging 0.022 opt Au with 0.21% Cu. Caledonia Resources drilled the property in 1987 and identified a higher grade core with gold resources on the order of 4.5 million tons averaging 0.044 opt Au.

Quaking Asp Mountain

Royal Gold drilled a large 30-mi² silicified zone on Quaking Asp Mountain south of Rock Springs in the Green River Basin. This zone was identified by the Wyoming State Geological Survey in 1995. The epithermal deposit contains secondary kaolinite, alunite, travertine, free sulfur, banded chert, and jasperoid. Although Royal Gold's drilling results were reportedly unfavorable, several other silicified zones have recently been identified in this structurally complex Tertiary basin (Gordon Marlatt, personal communication, 1996).

Rattlesnake Hills

Canyon Resources continued to hold their interest in the Rattlesnake Hills gold deposit west of Casper in central Wyoming. The Rattlesnake Hills represents a fragment of an Archean greenstone belt intruded by several Tertiary alkalic plugs and dikes. Gold mineralization occurs in stratabound exhalites, breccia veins, stockworks, and in Tertiary volcanics. The district has been explored by a few major companies searching for a large-tonnage, disseminated gold deposit.

OIL AND GAS

Drilling activities and well completions

Based on data available from Petroleum Information/Dwights LLC (1997), there were 372 well completions in Wyoming in 1996, which is a large drop from the 514 completions in 1995 (**Figure 14**). Of the 372 completions, 70 were exploration wells and 302 were development wells. The success rate for exploration wells was 31.4% compared to a success rate of 37.2% for exploration wells in 1995. There were nine new oil discoveries and 13 new gas discoveries in 1996. In all, 289 wells found oil or gas for a success rate of 77.7% compared to a success rate of 81.7% in 1995.

The average daily rig count in 1996, as reported by Hughes Rig Count, was 24, the same as in 1995 (**Figure 15**). Rigs in Wyoming drilled over 2.5 million feet in 1996, a drop of 1.1 million feet from 1995 (**Figure 16**). The average depth of all wells drilled in Wyoming in 1996 was 6,829 feet (**Figure 17**). The average depth of an exploration well in Wyoming in 1996 was 8,088 feet, which is the deepest average since 1988 (**Figure 17**).

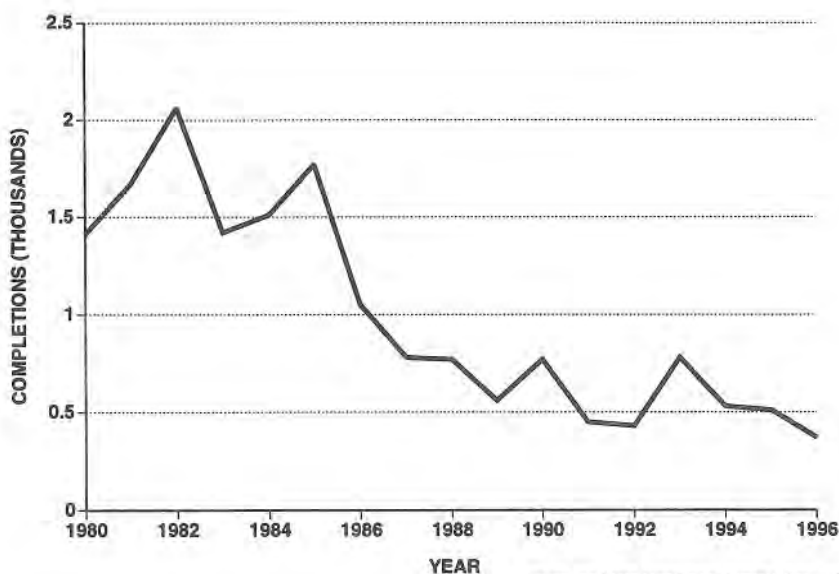
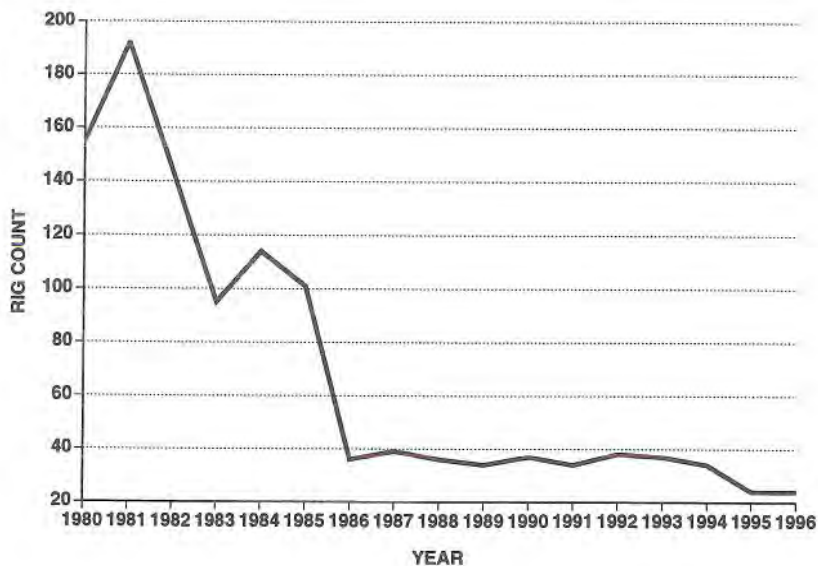
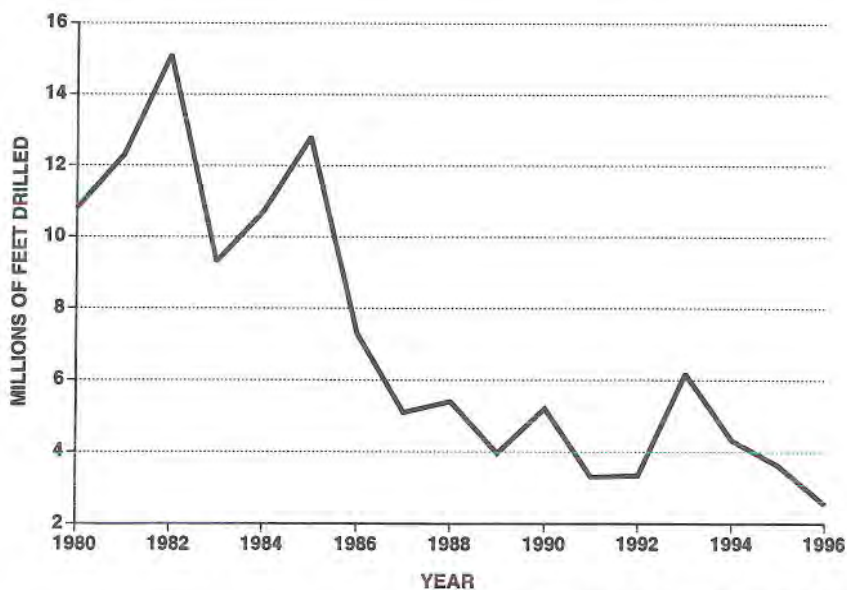


Figure 14. Number of well completions by year (1980-1996).



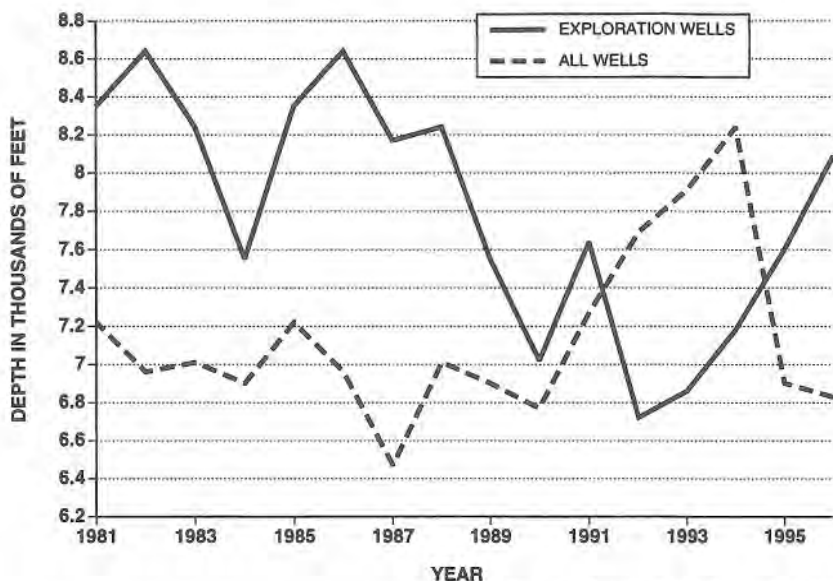
Wyoming State Geological Survey, April, 1997

Figure 15. Average daily rig count by year (1980-1996).



Wyoming State Geological Survey, April, 1997

Figure 16. Millions of feet drilled by year (1980-1996).



Wyoming State Geological Survey, April, 1997

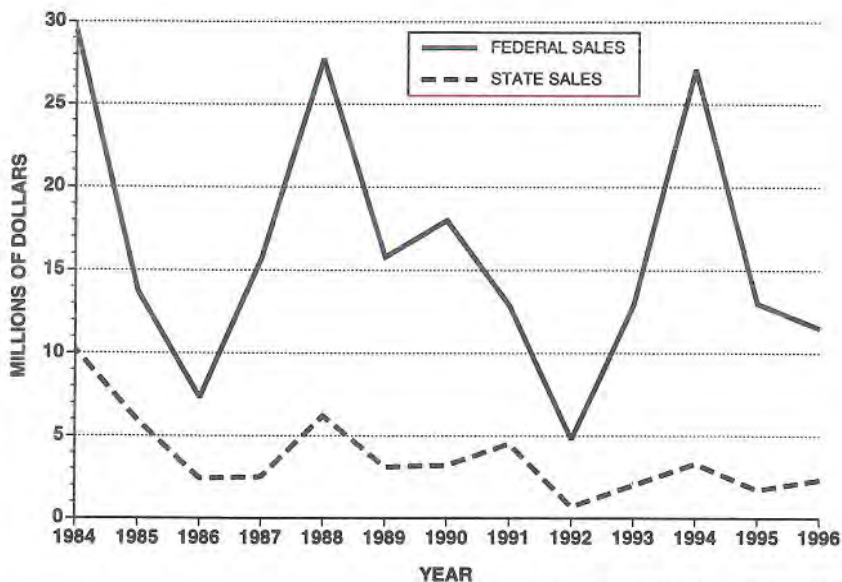
Figure 17. Average depth of exploration wells and all wells drilled by year (1981-1996).

Lease sales

The five Federal lease sales held by the U.S. Bureau of Land Management (BLM) in 1996 grossed over \$11 million (Figure 18), with an average price per acre of \$15.53 (Figure 19). In 1995, six Federal sales grossed over \$13 million, with an average price per acre of \$11.76. Of the 1.4 million acres that were available for lease in 1996, 52.7% were leased. In 1995, 47.7% of the 2.3 million acres available at Federal sales were leased.

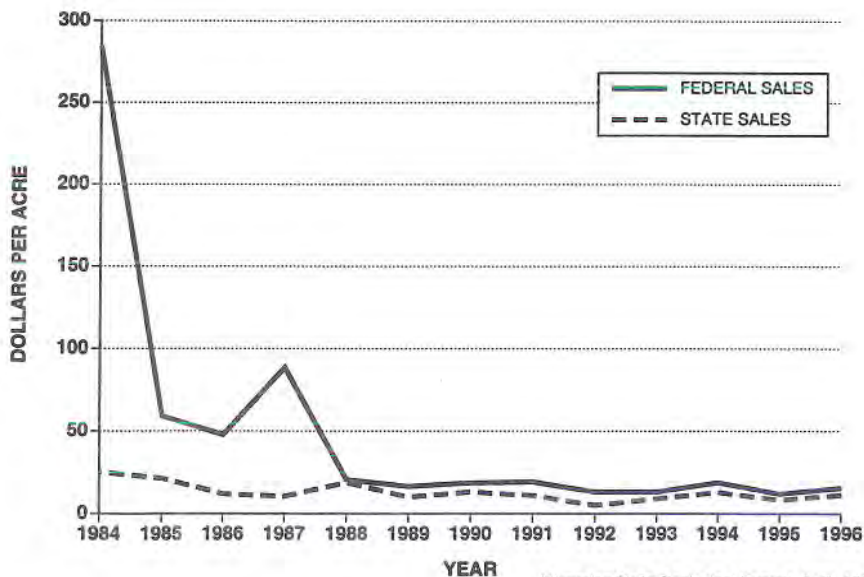
The four lease sales held by the State Land and Farm Loan Office in 1996 grossed over \$2.3 million (Figure 18), with an average price per acre of \$11.24 (Figure 19). Of the 418,000 acres available for lease in 1996, 49.5% were leased. For comparison, the four sales in 1995 grossed over \$1.6 million. Of the 324,000 acres available for lease that year, 62.6% were leased, at an average price of only \$8.17 per acre.

The State Land and Farm Loan Office reduced its royalty rates by 10% for both oil and gas discoveries drilled on primary State leases between July 6, 1996, and September 30, 1997. The reduced rate will apply to all wells drilled on a qualifying lease and will be effective for as long as commercial production exists from those wells. The 10% royalty rate will, however, return to a rate of 16 2/3% if a producer receives more than \$22 per barrel for oil or more than \$2 per thousand cubic feet of gas, averaged over any six-month period.



Wyoming State Geological Survey, April, 1997

Figure 18. Millions of dollars paid for Federal and State oil and gas leases by year (1984-1996).



Wyoming State Geological Survey, April, 1997

Figure 19. Average price per acre paid for Federal and State oil and gas leases by year (1984-1996).

Powder River Basin

With 19 new field discoveries, including three oil discoveries, Campbell County was the second leading county in the Rocky Mountain Region in 1996. Campbell County was also the fifth leading county in the Rocky Mountain Region in regard to the total number of wells completed, with 86. Among the 86 completions were 25 oil wells and 25 gas wells. Most of the gas wells were completed in Fort Union coals, as the coalbed methane play in the Powder River Basin accelerated. Most of the new discoveries in the basin were completed in the Muddy Sandstone and the Minnelusa Formation.

Greater Green River Basin

Sweetwater County tied for fifth in the number of new field wildcats among counties in the Rocky Mountain Region. There were seven wildcat wells completed in the county, with one finding oil and five finding gas. Sweetwater County was the seventh leading county in the Rocky Mountain Region for the total number of well completions, with 69. Of the 69 well completions, three found oil and 62 found gas. McMurray Oil and Snyder Oil completed several Lance and Mesaverde wells in Jonah Field and have plans to drill an additional 150-450 wells in a 63,000-acre area in and around Jonah Field. Snyder Oil subsequently sold a 50% interest in its Jonah Field project to Amoco.

Wind River Basin

Barrett Resources, Chevron USA, and W.A. Moncrief, Jr. all completed high-volume producers at the Cave Gulch Unit in the Waltman Field area. The Lance, Fort Union, Mesaverde, and Meeteetse all produce in this area. In December, 1996, there were 11 wells producing in Waltman Field at a combined rate of 89.6 million cubic feet of gas and 383 barrels of condensate per day. Production for 1996 was 33.6 billion cubic feet of gas and 157,631 barrels of condensate. Santee also had a high-volume gas discovery in the Lance about 12 miles southwest of Waltman Field.

Tom Brown, Inc. executed an exploration agreement with the Eastern Shoshone and Northern Arapaho tribes of the Wind River Indian Reservation. Brown has a 60% working interest in this agreement and Brownlie, Wallace, Armstrong & Bander Exploration has the balance. Subsequently, Tom Brown and Louisiana Land & Exploration (LL&E) agreed to form a joint exploration alliance on approximately 500,000 gross acres on lands covered by the earlier agreement with the tribes. Tom Brown will be the operator and will have a 50% working interest. LL&E will have a 40% working interest, with the remaining 10% held by Brownlie, Wallace, Armstrong & Bander Exploration. Brown's oil and gas interests in the Wind River Basin now total approximately one million gross acres.

Bighorn Basin

KCS Energy completed several high-volume Phosphoria oil producers in Manderson Field. Data obtained from drilling indicate that the field is substantially larger than the company originally thought. Leasing activity at the 1996 BLM and State sales increased in the basin, with leasing particularly brisk around Manderson Field.

Overthrust Belt

Amoco Production completed a Darby producer in Whitney Canyon-Carter Creek Field that flowed 31.9 million cubic feet of gas and 322 barrels of condensate per day. Previously, one other well in the field tested the Darby, but there is no record of the well ever producing from the Darby. Union Pacific Resources completed a high-volume Phosphoria sour gas producer in Yellow Creek Field.

RUBY AND SAPPHIRE

The Wyoming State Geological Survey (WSGS) completed investigations in the Tin Cup district in the Granite Mountains of central Wyoming. The district is underlain by amphibolite-grade Archean gneiss, schist, and amphibolite, intruded by 2.6-billion-year-old (Ga) granite, and has very little potential for gold mineralization. However, massive jasper, banded agate, jade, rubies, sapphires, and some massive pyrite were found in the district. Mapping of the Red Dwarf ruby deposit by the WSGS indicated a 4,000-ft trace along strike and widths of 20 to 50 ft. The gneiss contains common ruby porphyroblasts and fuchsite pseudomorphs after ruby. These range from 2 in. across to millimeter size. A sapphire-bearing serpentinite was also found nearby (Robert Odell, personal communication, 1996).

URANIUM

In 1996, Wyoming continued to produce more uranium than any other state. Uranium production increased to about 4.3 million lbs of yellowcake, partially in response to increased prices. The spot market price for uranium more than doubled between April, 1995, and September, 1996, but fell somewhat a little later in the year.

At year's end, CAMECO, a Canadian uranium producer, announced its purchase of Power Resources, which produces yellowcake from in-situ mining of uranium at the Highland and Morton Ranch properties in the Southern Powder River Basin district. The purchase was completed in January, 1997. CAMECO also acquired Power Resources' property in the Gas Hills and announced they were applying for a permit to mine uranium by in-situ methods at that location.

COMIN, a subsidiary of COGEMA, continued in-situ uranium production from its Christiansen Ranch property, while Energy Fuels Nuclear continued to study the feasibility of an in-situ production facility at its Reno Ranch property. Rio Algom Mining Co. proceeded with the development of the Smith Ranch property in the Southern Powder River Basin district. The Green Mountain Mining Venture (GMMV) announced a plan to purchase Kennecott Uranium's 50% interest in the Jackpot underground mine on Green Mountain, south of Jeffrey City. Kennecott purchased this interest from GMMV several years ago.

Anaconda Uranium Corp., a company based in Toronto, Ontario, conducted exploration and acquired property on Copper Mountain. The property includes a mine site originally proposed by Union Pacific in the late 1970s and early 1980s. The geology of this uranium occurrence is similar to deposits in the Athabasca region of Canada and those in northern Australia.

Other companies explored for uranium in the Oshoto trend in northeastern Wyoming and in the Pumpkin Buttes and western Shirley Basin areas.

Reference Cited

Petroleum Information/Dwights LLC, 1997, 1996 annual review, Rocky Mountain region: Rocky Mountain Region Report, v. 70, no. 53, p.17-40.

PART 1: 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 will only discuss Teton County. Part 2, which will be published in the next issue of *Wyoming Geo-notes*, will discuss 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 20**). Both of those fault systems are capable of generating magnitude 7.3-7.5 earthquakes.

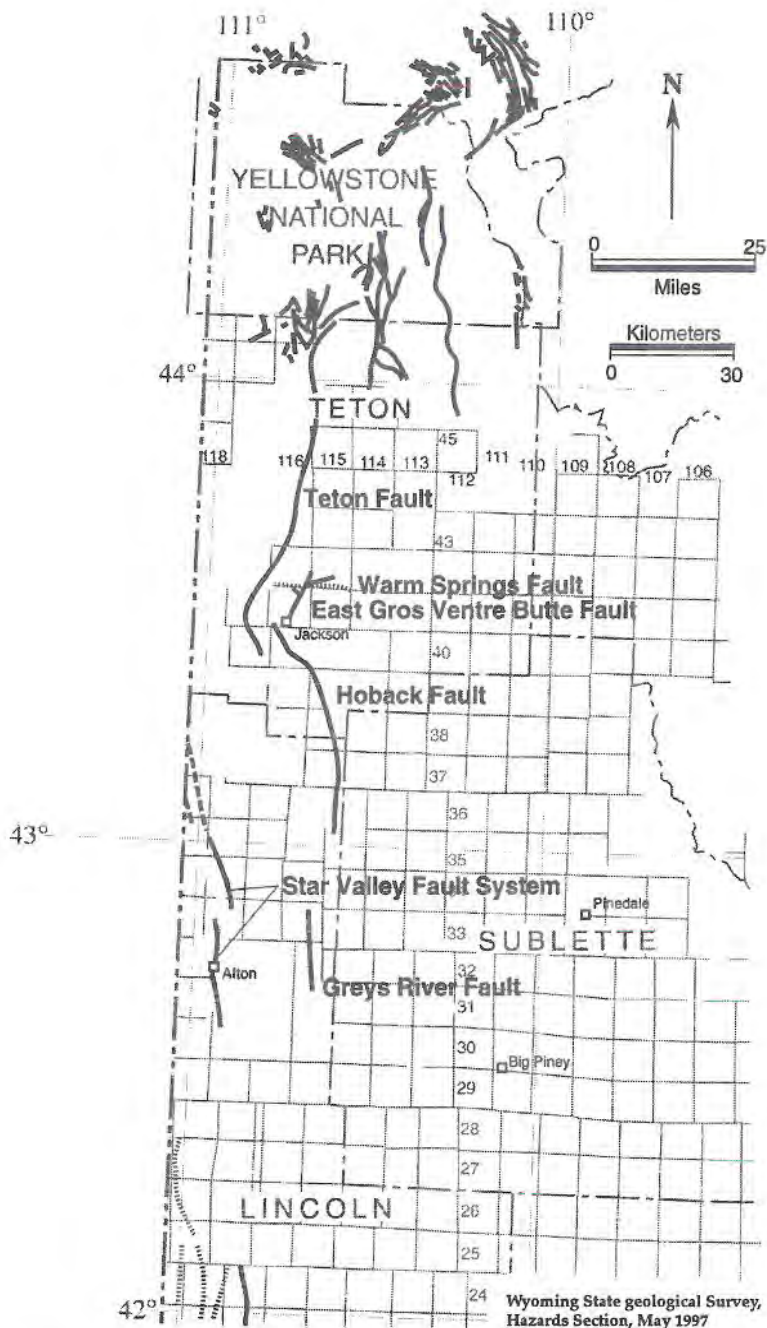


Figure 20. Known and suspected active faults in western Wyoming.

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 21 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 21** or described in the discussions below.

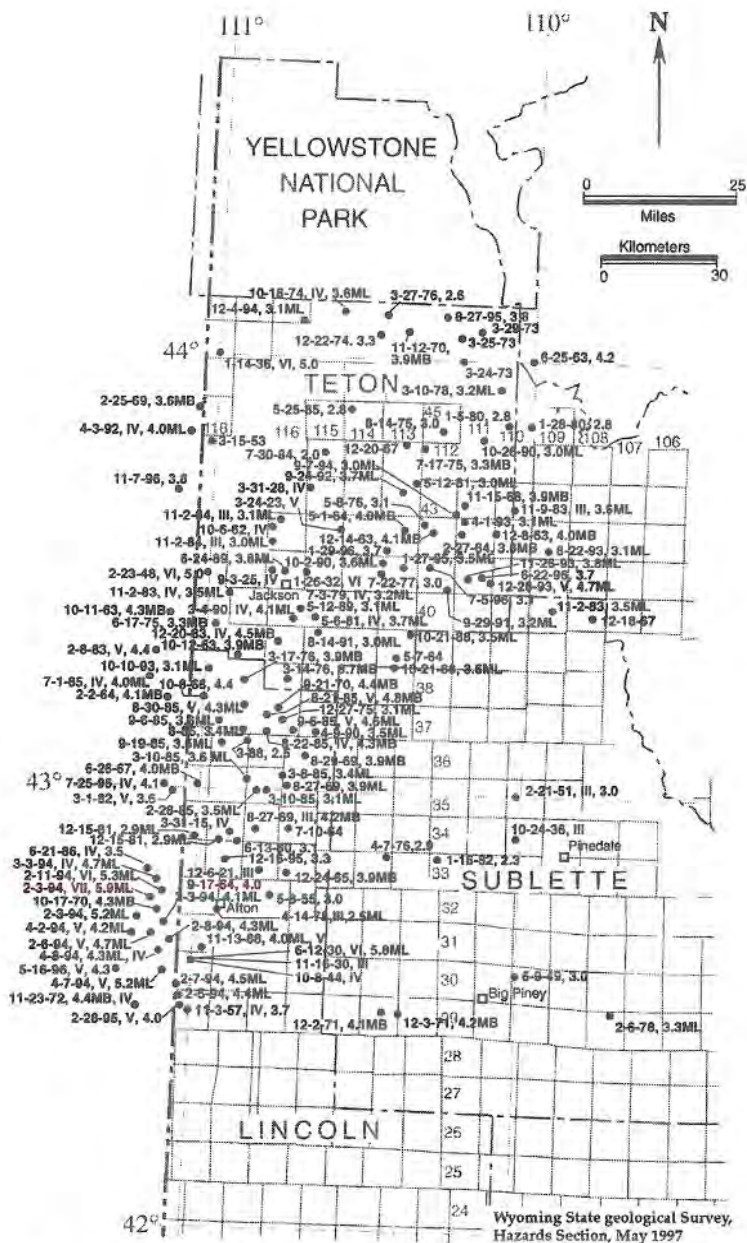
Consequently, the following discussion includes most, but not all, of the earthquakes that have caused damage in western Wyoming. Since so few earthquakes have occurred in Sublette County and the northwestern tip of Fremont County, discussions of earthquakes in those areas are incorporated into those 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.

OVERVIEW OF EARTHQUAKES IN TETON COUNTY, 1923-1996

Approximately sixty earthquakes are plotted in or near Teton County on **Figure 21**. While the first earthquake recorded in the county and plotted on **Figure 21** occurred in 1923, the most recent plotted earthquake occurred in late 1996. None of the plotted earthquakes are directly associated with active fault systems exposed at the surface, such as the Teton Fault. In fact, few historic earthquakes have occurred in the near vicinity of the Teton Fault, which has led some researchers to postulate that the fault is in a seismic gap. This may mean that stresses are building on the fault, or that regional stresses are being released in another area.

Earthquakes from 1920 through the 1950s

One of the earliest recorded earthquakes in Teton County occurred on March 24, 1923. The earthquake, which was approximately located thirteen miles northeast of Jackson, had a maximum reported intensity of V. The earthquake was felt as far south as the Green River Basin. The *Jackson Hole Courier* (March 29, 1923) reported that several shocks were felt, with the largest rocking buildings all over the county. The paper reported that "Rocks weighing tons were shaken loose along the Tetons and in the hills about Grovont, and rolled into the valley. Many of the snow slides which run about this time of year or a little later were started on their way by the Quake". A local resident



reported that it felt like his home had been lifted up and shaken violently, and set down with a thump. No significant damage was reported.

On June 23, 1925, the lower Gros Ventre landslide north of Jackson activated, damming the Gros Ventre River. Nearby seismic activity on June 21, 1925, was reported by the *Jackson Hole Courier* (June 25, 1925). The activity was described as being "quite severe". Voight (1978) described a report of local seismic activity on June 22, 1925, the night before the Gros Ventre River was dammed by the landslide. Because these earthquakes are not accurately located, they do not appear on **Figure 21**.

On September 3, 1925, an intensity IV earthquake was reported near Jackson. The earthquake, which was approximately located three miles northwest of Jackson, was felt by most town residents. Objects were rattled, but no damage occurred (Blackwelder, 1926). Reports of the incident mentioned that during the preceding winter there were light shocks in the vicinity of Moran, near the outlet of Jackson Lake. Unfortunately, no records of those earlier events were kept.

On March 31, 1928, an intensity IV earthquake occurred approximately eighteen miles north of Jackson. Reports indicated that many residents in the area felt a trembling. It was reported that this was the strongest earthquake to date along the Gros Ventre River above Kelly. The earthquake was not felt at Moran (Heck and Bodle, 1930).

One of the most severe earthquakes in years occurred on March 26, 1932. The intensity VI earthquake, located approximately four miles northeast of Jackson, broke the plaster on the walls and cracked the foundations in several Jackson homes and businesses. The main shock was preceded by a few events along the Upper Gros Ventre River, and was followed by a number of aftershocks. Because the event occurred at night, several residents ran from their homes without grabbing any clothing, and a few were thrown from their beds. The earthquakes were felt in Jackson, Kelly, Grovont, Wilson, and Teton Pass. The earthquakes were barely felt in the Snake River Canyon, and were not felt at Moran (*Jackson Hole Courier*, January 28, 1932).

On January 14, 1936, an intensity VI, magnitude 5.0 (estimated) earthquake occurred approximately nineteen miles southwest of the south entrance to Yellowstone National Park. The earthquake, which was not felt in Jackson, cracked two brick chimneys for several feet, and moved small objects. Beds were rocked at Moran (Neumann, 1938).

The next reported earthquake occurred on February 23, 1948. The intensity VI, magnitude 5.0 (estimated) earthquake, was approximately located thirteen miles west of Jackson. Some residents reported that their houses seemed to rock and sway in an east-to-west direction. There were reports of dishes and windows rattling, and pictures falling from walls. Logs were cracked and twisted in certain local buildings in Jackson (*Jackson Hole Courier*, February 26, 1948).

Only one earthquake was reported in Teton County in the 1950s. That event occurred on March 15, 1953, and was approximately located near Alta, Wyoming, on the west flank of the Teton Range. The intensity IV event was felt by many area residents who reported that buildings creaked and loose objects rattled. There were thunderous sounds heard before and during the earthquake (Murphy and Cloud, 1955).

Earthquakes in the 1960s and 1970s

Although a number of earthquakes were recorded in Teton County in the 1960s and 1970s, little or no damage was reported. Most of the earthquakes that occurred during this period were located in the southwestern quarter and eastern half of the county.

The first earthquake reported in the 1960s occurred on October 6, 1962, and had an intensity of IV. The earthquake, which was located approximately eleven miles north of Jackson, lasted a few seconds and rattled windows and dishes (*Casper Tribune-Herald and Star*, October 7, 1962). No detailed reports are available for other earthquakes in Teton County in the 1960s.

The first earthquake reported in the 1970s actually occurred just south of Teton County in northern Lincoln County near the Elbow Campground. This earthquake is reported in the Teton County discussion because it was apparently felt only in Teton County and Sublette County. The *Jackson Hole Guide* (September 24, 1970) reported that the magnitude 4.4 earthquake, which occurred on September 21, 1970, 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.

Although numerous earthquakes occurred in Teton County in the 1970s, no others were described until mid-1979. On July 3, 1979, a magnitude 3.2, intensity IV earthquake occurred approximately five miles southeast of Jackson. Jackson residents reported that dishes rattled and that pictures on walls moved. Horses at the Teton County Fairgrounds were also noticeably disturbed (*Casper Star-Tribune*, July 4, 1979).

Ten other earthquakes that occurred in the 1960s and thirteen other earthquakes that occurred in the 1970s are shown on **Figure 21**. Many of the events from the 1960s are located in or near the Gros Ventre Range, east and northeast of Jackson. The following earthquakes from the 1960s and 1970s are shown on **Figure 21**. Earthquakes that did not originate in the county are denoted by an asterisk.

<u>Date - 1960s</u>	<u>Magnitude/Intensity</u>	<u>Date - 1970s</u>	<u>Magnitude/Intensity</u>
October 6, 1962	IV	September 21, 1970 *	4.4
October 11, 1963 *	4.3	November 12, 1970	3.9
October 12, 1963	4.0	March 25, 1973	—
December 14, 1963	4.1	March 29, 1973	—
February 27, 1964	3.8	October 18, 1974	3.6, IV
May 1, 1964	4.0	December 22, 1974	3.3
May 7, 1964	—	June 17, 1975	3.3
December 20, 1967	—	July 17, 1975	3.3
November 15, 1968	3.9	August 14, 1975	3.0
February 25, 1969 *	3.6	March 14, 1976	3.7
		March 27, 1976	2.6
		May 8, 1976	3.1
		July 22, 1977	3.0
		March 10, 1978	3.2
		July 3, 1979	3.2

Earthquakes in the 1980s

A number of earthquakes occurred in or near Teton County in the 1980s, although few caused any significant damage. The first earthquake from the 1980s that is shown on **Figure 21**, occurred on January 5, 1980, in the east-central part of Teton County. The magnitude 2.8 event did not cause any damage, and no one reported feeling it.

The first earthquake felt in the 1980s occurred on May 6, 1981. The magnitude 3.7, intensity IV earthquake occurred approximately seven miles south-east of Jackson. A local disc jockey reported that "window frames changed position briefly, and the turntable and the seat of my pants came up and down at the same time". A local secretary said her desk moved during the event (*Casper Star-Tribune*, May 7, 1981).

The next earthquake that was felt occurred on February 8, 1983. The magnitude 4.4, intensity V earthquake was located in Idaho, approximately twenty-four miles southwest of Jackson. No damage was reported. On November 2, 1983, a magnitude 3.5, intensity IV earthquake occurred approximately ten miles west-southwest of Jackson. Although the event was felt, no damage occurred. This event was followed on December 20, 1983, by a magnitude 4.5, intensity IV earthquake located approximately ten miles south of Jackson. This earthquake was felt from Jackson to the Palisades Reservoir in Idaho. In Jackson, there were reports of Christmas trees falling over and dishes breaking (*Laramie Daily Boomerang*, December 21, 1983). The December 20, 1983, earthquake had a number of aftershocks, with one of the largest, a magnitude 3.4 earthquake, occurring on December 22, 1983. On January 5, 1984, another aftershock, with a magnitude of 3.0, occurred in the same area.

In August and September of 1985, four earthquakes occurred in northern Lincoln County, three of which were felt in Jackson. The first, a magnitude 4.8, intensity V event on August 21, 1985, was lightly felt in Jackson. A local business reported that "it felt like something hit the side of the building" (*Casper*

Star-Tribune, August 22, 1985). The second earthquake, occurring on August 22, 1985, was not felt in Jackson. The third, a magnitude 4.3, intensity V event on August 30, 1985, was felt in Jackson, but caused no damage (*Laramie Daily Boomerang*, August 31, 1985). The last earthquake, a magnitude 4.6, intensity V event on September 6, 1985, was felt as an intensity IV earthquake 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 May 12, 1989, a magnitude 3.1, intensity III earthquake occurred approximately five miles southeast of Jackson. The U.S. Geological Survey's National Earthquake Information Center reported that the earthquake was felt as an intensity III event in Jackson. No damage occurred. On June 24, 1989, two earthquakes were felt strongly at Jackson. They both occurred approximately two miles north of Jackson. The first earthquake, which occurred at 3:25 am, had a magnitude of 3.8. The second earthquake, which occurred one hour later, had a magnitude of 3.7. No damage was reported, but some windows did rattle (*Casper Star-Tribune*, June 25, 1989).

A summary of earthquakes that are shown on **Figure 21**, and that occurred in or near Teton County in the 1980s, is presented below. Earthquakes that did not originate in the county are flagged with an asterisk.

<u>Date - 1980s</u>	<u>Magnitude/Intensity</u>	<u>Date - 1980s</u>	<u>Magnitude/Intensity</u>
January 5, 1980	2.8	May 25, 1985	2.8
January 28, 1980 *	2.8	August 21, 1985 *	4.8, V
May 6, 1981	3.7, IV	August 22, 1985 *	4.3, IV
May 12, 1981	3.0	August 30, 1985 *	4.3, V
February 8, 1983 *	4.4, V	September 6, 1985 *	4.6, V
November 2, 1983	3.5	October 21, 1988	3.6
November 2, 1983 *	3.5, IV	May 12, 1989	3.1
November 9, 1983	3.6, III	June 24, 1989	3.8, 3.7
December 20, 1983	4.5, IV		
November 2, 1984	3.1, III		
November 2, 1984	3.0		

Earthquakes from 1990 through 1996

Most of the earthquakes that have occurred in or near Teton County from 1990 through 1996 were located in the southeastern half of the county. As with the previous few decades, only minor damage resulted from the events. The first earthquake from the 1990s that is shown on **Figure 21**, occurred on March 4, 1990, approximately six miles south of Jackson. The magnitude 4.1, intensity IV earthquake was felt by residents in the Jackson area, but no damage was reported (*Casper Star-Tribune*, March 6, 1990).

The next earthquake that caused any concern, occurred on April 3, 1992. The magnitude 4.0, intensity IV earthquake, which was approximately located in Idaho, near Alta, Wyoming, did not cause any damage (*Casper Star-Tribune*, April 4, 1992). The earthquake was felt as an intensity III event at Moose and

Wilson. On September 24, 1992, a magnitude 3.7 earthquake occurred in the Mount Leidy area, approximately twenty-five miles northeast of Jackson. The earthquake was not felt in Jackson.

On December 28, 1993, a magnitude 4.7, intensity V earthquake occurred in the vicinity of Sportsman Ridge, approximately thirty-four miles east of Jackson. The earthquake was felt in Jackson, Dubois, Hudson, Lander, and Rock Springs. Most reports indicated that the earthquake felt like a heavy truck passing by. A ranch near the epicenter reported swinging lights, but no damage.

On August 27, 1995, three earthquakes occurred in the vicinity of Joy Park and Enos Lake in northeastern Teton County. The first event had a magnitude of 4.5, and was felt at Flagg Ranch, south of Yellowstone National Park, as well as at Fishing Bridge and Grant Village within the Park. At Flagg Ranch, there were reports of buildings vibrating and dishes rattling. At Grant Village, the event was felt for 10-15 seconds, and a few items fell off the shelves at the Hamilton Store. The magnitude 4.5 earthquake was quickly followed by a magnitude 2.6 earthquake that caused no damage. Within two hours, a non-damaging magnitude 3.8 earthquake also occurred.

On January 29, 1996, a magnitude 3.2 earthquake occurred in the vicinity of Lower Slide Lake, northeast of Jackson. No damage was associated with the earthquake. As mentioned previously, there were reports of seismic activity in the same area in 1925.

A summary of earthquakes that are shown on **Figure 21**, and that occurred in or near Teton County in the 1990s, is presented below. Earthquakes that did not originate in the county are flagged with an asterisk.

<u>Date - 1990-1996</u>	<u>Magnitude/Intensity</u>	<u>Date - 1990-1996</u>	<u>Magnitude/Intensity</u>
March 4, 1990	4.1, IV	April 1, 1993	3.1
October 2, 1990	3.6	August 22, 1993 *	3.1
October 26, 1990	3.0	November 26, 1993	3.8
August 14, 1991	3.0	December 28, 1993	4.7, V
September 21, 1991	3.2	September 7, 1994	3.0
September 29, 1991	3.2	December 4, 1994	3.1
April 3, 1992 *	4.0, IV	January 27, 1995	3.5
September 24, 1992	3.7	August 27, 1995	4.5, 2.6, 3.8
		January 29, 1996	3.2
		June 22, 1996	3.7
		July 5, 1996	3.2
		November 7, 1996 *	3.8

References cited

- Blackwelder, E., 1926, Earthquakes in Jackson Hole, Wyoming: Bulletin of the Seismological Society of America, v. 16, no. 3, p. 196.
- Heck, N.H., and Bodle, R.R., 1930, United States earthquakes 1928: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 483, 28 p.
- Murphy, L.M., and Cloud, W.K., 1955, United States earthquakes 1953: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 785, 51 p.
- Neumann, F., 1938, United States earthquakes 1936: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 610, 45 p.
- Voight, B., 1978, Lower Gros Ventre slide, Wyoming, U.S.A., in Voight, B., editor, Rockslides and avalanches, 1, natural phenomena: Elsevier Scientific Publishing Company, New York, p. 113-166.
-

ROCK HOUND'S CORNER

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

BERYL

Beryl, a hexagonal beryllium oxide, is found at several localities in Wyoming. Much of the beryl found in Wyoming occurs as well-formed, greenish, opaque crystals in pegmatite. In addition to this poorer quality opaque beryl, some gemstone varieties of beryl have also been found in the State. These include light-blue aquamarine and apparently some emerald. Emerald (green transparent to translucent beryl) was found in the Sierra Madre a few years ago by a prospector from Laramie; however, the locality of the stones was never verified as the exact location was kept secret. Red beryl is another gemstone variety of beryl. Although red beryl is found in neighboring Utah, none has ever been found in Wyoming.

Beryl crystals found in Wyoming have ranged from less than one inch to well-formed crystals more than a foot in length. One large specimen of gem quality aquamarine was found in the Anderson Ridge area of South Pass several years ago. However, most of the beryl found elsewhere in the Anderson Ridge area has been poor quality, yellowish-green, opaque beryl.

Gem quality beryl has also been reported from pegmatites along Hoodoo Creek in the southern portion of Copper Mountain in the Owl Creek Mountains near Shoshoni. Beryl has also been reported in several pegmatites in the Hartville uplift in eastern Wyoming, and some of the better quality specimens of opaque beryl have been found on Casper Mountain in central Wyoming.

In that beryl typically occurs in hard, granitic pegmatite, it is very difficult to recover the crystal. Typically, recovery of crystals requires considerable effort.

LICENSURE OF GEOLOGISTS IN WYOMING NOW REQUIRED

The 1997 Wyoming Legislature passed Senate Enrolled Act No. 73 (Chapter 170) which amended the Geologists Practice Act of 1991 (W.S. 33-41-101 through W.S. 33-41-121). The amended statutes change the original act from simply a title act to a practice act as well. The act now requires the licensure of anyone wishing to practice geology before the public in Wyoming. "Practice before the public" is defined as "the performance of geological services or work including consultation, investigation, evaluation, planning, preparation of geologic reports and maps, the inspection of geological work, and the responsible supervision of geological services or work, the performance of which is relevant to public welfare or the safeguard of life, health, property, and the environment, unless exempted under the act."

During the first year following the effective date of the new statutes (July 1, 1997 through June 30, 1998), a grandfather clause allows geologists, who meet minimum statutory requirements, to apply for licensure without taking any examinations. The grandfather clause will also allow geologists who meet the statutory requirement for education, but lack the required experience, to apply for certification as geologists-in-training without an examination.

Applications for the grandfather period will be available on or before June 1, 1997. Individuals wishing to receive applications for licensure should send their names, mailing addresses, and phone numbers to the Board address shown below:

Mail: Wyoming Board of Professional Geologists
P.O. Box 3008
Laramie, WY 82071-3008

Phone: (307) 766-2490
Fax: (307) 766-2713
E-mail: wbrpg@wsgs.uwyo.edu

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.

Oil and gas map of Wyoming, by R.H. De Bruin: Map Series MS-48.-\$15.00.

Index to U.S. Geological Survey topographic maps of Wyoming available from the Wyoming State Geological Survey: Miscellaneous publication, one folded sheet printed on two sides (scale 1:1,000,000).-Free on request.

A self-guided geologic tour of the Chief Joseph Scenic Highway and surrounding area, northwestern Wyoming, by H.P. Heasler, C. Jaworowski, R.W. Jones, R.H. De Bruin, and A.J. Ver Ploeg: Public Information Circular PIC-35.-\$15.00.

A new look at the Laramide orogeny in the Seminoe and Shirley Mountains, Freezeout Hills, and Hanna Basin, south-central Wyoming, by J.A. Lillegraven and A.W. Snoke: Public Information Circular PIC-36.-\$12.00.

A geological traverse across Wyoming following U. S. Interstate Highway 80, by D.L. Blackstone, Jr.: Public Information Circular PIC-37.-\$4.00.

Geology and gold mineralization of the Rattlesnake Hills, Granite Mountains, Wyoming, by W.D. Hausel: Report of Investigations RI-52.-\$7.00.

*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. 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

(E-mail: jim_case@wsgs.uwyo.edu)

Rodney H. De Bruin - Oil and gas

(E-mail: rod_debruin@wsgs.uwyo.edu)

Ray E. Harris - Industrial minerals and uranium

(E-mail: ray_harris@wsgs.uwyo.edu)

Alan J. Ver Ploeg - Geologic mapping and stratigraphy
(E-mail: alan_verploeg@wsgs.uwyo.edu)
Gary B. Glass- Coal
(E-mail: gary_glass@wsgs.uwyo.edu)

*New releases since the last issue of *Wyoming Geo-notes*.

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 at the 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.

RECREATIONAL MAP PURCHASERS!

The Wyoming State Geological Survey now carries U.S. Bureau of Land Management Surface Management Status maps for the 1:100,000-scale metric topographic quadrangles in Wyoming.-\$5.50 each. Coverage may be limited for specific areas; please call for map availability.

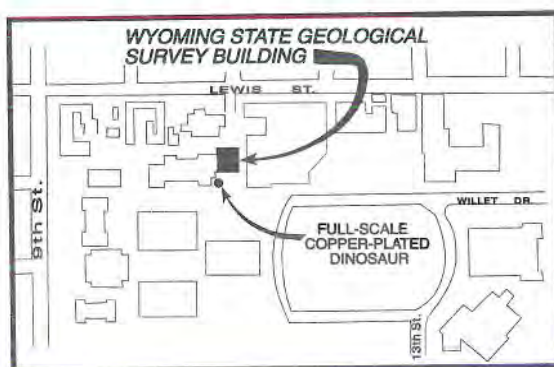
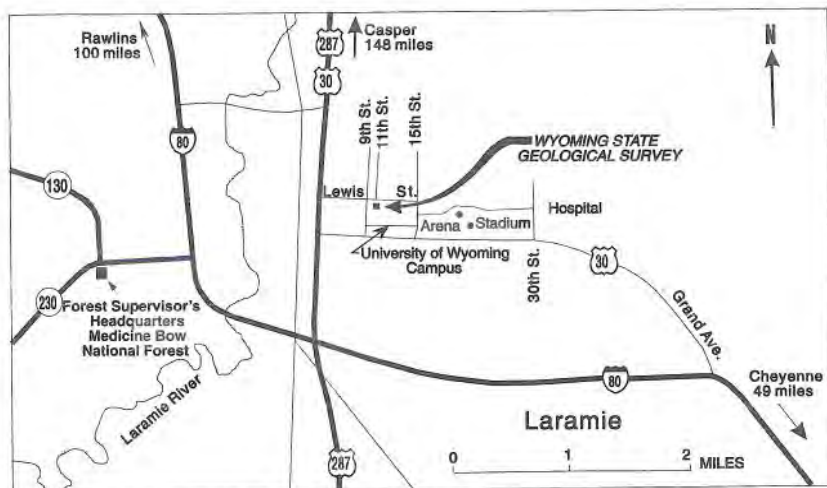
In addition, we carry the *Recreational map of Wyoming*, published by GTR Mapping. This folded, glove-compartment-style map is available for \$3.95. The 1:792,000-scale (1 inch equals about 12.5 miles) map is an ideal companion to the *Geological highway map of Wyoming*, which is also available at the Wyoming State Geological Survey for \$7.00.

These maps (plus other topographic maps of Wyoming) are available over-the-counter at the Survey offices in Laramie or by mail. We do not offer quantity discounts and can make no exchanges or refunds. Sales tax of 6% is added for Wyoming addresses and postage and map tubes for rolled maps are added on when appropriate.

Prices may change at any time.

WYOMING STATE GEOLOGICAL SURVEY

LOCATION MAPS



ORDER FORM

Send this order and make checks payable to:

Wyoming State Geological Survey
P.O. Box 3008
Laramie, Wyoming 82071-3008

Your name, address, zip:

Phone: (307) 766-2286

Fax: (307) 766-2605

E-mail: wsgs@wsgs.uwyo.edu

*No postage charged on prepaid orders unless otherwise specified. If ordering **Memoir 5**, postage for shipping each copy is: \$5.00 (Wyoming), \$10.00 (other U.S. States), and \$20.00 (International, including Canada).

Quantity	Publication Number	Publication Title	Price	Total Price
			Rolled maps (\$1.50 each tube)	
			WYOMING RESIDENTS ADD 6% SALES TAX (or furnish proof of exempt status)	
			TOTAL ENCLOSED*	

Rolled maps (\$1.50 each tube)

WYOMING RESIDENTS ADD 6% SALES TAX
(or furnish proof of exempt status)

TOTAL ENCLOSED*

Wyoming State Geological Survey
P.O. Box 3008
Laramie, Wyoming 82071-3008