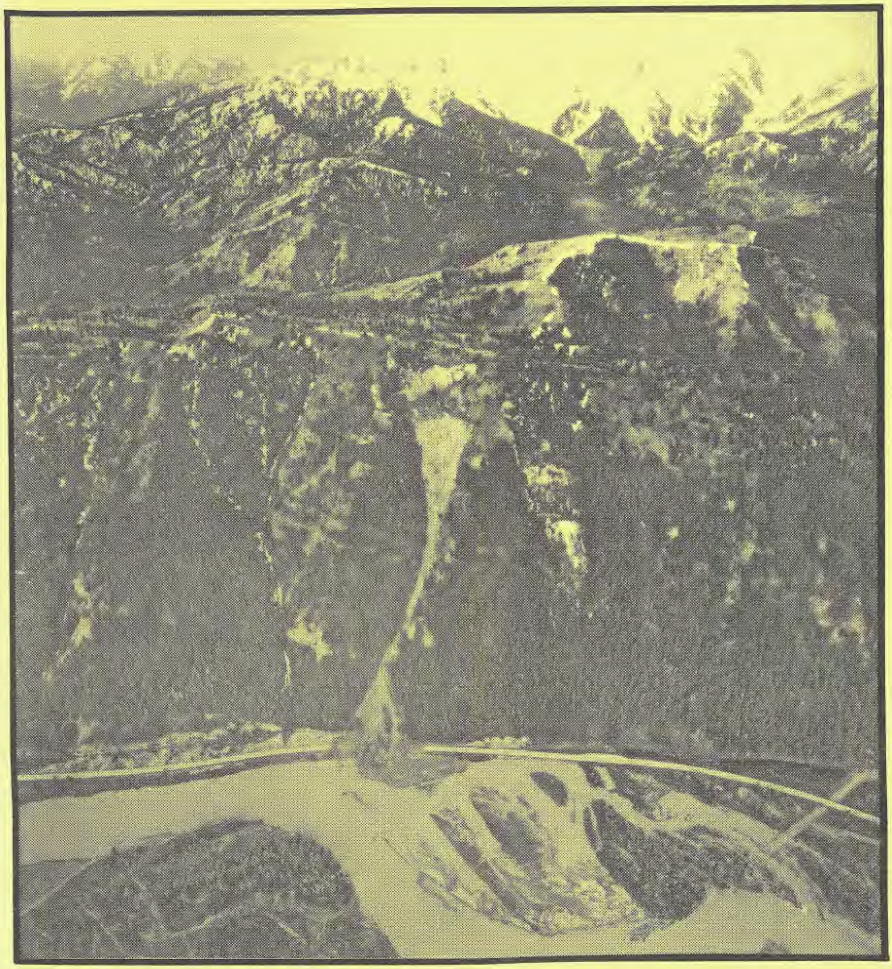
Wyoming Geo-notes

Number 57



Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
February, 1998

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

WYOMING GEO-NOTES
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Cover: For several weeks last year, the Wolf Mountain slide, closed U.S. Highway 26/89 south of Jackson. See article on pages 56-61 in this issue. (Photo courtesy of the Wyoming Department of Transportation).

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MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

The forecasts in this issue of *Wyoming Geo-notes* now reflect changes made by the Consensus Revenue Estimating Group (CREG) in January of 1998. Not all forecasts changed. For example, uranium production (**Table 1**), trona production (**Table 1**) and oil production (**Table 1** and **Figure 1**) were left unchanged. In the case of oil production, the annual decline between 1996 and 1997 was 5.3%. This compares with a 4.4% decline at the end of the third quarter of 1997, and may be a reflection of reduced demand and persistent low prices paid for Wyoming crude, especially in December.

In regard to natural gas, the forecast production for 1997 was lowered to 1,034.9 billion cubic feet, which is 10 billion cubic feet below CREG's October estimate (**Table 1**; **Figure 2**). This was an increase of only 1.1% over 1996 production. Mild weather in the State's market area easily accounts for this small adjustment. The estimates for 1998 through 2004 were not changed. The 8.6% increase forecast for 1998 reflects completed increases to the capacities of pipelines carrying our gas to market.

Table . Wyoming mineral production (1985-1996) with forecasts to 2004[1].

Calendar Year	Oil[2,3]	Methane[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	987.5	148.8	1.11	263.9	18.1	1.3	1.20
1996	73.9	1,023.4	149.0	1.10	278.4	17.5	1.9	1.22
1997	*70.0	*1,034.9	*149.0	*1.10	*281.5	*19.4	*2.4	*1.20
1998	66.3	1,124.9	149.0	1.10	297.5	20.0	3.5	1.20
1999	62.8	1,150.4	149.0	1.10	314.5	21.1	3.5	1.20
2000	59.5	1,176.4	149.0	1.10	334.6	21.8	3.5	1.20
2001	56.3	1,203.3	149.0	1.10	346.7	22.6	3.5	1.20
2002	53.3	1,230.0	149.0	1.10	350.2	23.5	3.5	1.20
2003	50.5	1,257.6	149.0	1.10	353.7	24.4	3.5	1.20
2004	47.8	1,285.8	149.0	1.10	357.2	25.9	3.5	1.20

*Estimated until official figures are available.
[1]Modified from CREG's Wyoming State Government Revenue Forecast, January, 1998; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1985-1996; [4] Billions of cubic feet; [5]Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; [6]Millions of short tons (Wyoming State Inspector of Mines, 1985-1996); [7]Wyoming State Inspector of Mines, 1985-1996; [8]Millions of pounds of yellowcake (not available [N/A] for 1985 and previous years because it was only reported as taxable value); [9]Millions of short tons.

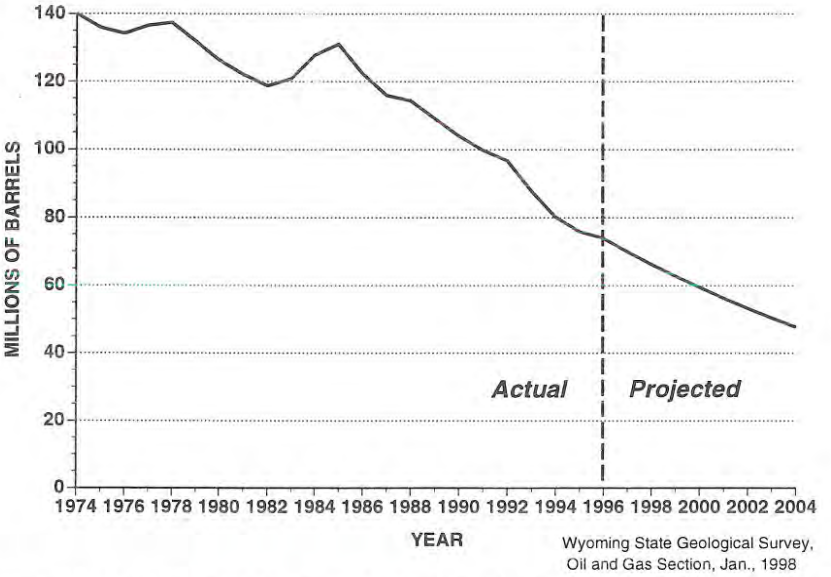


Figure 1. Annual oil production from Wyoming (1974 to 1996) with forecasts to 2004.

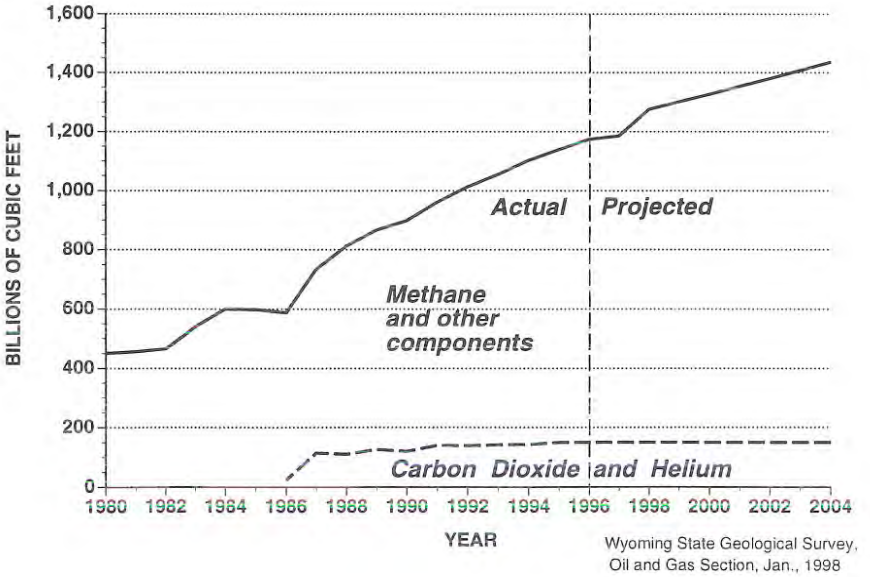


Figure 2. Annual natural gas production from Wyoming (1980 to 1996) with forecasts to 2004.

Forecast coal production showed the greatest change. For 1997, estimated production was decreased to 281.5 million tons, which is a reduction of 6.8 million tons (**Table 1**; **Figure 3**). This change was a direct result of delivery problems that plagued the Union Pacific/Southern Pacific Railroad throughout much of the year. The reduction in production translates into a 1.1% increase over 1996 production, instead of the 3.6% increase that had been forecast in October. Assuming the delivery problems are not a long-term problem, production for the years 1998 through 2000 are now forecast to increase by 5.7%, 5.7%, and 6.4%, respectively. Forecasts of annual production between 2001 and 2004 were left unchanged.

CREG also made some changes to forecast prices, but only for 1997. The trona price estimate was left unchanged. The estimated prices for oil and methane were increased while the estimated price for coal was decreased.

Despite the poor prices in December, the average oil price for 1997 was increased to $17.45, rather than the earlier estimate of $17.30 (**Table 2**; **Figure 4**). This was due to the very high prices received in the first quarter of the year. The out years were left at $15.00 a barrel.

The estimated average price paid for Wyoming methane in 1997 was also increased. CREG now forecasts methane at $1.96, rather than the $1.74 esti-

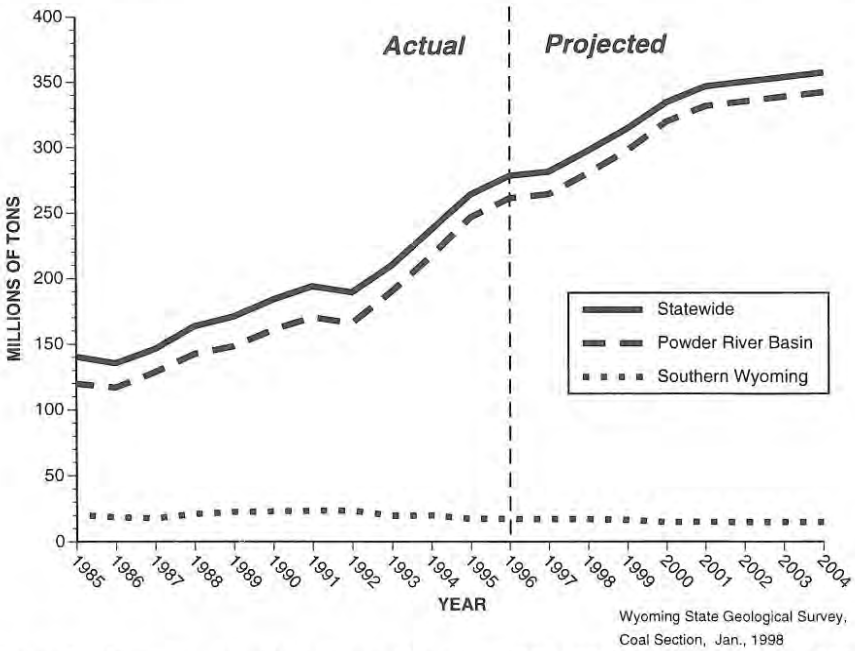


Figure 3. Annual coal production from Wyoming (1985-1996) with forecasts to 2004. Data from Wyoming State Inspector of Mines (1985-1996) and Wyoming Consensus Estimating Group (1997-2004).

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1996) with forecasts to 2004[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	41.86
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	44.50
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.47	6.15	45.86
1997	*17.45	*1.96	*6.06	*42.62
1998	15.00	1.50	5.97	43.34
1999	15.00	1.50	5.82	42.93
2000	15.00	1.50	5.64	43.25
2001	15.00	1.50	5.55	43.44
2002	15.00	1.50	5.48	43.92
2003	15.00	1.50	5.40	44.24
2004	15.00	1.50	5.32	44.45

* Estimated until official figures are available.
[1] Modified from CREG, Wyoming State Government Revenue Forecast, January, 1998; [2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1996; [3] Wellhead price in dollars per thousand cubic feet (MCF). Source: Wyoming State Land and Investment Office, 1989-1996 (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, 1991-1996; [5] Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1996.

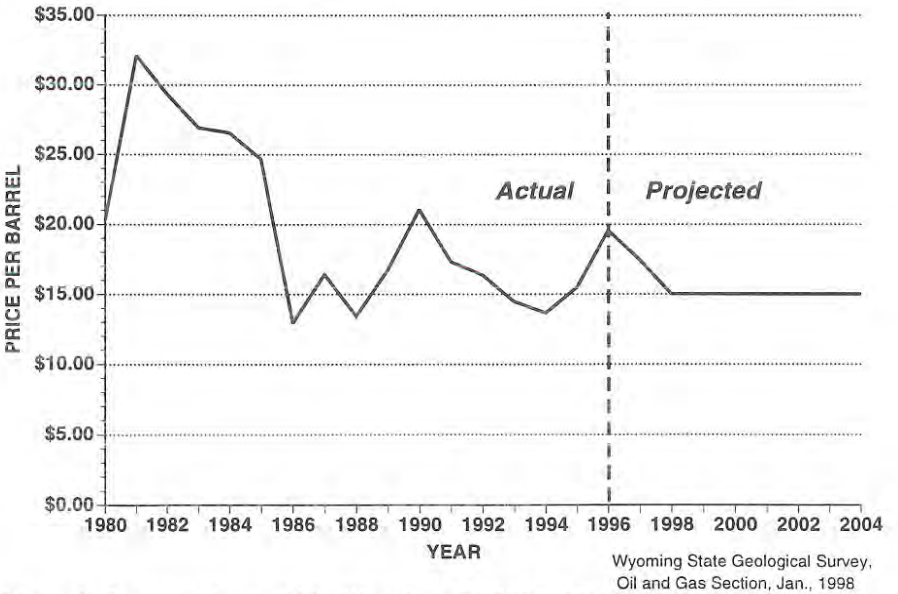


Figure 4. Average prices paid for Wyoming oil (1980 to 1996) with forecasts to 2004.

mate made in October (**Table 2**; **Figure 5**). Because demand was down, the higher price is more a reflection of national pricing than anything else. For 5 of the 12 months in 1997, Wyoming prices averaged more than $1.95.The out years; however, were left at $1.50 per thousand cubic foot (MCF).

Conversely, the forecast average coal price for 1997 was decreased to $6.06 a ton, which is a difference of only five cents a ton (**Table 2**; **Figure 6**). Although the out years were left unchanged, there is an upside chance that prices might flatten out closer to $5.55 after 2001.

The **Oil and Gas Update** in this issue not only provides more detailed tables and graphs depicting monthly production and prices of these two energy resources, but it also discusses drilling, seismic exploration, and leasing activities in the fourth quarter of 1997.

The **Coal Update** also has additional tables and graphs as well as discussions of the rapidly condensing number of coal operators in the State. In the Powder River Basin alone, three major companies have their mines for sale, and another is closing its mine in 1999. Even while the number of companies and mines diminish, production is forecast to increase well into the next decade.

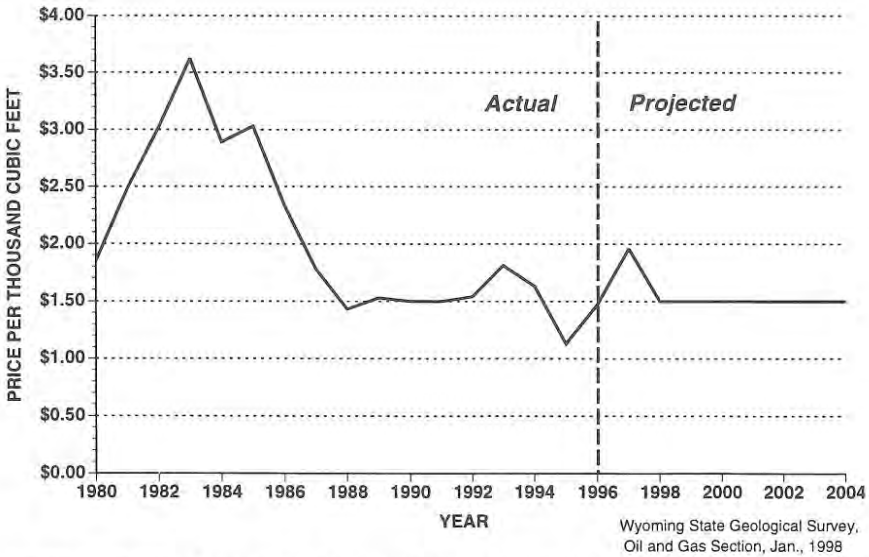


Figure 5. Average prices paid for Wyoming methane (1980 to 1996) with forecasts to 2004.

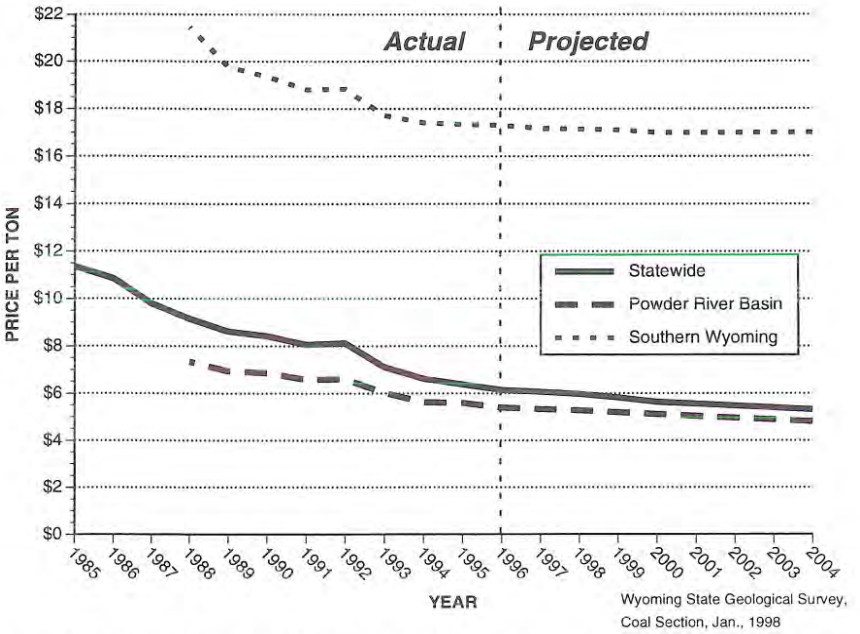


Figure 6. Average prices paid for Wyoming coal (1985 to 1996) with estimates to 2004. Sources: U.S. Energy Information Administration (1985-1990); Wyoming Department of Revenue (1991-1996); and Consensus Revenue Estimating Group (1997-2004).

In regard to other minerals, recent interest in aggregate; lapidary, decorative, and dimension stone; feldspar; and limestone are highlighted in the **Industrial Minerals and Uranium Update**. The **Metals and Precious Stones Update** discusses occurrences of diamonds, peridot, cordierite, jade, and gold in Wyoming. The **Rock Hound's Corner** also deals with diamond occurrences in Wyoming.

There are descriptions of recent and planned geologic mapping in the State, as well as a note that the Wyoming Office of State Lands and Investments is proposing some significant changes to their rules for commercial and scientific fossil collecting on State lands (**Geologic Mapping, Paleontology, and Stratigraphy Update**).

In regard to geologic hazards, this issue includes a special article on the landslide hazard in Wyoming.

OIL AND GAS UPDATE

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

While prices paid to Wyoming oil producers during the fourth quarter of 1997 averaged $16.53 per barrel, the average for the year was $17.45 (**Table 3**). The average price for 1997 is $2.11 lower than for 1996, but is higher than it was for 1992-1995 (**Figure 4**; **Tables 2** and **3**). **Figure 7** shows the posted Sweet and Sour crude prices and first purchase price for Wyoming oil averaged by month.

Oil production in Wyoming for the first nine months of 1997 was an estimated 52.2 million barrels (**Table 4**), according to preliminary figures from Petroleum Information Inc. This production is a drop of about 4.4% from last year's first nine months of oil production.

Spot prices for natural gas at Opal, Wyoming, averaged $2.33 during the fourth quarter of 1997 (**Table 5**; **Figure 8**). This is slightly lower than last year's fourth quarter average price of $2.42. The average price in 1997 of $1.96 was the highest since 1986 (**Figure 5**).

Natural gas production in Wyoming for the first nine months of 1997 was an estimated 882.9 billion cubic feet, according to preliminary production figures from Petroleum Information Inc. (**Table 6**). Production was only up 0.4% over the first nine months of 1996, but production should show an increase during the fourth quarter when pipeline capacity out of the State increased.

Public Service of Colorado plans to construct and operate a new 53-mile natural gas pipeline between its Fort St. Vrain power plant north of Denver and a group of pipelines just south of Cheyenne, Wyoming. The pipelines south of Cheyenne access gas-producing areas in Wyoming. The 24-inch diameter pipeline will have an initial capacity of 269 million cubic feet of gas per day. According to a spokesman for the company, the pipeline will be needed by the 1998-1999 winter heating season to serve the company's growing markets in the Front Range area. The project will be jointly funded by Public Service of Colorado and Colorado Interstate Gas, and is subject to regulatory approval.

The U.S Bureau of Land Management (BLM) is working on an environmental assessment (EA) for the Cooper Reservoir Field in western Natrona County. Intoil Inc. proposed the drilling of 85 wells under an expanded development proposal that was originally for 18 wells. The BLM expects to release the EA sometime in February, 1998.

The Wyoming Board of Land Commissioners extended its drilling window, which provides reduced royalty rates for discoveries on State leases. A lease upon which a wildcat well is completed that produces paying quantities of hydrocarbons will be assessed a royalty of 10% rather than 16 2/3%. The drilling window was set to expire September 30, 1997, but was extended through July

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1994 to 1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	$ 11.15	$ 11.15	$ 14.77	$ 14.77	$16.38	$16.38	$22.56	$22.56
FEB	$ 11.01	$ 11.08	$ 15.55	$ 15.16	$16.28	$16.33	$19.45	$21.01
MAR	$ 11.04	$ 11.07	$ 15.26	$ 15.19	$18.63	$17.09	$17.99	$20.00
APR	$ 12.59	$ 11.45	$ 16.73	$ 15.58	$20.29	$17.90	$16.81	$19.20
MAY	$ 14.53	$ 12.07	$ 16.65	$ 15.79	$18.85	$18.08	$17.74	$18.91
JUN	$ 15.73	$ 12.68	$ 15.52	$ 15.75	$18.15	$18.10	$15.90	$18.41
JUL	$ 16.31	$ 13.20	$ 14.50	$ 15.57	$18.98	$18.22	$16.29	$18.11
AUG	$ 14.89	$ 13.41	$ 15.09	$ 15.51	$19.59	$18.39	$16.61	$17.92
SEP	$ 14.10	$ 13.49	$ 15.41	$ 15.50	$21.48	$18.74	$16.42	$17.75
OCT	$ 14.53	$ 13.59	$ 14.67	$ 15.42	$22.63	$19.13	**$17.90**	**$17.77**
NOV	$ 14.68	$ 13.67	$ 15.32	$ 15.41	$21.19	$19.31	**$16.70**	**$17.67**
DEC	$ 13.71	$ 13.67	$ 16.43	$ 15.50	$22.42	$19.56	**$15.00**	**$17.45**
Average yearly price		**$ 13.67**		**$ 15.50**		**$19.56**		

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

Wyoming State Geological Survey, Oil and Gas Section, January,1998

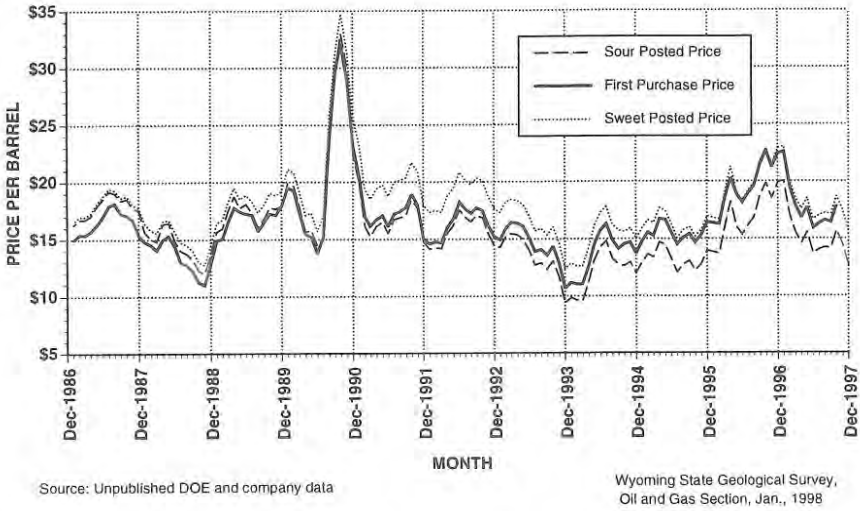


Figure 7. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to 1997).

5, 1998. The lower rate will apply only to production from the eligible lease and will be effective as long as qualified wells produce commercial volumes of hydrocarbons. The 10% rate will revert to 16 2/3% if an average producer price of $22 per barrel for oil and $2 per thousand cubic feet of gas is exceeded over a period of six consecutive months.

Howell Corp. executed a definitive purchase and sale agreement with Amoco Production Co. to purchase producing properties that are primarily located in Wyoming for $302.5 million. The three largest fields are Beaver Creek in the Wind River Basin, Elk Basin in the Bighorn Basin, and Salt Creek in the Powder River Basin. Current net daily production from all of the properties in the package is 8,300 barrels of oil and 21 million cubic feet of gas. However, Snyder Oil Corp. has filed a suit to block the sale of the Beaver Creek property. The purchase of the other properties is apparently not a matter of litigation.

Burlington Resources completed its merger with Louisiana Land & Exploration. The $3 billion merger creates a company, to be known as Burlington Resources, that had reserves of 7.1 trillion cubic feet of gas equivalent at the time of the merger.

Seneca Resources, Texaco, Kirkwood Oil and Gas, and Loma Energy formed a joint venture to explore 165,000 acres in the Bighorn Basin. Drilling operations are scheduled to begin in 1998. Texaco will be the operator and will hold 40% of the interest in the joint venture; Seneca will hold 35%; Kirkwood will hold 15.6%; and Loma will hold 9.4%.

Table 4. Monthly oil production from Wyoming in barrels (1994 to September, 1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	7,115,472	7,115,472	6,700,000	6,700,000	6,153,037	6,153,037	5,959,700	5,959,700
FEB	6,387,147	13,502,619	6,100,000	12,800,000	5,693,084	11,846,121	5,458,036	11,417,736
MAR	6,984,248	20,486,867	6,300,000	19,100,000	6,176,805	18,022,926	6,012,397	17,430,133
APR	6,672,207	27,159,074	6,200,000	25,300,000	5,977,362	24,000,288	5,726,360	23,156,493
MAY	6,847,709	34,006,783	6,300,000	31,600,000	6,035,505	30,035,793	6,048,990	29,205,483
JUN	6,594,914	40,601,697	6,200,000	37,800,000	5,916,019	35,951,812	5,753,173	34,958,656
JUL	6,773,956	47,375,653	6,300,000	44,100,000	6,076,992	42,028,804	5,895,238	40,853,894
AUG	6,685,423	54,061,076	6,100,000	50,200,000	6,414,850	48,443,654	5,747,778	46,601,672
SEP	6,446,719	60,507,795	6,100,000	56,300,000	6,180,180	54,623,834	5,588,885	52,190,557
OCT	6,525,817	67,033,612	6,300,000	62,600,000	6,186,019	60,809,853		
NOV	6,257,924	73,291,536	6,100,000	68,700.000	6,221,912	67,031,765		
DEC	6,236,204	79,527,740	6,300,000	75,000,000	6,330,701	73,362,466		
Total Barrels Reported[1]		**79,527,740**		**75,000,000**		**73,362,466**		
Total Barrels Not Reported[2]		**651,400**		**554,113**		**525,957**		
Total Barrels Produced[3]		**80,179,140**		**75,554,113**		**73,888,423**		

[1]Monthly production reports from Petroleum Information, except for 1995 which was estimated by the Wyoming State Geological Survey. [2] (Total barrels produced) minus (total barrels reported by Petroleum Information). [3] Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, January, 1998.

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1994 to 1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	$ 1.90	$ 1.90	$ 1.40	$ 1.40	$1.25	$1.25	$3.90	$3.90
FEB	$ 1.80	$ 1.85	$ 1.10	$ 1.25	$1.20	$1.23	$2.50	$3.20
MAR	$ 1.95	$ 1.88	$ 1.05	$ 1.18	$1.20	$1.22	$1.40	$2.60
APR	$ 1.60	$ 1.81	$ 1.05	$ 1.15	$1.05	$1.18	$1.45	$2.31
MAY	$ 1.60	$ 1.77	$ 1.10	$ 1.14	$0.95	$1.13	$1.60	$2.17
JUN	$ 1.35	$ 1.70	$ 1.15	$ 1.14	$1.10	$1.13	$1.35	$2.03
JUL	$ 1.45	$ 1.66	$ 1.00	$ 1.12	$1.20	$1.14	$1.45	$1.95
AUG	$ 1.45	$ 1.64	$ 0.90	$ 1.09	$1.25	$1.15	$1.40	$1.88
SEP	$ 1.35	$ 1.61	$ 1.05	$ 1.09	$1.20	$1.16	$1.50	$1.84
OCT	$ 1.20	$ 1.57	$ 1.05	$ 1.09	$1.30	$1.17	$2.05	$1.86
NOV	$ 1.50	$ 1.56	$ 1.25	$ 1.10	$2.45	$1.29	$3.00	$1.96
DEC	$ 1.60	$ 1.57	$ 1.30	$ 1.12	$3.50	$1.47	$1.95	$1.96
Average yearly price		**$ 1.57**		**$ 1.12**		**$1.47**		**$1.96**

Source: American Gas Association's monthly reports

Wyoming State Geological Survey, Oil and Gas Section, January, 1998

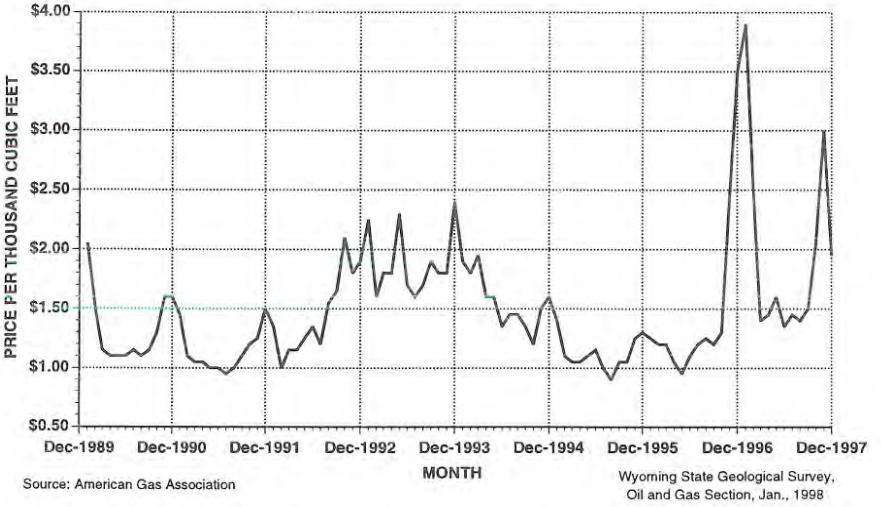


Figure 8. Spot sale price for methane at Opal, Wyoming, averaged by month (1990 to December 1997).

Cabot Oil & Gas completed its $44 million purchase of Equitable Resources' assets in the Greater Green River Basin. The purchase includes 74 billion cubic feet of natural gas equivalent, 65 wells that are currently producing 10 million cubic feet of gas equivalent per day, and 70 additional drilling locations. Cabot intends to drill 11 new wells on the acreage in the near future.

The 29 member states of the Interstate Oil and Gas Compact Commission (IOGCC) unanimously supported major components of legislation that would allow states to assume regulatory authority over oil and gas operations on Federal lands within their borders. The vote is a precursor to development of draft legislation for congressional consideration. Acting through resolution, the IOGCC also supported state involvement in the development of a royalty-in-kind program that would permit states to market their share of oil and natural gas produced on Federal lands within their borders.

Equity Oil Co. signed a letter of intent to purchase proved reserves of 1.1 million barrels of oil and 438 million cubic feet of gas from an undisclosed private party for $3.28 million. The properties are primarily located in the Bighorn Basin and are currently producing 782 barrels of oil and 870,000 cubic feet of gas per day.

Abraxas Petroleum executed an agreement to purchase Vessels Energy. Vessels owns producing properties in southwestern Wyoming that are close to existing Abraxas acreage. Vessels also owns exploratory acreage in the Bighorn Basin. Abraxas has started a development program to drill 21 wells over the next 18 months in Echo Springs, Baldy Butte, and Siberia Ridge fields in southwestern Wyoming.

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1994 to September 1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	93,146,775	93,146,775	100,224,249	100,224,249	101,359,648	101,359,648	99,445,797	99,445,979
FEB	85,623,666	178,770,441	86,691,577	186,915,826	96,303,300	197,662,948	91,707,072	191,152,869
MAR	94,388,052	273,158,493	94,344,991	281,260,817	103,541,127	301,204,075	104,095,200	295,248,069
APR	92,362,726	365,521,219	93,929,323	375,190,140	99,479,609	400,683,684	99,399,951	394,648,020
MAY	93,886,923	459,408,142	95,791,327	470,981,467	97,900,863	498,584,547	100,971,078	495,619,098
JUN	81,764,661	541,172,803	92,140,614	563,122,081	87,069,612	585,654,159	91,832,885	587,451,983
JUL	94,998,414	636,171,217	92,796,301	655,918,382	100,219,275	685,873,434	100,038,548	687,490,531
AUG	93,743,790	729,915,007	90,393,416	746,311,798	99,874,019	785,747,453	97,482,350	784,972,881
SEP	88,476,703	818,391,710	92,589,092	838,900,890	93,510,551	879,258,004	97,963,437	882,936,318
OCT	95,232,646	913,624,356	98,386,458	937,287,348	95,441,022	974,699,026		
NOV	95,312,491	1,008,936,847	94,939,660	1,032,227,008	94,015,007	1,068,714,033		
DEC	87,115,084	1,096,051,931	99,314,617	1,131,541,625	99,141,298	1,167,855,331		
Total MCF Reported[1]		**1,096,051,931**		**1,131,541,625**		**1,167,855,331**		
Total MCF Not Reported[2]		**6,879,705**		**6,448,396**		**5,663,874**		
Total MCF Produced[3]		**1,102,931,636**		**1,137,990,021**		**1,173,519,205**		

[1] Monthly production reports from Petroleum Information, Inc.
[2] (Total MCF produced) minus (total MCF reported by Petroleum Information).
[3] Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, January, 1998

In the fourth quarter of 1997, there were four lease sales. Leasing activity at the October U.S. Bureau of Land Management (BLM) sale was concentrated in the Powder River Basin, the Greater Green River Basin, and the Bighorn Basin (**Figure 9**). The total revenue for the October sale set a record for a lease sale in Wyoming. Total revenue from 1997 BLM sales also set a record for yearly revenue (**Table 7**). Ultra Resources led the way with high bids of $150 or more per acre on 17 parcels in the northern part of the Greater Green River Basin in the Jonah Field-Pinedale anticline area. The high per-acre bid was $400 by Ultra Resources for a 1,200-acre parcel covering all or portions of sections 23, 24, 25, and 35, T31N, R108W (location A, **Figure 9**). The lease is about four miles east of Pinedale Field and about 11 miles north of Jonah Field. Ultra Resources also paid $400 per acre for a 68.83-acre lease that covers part of section 1, T30N, R108W (location B, **Figure 9**). Ultra Resources paid $330 per acre for a 1,920-acre parcel that covers sections 12, 13, and 14, T31N, R108W (location C, **Figure 9**). Ultra Resources paid $320 per acre for a 1,265.05-acre lease that covers parts of sections 5, 6, and 8, T30N, R107W (location D, **Figure 9**). Yates Petroleum paid $320 per acre for an 844.36-acre parcel that covers parts of sections 3, 4, 5, 10, 12, 15, and 18, T34N, R112W (location E, **Figure 9**). Ultra Resources paid $310 per acre for a 1,346.81-acre lease that covers parts of sections 19, 20, 21, 28, 29, and 32, T32N, R108W (location F, **Figure 9**). Ultra Resources paid $300 per acre for a 1,335.95-acre

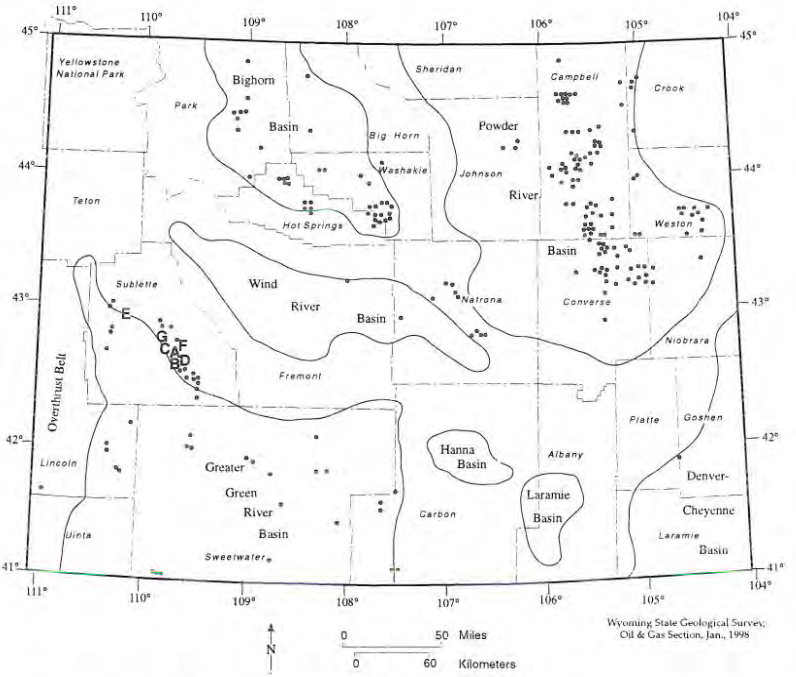


Figure 9. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the October, 1997, sale.

Table 7 . Federal and State competitive oil and gas lease sales in Wyoming.

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1993							
TOTAL	$12,942,008	2,769	1,469	2,065,942	995,344	$13.00	$400.00
1994							
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.00
1995							
TOTAL	$13,047,246	2,649	1,264	2,326,988	1,109,711	$11.76	$1,100.00
1996							
February	$1,635,668	455	192	358,478	137,901	$11.86	$220.00
June	$1,438,325	460	282	337,440	181,338	$ 7.93	$210.00
August	$2,021,488	289	182	261,321	118,267	$17.09	$145.00
October	$3,058,248	363	255	280,434	163,054	$18.76	$270.00
December	$3,333,838	261	214	165,771	138,945	$23.99	$1,450.00
TOTAL	$11,487,567	1,828	1,125	1,403,444	739,505	$15.53	$1,450.00
1997							
February	$2,463,137	267	210	222,486	148,148	$16.63	$250.00
April	$2,612,013	145	137	98,865	90,948	$28.72	$400.00
June	$4,642,113	285	249	313,519	262,682	$17.67	$310.00
August	$4,636,555	426	365	430,213	327,172	$14.17	$600.00
October	$12,133,207	286	227	234,561	169,264	$71.68	$400.00
December	$5,489,578	378	297	279,294	208,428	$26.34	$410.00
TOTAL	$31,976,603	1,787	1,485	1,578,938	1,206,642	$26.50	$600.00

STATE SALES (OFFICE OF STATE LANDS AND INVESTMENTS)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1993							
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
1994							
TOTAL	$3,304,152	800	607	331,779	255,152	$12.95	$205.00
1995							
TOTAL	$1,656,218	799	492	323,887	202,708	$8.17	$130.00
1996							
March	$308,927	199	96	85,369	41,909	$7.37	$108.00
June	$656,177	250	114	103,621	48,638	$13.49	$206.00
October	$663,241	300	134	115,495	54,538	$12.16	$175.00
December	$697,152	300	164	113,626	61,729	$11.29	$86.00
TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
1997							
April	$719,005	300	189	119,436	80,548	$8.93	$170.00
June	$1,008,470	300	185	108,470	62,447	$16.16	$162.00
October	$627,935	300	165	102,802	63,003	$ 9.97	$115.00
December	$795,610	298	165	107,588	57,202	$13.91	$340.00
TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	$340.00

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

lease that covers parts of sections 1, 2, and 3, T32N, R109W (location G, **Figure 9**). There were 74 parcels at this sale that sold for $50 or more per acre.

Leasing activity at the Wyoming Office of State Lands and Investments' October sale was concentrated in the Powder River Basin and the Bighorn Basin. There was also heavy leasing activity in Platte and Goshen Counties near the inactive Chugspring Field, although all of the parcels sold for the minimum bid of $1 per acre. The sale's high per-acre bid of $115 was made by Don J. Colton for a 640-acre lease that covers section 36, T48N, R74W (location A, **Figure 10**). The tract is about a mile southeast of Parkman production at Twenty-One Mile Butte Field. The second high per-acre bid of $114 was made by Springfield Oil for a 40-acre lease that covers NE NW section 35, T40N, R93W (location B, **Figure 10**). This parcel is about five miles north of Fort Union and Lance production in the Howard Ranch and Bonneville fields. Only five tracts at this sale received per-acre bids of $50 or more.

Leasing activity at the BLM's December sale was concentrated in the Powder River Basin, the Bighorn Basin, and the Greater Green River Basin. The sale's high per-acre bid of $410 was made by Maurice W. Brown for a 78.47-acre tract that covers part of section 12, T54N, R70W (location A, **Figure 11**). The parcel is on the eastern flank of Muddy production at Soda Well East Field. The second high per-acre bid of $255 was made by Coleman Oil and Gas for a 320-acre lease that covers the W/2 section 20, T19N, R92W (location B, **Fig-**

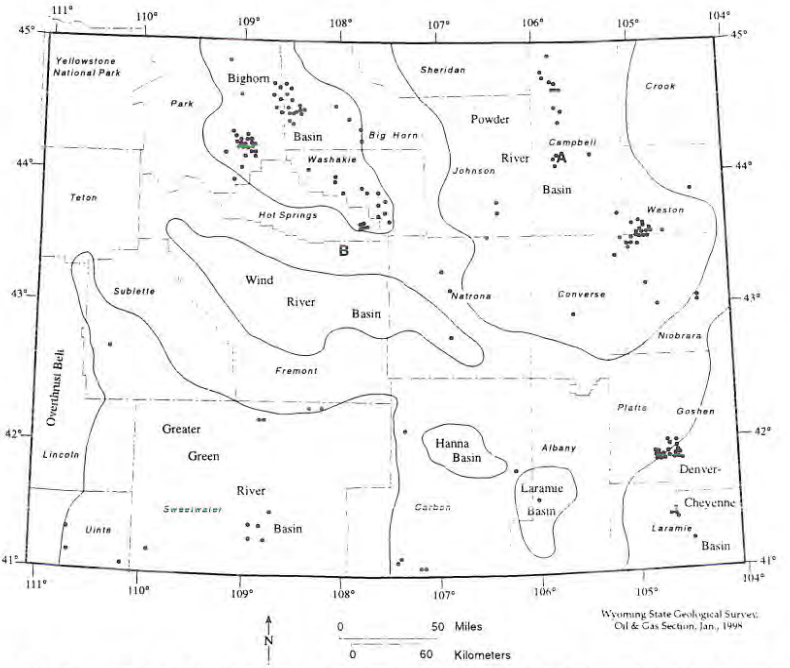


Figure 10. Locations of State oil and gas tracts leased by the Office of State Lands and Investments at the October, 1997, sale.

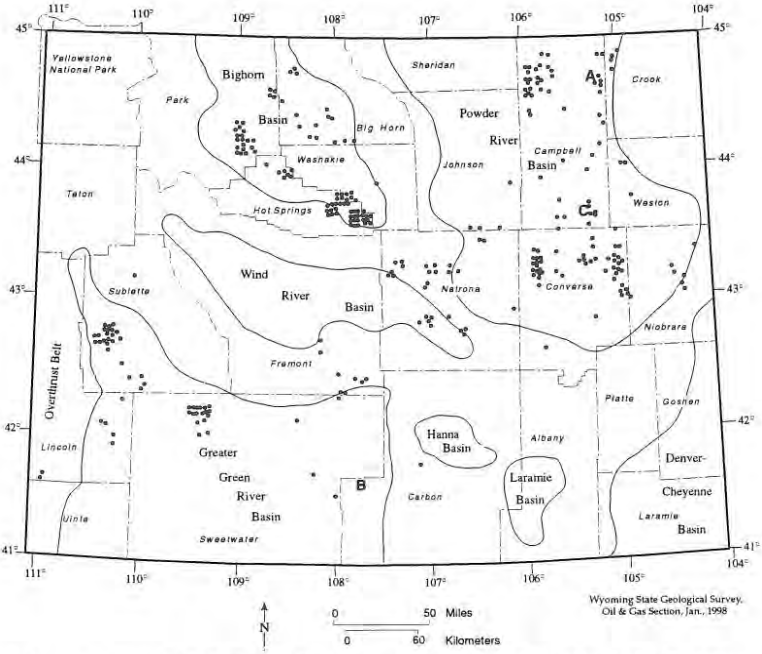


Figure 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the December, 1997, sale.

ure 11). The parcel is a little over a mile east of Almond production at Echo Springs Field. The third high per-acre bid of $200 was made by William E. Jeffers for a 201.52-acre parcel that covers part of section 30, T42N, R72W (location C, **Figure 11**). The parcel is about two miles north of shut-in Frontier production at Mongoose Field. There were 54 tracts at this sale that received per-acre bids of $50 or more.

Leasing activity at the Wyoming Office of State Lands and Investments' December sale was heaviest in the Powder River Basin. Yates Petroleum made the sale's two high per-acre bids of $340 and $330 for two tracts that are about three miles north and northwest of Jonah Field. The company paid $340 for a 640-acre tract that covers section 36, T30N, R109W (location A, **Figure 12**) and $330 for a 320-acre lease that covers the S/2 section 16, T30N, R108W (location B, **Figure 12**). True Oil made the sale's third highest per-acre bid of $320 for a 40-acre parcel that covers SE SE section 5, T53N, R69W (location C, **Figure 12**). The tract offsets Minnelusa oil production at York Field. There were nine parcels at this sale that received per-acre bids of $50 or more.

The Wyoming Oil and Gas Conservation Commission approved 1,908 Applications for Permit to Drill (APD) in 1997 (**Table 8**). APDs for 1997 exceeded the total number of APDs in each of the last five years. Nearly 50% of the applications were for Campbell County, and an estimated 700 to 800 of the Campbell County APDs were for shallow coalbed methane tests.

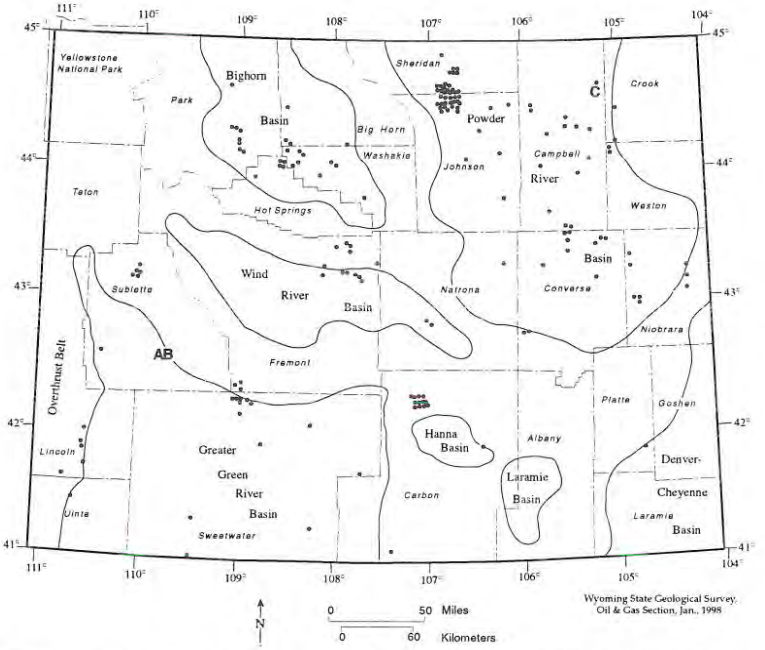


Figure 12. Locations of State oil and gas tracts leased by the Office of State Lands and Investments at the December, 1997, sale.

The number of seismic projects permitted by the Wyoming Oil and Gas Conservation Commission was 65 in 1997 (**Table 9**). Over half of the seismic projects permitted in 1997 were in counties in the Powder River Basin; however, counties in the Greater Green River Basin accounted for nearly half of the permitted 3-D square miles. There were two permits in Goshen County for 227 conventional miles. Those two permits were the first issued in Goshen County since 1992.

The average daily rig count for the fourth quarter of 1997 was 47, which is the same as in the third quarter of 1997. The monthly rig count for 1997 had been increasing every month since February, but it dropped slightly during the last three months of the year **Figure 13**). The average rig count of 39 for 1997 is the highest yearly average since 1987 (**Figure 14**). Compared to all other major oil- and gas-producing states, Wyoming had the largest percentage increase in average rig count for 1997. Wyoming's 1997 rig count improved by 62.5% over 1996. New Mexico was second best with a 54.7% increase, and Texas was third best with a 25.9% increase.

Exploration and Development

Company data, news releases, and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the fourth quarter of 1997. The numbers preceding discussions below refer to locations on **Figure 15**.

Table 8. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1993 to 1997).

County	1993 APDs	1994 APDs	1995 APDs	1996 APDs	1997 APDs
Albany	0	0	1	1	0
Big Horn	17	3	16	53	59
Campbell	126	105	151	554	941
Carbon	35	135	50	77	84
Converse	34	74	29	20	16
Crook	29	9	15	37	26
Fremont	16	46	30	26	58
Goshen	0	0	0	0	0
Hot Springs	12	4	13	24	42
Johnson	18	16	6	16	6
Laramie	33	15	10	2	3
Lincoln	135	103	64	55	122
Natrona	36	63	80	74	59
Niobrara	5	4	4	7	8
Park	22	18	20	30	25
Platte	0	2	0	0	0
Sheridan	7	3	0	0	2
Sublette	80	113	61	118	179
Sweetwater	156	204	153	136	210
Teton	0	0	0	0	0
Uinta	48	11	11	10	27
Washakie	17	12	31	30	36
Weston	23	6	10	10	5
TOTALS	**849**	**946**	**755**	**1280**	**1908**

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, January, 1998.

1. Chevron USA began work on a Nugget test in Painter Reservoir Field. The 14-8AHPRU well will be horizontally-drilled from a surface location in SE SW section 8, T15N, R119W to a true vertical depth of 12,207 feet. The well is a mile east of Chevron's 14-18AHPRU well, a horizontally-drilled Nugget producer that was completed in August, 1996.

2. Amoco Production completed a new well in Whitney Canyon-Carter Creek Field. The 4 Champlin-457 Amoco-A in SE NE section 7, T17N, R119W flowed 28.6 million cubic feet of gas and 164 barrels of condensate per day. Production is commingled from the Lodgepole between 13,014 and 13,396 feet, the Darby between 13,500 and 13,723 feet, the Bighorn between 14,022 and 14,280 feet, and the Cambrian between 14,488 and 14,510 feet. This well establishes the first production from the Cambrian in the Overthrust Belt.

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1994 to 1997).

	1994			1995			1996			1997		
County	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	1	18	0	0	0	0
Big Horn	5	24	4	1	16	0	2	3	66	2	0	45
Campbell	13	17	50	12	24	43	32	56	220	20	52	79
Carbon	11	117	86	1	0	16	2	5	18	3	7	190
Converse	0	0	0	4	39	20	1	4	0	1	5	0
Crook	3	3	2	1	0	5	5	3	20	7	8	18
Fremont	6	12	104	6	32	56	2	5	15	6	43	126
Goshen	0	0	0	0	0	0	0	0	0	2	227	0
Hot Springs	1	9	0	2	70	9	4	17	29	1	8	0
Johnson	0	0	0	1	4	0	0	0	0	2	7	17
Laramie	3	57	0	0	0	0	0	0	0	0	0	0
Lincoln	0	0	0	2	18	110	0	0	0	3	7	116
Natrona	1	0	17	3	27	3	0	0	0	5	14	101
Niobrara	1	0	11	0	0	0	2	0	23	0	0	0
Park	1	0	7	0	0	0	6	20	82	4	56	58
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	0	0	0	1	5	0	0	0	0
Sublette	5	4	145	2	0	162	2	21	52	1	0	61
Sweetwater	4	59	0	9	17	497	8	17	670	4	66	296
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	2	0	89	0	0	0	1	0	40	0	0	0
Washakie	0	0	0	0	0	0	0	0	0	3	36	0
Weston	0	0	0	1	13	0	1	0	16	1	0	17
TOTALS	**56**	**302**	**515**	**45**	**260**	**921**	**70**	**174**	**1251**	**65**	**536**	**1124**

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

Wyoming State Geological Survey, Oil and Gas Section, January, 1998.

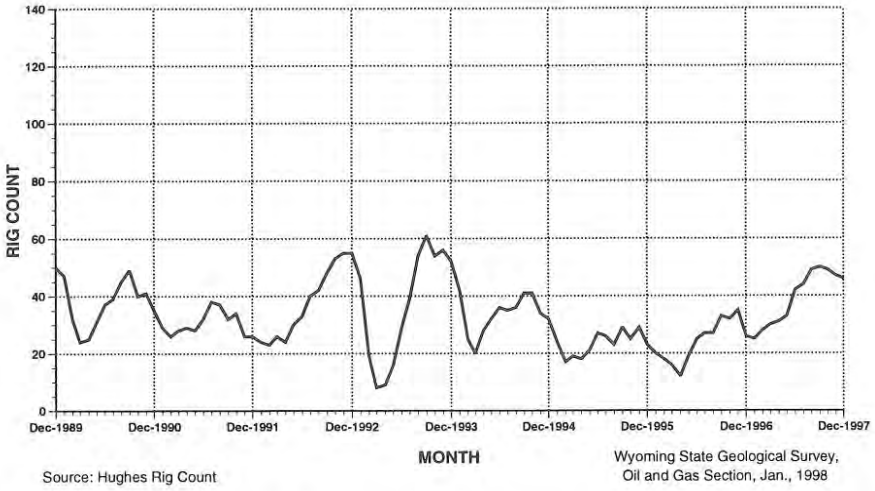


Figure 13. Wyoming daily rig count averaged by month (1990 to December 1997).

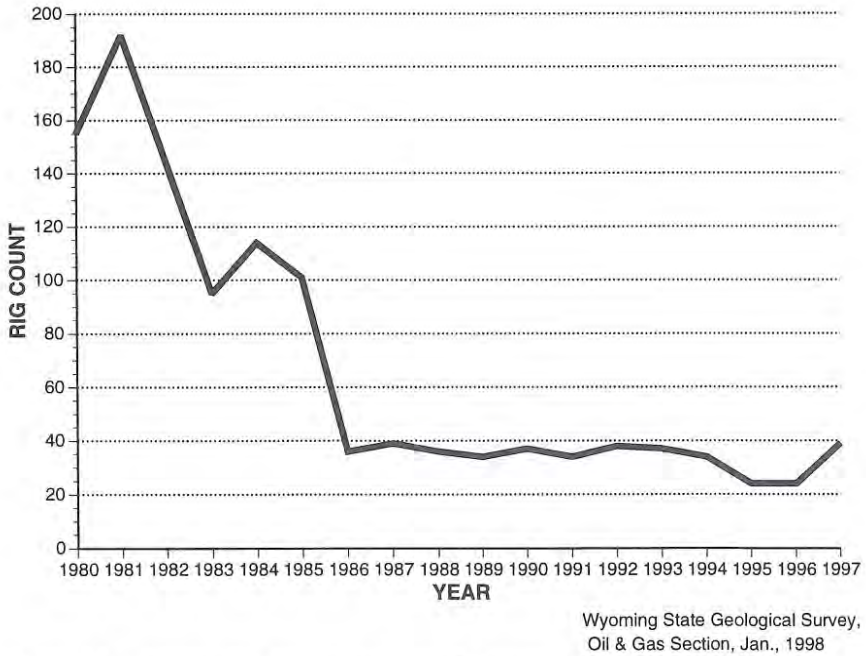


Figure 14. Wyoming daily rig count averaged by year (1980 to 1997).

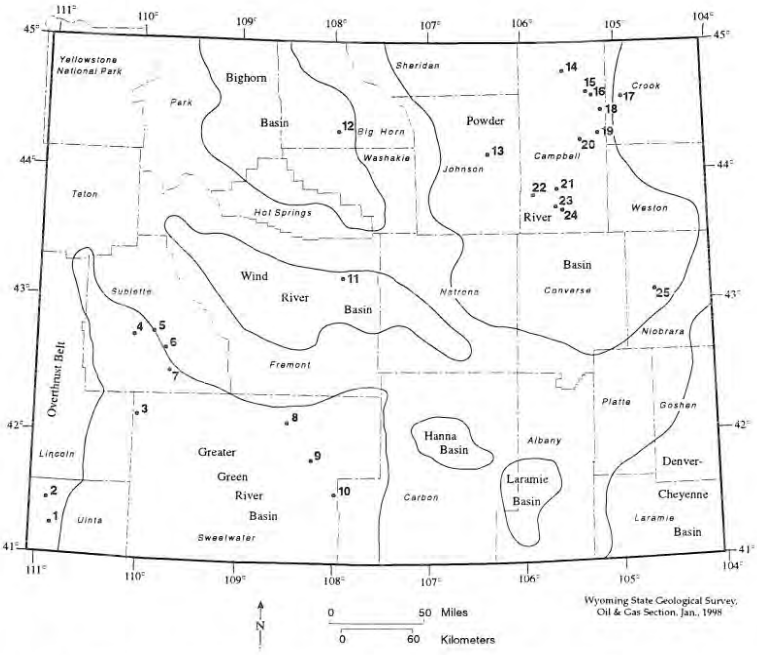


Figure 15. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 1997 (exclusive of coalbed methane activities).

3. Cabot Oil and Gas completed three new wells on the Moxa Arch. The 40-27 Little Monument Butte well in SW SW section 27, T25N, R111W, flowed 6.7 million cubic feet of gas per day from the Frontier at about 9,500 feet. The 32-28 Little Monument Butte well in SW NE section 28, T25N, R111W, flowed 2.2 million cubic feet of gas per day from an undisclosed interval in the Frontier. The 30-20 Lincoln Road well in SE SE section 20, T24N, R111W flowed 400,000 cubic feet of gas and 450 barrels of oil per day from an undisclosed interval in the Dakota.

4. Alpine Gas completed its 32-33 Cottonwood-Federal well in SW NE section 33, T32N, R111W. The well was drilled to a total depth of 11,960 feet and flowed 1.0 million cubic feet of gas per day from seven intervals between 10,810 and 11,050 feet in the Ericson.

5. Ultra Petroleum tested a wildcat well in SW SE section 8, T32N, R109W. The 15-8 Lovatt Draw well flowed 3.7 million cubic feet of gas per day from eight Lance sands between 12,450 and 12,832 feet. Ultra also tested another discovery in NE SW section 25, T32N, R110W. The 11-25 Luman flowed 850,000 cubic feet of gas per day from an undisclosed interval in the Lance. Ultra purchased a number of parcels in this area at the October U.S. Bureau of Land Management lease sale, purchased Burlington Resources'

land position on the Pinedale anticline for $11.3 million, and staked locations for additional wells in the northern part of the Greater Green River Basin. Western Gas Resources signed separate agreements with Ultra Resources (a subsidiary of Ultra Petroleum) and RIS Resources. Under the terms of the agreement with Ultra, a previous area of mutual interest was expanded to a total of 1.5 million acres in the northern part of the Greater Green River Basin. Western and Ultra, as operator, will explore and develop a minimum of 16 prospects. Any gas from those prospects will be dedicated to Western's Granger gas plant, located in T18N, R111W. Under the terms of the agreement with RIS, Western and RIS will install gathering facilities to connect the prospects to the Granger gas plant. Subject to certain approvals, RIS will have two options to purchase up to a 50% interest in the Granger and Lincoln Road gathering and processing complex for a total of $110 million. Ultra Petroleum recently received an independent analysis of its net proved reserves and probable resources for part of its acreage in the Jonah-Pinedale area. The analysis reported net reserves and probable resources, after royalties and local taxes, of 309 billion cubic feet of gas and 3.2 million barrels of condensate.

6. Western Gas Resources and Ultra Petroleum tested a wildcat well in SW SW section 28, T31N, R108W. The 13-28 Lizard Head-Federal well flowed 5.1 million cubic feet of gas per day from a Lance interval between 11,448 and 11,604 feet.

7. McMurray Oil completed a new well in Jonah Field. The 2-36 Stud Horse Butte well in NW NE section 36, T29N, R108W, flowed 2.1 million cubic feet of gas, 22 barrels of condensate, and 10 barrels of water per day from the Lance between 9,030 and 11,444 feet.

8. BTA Oil Producers discovered gas at its 1 Jade Unit 9408 JV-P well in NW SW section 11, T24N, R98W. The well flowed 581,000 cubic feet of gas, five barrels of condensate, and 23 barrels of water per day from the Lewis between 9,230 and 9,250 feet.

9. Union Pacific Resources completed a wildcat well in C SW section 23, T21N, R96W. The 4-23 Wooly Bully flowed 1.6 million cubic feet of gas and 180 barrels of water per day from perforations in the Lewis between 7,386 and 7,396 feet and 7,764 and 7,779 feet.

10. Union Pacific Resources also completed a wildcat well in SE NW section 24, T18N, R94W. The 1-24 Lister well flowed 1.1 million cubic feet of gas, 28 barrels of condensate, and 35 barrels of water per day from an undisclosed Almond interval.

11. W.A. Moncrief, Jr. completed a new discovery in NW NE section 16, T37N, R92W. The 16-1 Matador well flowed 1.2 million cubic feet of gas and 163 barrels of water per day from the Lance between 8,514 and 8,537 feet and 8,676 and 8,680 feet.

12. KCS Mountain Resources completed a workover in Manderson Field. The 12-18P (L) Manderson well in SW NW section 18, T50N, R92W pumped 326 barrels of oil and 19 barrels of water per day through perforations in the Octh Louie (Mowry) between 5,032 and 5,038 feet and 5,074 and 5,080 feet.

13. M. John Kennedy discovered oil at the 31-28 Big Cat-Federal well in NW NW section 28, T48N, R79W. The well produced 34 barrels of oil and 15,000 cubic feet of gas per day in September, 1997, from an undisclosed interval in the Sussex.

14. Trend Exploration completed a wildcat well in SE NW section 7, T55N, R72W. The 7-1 Trend-Federal well pumped 314 barrels of oil and 439 barrels of water per day from the Minnelusa between 8,723 and 8,725 feet.

15. Trend Exploration also discovered oil at a wildcat well in SW NW section 6, T53N, R70W. The 6-1 Boothill-Federal well pumped 241 barrels of oil and 128 barrels of water per day from the Minnelusa between 7,661 and 7,666 feet.

16. Lario Oil and Gas completed a new oil well in NW SW section 14, T53N, R70W. The 2 Sagebrush-Federal well pumped 240 barrels of oil per day from the Minnelusa between 7,440 and 7,446 feet.

17. L&J Operating completed an offset well to the Sidner Draw Field discovery well. The 1 Montana-Berger in SW SW section 17, T53N, R67W, pumped 61 barrels of oil per day from the Minnelusa between 6,068 and 6,097 feet.

18. Plains Petroleum completed an oil well in Bracken Field. The 21-13 BMU-Federal well in NE NW section 13, T52N, R69W, produced an average of 340 barrels of oil and 28 barrels of water per day from an undisclosed interval in the Minnelusa.

19. Barrett Resources completed a discovery well about a mile north of Minnelusa oil production in Halverson Field. The 13-31 Hoffman et al well in NW SW section 31, T50N, R69W, pumped 1,289 barrels of oil and 64,000 cubic feet of gas per day from the Minnelusa between 8,500 and 8,524 feet.

20. Fancher Oil began completion operations at a stepout well from Olsen Field. Swab tests at the 10-2 Pickrel well in NE NW section 10, T49N, recovered 10 to 12 barrels of oil per hour from the Minnelusa between 9,546 and 9,558 feet

21. Devon Energy completed two oil wells in House Creek Field. The 38-3 House Creek well in SW SE section 32, T45N, R73W, pumped 418 barrels of oil and 342 barrels of water per day from the Sussex between 8,024 and 8,048 feet. The 32-3 House Creek well in NE NW section 32, T45N, R73W, pumped 76 barrels of oil and 369 barrels of water per day from the Sussex between 8,000 and 8,028 feet.

22. Exxon Corp. completed an oil well in Hartzog Draw Field. The 4553 Hartzog Draw Unit well in SE NW section, T44N, R75W, pumped 293 barrels of oil, 57,000 cubic feet of gas, and two barrels of water per day from the Shannon between 9,480 and 9,512 feet.

23. Yates Petroleum established Muddy production in K-Bar Field with the completion of its 1 Grove well. The new well is in SE SW section 6, T43N, R73W, and is producing 80 barrels of oil per day from the Muddy between 11,498 and 11,561 feet, from the Turner between 10,508 and 10,548 feet, and from the Parkman between 7,556 and 7,634 feet.

24. Yates Petroleum also reentered a Turner discovery and recompleted it as a producer in three zones. The 1 Bunn-Federal well in SE NE section 13, T43N, R73W, pumped 84 barrels of oil per day from the Turner between 10,827 feet, from the Sussex between 8,480 and 8,494 feet, and from the Parkman between 7,516 and 7,526 feet.

25. Energas Corp. completed a wildcat well in SW NE section 36, T36N, R65W. The 2-36 Finley-State well produced 35 barrels of oil and 122 barrels of water per day during September, 1997. The well is producing from an undisclosed interval in the Lakota.

COAL UPDATE

Robert M. Lyman
Staff Geologist-Coal, Wyoming State Geological Survey

Coal delivery figures, as reported on the Federal Energy Regulatory Commission's (FERC's) Form 423, showed Wyoming leading the nation in steam coal deliveries through the third quarter of 1997. Wyoming deliveries for the period totaled 202.9 million tons (**Table 10**). Compared to 202.8 for the same period in 1996, the 1997 deliveries showed a very modest increase over the year before. **Figure 16** shows monthly coal deliveries over the past three years. **Figure 17** breaks these monthly deliveries into spot sales and contract sales.

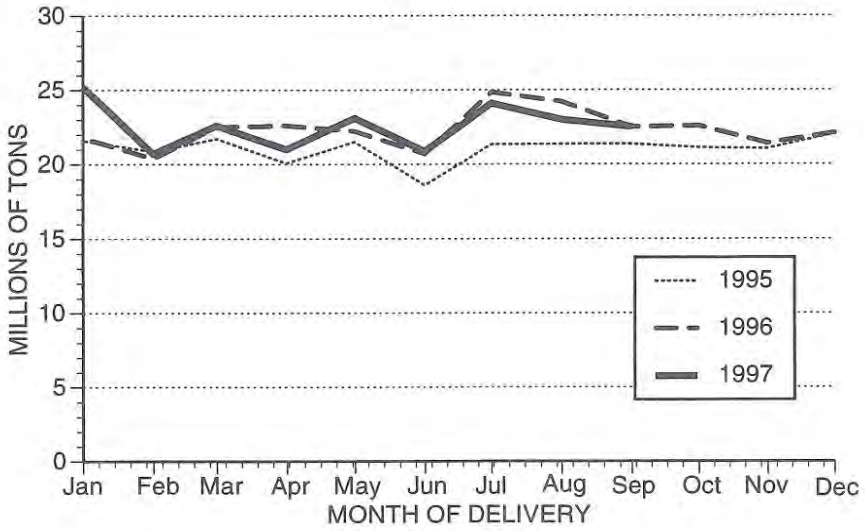
Table 11 depicts projected coal production by county. It also shows an estimate of the percentage of coal from the Powder River Basin, which sells for more than $5.00/ton. The tonnage sold at these higher prices is the remaining older long-term contracts that had escalation clauses built into them. **Table 12** shows a breakdown of average prices for coal produced in northeastern Wyoming and southern Wyoming.

Table 13 shows the permit capacity of Wyoming mines according to data from the Air Quality Division of the Wyoming Department of Environmental Quality.

Table 10. Monthly coal deliveries from Wyoming's mines in short tons (1994 to September, 1997).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	19,326,770	19,326,770	21,586,303	21,586,303	21,793,387	21,793,387	25,165,405	25,165,405
FEB	17,171,910	36,498,680	20,839,926	42,426,229	20,374,055	42,167,442	20,743,224	45,908,629
MAR	19,178,990	55,677,670	21,707,422	64,133,651	22,507,800	64,675,242	22,566,012	68,474,641
APR	17,839,110	73,516,780	20,066,616	84,200,267	22,579,959	87,255,201	20,961,008	89,435,649
MAY	18,652,290	92,169,070	21,509,916	105,710,183	22,216,016	109,471,217	23,102,867	112,538,516
JUN	17,741,480	109,910,550	18,602,505	124,312,688	20,698,814	130,170,031	20,862,610	133,401,126
JUL	18,213,540	128,124,090	21,334,608	145,647,296	24,842,971	155,013,002	24,074,929	157,476,055
AUG	20,572,120	148,696,210	21,356,870	167,004,166	24,421,537	179,434,539	23,002,254	180,478,309
SEP	19,129,450	167,825,660	21,355,730	188,359,896	23,339,792	202,774,331	22,452,566	202,930,875
OCT	18,189,260	186,014,920	21,178,610	209,538,506	22,615,721	225,390,052		
NOV	18,595,500	204,610,420	21,042,260	230,580,766	21,421,085	246,811,137		
DEC	20,866,710	225,477,130	22,032,910	252,613,676	22,105,530	268,916,667		
Total Tonnage Reported[1]		**225,477,130**		**252,613,676**		**268,916,667**		
Total Tonnage Not Reported[2]		**11,430,937**		**11,324,347**		**9,508,289**		
Total Tonnage Produced[3]		**236,908,067**		**263,938,023**		**278,424,956**		

[1] COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities (1994-1995); From bulletin board of the Federal Energy Regulatory Commission in 1996 and 1997.
[2] Includes estimates of residential, industrial, and exported coal, plus tonnages not reported on FERC's 423 forms.
[3] Wyoming State Mine Inspector's Annual Reports.
Wyoming State Geological Survey, Coal Section, January, 1998.



Wyoming State Geological Survey, Coal Section, Jan., 1998

Figure 16. Reported monthly deliveries from Wyoming coal mines (1995 through September, 1997). From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997.

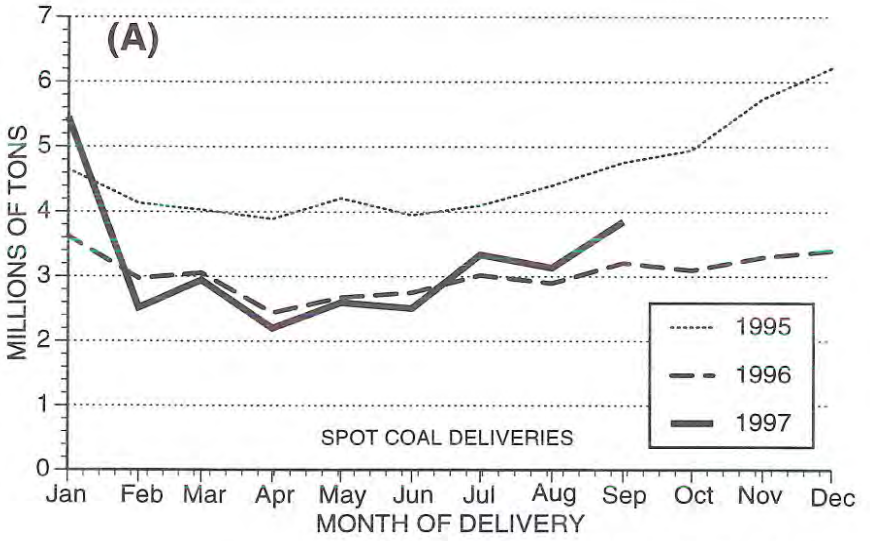
Developments in the Powder River Basin

Early in the first quarter of 1998, Kerr-McGee Corp. announced it was going to sell its Jacob Ranch mine in Campbell County. This mine produced about 27 million tons of coal in 1997 and employs 370 workers.

PacifiCorp announced plans to close their Dave Johnston mine in 1999. The mine, which is operated by Glenrock Coal Co., will continue working at full production for the next 18 to 24 months, then shift into a reclamation mode for the next three to five years. Citing poor coal quality, especially higher than desired sulfur; increasingly complex coal mining; and associated higher mine cost, PacifiCorp estimates it will net nearly $15 million in pre-tax savings each year by shutting down the mine.

The mine employs 177 workers. According to the company, 45 of the workers are eligible for an early retirement plan. Other employees may be transferred, and some positions will be eliminated by normal attrition. The mine is located near the town of Glenrock in Converse County.

In preparation to shutting the mine down, PacifiCorp plans to build a coal-handling facility, so that their Dave Johnston power plant is capable of handling rail deliveries of coal. The new coal source most likely will come from the



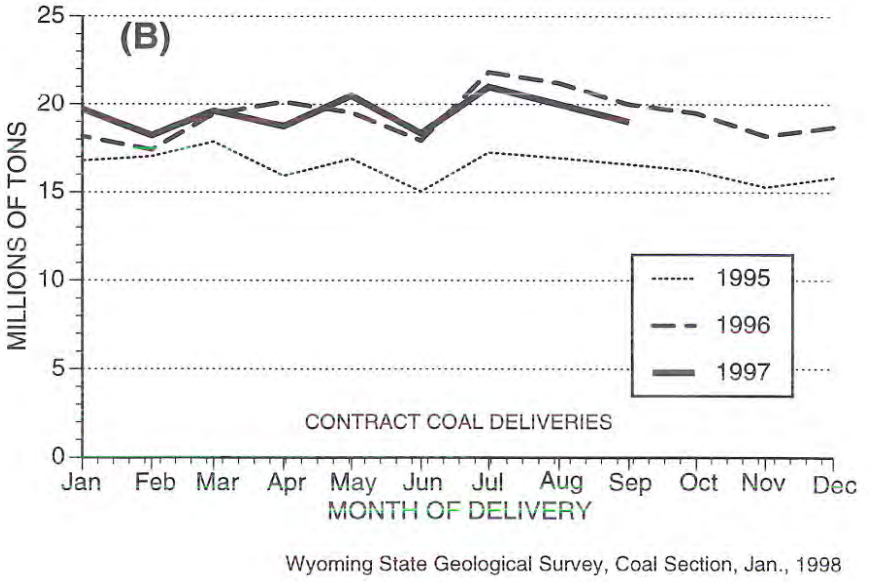


Figure 17. Monthly coal deliveries from Wyoming (1995 through September, 1997). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997).

Table 11. Wyoming coal production by county (in millions of tons), from 1993 to 1996 with forecasts to 2004.

	1993	1994	1995	1996	1997[1]	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]	2004[1]
Campbell County	181.2	205.2	232.4	245.3	249.7	265.3	282.5	304.3	316.4	319.9	323.4	326.9
Converse County	10.2	11.7	14.1	15.8	14.5	15.0	15.3	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	M
Carbon County	4.4	4.4	3.8	4.7	4.3	4.2	3.7	2.0	2.0	2.0	2.0	2.0
Sweetwater County	9.2	11.2	9.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	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	5.0
Total Wyoming	209.2	236.9	263.9	278.4	281.5	297.5	314.5	334.6	346.7	350.2	353.7	357.2
Annual Change	10.8%	12.9%	11.4%	5.5%	1.1%	5.7%	5.7%	6.4%	3.6%	1.0%	1.0%	1.0%
Higher-priced coal[2]	36%	33%	26%	24%	22%	17%	13%	9%	6%	4%	4%	4%

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

Table 12. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1996) with forecasts to 2004.

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	$5.40	$17.30	$6.15
1997	$5.33	$17.21	$6.06
1998	$5.28	$17.17	$5.97
1999	$5.19	$17.10	$5.82
2000	$5.11	$17.00	$5.64
2001	$5.03	$17.00	$5.55
2002	$4.96	$17.00	$5.48
2003	$4.89	$17.00	$5.40
2004	$4.81	$17.00	$5.32

Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1996 are derived from Wyoming Department of Revenue information; estimates for 1997-2004 are derived from the Consensus Revenue Estimating Group's report of January, 1998; and all regional breakdowns are estimated by the Wyoming State Geological Survey.

remaining Powder River Basin (PRB) surface mines, some of which PacifiCorp is currently in the process of acquiring (see below).

The British Government gave approval to PacifiCorp's $6.2 billion take-over of The Energy Group (*Coal Outlook*, 12/22/97). With one major hurdle jumped, the international deal still awaits approval from the U.S. Federal Trade Commission. The Energy Group is the parent company of Peabody Holding Company. Peabody's subsidiary, Powder River Coal Co., operates the Caballo, North Antelope, Rawhide, and Rochelle mines in the Powder River Basin.

Meanwhile, Peabody Holding Co. struck an agreement for Powder River Coal's Caballo Coal Co. to buy Montana Power's Rocky Butte reserves. Consisting of 280 million tons of recoverable coal, the purchase was agreed to on December 22, 1997 (*Coal Outlook,* 1/5/98). The Rocky Butte reserve area will extend the life of Caballo's current pit by nearly ten years.

As noted in the last issue of *Wyoming Geo-notes*, Powder River Coal intends to idle its Rawhide mine in April of 1998. Peabody will reportedly offer Rawhide's 154 employees jobs at its other mines in the PRB (*Coal Age*, 12/97).

Table 13. Permitted capacity of Wyoming coal mines in 1997[1]

Mine	County	Capacity in Million Tons/year
Belle Ayr	Campbell	25.0
Black Thunder	Campbell	55.0
Buckskin	Campbell	24.0
Caballo-Rocky Butte	Campbell	51.0
Coal Creek	Campbell	18.0
Cordero-Rojo	Campbell	60.0
Dry Fork	Campbell	15.0
Eagle Butte	Campbell	35.0
Fort Union	Campbell	9.4
Jacobs Ranch	Campbell	35.0
North Antelope	Campbell	35.0
North Rochelle	Campbell	20.0
Rawhide	Campbell	24.0
Rochelle	Campbell	30.0
Wyodak	Campbell	10.0
	Subtotal =	**446.4**
Cyprus Shoshone	Carbon	3.5
Medicine Bow	Carbon	4.0
Rosebud	Carbon	1.8
Seminoe II	Carbon	2.1
	Subtotal =	**11.4**
Antelope	Converse	30.0
Dave Johnston	Converse	4.2
	Subtotal =	**34.2**
Kemmerer	Lincoln	1.5
Skull Point	Lincoln	4.2
	Subtotal =	**5.7**
Black Butte	Sweetwater	7.0
Jim Bridger	Sweetwater	7.9
Leucite Hills	Sweetwater	2.5
Lion Coal	Sweetwater	0.3
Pilot Butte	Sweetwater	2.0
	Subtotal =	**19.7**
	Wyoming Total =	**517.4**

[1] From Air Quality Division, Wyoming Department of Environmental Quality

Letting the "rails rust" at Rawhide will not eliminate the mine's approximately 12 million tons of annual production from the PRB. Rawhide's contracts should shift easily to Powder River Coals' other mines in the basin.

In October, ARCO Inc. received several preliminary bids for their subsidiary, ARCO Coal Co. Early in November, the parent company and its investment advisors selected a short list of prospective purchasers for all or a portion of ARCO's coal assets (*Coal Outlook*, 11/3/97). Reportedly, Arch Coal, Beacon Group, Cyprus-Amax, Kennecott Energy, Kerr-McGee, and Zeigler Holding Co were invited to ARCO's Denver data center.

Early in December, Kerr-McGee and Zeigler Holding Co. were apparently dropped from the short list of contenders. Some sources suggest the bids will be between $1.6 and $1.8 billion (*Coal Outlook*, 12/8/97).

Coal Week, (12/15/97) reported that Zeigler Holding Co. had opened the door to its sale by announcing that it is exploring moves to enhance shareholder value. Zeigler is the parent company of Triton Coal, which owns the Buckskin and North Rochelle mines in the PRB.

The *Casper Star-Tribune* (12/3/97) reported the Buckskin mine had lost its main contract with Cajun Electric. Representing almost half of the mine's annual production, the loss of the contract may force Zeigler to idle the mine by the middle of 1998. Zeigler's other mine in the PRB, the North Rochelle mine, is scheduled to open in late fall of 1998. By that time, North Rochelle could probably supply the remaining Buckskin commitments.

SGI International said a study by Hill & Associates indicates a strong market for ENCOAL's upgraded coal-derived solid fuel (*Coal Outlook*, 11/17/97). The market demand for PDF (Process Derived Fuel) was estimated at 21 million tons per year by the year 2000, and growing to 74 million tons per year by 2011.

In November, Kennecott Coal outlined the company's Wyoming expansion plans (*Coal Outlook*, 11/10/97). The main plan calls for boosting annual production from the Cordero Rojo complex and the Antelope mine, from their current 44 million tons per year level to 76 million tons per year by 2001.

Antelope will increase production from 14 million tons to 24 million tons by 1999. With the addition of a second dragline by 2001, production should reach 30 million tons per year.

At the Cordero Rojo complex, a second dragline is now under construction. Addition of the new machine will boost the mine's yearly production to 46 million tons by the year 2000.

KFx Inc. put their facilities back into commercial production the first week of December. KFx is reportedly doing their own mining out of Pit No. 1 of the Fort Union mine (*Coal Outlook*, 12/1/97). Using coal from the Fort Union mine is reportedly a stop gap measure until a 10-year contract can be finalized with the Dry Fork mine. Under current plans, the KFx facility should produce 500 thousand tons per year of the upgraded coal product.

Coal Outlook (10/13/97) reported that North American Power Group had received enough customer interest to begin construction of their proposed 250-MW Two Elk power plant this spring. The plant site is located next to the Black Thunder mine. The plant will burn waste coal from surrounding area mines.

Developments in southern Wyoming

The Laramie Daily Boomerang (12/9/97) reports that Cyprus Shoshone Coal Co. will reduce production by 25% in 1998, because of transportation problems and loss of spot market sales. This year the Hanna Basin operation produced nearly 2.8 million tons. Next year, their production target is only 2.1 million tons. This is the only active underground coal mine in Wyoming.

Cyprus Shoshone began downsizing its workforce in light of the reduced production target *(Casper Star-Tribune*, 1/10/97). The company is trying to avoid direct layoffs, hoping to reduce the mine's work force by 22. This would reduce the number of employees to 120. The company hopes to effect the reduction using natural attrition, retirement, and employee transfers to other company operations. Currently, there are 700,000 to one million tons of coal stockpiled at the mine.

In February, Nevada regulators will begin allowing Sierra Pacific to buy down their above-market Black Butte coal contract for their Valmy plant. Between February and the end of 1999, whenever Sierra Pacific's net earnings exceed 12%, the utility may take the excess and either buy down the coal contract, or give a refund to its customers. The Black Butte contract has been receiving accelerated takes and should expire by the end of 1999.

Sierra Pacific said that at this point, on a present-value-basis, there is nearly $19 million in excess cost associated with the Black Butte contract (*Coal Outlook*, 11/3/97). Sierra Pacific is responsible for 50% of the value; Idaho Power also has a 50% interest in the contract.

Transportation developments

Rail service in Wyoming in 1997 was so poor that coal production at some mines was curtailed. Coal shortages at several utilities caused them to limit burns, seek alternate coal sources, and file some lawsuits (*Coal Age*, 12/97).

Empire District Electric Co. filed a suit against both the Union Pacific/Southern Pacific (UP/SP) and the Kansas City Southern railroads in a Missouri court alleging breach of service standards. Empire stated; however, that its suit was an ongoing dispute and not related to the current problems of the UP/SP line (*Coal Outlook*, 10/13/97).

Entergy sued UP/SP in Federal court at Baton Rouge, Louisiana, seeking damages and release from coal hauling contracts serving their plants at Independence and White Bluff, Arkansas. Both plants were reportedly operating at less than full capacity due to low fuel stockpiles. Entergy said that its contract with the railroad prevented them from hiring other railroads to haul their coal. The two power plants account for over 12% of the company's output of electricity.

Coal Outlook (11/24/97) reported that San Antonio Public Service Co. is buying Colombian coal to cover delivery shortfalls from the Powder River Basin (PRB). The shortfalls were blamed on the UP/SP railroad.

Central Louisiana Electric Co. (CLECO) will test a rail-barge-truck sequence in hauling coal from the PRB to its Rodemacher plant (*Coal Outlook*, 10/13/97). CLECO wants to test the multi-modal transportation for comparison to single rail haul. The reason given was that "the UP/SP is not meeting our needs".

The Burlington Northern-Santa Fe (BNSF) railroad took over some of the UP/SP coal deliveries. The BNSF agreed in October to haul a portion of the UP/SP's coal volume to Texas utilities, sending one train set into service for the Lower Colorado River Authority, and two more train sets to increase service to City Public Service of San Antonio. Also in October, two BNSF train sets were dedicated to serve TVA in moving PRB coal to their Shawnee steam plant. BNSF also dedicated two trains to the Southern Co. to move PRB coal to Southern's Scherer plant (*Coal Outlook*, 10/17/97).

BNSF also had its own problems during the fourth quarter of 1997. The Surface Transportation Board (STB) ordered the BNSF to pay $11.4 million to West Texas Utilities for excessive rates in coal hauling over a period from 1994 through the third quarter of 1997.

On a more positive note, *Coal Outlook* (1/5/98) reports, that the BNSF railroad predicts a 9% increase in its coal business in 1998. They estimated they moved 202 million tons of coal in 1997, and expected to move 220 million tons this year.

Dakota, Minnesota, and Eastern Railway Corp. (DM&E) has selected its southern route, which parallels much of the Cheyenne River drainage, from Wasta, South Dakota, to its entrance into the Powder River Basin, terminating south of Gillette near the North Antelope mine. According to a story in the *Laramie Daily Boomerang* (1/8/97), the DM&E is also considering a spur line to the Antelope mine in Converse County. While coal groups are welcoming the new railroad, some ranchers are trying to stop the new line.

One effort to discourage the new line is led by the Mid-State Coalition for Progress. The coalition wants to change Wyoming's laws on eminent domain to exclude railroads.

Coalbed methane developments

The *United States Court of Appeals for the Tenth Circuit*, in the case of the Southern Ute Indian Tribe v. Amoco, reversed a lower court decision by saying that coal reserves, covered under the Federal Coal Lands Act of 1909 & 1910 includes the coalbed gas. Prior to this ruling, a 1981 Solicitor's opinion ruled that coalbed gas was not part of the coal mineral estate. Consequently, a coal lease did not include coalbed methane.

The U.S. Bureau of Land Management (BLM), under their Coalbed Instruction Memo #98-28, is advising their oil and gas lessors that development of coalbed gas from federally owned coal is at their own risk. In regards to those areas where the coal is non-federal, the BLM may continue work on environmental assessments (EAs), but they cannot approve any APDs, nor issue any new Federal oil and gas leases for coalbed gas on such lands.

If the ruling stands, it calls into question the BLM's leasing of coalbed methane in areas where the coal estate is not owned by the Federal government. It also calls into question non-federal, coalbed gas leases on areas of federally owned coal reserves.

Chevron USA Production Co. has scheduled a 3,000-foot wildcat well to evaluate the coalbed methane potential of the basal Evanston Formation (Upper Cretaceous) in the Overthrust Belt, three miles east of Evanston, Wyoming (*Rocky Mountain Region Report*, 11/18/97). The estimated top of the targeted Evanston Formation coal is at a depth of 2,250 feet.

Barrett Resources Corp. (Barrett) and Western Gas Resources (Western) disclosed an agreement between Barrett and Lance Oil & Gas Co. Inc., a newly formed subsidiary of Western. The agreement calls for joint development of coalbed methane reserves in the northeast portion of the Powder River Basin (*Rocky Mountain Region Report*, 11/4/97).

Reportedly, the two partners collectively control over 250,000 acres, producing approximately 24 million cubic feet of methane per day. The partner companies have outlined an area of mutual interest (AMI) consisting of 2.1 million acres in an area extending from Gillette south to Wright in Campbell County. Within the AMI, both partners will develop certain specific areas. Barrett will be the principal operator over the next twenty months. Western has agreed to buy all the coalbed gas produced from within the AMI. Western also agreed to install additional compressor and transmission facilities as needed to handle the increased gas volume.

Coastal Corp.'s pipeline affiliate, Wyoming Interstate Co. Ltd. (WIC), is seeking regulatory approval for another expansion to its pipeline capacity. New compression will boost capacity in the Powder River Basin lateral pipeline by 52 million cubic feet per day. Coastal Corp.'s subsidiary, Colorado Interstate Gas Co. (CIG) owns the lateral. WIC proposes to lease capacity on CIG's lateral for delivery of coalbed gas to Midwest markets. Assuming approval and no regulatory delays, the expansion in service is slated for completion by November 1, 1998 (*Rocky Mountain Region Report*, 12/16/97).

Regulatory developments

The U.S. Environmental Protection Agency (EPA) has finalized its Toxic Release Inventory (TRI) rule, under Sec. 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). The coal industry is directly impacted by this rule. The electric utility industry must report the burning of coal as a toxic release due to the chemical nature of coal (*The Coal Journal*, Winter, 1997).

The EPA recently released two documents which may help coal producers comply with the new rule. One document is titled *Guidelines for coal mining facilities*. The other is known as *EPCRA 313 question and answers*. Both are available from EPA's Internet site or by calling 1-800-535-0202.

The Office of Surface Mining (OSM) is reportedly exploring the possibility of allowing companies that are involved in the reclamation of abandoned mine sites, to sell coal recovered during the site clean-up (*Casper Star-Tribune*, 10/24/97). This would help to offset cleanup costs.

OSM has proposed two new rules under the Surface Mining Reclamation and Enforcement Act (SMCRA) (*Coal Age*, 11/97). The first states "neither subsurface activities that may result in subsidence, nor actual subsidence, would be prohibited on lands protected by Sec. 522(e) of SMCRA". Section 522(e) deals with the designation of lands unsuitable for surface mining. The second rule states that for a coal property owner to have a valid existing right, the owner must have obtained all state and Federal permits and other necessary authorization before 1977. That was the year SMCRA became law.

The U.S. Department of Labor's (DOL's) proposed black lung regulations may result in $3.3 to $7.1 billion in additional overall costs to the nation's coal operators, insurers, and the Federal Black Lung Disability Trust Fund (*Engineering and Mining Journal*, 10/97). According to the article, various interest groups, including the National Mining Association, are opposed to the new regulations.

Global Warming is a current topic in the coal community. In an article in the *Laramie Daily Boomerang* (12/9/97), University of Wyoming Professor Jay Shongren reported that economic models indicate that 60% to 80% of the cost of reducing greenhouse gas emissions of this country would fall on the coal industry and utilities. This could triple the cost of using coal, forcing utilities to shift to other fuel sources.

Market developments and opportunities

Coal Outlook (12/1/97) reported that several companies attended a conference to look at what effects trading of electricity futures and coal futures might have on their industry. The meeting's look at coal futures included an update on the status of a proposed coal filing contract from the New York Mercantile Exchange. Companies in attendance included Zeigler, Cyprus-Amax, Kennecott Energy, and Powder River Coal Co., among others.

As reported by *Coal Market Bulletin* (12/8/97), Powder River Basin (PRB) coal prices remained firm during the final months of 1997. With diminished rail service, several mines and mining companies up for sale, a few mines idled or slated for idling, and reports that much of the 1998 production was already sold out, production figures and sale prices were hard to track in 1997. And coal buyers are still receiving mixed signals on the availability of PRB coal in 1998.

Some utilities, such as Wisconsin Utility which is seeking bituminous coal for its Pulliam plant, are trying to switch coal sources to offset less timely shipments from their traditional coal suppliers (*Coal Outlook*, 11/3/97). This might open a market for the bituminous coals in southern Wyoming.

Houston Lighting & Power announced that it is looking at buying non-lignite fuel. The alternatives should include PRB coal for all or part of its needs at its Limestone generating station (*Coal Outlook*, 10/13/97).

Coal Outlook (10/13/97) also noted that Central Electric Power Co. would likely convert their Chamois plant to PRB coal. The earliest switch would be spring of 1999. A phase II plant, Chamois can burn PRB coal and comply with sulfur dioxide limits without a scrubber. The plant could burn 200,000 to 250,000 tons per year.

In regard to compliance with Phase II of the Air Quality Act, a strategy of some utilities includes increasing their burn of PRB coal, which produces less sulfur and NOx than some Eastern U.S. coals (*Coal Week*, 11/10/97). Late last year, Tampa Electric announced that they will increase the use of PRB coal at their Big Bend and Gannon stations to reduce NOx emissions (*Coal Outlook*, 11/17/97).

Central Louisiana Electric Co. (CLECO) said that a test of PRB coal caused no problems at their Dolet Hill plant, which currently burns Louisiana lignite.

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

Reference cited

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

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

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	Alabama Power	Miller	Powder River Basin	C	8.5 million in 1999 7.0 million in 2000 5.0 million in 2001	Two producers. One producer. Two producers.
2.	Arizona Public Service Co.	Cholla	Powder River Basin	So	240,000-360,000 t	Delivery starting near end of first quarter 1998.
3.	Central Louisiana Electric Co.	Rodemacher	Jacobs Ranch/PRB	So	300,000 t	Spot for 1998 on UP/SP.
4.	Colorado Springs	Nixon	Jacobs Ranch/PRB Belle Ayr/PRB Antelope/PRB Cordero Rojo/PRB	T T T T	Two trains One train Three trains One train	After November 10, 1997, plan to run with a 30% PRB coal blend.
5.	Commonwealth Edison	Unspecified	Black Thunder/PRB Jacobs Ranch/PRB Rochelle/PRB	C C C	4,000,000 t/y 3,000,000 t/y 4,500,000 t	1998 to 2000. 1998 to 2000. For 1998 delivery.
6.	Detroit Edison	System wide	Black Thunder/PRB	Sp	up to 3,000,000 t	1998 delivery.
7.	Grand Island Electric	Platte	Jacobs Ranch/PRB	Sp	350,000 t	8700 Btu/lb. @ $4.25/t FOB mine.
8.	Grand River Dam Authority	Unspecified	Powder River Basin	So	500,000 - 1,000,000 t/y	Delivery over 1 to 3 years.
9.	Illinois Power and Light	Havana	Medicine Bow/Hanna	Sp	100,000 t	Originates on the UP/SP with final delivery via the Illinois & Midland.
10.	Kansas City Board of Public Utilities	Unspecified	Cordero Rojo	Sp	350,000 t	Supplemental coal for 1998.
11.	Lansing Board of Water	Eckert	Antelope/PRB	Sp	500,000 t	For 1998 delivery.
12.	Lower Colorado River Authority	Unspecified	Coal Creek/PRB Cordero Rojo/PRB	Sp Sp	200,000 t 200,000 t	8400 Btu for delivery in first quarter of 1998.

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

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
13.	Mid-American Energy (broker)	Several in Iowa	Cordero Rojo/PRB	Sp	400,000 t	For 1997 delivery.
			Buckskin/PRB	Sp	1,100,000 t	For 1998 delivery.
			Rochelle/PRB	Sp	1,100,000 t	For 1998 delivery.
			Caballo/PRB	Sp	1,100,000 t	For 1998 delivery.
			Shoshone/Hanna	Sp	300,000-400,000 t	For 1998 delivery.
14.	Oklahoma Gas and Electric	Unspecified	Powder River Basin	So	6,400,000 t	1,500,000 t for 1998 delivery, rest in 1999 (backup if North Rochelle not on line by second half of 1998.
15.	Omaha Public Power District	North Omaha & Nebraska City	Triton Coal/PRB	Sp	300,000 t	To be shipped before end of 1997.
			Coal Creek/PRB	Sp	1.7-2.1 million t	To be shipped on BN/SF.
			Powder River Basin	So	2.4-4.8 million t	Over 5 years starting in 1999.
16.	Ontario Hydro	Nanticoke	Antelope/PRB	Sp	1.5 million t	1998 delivery.
			Cordero Rojo/PRB	Sp	150,000 t	1998 delivery.
			North Antelope/PRB	Sp	500,000 t	1998 delivery.
			Antelope/PRB	Sp	1.5 million t	1999 delivery.
17.	Portland General Electric	Boardman	Rochelle/N. Antelope/PRB	Sp	300,000 t	Delivery begins 2nd quarter 1998.
			Cordero Rojo/PRB		500,000 t	Delivery begins 2nd quarter 1998.
			Jacobs Ranch/PRB		500,000 t	Delivery begins 2nd quarter 1998.
18.	Tampa Electric Co.	Gannon	Jacobs Ranch/PRB	Sp	1,000,000 t	Equal monthly shipments.
19.	Texas Municipal Power Agency	Gibbons Creek	Cordero Rojo/PRB	T	200,000 t	Test made from listed mines; potential 2-year supply contract beginning in 1998.
			North Antelope/PRB	T		
			Coal Creek/PRB	T		
			Caballo/PRB	T		
			Black Thunder/PRB	T		
20.	Tennessee Valley Authority	Unspecified	Antelope/PRB	C	1 million t/y	Six years with reopener in the middle.
21.	Western Fuels	Sikeston (MO)	Black Thunder/PRB	C	1 million t/y	5-year contract.

[1]Data obtained from : Coal Week©, Coal Outlook©, Coal Market Bulletin©, FERC database, and personal contacts.
C =contract coal; Sp =Spot coal;So =solicitation; T =Test burn; t =short ton; t/y =short tons per year; PRB =Powder River Basin
Wyoming State Geological Survey, Coal Section, January, 1998.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

Construction Aggregate

Rissler McMurry permitted a new crushed rock aggregate quarry east of Guernsey in November (**Figure 18**). The source rock is dolomitic limestone from the Pennsylvanian Hartville Formation. Dolomitic limestone from the Hartville Formation is used for aggregate production at other sites, such as the Gray quarry north of Glendo (**Figure 18**).

The U.S. Corps of Engineers (CE) plans to remove approximately 12,300 cubic yards of gravel from the main channel of the Hoback River northwest of Bondurant in Sublette County (**Figure 18**). According to the CE, unusually large amounts of gravel have washed into the river above this site from high runoff during the last two spring snowmelts. The gravel has constricted the main channel of the river, which may cause the river to flood and seek a new channel, as it has done in the geologic past. The removed gravel will be given to a sand and gravel producer in Jackson, where it will be stockpiled and used for construction aggregate.

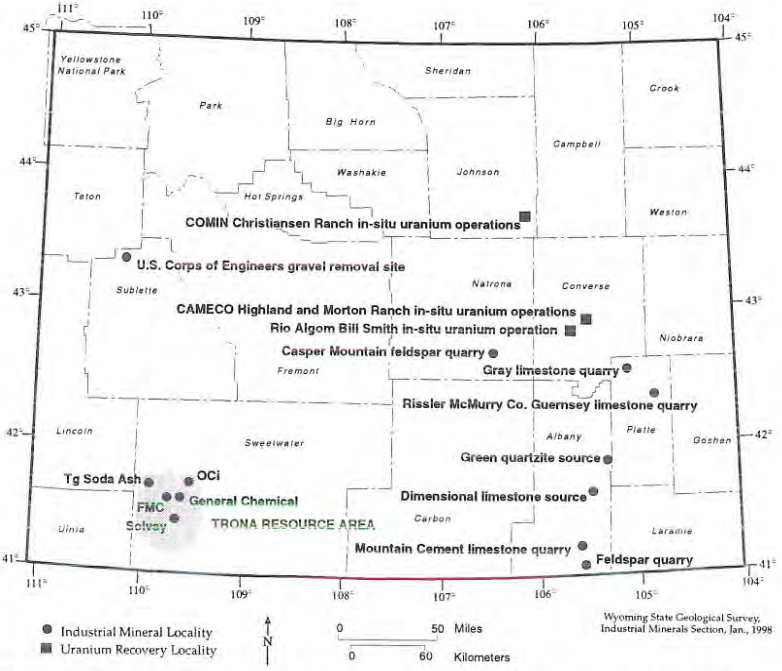


Figure 18. Map of Wyoming showing industrial mineral and uranium localities of interest, fourth quarter, 1997.

Decorative Stone

The Wyoming State Geological Survey (WSGS) and the Wyoming Department of Commerce sponsored a booth at the StonExpo '97 in Denver in November. Over 500 attendees visited the convention. As a result, companies from South Africa and Saudi Arabia expressed an interest in investing in Wyoming's decorative stone resources, and are planning visits to the state to locate and assess quarry sites and potential fabricating plant sites.

Also as a result of Wyoming's booth at the StonExpo, a small producer of lapidary stone visited Wyoming in late November. With assistance from the WSGS, Penney's Gems of Beaver, Utah, located a source of green quartzite in Albany County for producing small, carved figurines (**Figure 18**).

The WSGS located a source of dimensional limestone for a potential producer. The quarry site is in the Pennsylvanian Casper Formation. It is located 30 miles north of Laramie adjacent to Wyoming State Highway 34 (**Figure 18**). Feasibility studies will be conducted by the producer in the spring of 1998.

Feldspar

A new feldspar quarry will open south of Laramie, in Albany County (**Figure 18**). The landowner obtained a permit to mine from the Wyoming Department of Environmental Quality. He intends to sell the orange-pink feldspar to decorative aggregate retailers in Colorado. The other feldspar production in Wyoming is from Casper Mountain, in Natrona County. The Casper Mountain quarry is operated by Colorado Quarries. This feldspar is shipped to the Pacer Corporation in Custer, South Dakota, where it is used in high-purity ceramic glazes.

Limestone (chemical-grade)

Mountain Cement acquired a permit for a new limestone quarry southeast of Laramie (**Figure 18**). Limestone from the new quarry will be used to produce cement at Mountain Cement's plant south of Laramie. When opened, limestone from the new quarry will replace limestone from previously mined-out quarries. These limestones are all in the Pennsylvanian Casper Formation.

Trona

Trona is mined at five localities in the Green River Basin west of the town of Green River, and refined into soda ash and other sodium-based products at refining plants near the mines. The operators, FMC Wyoming, General Chemical Partners, OCi, Solvay Minerals, and Tg Soda Ash are all planning or constructing for increased sodium product capacity (**Figure 18**). Due to a slowdown of railroad shipments, trona producers reduced the rate of trona production during the fourth quarter of 1997. This may result in a decline in production from the 1996 level.

The financial problems with Far Eastern stock markets may reduce the amount of trona mined in Wyoming in 1998. The Far East is a buyer of Wyoming soda ash, and if the financial situation creates an economic slowdown in this region, orders for Wyoming soda ash could decline, resulting in a decline in the amount of trona mined in Wyoming.

Trona is Wyoming's most important industrial mineral in terms of production value. It ranks fourth in value of all mineral products produced in Wyoming. The top five, in order of value in 1996, were: oil, coal, natural gas, trona, and bentonite. The total valuation of all minerals in Wyoming that year was $3.9 billion, which is slightly greater than the $3.3 billion total valuation of all other sources of revenue for Wyoming (Consensus Revenue Estimating Group, 1997).

Uranium

The price of domestic yellowcake decreased in the fourth quarter of 1997, reversing a three-month increase that began in October, 1997. As reported in the September edition of the *Rocky Mountain Scout*, the December 31 price of restricted uranium was $12.05 per pound, down from a year-high $12.75 per pound on Dec. 1, 1997 (**Figure 19**).

Uranium continues to be produced at three in-situ localities in Wyoming: CAMECO's Highland and Morton Ranch operations, COMIN's Christiansen Ranch operation, and Rio Algom's Smith Ranch operation (**Figure 18**).

In regard to the reclamation of old uranium mill sites and tailing ponds, the last issue of *Wyoming Geo-notes* erred in who was reclaiming Federal American Partners' old uranium mill site. Because American Nuclear Corp. forfeited their bond in 1994, the Land Quality Division (LQD) of the Wyoming Department of Environmental Quality has let two contracts that have resulted in the reclamation and stabilization of most of the surface. The LQD is awaiting Title X reimbursements from the U.S. Department of Energy to complete the surface reclamation. The LQD also cautions that while reclamation of uranium tailings ponds may be completed in the next few years, remediation of contaminated ground water at most of the sites may add additional years onto reclamation efforts.

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Consensus Revenue Estimating Group, 1997, Wyoming State Government Revenue Forecast FY1998-FY2004: Consensus Revenue Estimating Group report, October, 1997, 21 p.

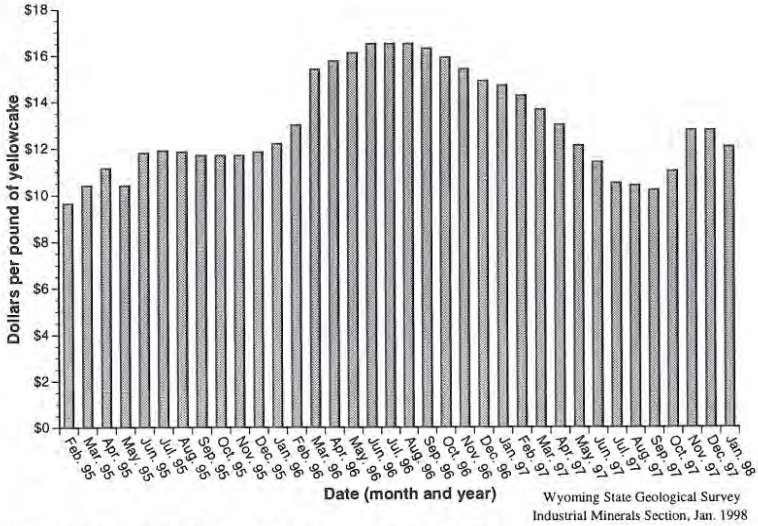

Figure 19. Domestic yellowcake prices, February 1995 through January 1998.

METALS AND PRECIOUS STONES UPDATE

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

In spite of worldwide economic troubles in the mining industry, the Wyoming State Geological Survey (WSGS) continued receiving numerous inquiries into the State's resources of metals and precious stones. Most inquiries were directed at the State's diamond potential, with other inquiries about platinum-group metals, nickel, copper, iron, titanium, silver, and gold resources. During the past six months, a few properties were acquired by companies, and drilling programs were scheduled for the 1998 field season.

The WSGS continued to evaluate the diamond potential of the Wyoming craton. It is believed that with a significant increase in exploration effort, the State could become an important province for diamonds, as much of Wyoming is considered to have moderate to high potential for the discovery of diamond deposits.

Due north of Wyoming, significant exploration activity in Canada has led to several recent diamond discoveries in the Northwest Territories, such that Canada will probably become the world's leading diamond producer within the first few decades of the 21st Century. Major diamond mines are scheduled to come on line in late 1998, which will result in a brand new billion-dollar industry, where one did not previously exist for the country. As an example of the potential value of a diamond industry, DeBeers reportedly produced $2.75 billion in diamonds from their South African mines in 1980 for a net of $800 million. At today's prices, that would be considerably higher. *The Economist* (11/

20/97) reported that 1996 sales of gem diamonds amounted to $52 billion. And while most mined commodities have declined in price, diamonds have shown a 50% increase in price from 1986 to 1996.

Diamond exploration activity in Canada in recent months has extended to a region north of the Wyoming craton in Saskatchewan and Alberta. Since these provinces have similar cratonic environments as Wyoming, one can anticipate that it is just a matter of time before Wyoming realizes substantial increased exploration interest for diamonds.

Similar activity can be expected to extend into Wyoming in the future, due to the geological similarities between the Wyoming Province and the Hearne Province of Saskatchewan and Alberta. Wyoming could take advantage of this activity with increased field and laboratory research related to diamond deposits. The WSGS has considerable expertise in diamond exploration and evaluation, with more than 20 years experience in this complex field. This experience is very helpful because diamond exploration targets are difficult to find and have unique and rare minerals associated with the deposits. Typically diamonds are associated with very small pipes or dikes (often less than 20 acres in surface area) that erode rapidly and are often covered by alluvium. The pipes; however, release unique minerals into the surrounding drainages which can be found through panning. These minerals are extremely rare, and are not easily identified. But once found, geochemical studies of these kimberlitic minerals can provide valuable information on the potential diamond grade of the source pipe. If more minerals of favorable geochemistry are identified, Wyoming could expect a major diamond rush similar to Canada.

To aid prospectors and geologists in the exploration for diamond pipes, the WSGS will schedule some Diamond Exploration Short Courses in the upcoming year. For further information, watch upcoming issues of *Wyoming Geo-notes*, or contact W. Dan Hausel at (307) 766-2286 (dhause@wsgs.uwyo.edu).

Diamond Exploration

Green River Basin: Company exploration continued throughout 1997. Some success was reported in the Green River Basin where at least three companies were known to be searching for diamonds. Guardian Enterprises Ltd. reported a total of 115 claims had been staked and seven State leases had been acquired in a 240-square-mile region of southwestern Wyoming (Guardian Enterprises, press release, 8/27/97).

Guardian Enterprises reported in November that they had discovered another pipe 2,500 feet north of their DK pipe. The DK pipe previously was reported to have yielded three gem-quality diamonds from 30 feet of core during sampling (Guardian Enterprises, press release, 11/25/97). This was the 11th pipe found in this area by Guardian. Guardian also reported that another probable pipe was found 8 miles northeast of the other 11 pipes. Several circular to elongate magnetic anomalies were detected in the area near the newly discovered anomaly, suggesting that a second cluster of pipes may occur in this area.

Another interesting anomaly was discovered near Carter in southwestern Wyoming, by a local rock hunter from Ft. Bridger (Jerry Yates, personal communication, 1997). Several out-of-place rounded cobbles and boulders of Madison Limestone (?), andesite porphry, and basalt were found in Bridger Formation (Tertiary) siltstones. The source of these rocks has yet to be determined and is enigmatic, as andesites are rare in cratonic environments. The only known andesite porphyries in Wyoming are in the Absaroka Mountains and Yellowstone area more than 150 miles to the north. However, this Tertiary volcanic field is separated from the Green River Basin by the Laramide-age Wind River and Gros Ventre mountain ranges. In hand specimen, the andesites have porphyritic texture with black amphibole phenocrysts set in a grey groundmass. Preliminary petrographic analysis of the andesites show relatively fresh hornblende and plagioclase phenocrysts with altered sanidine (?) phenocrysts in an aphanitic groundmass containing microphenocrysts of plagioclase in a trachyitic texture. The source of these rocks is unresolved.

Leucite Hills: During the 1997 field season, the WSGS completed the first phase of the Leucite Hills volcanic field study to the north of Rock Springs, by mapping and sampling all of the known lamproites in the district. The volcanic field is located on the Rock Springs uplift, which is partially overlain by a dune field along its northern edge. The dune field has been interpreted as a major east-west structure (Gordon Marlatt, personal communication, 1996); however, fieldwork was unable to verify or disprove the presence of a major structure associated with the sand dunes. This feature was prospected for the presence of hidden olivine lamproites with no success.

Currently, the WSGS is completing petrographic studies on the Leucite Hills lamproites, and the WSGS lab is processing rock collected from the various lamproites to search for diamond and diamond-indicator minerals. One interesting discovery during the project was gem-quality olivine (peridot) associated with the olivine lamproites along the northeastern margin of the field. At one locality, the author discovered anthills with so much peridot, that they were actually green. More than 10,000 carats of peridot were collected from just two anthills.

The peridot from the anthills were as much as 8 mm in length (the maximum size that could be carried by the ants), transparent to translucent, and ranged in color from beautiful olive-green to reddish brown. Larger grains (greater than one inch) were found in the host rock near the anthills. Whether or not this district contains diamonds, there appears to be some potential for peridot recovery on a small scale.

In addition to the peridot, several chromite grains were recovered and are scheduled for microprobe analysis (some chromites can be used as a diamond indicator in olivine lamproites). This could be a significant find as some chromite from the Leucite Hills was reported to have geochemistry similar to diamond-inclusion chromites (Robert Kirkwood, personal communication, 1997).

State Line district: Exploration activity continued in the State Line district during 1997, with some companies attempting to gain access to kimberlite on

the Wyoming side of the district. Redaurum's Kelsey Lake mine continued to produce large diamonds including a 28.18-carat gemstone that was cut into an attractive 16.8-carat gem (*Denver Post*, 9/25/97).

In a surprise development, Redaurum was reported to be getting out of the diamond business and put all of its mines up for sale according to the *Northern Miner* (12/22-28/97). The company holds 50% interest in the River Ranch diamond mine in Zimbabwe, 80% interest in the Avontuur mine in South Africa, and 100% of the Kelsey Lake mine along the Colorado-Wyoming border. According to the Northern Miner, 65% of diamonds recovered from Kelsey Lake are gem quality with about 50% weighing more than 1 carat, and the mine is believed to be capable of producing 600,000 tonnes of ore per year over a mine life of 15 years. The Avontuur mine has been producing 93% gemstones. In addition, the Kelsey Lake mine has produced several of the largest diamonds found on the North American continent.

Iron Mountain district: The WSGS continued processing samples from the Iron Mountain district in the Laramie Mountains northeast of Laramie. The district was examined by WSGS staff this past field season and a few additional, small kimberlites were discovered during field investigations. Most of the kimberlites were sampled for petrographic and geochemical studies. In addition, samples were collected for diamond testing, principally because the kimberlites have yielded some diamond-inclusion pyropes (McCallum and Waldman, 1991).

Other Gemstones

The WSGS continued to evaluate gemstone occurrences in Wyoming, and continued to collect data and conduct research for a publication on the State's gemstone and lapidary occurrences. The WSGS also continued to examine rubies and sapphires collected in the Palmer Canyon area west of Wheatland, and in the Tin Cup district northwest of Jeffrey City. Samples of nephrite jade collected in the Jeffrey City area were also examined along with wallrock alteration associated with the jade. The style of wallrock alteration appears to be unique, and possibly could be used as a guide to hidden jade deposits. This could be very useful in the search for commercial jade mineralization as much of the significant jade mineralization has long been mined out.

Wallrock alteration associated with nephrite jade produces a bleached leucocratic granitic gneiss. The altered gneiss typically is mottled pink, white, and green due to secondary pink to green clinozoisite, pink zoisite, pistachio green epidote, lavender microscopic lepidolite, and plagioclase that is pervasively altered to white mica. This unusual alteration assemblage was recognized at essentially every jade occurrence in the district, as well as at a few unprospected localities, suggesting the presence of shallow, undiscovered, jade mineralization.

Another interesting gemstone was discovered by the WSGS in 1996 in the Laramie Mountains west of Wheatland. Gem-quality cordierite was found as distinct violet-blue, transparent, rounded mineral grains in gneiss. However,

the presence of well-developed cleavage may preclude the cutting of any large stones from this material. One hand specimen of the host gneiss collected by the author contained as much as 20% gem-quality cordierite. The cordierite is found in association with poor-quality translucent to opaque industrial rubies, sapphires, kyanite, and sillimanite. This region may also have potential for other gemstones as the WSGS recovered microscopic, gem-quality rubies and sapphires in stream-sediment samples more than 10 years ago in this region.

Precious and Base Metals

Although gold exploration activity was at a low throughout the world because of very low gold prices which fell below $300 an ounce, some activity was reported in Wyoming, including a major mining company which obtained rights to explore a potential world-class gold deposit at an undisclosed location. In addition, the WSGS continued to examine various gold and copper prospects in the State, and there was also some company activity for platinum, nickel, titanium, and iron.

The WSGS examined a previously undocumented gold prospect in the Encampment district of the Sierra Madre, after initially obtaining some interesting sample results in 1996. The prospect, referred to as the Teddy Creek prospect (W/2 section 2, T14N, R85W on the Red Mountain 7.5-minute Quadrangle), has a prominent milky quartz vein with common sulfides (principally pyrite) and boxworks after sulfides, enclosed by a broad envelope of altered limonite-stained, felsic (?) schist country rock.

The prospect is underlain by Archean cratonic rocks of the Wyoming Province immediately north of the Cheyenne Belt suture zone, which separates Archean cratonic rocks from Proterozoic island arc metavolcanic and metasedimentary rocks of the Colorado Province (Hausel, 1986; 1997a). This region is considered to be one of the most under-explored Proterozoic terranes in North America, and the Encampment mining district contains hundreds of historical base and precious metal prospects and mines, yet this region has seen very little modern exploration activity.

Several trenches were cut into the broad gossaniferous envelope surrounding a sulfide-bearing milky quartz vein, sometime during the historical past. The presence of large trees growing out of the trenches and on the tailings suggested that much of the exploration occurred more than two decades ago, and possibly as early as the first half of the 20th Century. A collapsed timbered shaft on the property with some very old timbers may represent an even earlier phase of exploration, possibly during the 19th Century.

Samples collected by the author in 1996 were designed to test the vein and adjacent host rock for anomalous gold mineralization (Hausel, 1997b). A sample (RM3-96) of the quartz vein, which had considerable limonite boxworks after pyrite (?), yielded a weakly anomalous value of 45 parts per billion gold (45 ppb Au). A second sample (RM4-96) collected in the limonite-stained

wallrock yielded 7.03 parts per million (ppm) Au (0.21 ounce per ton [opt] Au), suggesting a potential for large tonnage, surface minable gold mineralization in the alteration envelope.

However, the assay results of the two samples were in question. Sample RM3-96 was anticipated to yield a much higher gold value than RM4-97 due to the presence of limonite boxworks and sulfides. Thus the property was resampled in 1997 to test the altered felsic schist for gold.

In 1997, a sketch map was completed showing the relative locations of samples in relationship to trenches and shafts on the property (**Figure 20**). Samples were collected across the 30- to 35-foot wide vein at the eastern edge of the property, and were also collected at the western end of the property where the vein pinches to a narrow structure.

These assay results show anomalous gold mineralization associated with the vein and in the adjacent altered host rock (Hausel, 1997c). Gold values

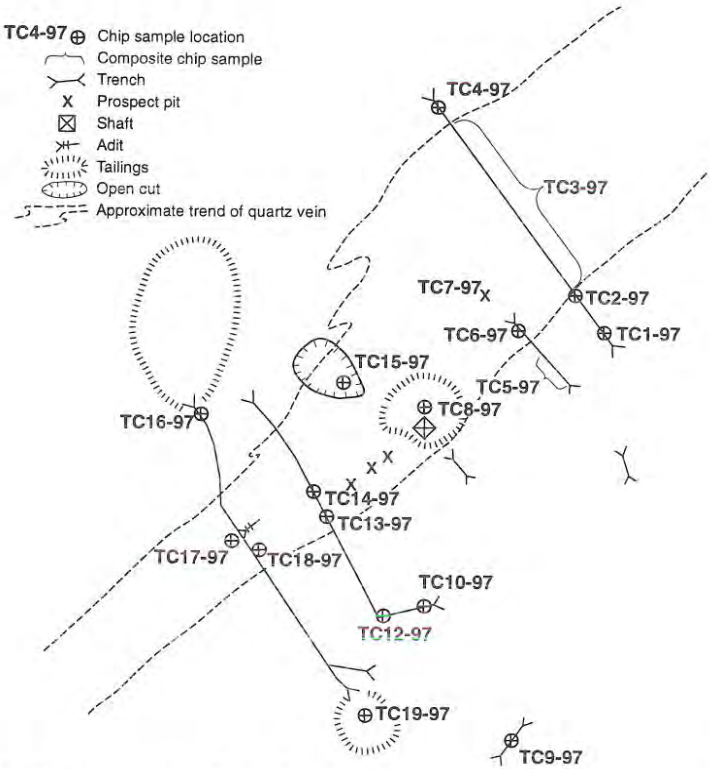

Figure 20. Sketch map of the Teddy Creek gold prospect showing sample site locations (Hausel, 1997c).

ranged from less than 5 ppb to 5.2 ppm (0.0 to 0.15 opt Au). However, the higher gold values were restricted to the vein, rather than the host rock. Based on these results, the assays reported for the 1996 samples may have been transposed.

Mineral Hill district: A cursory sampling project in the alkalic breccias in the Mineral Hill district of the Black Hills in northeastern Wyoming yielded disappointing results. The sampled breccias were poorly mineralized in contrast to some veins in the district. For example, veins sampled in the district yielded gold values from 360 ppb to 130 ppm (0.01 to 3.8 opt), and silver values from less than 5 ppm to 330 ppm (0.0 to 9.7 opt).

Ferris-Haggarty mine: Robert Gregory and the author recently visited and sampled a small portion of the underground workings of the Ferris-Haggarty mine in the Grand Encampment district of the Sierra Madre (Hausel, 1997b). After many decades, 1,400 feet of the lower production adit, known as the Osceola tunnel, were opened and retimbered. This provided the WSGS with an opportunity to sample the ore zone.

The Ferris-Haggarty mine was developed in a steeply dipping mineralized zone along a contact between footwall quartzite and hanging wall phyllite of the Magnolia Formation (Proterozoic). The mineralization was reported to be restricted to the quartzite. The ore zone was intersected in the tunnel about 1,200 feet from the portal. The ore lies in sheared metaconglomerate, which locally is relatively undeformed with rounded pebbles supported by a matrix of massive copper sulfides and silicates.

Samples collected by the WSGS yielded anomalous mineralization ranging from 0.05% to 7.5% Cu, less than 5 ppb to 631 ppb (0.0 to 0.02 opt) Au, less than 0.2 ppm to 10.3 ppm (0.0 to 0.3 opt) Ag. The samples demonstrated the presence of anomalous mineralization. It is hoped that there can be further sampling and studies in the mine.

Section 8 mine: Samples were collected from the Section 8 mine located in the NE section 17 and SW section 8, T14N, R85W on the Red Mountain Quadrangle of the Encampment district. The property consists of a primary shaft in section 17 with prospect pits extending into section 8. Mineralization occurs as a siliceous, folded exhalite in mafic schist of the Silver Lake Metavolcanics. The mafic schist includes amphibolite schist, almandine-amphibolite schist with almandine porphyroblasts as large as one inch across, and chlorite schist.

The exhalite is formed of banded quartz with interspersed bands of chalcopyrite, pyrite, minor bornite, and minor covellite. Samples RM2-97, RM3-97, and RM4-97, collected from the mine dump, ranged from 4.9 to 7.0% Cu, 89 ppb to 1.3 ppm (trace to 0.04 opt Au), and 19.8 to 23.8 ppm (0.58 to 0.69 opt) Ag.

Granite Mountains Project

The U.S. Geological Survey awarded the WSGS a research grant to begin mapping the geology and mineralization of the Granite Mountains in central Wyoming. The proposed project is for a three-year study to map the 1:100,000-scale Rattlesnake Hills Quadrangle, which encloses the Granite Mountains.

The Granite Mountains include a variety of rock types that range from relatively young sedimentary rocks to some very old gneissic rocks (greater than 3.3 billion years old). This region of Wyoming includes several significant and important mineral resources including jade, ruby, sapphire, uranium, agate, jasper, and gold.

In addition, the Granite Mountains have high potential for the discovery of kimberlite and diamonds, as the region lies in the interior of a craton similar to some of the diamond deposits that are currently mined in South Africa. During regional mapping, the WSGS will sample known mineral deposits as well as collect samples in the search for hidden diamond deposits.

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

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

Remaining Reserve Base (January 1, 1997)
- Measured reserves (Proved reserves) (Includes: 0.605 billion barrels of oil and 4.15 billion barrels of gas liquids and condensate) ..... 0.95 billion barrels[2]
- Indicated and inferred reserves (Reserve growth in conventional fields) ..... 2.61 billion barrels[1]
- Total ..... 3.56 billion barrels

NATURAL GAS

Remaining Technically Recoverable Resources (January 1, 1997)
- Discovered (Includes 36.6 trillion cubic feet (TCF) of methane[1] and 121.6 TCF of CO_2[3]) ..... 158.2 trillion cubic feet
- Undiscovered (Includes 14.72 TCF of conventional methane[1]; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO_2[3]) ..... 170.6 trillion cubic feet
- Total ..... 328.8 trillion cubic feet

Remaining Reserve Base (January 1, 1997)
- Measured reserves (Proved reserves) (Includes 11.2 TCF of methane[2] and 59.9 TCF of CO_2[3]) ..... 71.1 trillion cubic feet
- Indicated and inferred reserves (Reserve growth in conventional fields) ..... 25.0 trillion cubic feet
- Total ..... 96.1 trillion cubic feet

COAL

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

Remaining Reserve Base (January 1, 1997)
- Demonstrated strippable (Measured and indicated reserve base) ..... 25.3 billion tons[5]
- Demonstrated underground-minable (Measured and indicated reserve base) ..... 42.5 billion tons[5]
- Total ..... 67.8 billion tons

TRONA

Original Resources
- Trona ..... 76.0 billion tons[6]
- Mixed trona and halite ..... 51.0 billion tons[6]
- Total ..... 127.0 billion tons

URANIUM

Remaining Resource (December 31, 1989) ..... 1.99 billion pounds U_3O_8[9]

Remaining Reserve Base (December 31, 1989)
- Uranium oxide recoverable at $30.00 per pound ..... 66 million pounds[7]

OIL SHALE

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

[1] Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 1118, 20 p.
[2] Modified from Energy Information Administration, 1997, U.S. crude oil, natural gas, and natural gas liquids reserves: 1996 Annual Report, 131 p.
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GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE

Alan J. Ver Ploeg
Senior Staff Geologist-Geologic Mapping, Wyoming State Geological Survey

TWO NEW MAPS IN THE SOUTHERN BIGHORN MOUNTAINS

The Wyoming State Geological Survey (WSGS) recently completed two new preliminary geologic maps of a portion of the southern Bighorn Mountains (**Figure 21**). The new maps cover the Hole-in-the-Wall and the Poker Butte Quadrangles (1:24,000-scale) and bring the total to twelve quadrangles mapped in the southern Bighorns (**Figure 22**) since the beginning of this mapping project in 1985. The majority of this area had not been mapped in any detail since N.H. Darton mapped it in 1906.

Interest in the hydrologic characteristics and minerals in the area prompted the completion of these two maps. The WSGS has received requests for information on the general geology and structure of the area to help in the siting of water wells in the vicinity of local ranches, and there is interest in the potential for minerals in the area. Bentonite is mined from the Frontier Formation and Mowry Shale outcrops in the northeast corner of the Hole-in-the-Wall Quadrangle. Potential exists to extend these mines to the west and south along the

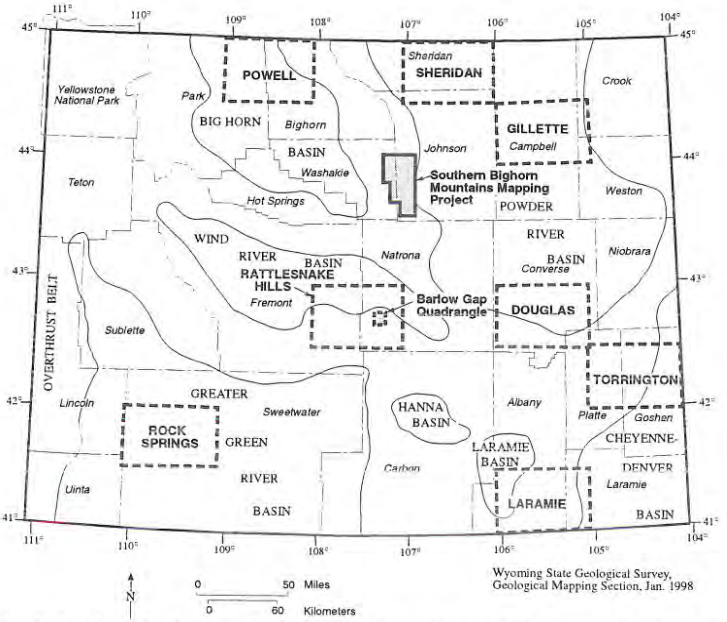

Figure 21. Index to selected geologic mapping projects and recently released maps in Wyoming.

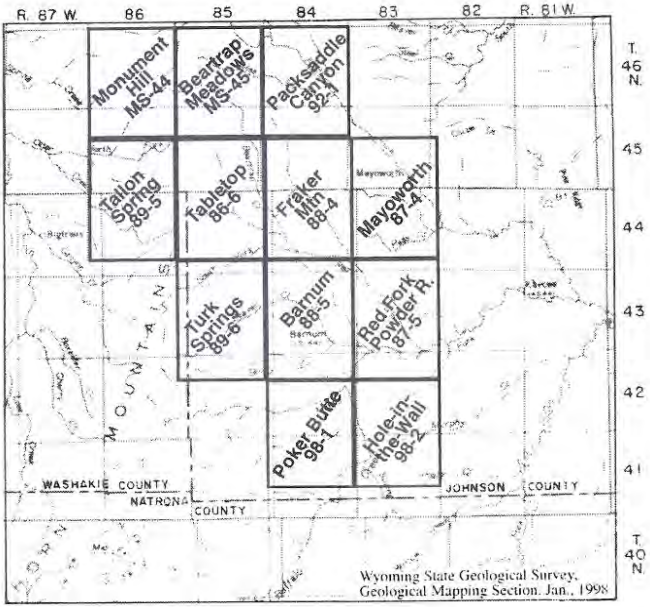

Figure 22. Geologic quadrangle maps of the southern Bighorn Mountains available from the Wyoming State Geological Survey. (Open File/Preliminary Geologic Maps are annotated with the year and number of each map, i.e., 88-5; MS indicates Map Series).

Frontier and Mowry outcrops shown on the map. In addition, there are numerous terrace deposits mapped on the two quadrangles which could serve as a local source of gravel for neighboring areas.

The maps are titled: *Preliminary Geologic Map of the Poker Butte Quadrangle, Johnson County, Wyoming* and *Preliminary Geologic Map of the Hole-in-the-Wall Quadrangle, Johnson County, Wyoming* and are numbered PGM 98-1 and PGM 98-2, respectively. They are 1:24,000-scale, black and white maps that include cross-sections to illustrate the subsurface structure of each area. These maps and any others completed in the area are available from the Publications Section of the WSGS.

STATEMAP FUNDING OF GEOLOGIC MAPPING IN WYOMING

STATEMAP efforts to date

STATEMAP is a component of the National Geologic Mapping Act of 1992 (re-authorized in 1997) in which states and the Federal government share

equally in the cost of geologic mapping projects. Participating states must match each Federal dollar with a non-federal dollar. The emphasis of the STATEMAP Program is on the acquisition of new geologic maps and the compilation of existing data at 1:100,000-scale for inclusion in the National Digital Geologic Map Database. Since the inception of the program, the Wyoming State Geological Survey (WSGS) has received a total of $61,499 from the STATEMAP Program for contract years 1994, 1995, 1996, and 1997. The WSGS mapped the Laramie and Red Buttes Quadrangles in 1994/1995 ($12,000), the Howell Quadrangle in 1995/1996 ($10,000), the Guernsey Quadrangle in 1996/1997 ($8499), and will complete the Guernsey Reservoir Quadrangle in 1997/1998 ($14,000).

These maps are part of the WSGS's ongoing program geared toward producing 1:24,000-scale geologic maps for the more populated areas of Wyoming. The purpose of the program is to provide detailed geologic information to the citizens, city/county planners, and developers in these areas, aiding them in their planning and siting efforts. The maps produced by the program include structural cross-sections and accompanying write-ups summarizing the information on the maps relating to mineral resources, groundwater resources, potential geologic hazards, and structural geology as it may relate to development and planning within the mapped area. In addition, these maps are intended for traditional exploratory use by the mineral and energy industries in the State. This program has been quite successful in the Laramie area with local consultants and planners using the new maps extensively. With the support of STATEMAP, this program will continue in the more populated areas in Wyoming, which lack up-to-date, accurate geologic mapping.

In 1997, $17,000 of STATEMAP monies funded the digitizing of existing 1:100,000-scale bedrock and surficial geologic maps. That project is still in progress and will include the Laramie, Rawlins, Cheyenne, and Casper surficial geologic maps and the Cheyenne bedrock geologic map. This represents a different type of mapping that is now funded by the STATEMAP Program.

STATEMAP Proposal for 1998

The WSGS recently received approval from the STATEMAP Review Panel for their 1998 STATEMAP proposal, requesting funds totaling $57,150. The 1998 STATEMAP proposal was a three-part proposal involving mapping the Laramie Quadrangle (1:100,000-scale), digitizing six existing 1:100,000-scale surficial geologic and bedrock geologic maps, and mapping the Barlow Gap 7.5-minute Quadrangle.

The Laramie Quadrangle (1:100,000-scale) is located in southeastern Wyoming, on the Colorado/Wyoming border (**Figure 21**). In the first phase of the subproject to compile this map, the Laramie, Red Buttes, and Howell Quadrangles (1:24,000-scale) were mapped to fill gaps in mapping and correct outdated mapping. The compilation of the Laramie 1:100,000-scale geologic map represents the culmination and final phase of this project and is proposed for completion in 1999 with funding from the 1998 STATEMAP Program. Requested funding ($18,500) will be used to acquire needed aerial photography, nega-

tives and orthophoto sheets for the 1:24,000-scale bases, for salary for one geological assistant, and for field vehicle rental. The Laramie Quadrangle (1:100,000-scale) will be mapped and compiled using the best available existing mapping and the new STATEMAP-generated mapping. Some field work and new mapping will be required in various relatively small localized areas to better define the structure and Tertiary outcrops along the crest and flanks of the Laramie Mountains from the north boundary of the map to the south boundary on the Wyoming/Colorado line. The WSGS will first release the map as a black and white Preliminary Geologic Map (PGM). Later, a color geologic map will be published as part of the Survey's Map Series (MS), and the map will be digitized.

The second subproject included in the 1998 STATEMAP proposal involves digitizing a total of six 1:100,000-scale surficial and bedrock geologic maps. The five surficial maps included in the digitizing effort are the Powell, Rock Springs, Douglas, Torrington, and Sheridan Quadrangles (**Figure 21**). The bedrock geologic map included in the subproject is the Gillette Quadrangle. For each map, the geology layer will be scanned, converted from a raster image to a vector image, and edited to be consistent with National Digital Mapping Standards. Digital topography and public land survey data exist for each map and will be acquired from the EROS Data Center. Funding in the amount of $20,000 will be used to acquire existing 1:100,000-scale digital topographic and public land survey data from the EROS Data Center, for salary for one geological assistant, and map scanning costs. Digital geologic maps are being more widely used by the Federal government, local and state governments, geologic and geographic researchers, and by private industry. This project will provide digital coverage of geologic maps that have been published and of preliminary maps of surficial geology that are not published. The maps also include more populated areas in the State where this type of data is in demand by city and county planners.

The third subproject includes compilation of the Rattlesnake Hills 1:100,000-scale geologic map located in central Wyoming (**Figure 21**). The three-year subproject will be initiated by collecting all available geologic maps of the area. These will be used for compilation followed by aerial photoreconnaissance, and field reconnaissance and mapping. During field reconnaissance, rock samples will be collected for petrographic and whole-rock analyses. In areas of notable mineralization, detailed maps will be prepared and rock alteration studies will be conducted. The Barlow Gap Quadrangle (1:24,000-scale), located in the central part of the Rattlesnake Hills Quadrangle (**Figure 21**), will be completed during the first year, funded at $18,650. The area is partially unmapped and hosts some recently discovered and potentially commercial, gold deposits. However, the overall objective of the subproject will be to produce a regional 1:100,000-scale geologic map of the Rattlesnake Hills Quadrangle, showing locations of all known mineral occurrences. The final map will be accompanied by a geologic report with interpretations.

PALEONTOLOGICAL ACTIVITY

The Wyoming Office of State Lands and Investments has recently released an amended set of proposed rule changes dealing with Exclusive Commercial and Non-exclusive Scientific Fossil Removal Permits on State lands (Chapter 11). These revised rule changes result from comments and concerns expressed at public hearings last September, as well as written comments. An overview of the original proposed Chapter 11 rule changes is included on page 52 of *Wyoming Geo-notes No. 56.*

The amended proposed rule changes were made available in late December of 1997. Several definitions and clarifications were added to the proposed rules as a result of the public comments. Specifically, comments relating to royalty rates for collected and sold fossils as well as comments concerning size limitations for scientific and commercial permits were addressed. Persons interested in the scientific or commercial collection and(or) sale of fossils may want to review these proposed rules. Copies of the proposed rules are available from the Office of State Lands and Investments at the following address:

Office of State Lands and Investments
122 West 25th Street
Herschler Building, 3W
Cheyenne, WY 82002-0600

Phone: 307-777-6643

The Office of State Lands and Investments will accept written comments on these revised proposed rules until March 18, 1998. There will be no public hearings on the rules unless formally requested by 25 persons, a governmental subdivison, or by an association having not less than 25 members. Comments and(or) questions should be directed to the Office of State Lands and Investments at the above address.

LANDSLIDE HAZARD IN WYOMING

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

Landslides are one of the most common geologic hazards in Wyoming, with some of the highest landslide densities in the country found in the State. One of the largest landslide complexes in the country is located southwest of Cody in northwestern Wyoming. The Carter Mountain landslide is more than 5 miles wide and 20 miles long. Landslides cause damage every year in Wyo

ming, but because many occur in remote areas, public awareness of their dangers is low.

LANDSLIDE MAPPING

Over the last seventeen years, most landslides in Wyoming have been mapped and classified by the Wyoming State Geological Survey (WSGS). **Figure 23** shows the landslides that have been mapped, with landslides present in most counties. All of the landslides shown have been mapped at scales of 1:24,000 or 1:62,500, with most being mapped at a scale of 1:24,000. All of the mapped landslides are available through a Preliminary Landslide Map series. Summary maps are also available at scales of 1:250,000 and 1:1,000,000. These maps can be ordered through the Geologic Hazards Section at the WSGS.

Not all of the mapped landslides are active, and many are presently quite stable. The WSGS has not made an attempt to assign stability rankings to the mapped landslides, however, because local conditions can change. Much of the Carter Mountain landslide appears to be stable, but occasionally a small part of it may destabilize. A site investigation with a geotechnical analysis is usually needed to determine a site's stability.

Many landslides that are currently active are reactivated older landslides or parts of older landslides. To a degree, the landslide maps that have been

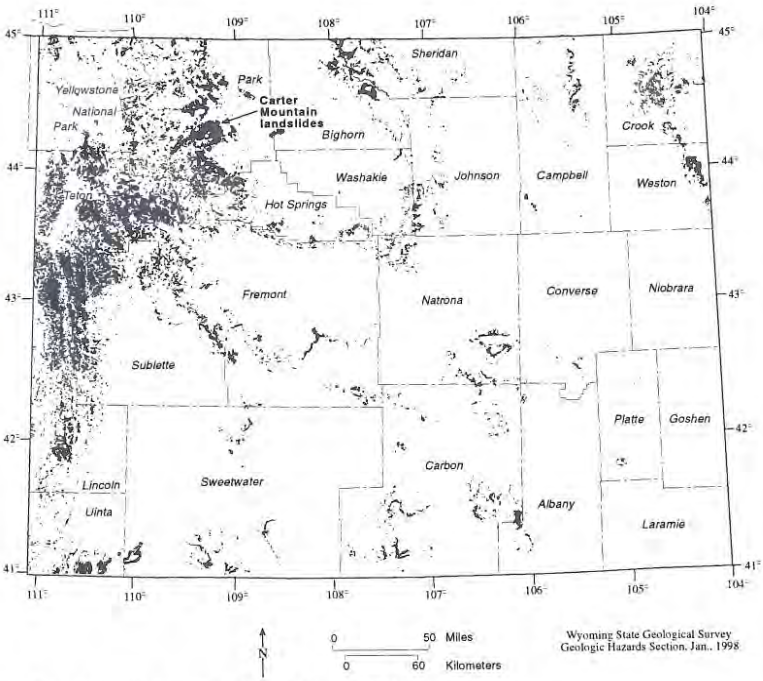

Figure 23. Generalized landslide map of Wyoming.

prepared by the WSGS can then be used to define landslide-prone areas. Not all landslide-prone areas; however, can be exactly identified by using existing maps. The Wolf Mountain landslide that blocked U.S. Highway 26/89 south of Jackson last year occurred in a drainage where there was no evidence of previous landslide activity. There had been a similar landslide in the drainage immediately to the north. There is only one way that the Wolf Mountain landslide could have been included in a landslide-prone area. Conditions similar to those found in the landslide to the north would have to be identified and recognized as a similar landslide-prone area. The landslide maps by themselves would not identify those conditions.

LANDSLIDE CLASSIFICATIONS

There are many types of landslides present in Wyoming. To properly describe landslide type, the WSGS developed a landslide classification modified from Varnes (1978) and Campbell (1985). As can be seen in **Figure 24**, there are five basic types of landslides that occur in three types of material. Falls, topples, slides, lateral spreads, and flows can occur in bedrock, debris, or earth. While individual landslide types can occur in nature, most landslides are complex, or composed of combinations of basic types of landslides.

Falls and topples are easy to visualize. In a fall, material detached from a steep slope or cliff descends through the air, and may bounce and roll. In a topple, a mass rotates forward about some pivot point. If a toppling mass pivots far enough, a fall may result.

Slides are characterized by shear displacement along one or several surfaces. Two general types of slides are recognized, rotational and translational. In a rotational slide, the surface of rupture is concave upward, and the mass rotates along the concave shear surface. Rotational slides are usually called slumps, and they can occur in bedrock, debris, or earth. In a translational slide, the surface of rupture is a planar or gently undulatory surface. In bedrock and earth, translational slides are usually called block slides if an intact mass slides down the slope. If rock fragments or debris slide down a slope on a distinct shear plane, the movements are called rock slides or debris slides. It is easy to see that confusion can result by applying the term "slide" to all types of landslides.

Lateral spreads are characterized by lateral extension movements in a fractured mass. Lateral spread movements may occur in bedrock and soil as a result of liquefaction or plastic flow of subjacent materials, or in bedrock without a well-defined basal shear surface or zone of plastic flow. Lateral spreads in bedrock without a well-defined zone of shearing or flow, usually occur on ridge crests.

In general, a flow is a moving mass that has differential internal movements that are distributed throughout the mass. While most flows occur in debris and earth, one type of flow, gravitational sagging, does occur in bedrock. Flows in debris and earth can be cohesive or non-cohesive. Both cohe-

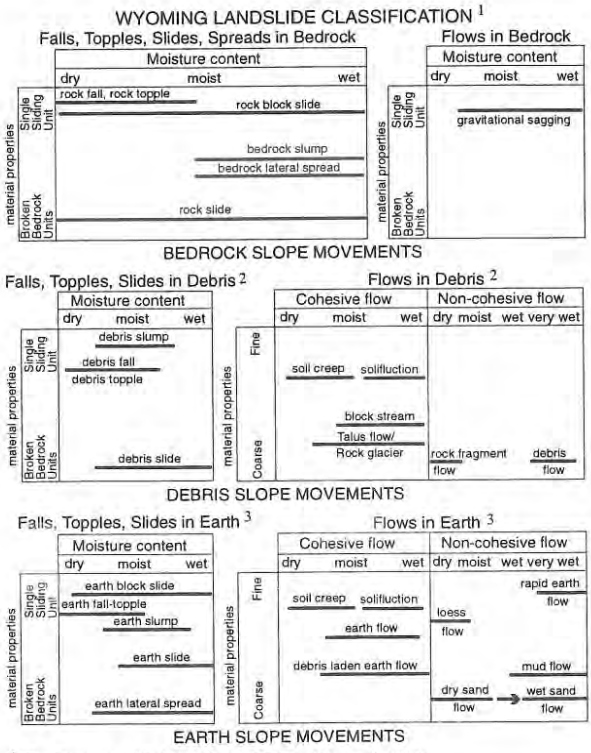

Figure 24. Wyoming landslide classification.

sive and non-cohesive flows are further subdivided by water content and material properties.

Cohesive flows in debris include soil creep, solifluction, block streams, talus flows, and rock glaciers. Soil creep is an imperceptibly slow deformation that continues under constant stress. Solifluction is a slow flow in soil that is often observed in areas with perennially or permanently frozen ground. Block streams are slow moving tongues of rocky debris on steep slopes, and are often fed by talus cones. Talus flows are slow flows that occur in the basal portions of talus slopes. Rock glaciers are not true landslides, but have been included in the classification scheme because they are mass movements composed of coarse debris. Interstitial ice between debris fragments plays a role in the movement of rock glaciers, which are similar in form to a true glacier.

Cohesive flows in earth include soil creep, solifluction, earth flows, and debris laden earth flows. Soil creep and solifluction in earth are similar to

those in debris. Earth flows are very slow to rapid flows that have a distinct source area, a main flow track, and a lobate depositional area. Debris laden earth flows are flows that appear to be earth flows but are composed of debris. Standard classifications do not recognize debris laden earth flows, but many have been observed in Wyoming. Many of the landslides present in Wyoming have an earth flow component.

Non-cohesive flows in debris include rock fragment flows and debris flows. Rock fragment flows are extremely rapid flows composed of dry to moist rock debris. This type of flow can be initiated by a rock fall, by seismic activity, or by other processes. In some cases, it appears that rock debris has moved on a cushion of air, although other mechanisms may have dominated the process. Rock fragment flows can cause significant destruction in a short period of time. Debris flows are a slurry flow composed of debris and a significant amount of water. They are usually associated with unusually heavy precipitation or with rapid snowmelt. Debris flows commonly follow preexisting drainageways, and commonly form debris levees along their main flow track. Debris flows are a significant component of alluvial fans in mountainous areas, with the main debris flow deposit having a broad, fairly flat fan shape. Debris flows are very common in the mountainous areas of Wyoming.

Non-cohesive flows in earth include loess flows, dry sand flows, wet sand flows, rapid earth flows, and mud flows. Loess flows and dry sand flows are rapid to very rapid flows of dry material. Loess flows are usually initiated by seismic activity, and are a fluid suspension of silt in air. Fortunately, none have yet been identified in Wyoming. Dry sand flows usually occur along shorelines or in eolian deposits. In Wyoming, most dry sand flows are very small. Wet sand flows occur along river banks or shorelines composed of saturated clean sand. The destabilized sand usually flows into an adjacent body of water. Wet sand flows are not common in Wyoming. Rapid earth flows, also called a quick clay flows, are very rapid flows that involve the liquefaction of subjacent material and the entire slide mass. They usually initiate in sensitive materials, such as quick clay, and are not common in Wyoming. Mud flows are a slurry flow composed of earth and a significant amount of water. They differ from debris flows only in the size of their component materials.

Most landslides mapped in Wyoming are classified as being complex. For example, many landslides in the State are slump/earth flow complexes. That type of landslide is composed of a slump at its head, with the main body and deposit being an earth flow. Block slides often grade into rock slides, which can further grade into earth flows or debris laden earth flows. Such a movement would be classified as a block slide/rock slide/ flow complex. The Wolf Mountain landslide south of Jackson, is a complex movement. It appears to be a slump/debris flow complex.

LANDSLIDE DISTRIBUTION

The generalized landslide distribution in Wyoming is shown in **Figure 23**, as previously mentioned. Most of the mapped landslides occur in mountainous areas with levels of precipitation significantly greater than in the State's basins, as would be expected. Some of the highest landslide densities also occur in areas with active faults exposed at the surface, and in areas with higher levels of seismic activity than the rest of the State. To date, however, very few studies have been done on the relationship between landslides and seismic activity. Of interest is the fact that small-scale seismic activity is thought to have been a contributing factor in the activation of the lower Gros Ventre landslide north of Jackson in 1925 (Voight, 1978). Landslides in Yellowstone National Park have also activated as a result of seismic activity (Case, 1996).

Local geology, geologic structure, hydrology, and precipitation are the primary reasons that landslides occur in specific areas. Human activities can also have an effect on the occurrence of landslides.

SUMMARY

Landslides are a very real and current hazard in Wyoming. Even a relatively small landslide, such as the Wolf Mountain landslide, south of Jackson, can cause a significant disruption in daily activities for residents of the State. A change in local conditions, whether through construction activities, irrigation, increased precipitation, or seismic activity, can all lead to the formation of landslides in new localities. For further information on landslides, including information on specific areas or slides, contact the Geologic Hazards Section of the WSGS.

References cited

Campbell, R.H., editor, 1985, Feasibility of a nationwide program for the identification and delineation of hazards from mud flows and other landslides: U.S. Geological Survey Open File Report 85-276, 58 p.

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ROCK HOUND'S CORNER

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

Diamonds are a girl's best friend, as well as a rock hound's best friend!

There are two basic crystal forms of natural diamond: (1) isometric, and (2) hexagonal. Terrestrial diamonds are isometric, whereas hexagonal diamonds (lonsdalite) are extremely rare, and restricted to some meteorites and associated impactites.

The more common form, the isometric diamond, is an equal-dimensional mineral, which in its simplest form produces six-sided cubes referred to as hexahedrons. However, the most common habit of diamond is the octahedron. Octahedrons are 8-sided bipyramids, although many octahedrons may develop ridges on the octahedral faces and produce a variety of other isometric crystal habits with 12-sided or 24-sided crystals. Four-sided tetrahedral diamonds are sometimes encountered, which are probably distorted octahedrons. Another common form of diamond is the macle, or twinned diamond. Many macles form flattened triangular crystals.

Diamonds have a brilliant greasy luster and produce beautiful refined gemstones. The luster can be likened to oiled glass. Gemstone diamonds are typically transparent colorless, green, yellow, brown, and rarely blue, pink, or orange. Opaque diamonds and heavily included diamonds are primarily used for industrial purposes and boart (abrasives), with the exception of some black diamonds, which can also produce attractive gems.

Diamond is brittle, extremely hard (H=10), with a specific gravity of 3.5. Even though diamond is heavier than water, it is nonwettable and will float on water under favorable circumstances. Diamonds are also grease attractive. Under ultraviolet light, many diamonds will fluoresce pale blue, green yellow, and rarely red.

To date, more than 120,000 diamonds have been recovered from the State Line district to the south of Laramie in the vicinity of the Colorado-Wyoming state line. Approximately 40 diamondiferous kimberlites have been identified in this region. Many high-quality diamonds have been recovered that are heavier than 1 carat. For instance, diamonds from the Kelsey Lake mine include gemstones weighing 28.3, 28.18, 16.29, 14.2, 11.85, 10.48, 9.4, and 6.2 carats. Approximately 65% of the Kelsey Lake diamonds are gem quality. And about 50% of all diamonds recovered from Wyoming have been gem quality.

WYOMING DIAMOND LOCALITIES

Most of Wyoming's diamonds have been recovered from the State Line district; however, there are reports of diamonds from several other localities in

the State, which suggest that Wyoming could become an important diamond province in the future! Diamonds have been reported from the following localities:

STATE LINE DISTRICT

Aultman 1 and 2 kimberlites: Bulk samples collected from the Aultman kimberlites in the early 1980s by Cominco American Inc. yielded grades of 1.09 carat/100 tonnes for the Aultman 1, and 0.33 carat/100 tonnes for the Aultman 2.

Kelsey Lake kimberlites: Commercial diamond production began in 1996 in the State Line district, after Redaurum Ltd. placed two of the Kelsey Lake kimberlites (KL1 and KL2) into production. These lie near the state line with much of the property located in Colorado. Most of the production has been from the Colorado side; however, diamonds have also been recovered from the Wyoming side. At least 26.35 carats (Harold Kemp, personal communication, 1997), including a 6.2-carat diamond (Howard Coopersmith, personal communication, 1997), have been recovered from Wyoming.

Diamonds recovered from the Kelsey Lake mine have predominately octahedral habit, and are for the most part colorless with some honey-brown gemstones (Coopersmith and Schultze, 1996).

Schaffer complex kimberlites: A group of kimberlite diatremes and blows, known as the Schaffer complex, occur on the Wyoming side of the district. The largest diamonds recovered from the Schaffer complex weighed 0.985 carat and 0.86 carat. The estimated diamond values (1980 prices for the uncut gemstones) recovered during testing in the early 1980s ranged from $40.30 to $270/carat.

GROS VENTRE MOUNTAINS

A 7- to 9-carat, blue-white gem quality diamond was reportedly found in a prospect pit in the Gros Ventre Range and verified by a gemologist from Jackson. The pit was dug in a hard, silicified, dark metamorphosed rock (J.D. Love, personal communication, 1981).

SOUTHERN LARAMIE MOUNTAINS

Iron Mountain district: The Iron Mountain district, located 45 miles north of the State Line district and south of Sybille Canyon along the eastern flank of the Laramie Mountains, includes 57 kimberlite intrusives. At least one kimberlite was tested by Cominco American Inc., but no diamonds were reported.

But these yield both G9 and G10 (diamond inclusion) peridotitic pyrope garnets and Group I (diamond inclusion) and Group II eclogitic pyrope-almandine garnets. The chemistry of these garnets indicates the Iron Mountain kimberlites originated in the diamond-stability field of the upper mantle. However, ilmenite compositions (which are thought to show oxidation/reduction

conditions of the magma) suggest that the kimberlite magma had high oxygen fugacity. According to McCallum and Waldman (1991), this would imply diamond preservation was unlikely. However, the ilmenite compositions are similar to ilmenites from Kelsey Lake where diamonds are well-preserved (Coopersmith and Schultze, 1996)! The WSGS is currently evaluating this district for diamond potential.

Elmers Rock greenstone belt: One of the more impressive regions for abundant kimberlitic indicator mineral anomalies discovered by the WSGS lies within the Elmers Rock greenstone belt, north of Sybille Canyon. This greenstone belt could potentially host dozens of undiscovered kimberlites. There is an unverified report of a diamond found in the Blue Grass Creek area in the Elmers Rock greenstone belt (R.W. Marrs, personal communication, 1981).

POWDER RIVER BASIN

Gillette area: Microdiamonds and some garnets were recovered from a coal seam near Gillette in the Powder River Basin of northeastern Wyoming.

MEDICINE BOW MOUNTAINS

Cortez Creek: In 1977, two near-gem octahedral diamonds were discovered in a gold placer on Cortez Creek in the northern Medicine Bow Mountains.

Northern Medicine Bow Mountains: A diamond was accidentally discovered in drill-core of Precambrian quartz-pebble conglomerate during gold exploration by Superior Minerals (T.E. McCandless, personal communication, 1995).

WIND RIVER MOUNTAINS

South Pass: A diamond was reportedly found in the Beaver placers of the South Pass-Atlantic City mining district of the southern Wind River Mountains in the late 1800s. According to historic newspaper reports, $1,000 was offered for the stone.

Tourist Creek area: A diamond (approximately 2 cm across) was reportedly found on a flat between Tourist and Well Creeks one mile west of Mount Solitude in the central Wind River Mountains. This stone, known as the Moore diamond, was verified by a jeweler and later destroyed in a ranch fire (J.D. Love, personal communication, 1981).

GREEN RIVER BASIN, SOUTHWESTERN WYOMING

Cedar Mountain: Eleven breccia pipes occur along the southwestern flank of Cedar Mountain near the Utah border (R.E. Kucera, personal communication, 1996). According to Guardian Enterprises, two gem-quality diamonds were recovered from a core sample from one of the pipes. A third gem-quality diamond was recovered from a sample concentrate collected north of the pipe.

This diamond was reported to have a diameter of 2.2 mm. The diamonds recovered from the core had maximum diameters of 1.07 mm and 0.13 mm. These diamonds were found in an area where some other diamonds were reported in the past, which included a group of 5 diamonds rumored to have been found in the early 1980s.

According to a Guardian Enterprises' press release (9/24/96), 48 other alluvial diamonds were recovered from sample concentrates collected from a new source other than the breccia pipes near Cedar Mountain. These were verified by Diamonds Direct in Vancouver, and weighed a total of 2.3 carats.

Butcherknife Draw: Four diamonds were reportedly found in the Butcherknife Draw area north of Cedar Mountain (Paul and Jean Miller, personal communication, 1994). One of the diamonds, currently owned by a Green River resident, was cut in Germany and mounted in a ring. The stone measures 0.3 inch across and was reportedly confirmed as a diamond by a gemologist with a GEM diamond tester (Wayne Sutherland, personal communication, 1995).

Sage Creek Basin: In the Sage Creek Basin (sections 32 and 33, T17N, R88W) near the northern edge of the Sierra Madre mountains, a fingernail-size diamond, estimated to have been more than 3 carats in weight, was found several years ago. That octahedral diamond, which was verified by a gemologist, was found at the base of some aspen trees (Ralph Platt, personal communication, 1997).

In addition to the preceding diamond occurrences, hundreds of kimberlitic indicator minerals have been found in Wyoming suggesting that diamond pipes could be widespread! For information on these discoveries, refer to Hausel and others (1997).

SUGGESTED READING

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NEW PUBLICATIONS OF THE WYOMING STATE GEOLOGICAL SURVEY

*Teddy Creek gold prospect, Red Mountain Quadrangle, Encampment mining district, Sierra Madre, southeastern Wyoming, by W.D. Hausel, 1997: Mineral Report MR97-3 - $1.50.

*Field reconnaissance of the Palmer Canyon coundum-kyanite-cordierite deposit, Laramie Mountains, Wyoming, by W.D. Hausel, 1998: Mineral Report MR98-1 - $1.50.

*Field reconnaissance of the Leucite Hills peridot (olivine) occurrence. Rock Springs uplift, Wyoming, by W.D. Hausel, 1998: Mineral Report MR98-2 - $1.50.

*Preliminary geologic map of the Poker Butte Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg, 1998: Preliminary Geologic Map PGM 98-1 - $4.00.

*Preliminary geologic map of the Hole-in-the-Wall Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg, 1998: Preliminary Geologic Map PGM 98-2 - $4.00.

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*Geologic road log, Jackson to Dinwoody and return (Second edition), by J.D. Love and J.M. Love, 1997: Public Information Circular 20 - $7.50. ISBN 1-884589-11-2.

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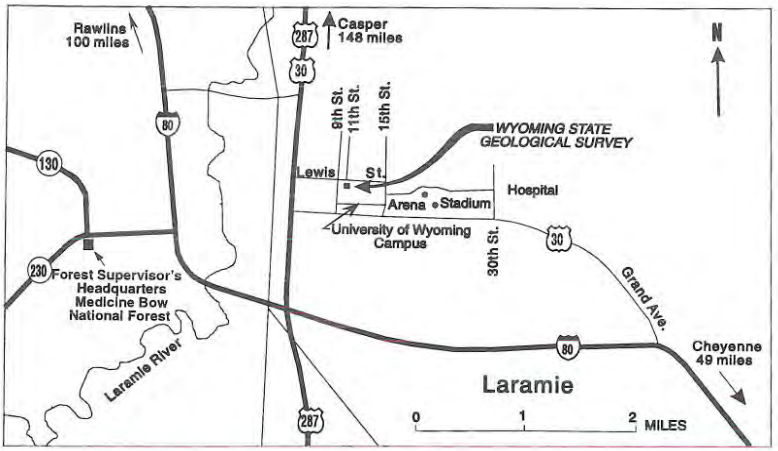

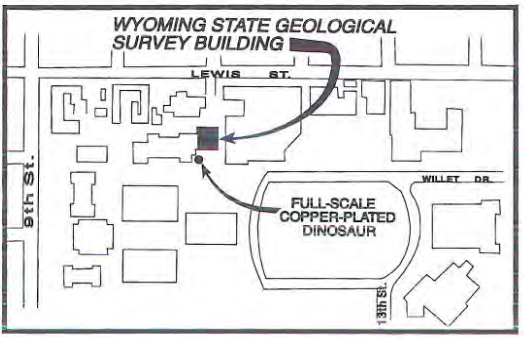

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