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Gary B. Glass, State Geologist

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WYOMING GEO-NOTES
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Cover: Gemstones from the Kelsey Lake diamond mine, Colorado-Wyoming State Line district. The diamonds in the photo include the largest diamond found in the State Line district to date: a 14.2-carat gemstone valued at $250,000 (Casper Star-Tribune, 12/30/95). The diamond is the 14th or 15th largest diamond found in the United States (Hausel, 1994). The Kelsey Lake mine was scheduled to begin operations in December, 1995, and will be the first commercial diamond mine in North America since limited quantities of diamond were mined from lamproite at Murfreesburo, Arkansas in 1906. (Photo courtesy of Howard Coopersmith and Redaurum Ltd.).

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MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

There were several significant things that happened in the last quarter of 1995, some good and some not so good. The discovery of potentially diamond-bearing kimberlites in the Green River Basin is quite noteworthy. The existence of these rocks has been suggested for some time, but until Guardian Resources announced their discovery in November, the location of these unique rocks had eluded discovery. Guardian has since provided a sample for testing in our diamond laboratory. Optimism that these kimberlites might be diamond-bearing stems from the fact that at least one and possibly more placer diamonds have been found in this area of Wyoming in the past. This discovery is discussed in more detail on p. 37 of this issue.

When the State's Consensus Revenue Estimating Group (CREG) met in January of this year, it increased its estimate of the oil price for 1995, its estimates of oil production, and its estimates of coal production from its October forecast. Forecasts for natural gas and trona production and prices were not changed. These new estimates are reflected in this issue of *Wyoming Geo-notes* (**Tables 1** and **2**; **Figures 1-8**).

The new projections increased CREG's forecast oil price for 1995 to $15.44, which is a 44 cent increase over the October estimate (**Table 2** and **Figure 3**). This change is attributed to an increase in the bonuses paid some producers of sour crude. In addition, CREG increased oil production by about one million barrels a year throughout the forecast period, including its 1995 estimate (**Table 1** and **Figure 1**). This is approximately a one percent increase. The higher production is attributed to the better than expected price, coupled with the effect of some legislative incentives. CREG left production declining at the rate of 4% per year, rather than the steeper declines of past years, which leads into one of the not so good events that actually occurred in January of 1996.

Express Pipeline Inc., a Canadian company, purchased the Platte oil pipeline, which connects Casper to the Midwestern markets. This pipeline now provides another market for the 62 million barrels of Canadian oil a year that Express hopes to bring into Casper, possibly as soon as the end of this year. The Express Pipeline, however, still has a few hurdles to cross before construction can begin. One of those hurdles might be a legal challenge that they are violating the NAFTA treaty. The bottom line is that the completion of this proposed pipeline into Casper could spell the end to any bonuses Wyoming producers are getting for their oil, and it could displace some of Wyoming's current markets. Also, if the oil price falls, the annual decline in oil production is likely to at least double.

Table 1. Wyoming mineral production (1981-1994) with forecasts to 2002[1].

Calendar Year	Oil[2, 3]	Natural Gas[3, 4]	Carbon Dioxide[3, 4]	Helium[4, 5]	Coal[6]	Trona[6]	In-situ Uranium[7, 8]	Sulfur[3, 9]
1981	122.1	455.4	—	—	102.7	11.2	?	0.05
1982	118.7	465.1	—	—	108.0	10.9	?	0.07
1983	120.9	539.8	—	—	112.2	11.6	?	0.57
1984	127.8	600.1	—	—	130.7	11.7	?	0.71
1985	131.0	597.9	—	—	140.4	11.8	?	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.04	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.06	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	1.16	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.07	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.1	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.1	1.18
1992	96.8	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	1.1	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
*1995	78.0	976.3	142.6	1.07	263.1	17.3	1.2	1.12
*1996	74.9	993.1	142.6	1.07	274.9	17.3	1.2	1.13
*1997	71.9	1,010.2	142.6	1.07	287.1	18.0	1.2	1.15
*1998	69.0	1,027.5	142.6	1.07	299.9	18.3	1.7	1.17
*1999	66.2	1,045.0	142.6	1.07	313.3	18.5	1.7	1.18
*2000	63.6	1,062.9	142.6	1.07	321.1	18.5	1.7	1.20
*2001	61.1	1,080.9	142.6	1.07	321.1	18.5	1.7	1.22
*2002	58.6	1,099.3	142.6	1.07	321.1	18.5	1.7	1.24

*Estimated until official figures are available.
[1]Adapted from CREG, Wyoming State Government Revenue Forecast FY96-FY2002, January, 1996; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1981-1994; [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, 1981-1994); [7]Wyoming Department of Revenue, 1986-1994; [8]Millions of pounds of yellowcake (not available for 1981-1985 because it was only reported as taxable value); [9]Millions of short tons.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1994) with forecasts to 2002[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	15.44	1.15	6.26	40.70
*1996	15.00	1.21	6.17	42.50
*1997	15.00	1.27	6.09	42.50
*1998	15.00	1.33	5.99	42.50
*1999	15.00	1.40	5.89	42.50
*2000	15.00	1.47	5.72	42.50
*2001	15.00	1.54	5.65	42.50
*2002	15.00	1.62	5.70	42.50

* Estimated until official figures are available.
[1] Adapted from CREG, Wyoming State Government Revenue Forecast FY96-FY2002, January, 1996; [2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil from Energy Information Administration, 1985-1994); [3] Wellhead price in dollars per thousand cubic feet (MCF) from Wyoming State Land and Farm Loan Office, 1989-1994 (derived from State royalty payments) and 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 from Energy Information Administration, 1985-1987 and Department of Revenue, 1988-1994; [5] Dollars per ton of trona, not soda ash from Wyoming Department of Revenue, 1985-1994.

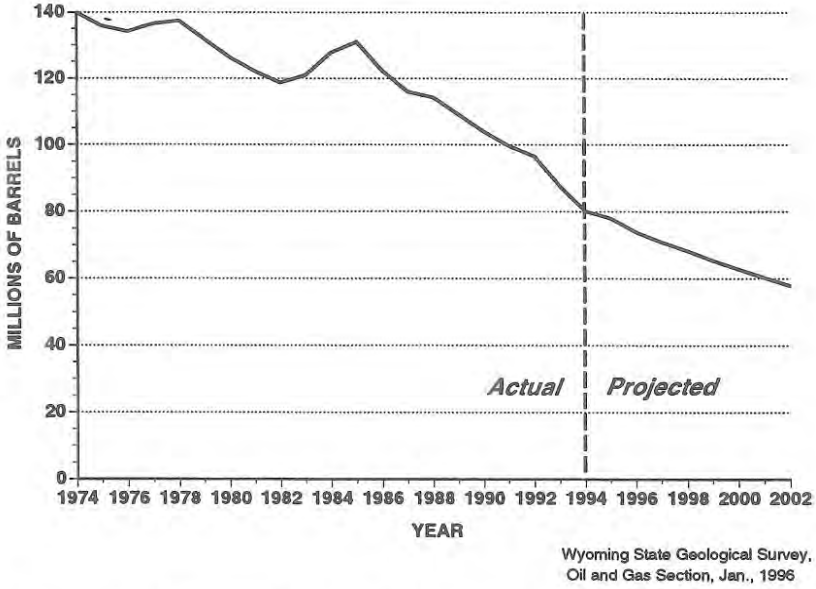

Figure 1. Annual oil production from Wyoming (1974 to 1994) with forecasts to 2002.

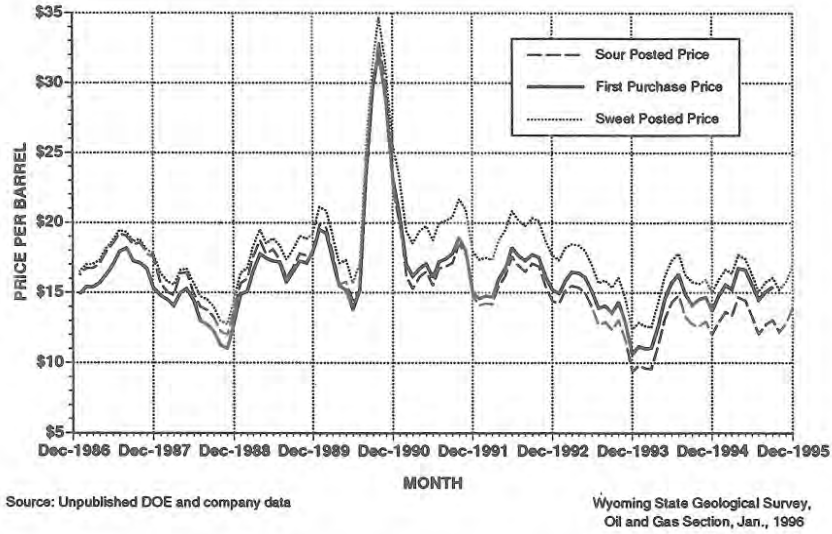

Figure 2. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

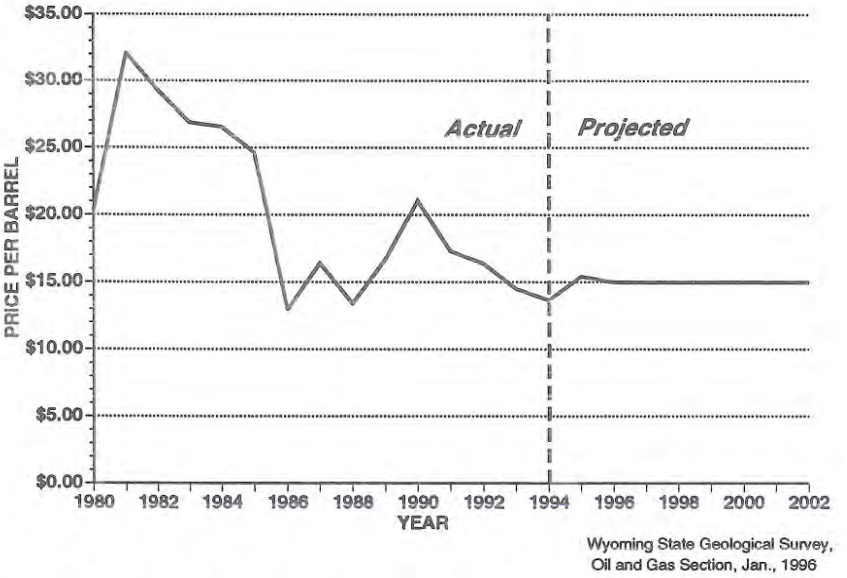

Figure 3. Average prices paid for Wyoming oil (1980-1994) with forecasts to 2002.

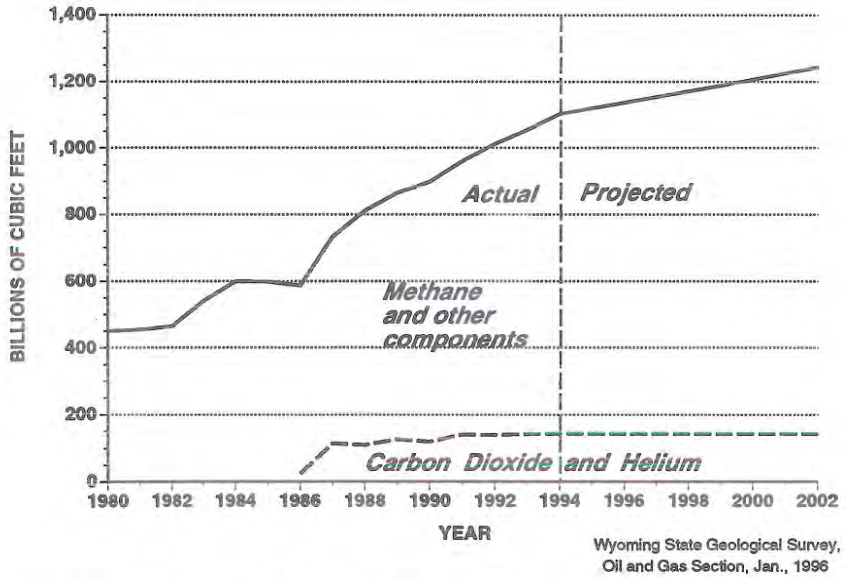

Figure 4. Annual natural gas production from Wyoming (1980 to 1994) with forecasts to 2002.

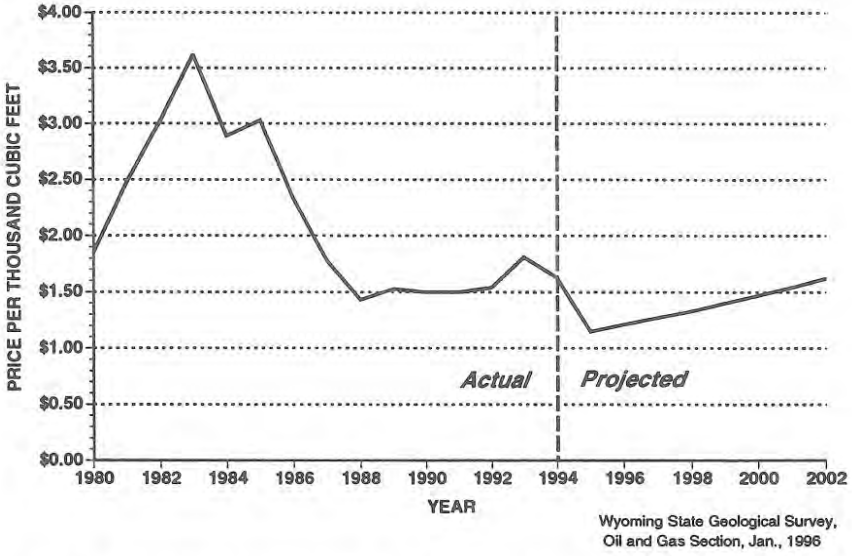

Figure 5. Average prices paid for Wyoming methane (1980 to 1994) with forecasts to 2002.

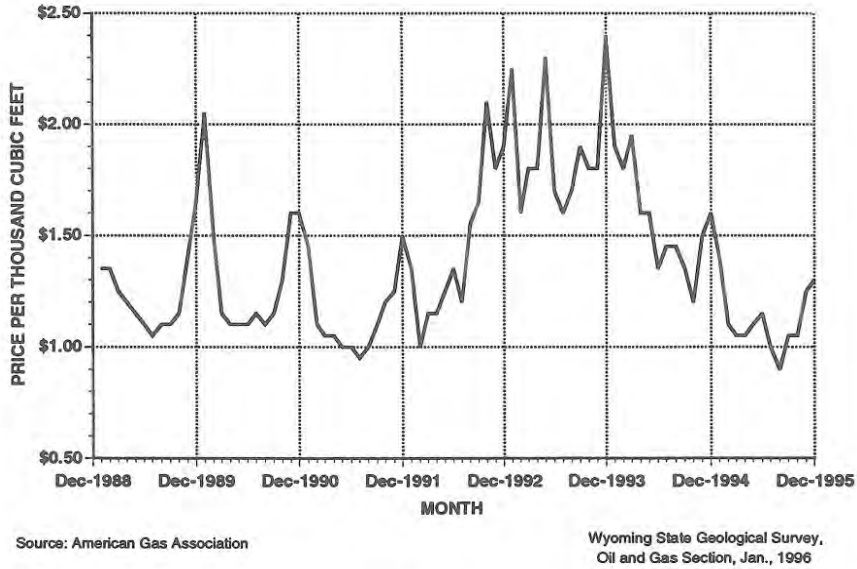

Figure 6. Spot prices for methane at Opal, Wyoming, averaged by month (1989 to present).

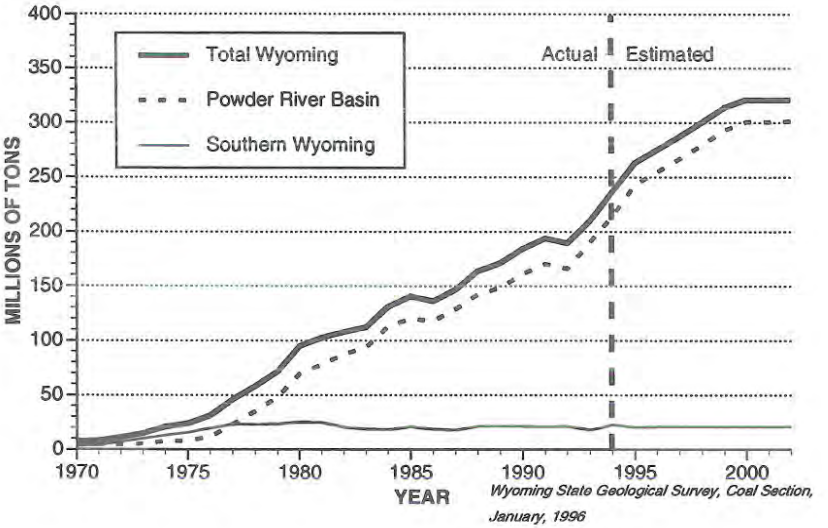

Figure 7. Annual coal production from Wyoming (1970-1994) with forecasts to 2002. Data from Wyoming Inspector of Mines (1970-1994) and Wyoming Consensus Revenue Estimating Group (1995-2002).

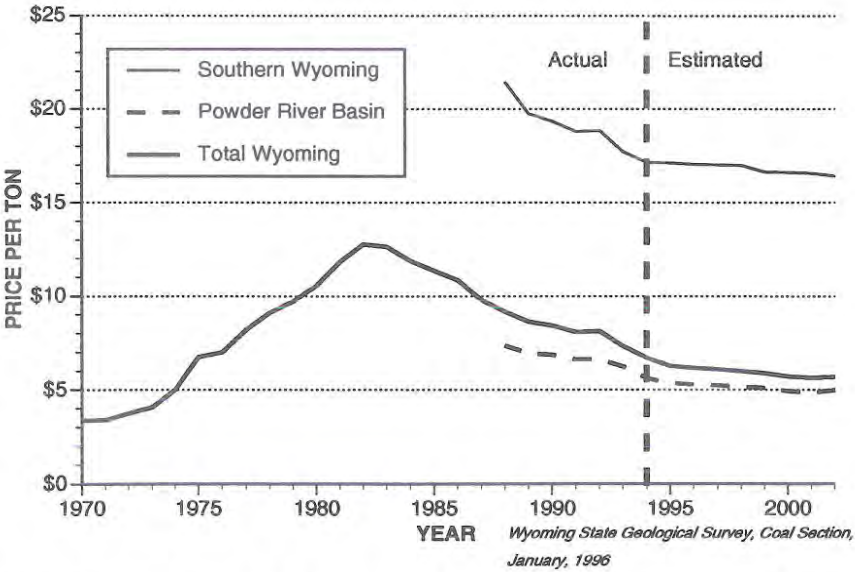

Figure 8. Average prices paid for Wyoming coal (1980 to 1994) with forecasts to 2002. Data from U.S. Energy Information Administration (1980-1987), the Wyoming Departmet of Revenue (1988-1994), and the Consensus Revenue Estimating Group (1995-2002).

The effects of Express Pipeline's purchase of the Platte pipeline were tempered somewhat when KN Energy announced they had purchased an Amoco pipeline, which they would convert into a natural gas pipeline. This will provide Wyoming gas producers with a new pipeline into the Midwestern markets. KN Energy had also been negotiating to buy the Platte pipeline and convert it into a gas pipeline.

In regard to natural gas, the CREG forecasts for both production and price were not changed in January (**Tables 1** and **2**; **Figures 4** and **5**). CREG is still forecasting an annual growth rate of 1.5%. **Figure 6** shows that the monthly average spot price for methane at Opal, Wyoming, in December was only $1.30. In 1995, the only monthly average higher than that was in January. In January 1996, however, the spot price had fallen to about $1.00 by mid-month.

In regard to coal, CREG increased its estimates of production from their October forecast by 3.5% (**Figure 7** and **Table 1**). Coal production in 1995 is now estimated at 263.1 million tons, which is 11% higher than the 236.9 million tons mined in 1994. CREG expects production to increase about 4.5% a year through 2000 and then level off through the remainder of the forecast years. This is the third year in a row that coal has seen annual growth greater than 10%. It is of some interest that the reported monthly deliveries in 1995 leveled off between 21.1 and 21.3 million tons for four consecutive months (July through October, which are the latest figures available). The peak monthly delivery in 1995 was 21.58 million tons, suggesting that either the market has leveled off or that something is capping capacity.

The average spot sale price of coal from the Powder River Basin in 1995, however, is not indicating a cap on supply as it actually seems to have fallen below that of 1994. For example, a major sale was consummated at only $3.45 per ton (p. 26 in this issue). CREG decreased its forecast prices of coal a few more cents each year because increased production of this lower priced coal lowers the average price paid for coal in Wyoming (**Table 2** and **Figure 8**). **Table 3** provides an historical breakdown of average prices paid for Wyoming coal as well as a forecast of prices through 2002.

On another positive note, uranium prices have increased from $7.00 a pound about a year ago to more than $12.00, with some predictions that they could top $15.00 by the end of this year. This reflects a slow but relatively steady improvement in price. Prices, however, are still far below the $44.00 a pound seen in the 1980s. While this improvement in price is not expected to start up a great number of new mines, it has raised hopes that it will cause some expansion at existing in-situ recovery operations. And it may help some companies move ahead with their proposed plans, particularly if the price continues to increase as some forecasters are suggesting.

Table 3. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and statewide (1988-1994) with forecasts to 2002[1].

YEAR	NORTHEASTERN	SOUTHERN	STATEWIDE
1988	$7.35	$21.45	$9.16
1989	$6.94	$19.76	$8.63
1990	$6.86	$19.36	$8.43
1991	$6.58	$18.81	$8.06
1992	$6.61	$18.84	$8.13
1993	$6.02	$17.72	$7.12
1994	$5.51	$17.13	$6.62
1995	$5.35	$17.12	$6.26
1996	$5.28	$17.05	$6.17
1997	$5.24	$17.02	$6.09
1998	$5.17	$16.99	$5.99
1999	$5.11	$16.64	$5.89
2000	$4.94	$16.61	$5.71
2001	$4.87	$16.57	$5.64
2002	$4.98	$16.41	$5.70

[1] Statewide data for 1988-1994 is derived from Wyoming Department of Revenue information; forecasts for 1995-2002 are from the Consensus Revenue Estimating Group's report of January, 1996; and regional breakdowns are estimated by the Wyoming State Geological Survey.

OIL AND GAS UPDATE

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

Prices paid to Wyoming oil producers in 1995 averaged an estimated $15.44 per barrel, which is $1.77 higher than the $13.67 per barrel average for 1994 and $.90 higher than the $14.54 per barrel average for 1993 (**Table 4**). The higher average price in 1995, coupled with legislative tax incentives, has had a positive effect on oil production in the State. Production through the first nine months of 1995 was 59.3 million barrels compared to 60.5 million barrels through the first nine months of 1994 (**Table 5**). This is only a 2% decline in production for the first nine months of 1995, compared with a 9.9% decline in production between 1993 and 1994 and an 8.1% decline in production between 1992 and 1993 (**Figure 1**). Wyoming's oil production has declined every year since 1985 at an average yearly rate of 5.3%. Because oil prices were firm during the last three months of 1995, there is good reason to believe that Wyoming's oil production only declined about 2% for the whole year. Production in 1995 is an estimated 78 million or more barrels (**Table 1**).

Natural gas production through the first nine months of 1995 is higher than production in the first nine months of 1994 despite much lower prices in 1995 (**Table 6**). The estimated average spot price at Opal this past year was $1.12 per thousand cubic feet (MCF), compared to $1.57 per MCF in 1994 and $1.89

Table 4. Average price (per barrel) received for oil in Wyoming (1992 to present).

	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative
JAN	$ 14.57	$ 14.57	$ 15.08	$ 15.08	$11.15	$ 11.15	$ 14.77	$ 14.77
FEB	$ 14.78	$ 14.68	$ 16.00	$ 15.54	$11.01	$ 11.08	$ 15.55	$ 15.16
MAR	$ 14.66	$ 14.67	$ 16.47	$ 15.85	$11.04	$ 11.07	$ 15.26	$ 15.19
APR	$ 15.99	$ 15.00	$ 16.41	$ 15.99	$12.59	$ 11.45	$ 16.73	$ 15.58
MAY	$ 16.77	$ 15.35	$ 16.11	$ 16.01	$14.53	$ 12.07	$ 16.65	$ 15.79
JUN	$ 18.23	$ 15.83	$ 15.11	$ 15.86	$15.73	$ 12.68	$ 15.52	$ 15.75
JUL	$ 17.66	$ 16.09	$ 13.91	$ 15.58	$16.31	$ 13.20	$ 14.50	$ 15.57
AUG	$ 17.27	$ 16.24	$ 14.08	$ 15.39	$14.89	$ 13.41	$ 15.09	$ 15.51
SEP	$ 17.73	$ 16.41	$ 13.57	$ 15.19	$14.10	$ 13.49	$ 15.41	$ 15.50
OCT	$ 17.51	$ 16.52	$ 14.23	$ 15.09	$14.53	$ 13.59	**$ 14.50**	**$ 15.40**
NOV	$ 16.21	$ 16.49	$ 12.92	$ 14.89	$14.68	$ 13.67	**$ 15.00**	**$ 15.36**
DEC	$ 15.23	$ 16.38	$ 10.66	$ 14.54	$13.71	$ 13.67	**$ 16.30**	**$ 15.44**
Average yearly price		**$ 16.38**		**$ 14.54**		**$ 13.67**		**$ 15.44**

All averages derived from unpublished monthly reports by the Energy Information Administration, except averages in bold print in 1995 are estimated from various unpublished posted price bulletins.

Wyoming State Geological Survey, Oil and Gas Section, January, 1996.

Table 5. Oil production from Wyoming (1992 to present).

	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative
JAN	8,527,905	8,527,905	7,616,208	7,616,208	7,115,472	7,115,472	6,712,839	6,712,839
FEB	7,933,484	16,461,389	6,583,954	14,200,162	6,387,147	13,502,619	7,865,974	14,578,813
MAR	8,392,491	24,853,880	7,690,771	21,890,933	6,984,248	20,486,867	6,391,954	20,970,767
APR	8,079,724	32,933,604	7,355,334	29,246,267	6,672,207	27,159,074	6,230,604	27,201,371
MAY	8,235,583	41,169,187	7,533,207	36,779,474	6,847,709	34,006,783	6,457,316	33,658,687
JUN	7,960,645	49,129,832	7,307,445	44,086,919	6,594,914	40,601,697	6,478,157	40,136,844
JUL	8,186,319	57,316,151	7,572,346	51,659,265	6,773,956	47,375,653	6,487,272	46,624,116
AUG	8,108,187	65,424,338	7,370,091	59,029,356	6,685,423	54,061,076	6,372,678	52,996,794
SEP	7,847,059	73,271,397	7,162,224	66,191,580	6,446,719	60,507,795	6,259,327	59,256,121
OCT	7,978,799	81,250,196	7,374,889	73,566,469	6,525,817	67,033,612		
NOV	7,728,632	88,978,828	6,897,568	80,464,037	6,257,924	73,291,536		
DEC	7,831,601	96,810,429	7,203,163	87,667,200	6,236,204	79,527,740		
Total Barrels Reported[1]		**96,810,429**		**87,667,200**		**79,527,740**		**59,256,121**
Total Barrels Not Reported		**169,781**		**1,233,006**		**651,400**		
Total Barrels Produced[2]		**96,980,210**		**88,960,236**		**80,179,140**		

[1]Monthly production reports from Petroleum Information.
[2] Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, January 1996.

Table 6. Natural gas production (MCF) by month from Wyoming (1992 to present).

	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative
JAN	89,618,649	89,618,649	88,172,339	88,172,339	93,146,775	93,146,775	100,141,930	100,141,930
FEB	81,194,839	170,813,488	80,726,687	168,899,026	85,623,666	178,770,441	86,077,800	186,219,730
MAR	83,058,343	253,871,831	88,920,212	257,819,238	94,388,052	273,158,493	94,252,719	280,472,449
APR	79,387,752	333,259,583	86,208,224	344,027,462	92,362,726	365,521,219	93,846,334	374,318,783
MAY	75,450,024	408,709,607	87,857,947	431,885,409	93,886,923	459,408,142	95,033,707	469,352,490
JUN	80,156,560	488,866,167	74,555,764	506,441,173	81,764,661	541,172,803	91,475,035	560,827,525
JUL	87,913,920	576,780,087	91,832,536	598,273,709	94,998,414	636,171,217	89,161,373	649,988,898
AUG	88,052,852	664,832,939	91,562,051	689,835,760	93,743,790	729,915,007	86,103,172	736,092,070
SEP	83,373,910	748,206,849	90,580,094	780,415,854	88,476,703	818,391,710	87,959,000	824,051,070
OCT	87,308,510	835,515,359	93,388,208	873,804,062	95,232,646	913,624,356		
NOV	88,671,889	924,187,248	88,046,821	961,850,883	95,312,491	1,008,936,847		
DEC	87,579,985	1,011,767,233	90,133,281	1,051,984,164	87,115,084	1,096,051,931		
Total MCF Reported[1]		**1,011,767,233**		**1,051,984,164**		**1,096,051,931**		**824,051,070**
Total MCF Not Reported		**201,080**		**2,715,623**		**6,879,705**		
Total MCF Produced[2]		**1,011,968,313**		**1,054,699,787**		**1,102,931,636**		

[1] Monthly production reports from Petroleum Information.
[2] Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, January 1996.

per MCF in 1993 (**Table 7**). Spot prices at Opal increased to $1.25 per MCF in November of 1995 and to $1.30 per MCF in December.

Even though the average rig count was lower in 1995 than in 1994 (**Figures 9 and 10**), there were 462 well completions through the first 11 months of 1995, compared to 456 well completions through the first 11 months of 1994. This seemingly contradictory statement only occurred because the average depth of a well in the first 11 months of 1995 was 7,250 feet, compared to an average depth of 8,347 feet a well in the first 11 months of 1994. Consequently, more holes were drilled with fewer rigs. Drilling companies are also using more efficient ways to drill and complete wells. Of the holes drilled, there were 76 exploratory wells and 26 discoveries completed during the first 11 months of 1995, compared to 57 exploratory wells and 17 discoveries completed during the first 11 months of 1994.

More oil and gas properties changed hands in the last quarter of 1995. Natural Gas Processing of Worland sold its exploration and production division to KCS Resources Inc. of Houston. The transaction included more than 65 billion cubic feet of natural gas reserves and oil production of 800 barrels per day. In two other deals involving UNOCAL, the company sold its interest in Worland Field to Devon Energy Corp. of Oklahoma for $51 million, and its interest in Casper Creek South, Poison Spider West, Dallas, Derby, AM-Kirk, and Big Hand fields to Mercury Exploration Co. of Fort Worth.

The U.S. Department of the Interior's Minerals Management Service (1995) reported that 1994 Federal royalty collections for Wyoming were $70.0 million for oil and $91.8 million for natural gas. These totals were down from the $90.2 million for oil and $97.0 million for natural gas that were collected in 1993. Production from Wyoming accounted for almost 27% of all natural gas royalties and over 38% of all oil royalties collected from Federal onshore leases.

Activity at oil and gas lease sales can give clues to the level and location of future drilling activities. In 1995, companies spent less money for leases and leased fewer acres than in 1994 (**Table 8**). But the sales in 1995, were as good as those in 1993 and better than those in 1992. Leasing at the U.S. Bureau of Land Management's (BLM's) October sale (**Figure 11**) and at the November State Land and Farm Loan Office's sale (**Figure 12**) was concentrated in the Powder River and the Greater Green River Basins. Leasing at the BLM's December sale (**Figure 13**) was heaviest in the Powder River Basin.

The BLM's sale in October had a high per-acre bid of $1,100 made by Marathon Oil Co. for a 493.92-acre parcel that covers lots 5-8, E/2 W/2, and SE section 19, T23N, R111W (location A, **Figure 11**). The parcel is in Storm Shelter and Emigrant Springs fields which produce natural gas and condensate from the Frontier Formation. Bids by Yates Petroleum Corp. ranged from $115 to $160 per acre for six parcels that are within five miles of natural gas and condensate production from the Lewis Shale or the Almond Formation at Patrick Draw and Wamsutter fields. The leases cover sections 24, 26, 34, and S/2 SW section 20, T21N, R97W, and sections 2, 10, 12, and 14, T20N, R96W (location B, **Figure**

Table 7. Average monthly spot price for natural gas at Opal, Wyoming (1992 to present).

	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative
JAN	$ 1.35	$ 1.35	$ 2.25	$ 2.25	$ 1.90	$ 1.90	$ 1.40	$ 1.40
FEB	$ 1.00	$ 1.18	$ 1.60	$ 1.93	$ 1.80	$ 1.85	$ 1.10	$ 1.25
MAR	$ 1.15	$ 1.17	$ 1.80	$ 1.89	$ 1.95	$ 1.88	$ 1.05	$ 1.18
APR	$ 1.15	$ 1.17	$ 1.80	$ 1.87	$ 1.60	$ 1.81	$ 1.05	$ 1.15
MAY	$ 1.25	$ 1.19	$ 2.30	$ 1.96	$ 1.60	$ 1.77	$ 1.10	$ 1.14
JUN	$ 1.35	$ 1.22	$ 1.70	$ 1.91	$ 1.35	$ 1.70	$ 1.15	$ 1.14
JUL	$ 1.20	$ 1.22	$ 1.60	$ 1.87	$ 1.45	$ 1.66	$ 1.00	$ 1.12
AUG	$ 1.55	$ 1.26	$ 1.70	$ 1.85	$ 1.45	$ 1.64	$ 0.90	$ 1.09
SEP	$ 1.65	$ 1.30	$ 1.90	$ 1.85	$ 1.35	$ 1.61	$ 1.05	$ 1.09
OCT	$ 2.10	$ 1.38	$ 1.80	$ 1.84	$ 1.20	$ 1.57	$ 1.05	$ 1.09
NOV	$ 1.80	$ 1.42	$ 1.80	$ 1.84	$ 1.50	$ 1.56	$ 1.25	$ 1.10
DEC	$ 1.90	$ 1.46	$ 2.40	$ 1.89	$ 1.60	$ 1.57	$ 1.30	$ 1.12
Average yearly price[1]		**$ 1.46**		**$ 1.89**		**$ 1.57**		**$ 1.12**

American Gas Association's monthly reports

Wyoming State Geological Survey, Oil and GasSection, January 1996.

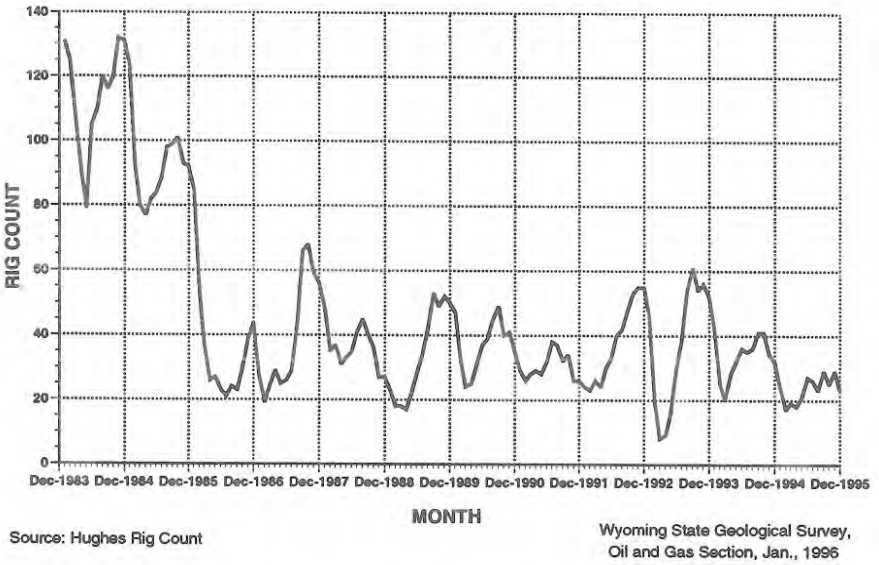

Figure 9. Wyoming daily rig count averaged by month (1984 to present).

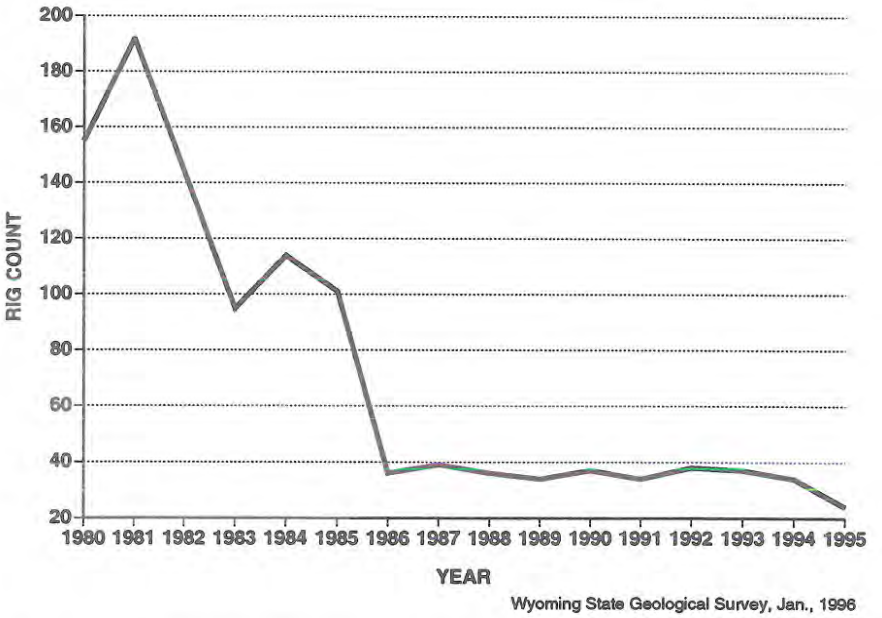

Figure 10. Wyoming daily rig count averaged by year (1980 to present).

Table 8. 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
1991							
TOTAL	$12,934,277	2,815	1,147	2,191,462	675,777	$19.14	$16,000.00
1992							
TOTAL	$4,778,940	2,122	664	1,434,268	364,478	$13.11	$2,500.00
1993							
February	$1,637,233	464	246	346,357	155,272	$10.54	$220.00
April	$2,116,184	478	259	351,465	177,989	$11.89	$220.00
June	$1,415,793	463	179	351,130	86,435	$16.38	$390.00
August	$1,877,405	462	262	374,274	208,495	$9.00	$400.00
October	$2,636,127	458	247	367,281	186,274	$14.15	$285.00
December	$3,259,266	444	276	275,435	180,879	$18.02	$320.00
TOTAL	$12,942,008	2,769	1,469	2,065,942	995,344	$13.00	$400.00
1994							
February	$3,909,085	442	290	374,969	237,761	$16.44	$160.00
April	$4,248,182	498	278	369,657	201,690	$21.06	$275.00
June	$3,759,282	480	270	417,447	233,664	$16.09	$325.00
August	$5,100,550	439	294	323,410	217,157	$23.49	$255.00
October	$4,703,706	492	341	411,117	269,003	$17.49	$11,200.00
December	$5,386,789	617	367	479,930	290,384	$18.55	$390.00
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.000
1995							
February	$3,252,668	533	332	473,177	290,046	$11.21	$425.00
April	$1,591,709	531	206	483,826	189,003	$8.42	$160.00
June	$3,499,604	393	246	384,746	238,863	$14.65	$660.00
August	$1,105,381	488	165	420,189	149,025	$7.41	$160.00
October	$2,761,689	477	227	384,683	174,453	$15.83	$1,100.00
December	$836,195	205	88	180,367	68,321	$12.24	$316.00
TOTAL	$13,047,246	2,649	1,264	2,326,988	1,109,711	$11.76	$1,100.00

STATE SALES (STATE LAND AND FARM LOAN OFFICE)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1991							
TOTAL	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
1992							
TOTAL	$745,738	799	419	277,755	150,613	$4.95	$230.00
1993							
March	$601,400	200	137	74,940	54,723	$10.99	$400.00
May	$362,840	200	141	82,388	56,770	$6.39	$90.00
September	$505,587	200	141	80,428	56,845	$8.89	$225.00
November	$510,290	200	143	73,517	53,801	$9.48	$155.00
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
1994							
March	$917,380	200	169	84,571	73,061	$12.56	$170.00
May	$802,688	200	141	75,523	54,199	$14.81	$205.00
September	$586,083	200	149	83,143	61,675	$ 9.50	$190.00
November	$998,001	200	148	88,542	66,217	$15.07	$142.00
TOTAL	$3,304,152	800	607	331,779	255,152	$12.95	$205.00
1995							
March	$524,165	199	131	89,371	57,702	$9.08	$130.00
May	$452,747	200	125	75,633	49,735	$9.10	$78.00
September	$421,454	200	134	78,032	53,527	$7.87	$65.00
November	$257,852	200	102	80,851	41,744	$6.18	$52.00
TOTAL	$1,656,218	799	492	323,887	202,708	$8.17	$130.00

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

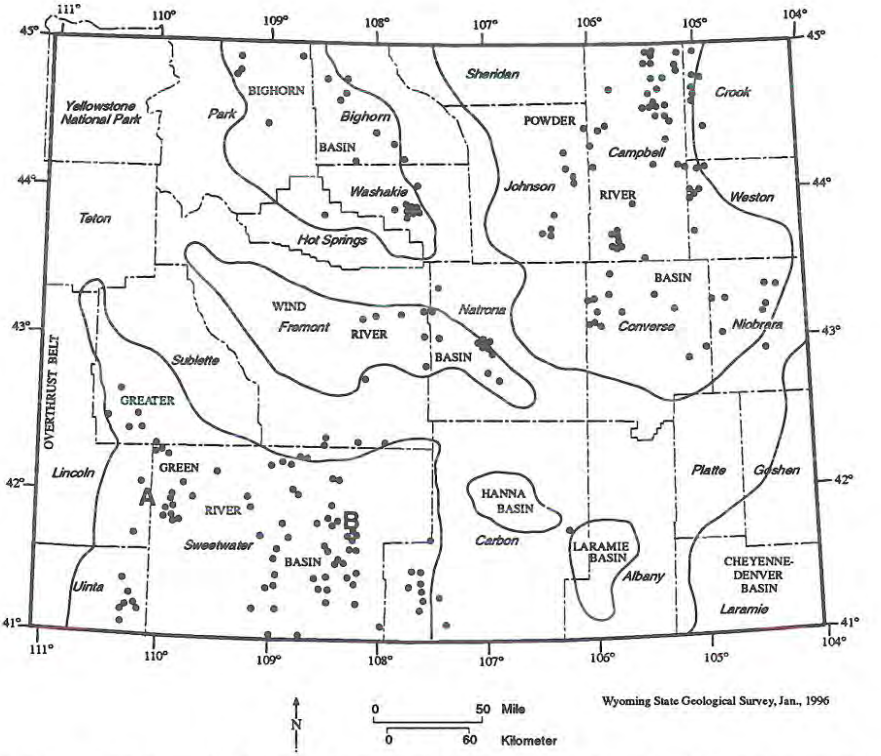

Fig 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the October, 1995, sale.

11). There were 16 tracts at this sale that received per-acre bids of $50 or more per acre.

The State Land and Farm Loan Office's sale in November had a high per-acre bid of $52 made by David Holwegner for a 320-acre parcel that covers E/2 section 16, T17N, R92W (location A, **Figure 12**). The lease is two miles from Mesaverde natural gas production in Baldy Butte Field. The second high per-acre bid of $48 was made by North American Resources Co. for a 119.68-acre parcel that covers parts of section 1, T25N, R115W (location B, **Figure 12**). The parcel is in a non-producing township southwest of the Big Piney/La Barge producing area.

The BLM's December sale had a high per-acre bid of $316 made by Prenalta Corp. for a 40-acre parcel that covers SE SE section 2, T21N, R94W (location A, **Figure 13**). The tract is less than two miles east of natural gas production from the Almond Formation at Siberia Ridge Field. The second highest per-acre bid of $176 was made by D. Guidrey-White for a 268.42-acre parcel that covers parts of sections 23, 27, and 34, T50N, R69W (location B, **Figure 13**). The tract

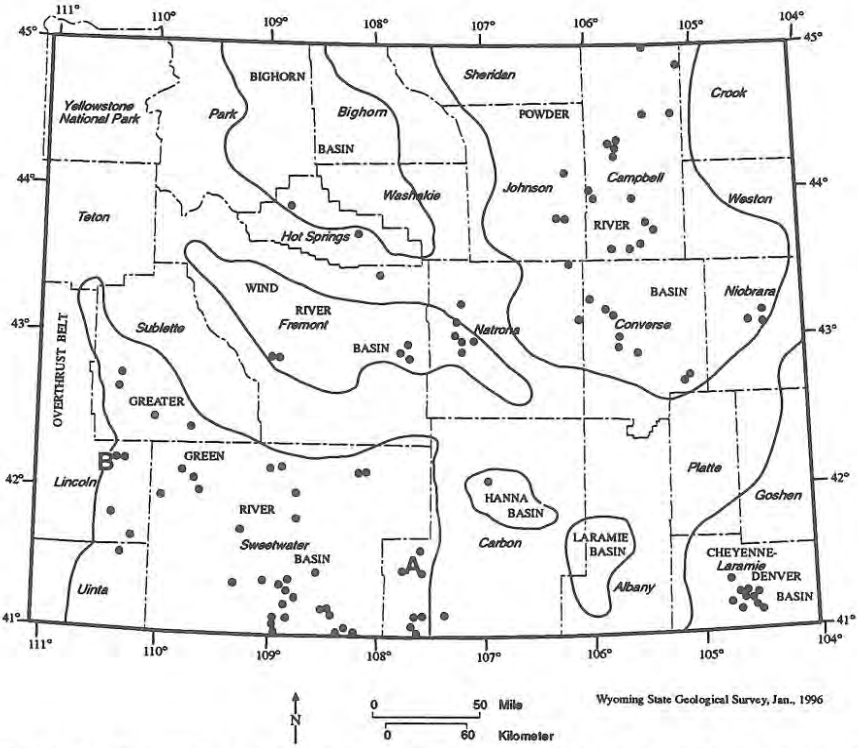

Figure 12. Locations of State oil and gas tracts leased by the State Land and Farm Loan Office at the November, 1995, sale.

is between Rozet and Right-A-Way fields, which both produce oil from the Minnelusa Formation. There were 10 tracts at this sale that received per-acre bids of $50 or more.

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 1995. The numbers preceding discussions below refer to locations on **Figure 14**.

1. Union Pacific Resources has permitted a well to test the Nugget Sandstone. The 1-10 Hanna-Federal well is located in C SW section 10, T20N, R82W. The closest Nugget production is at Hatfield Field, about 35 miles to the west.

2. Amoco Production completed a Mesaverde natural gas and condensate producer, extending the size of the Emigrant Trail Field. The 1 South Two Rim Unit well was drilled to 11,186 feet in C SW section 5, T17N, R95W and

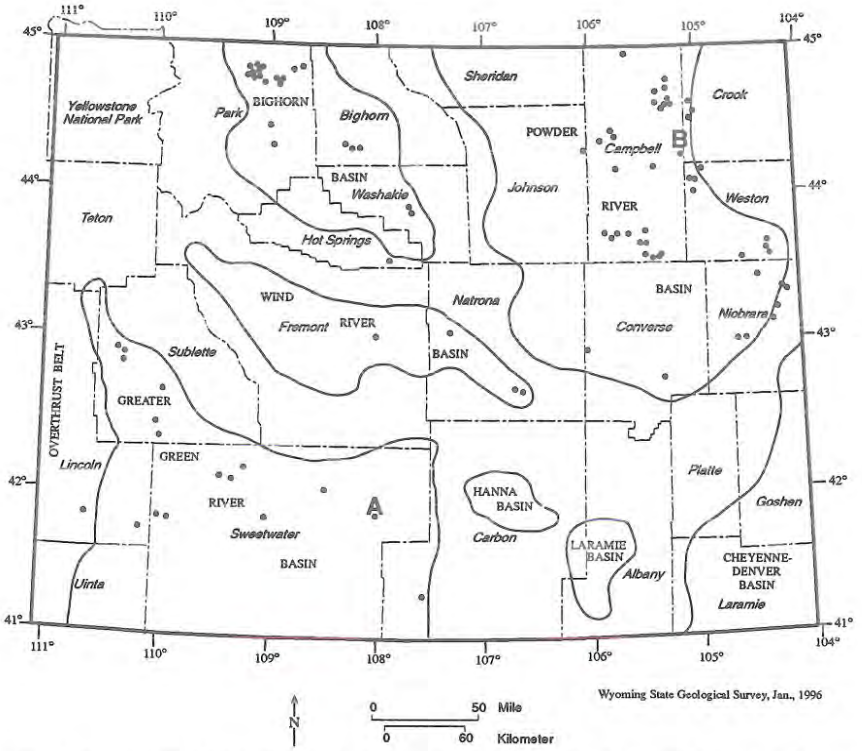

Figure 13. Location of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the December, 1995, sale.

produced an average of 3.6 million cubic feet of gas and 122 barrels of condensate per day during its first 20 days on line.

3. Kaiser-Francis Oil completed a new well in Higgins Field in the Almond Formation. The 1 Pronghorn well in C NW section 2, T17N, R99W flowed 2.9 million cubic feet of gas and 27 barrels of water per day from perforations between 6,406 and 6,464 feet.

4. BTA Oil Producers completed a new producer that extended Sinkhole Field. The 5 Bravo Unit well in NW NW section 4, T23N, R99W flowed 1.2 million cubic feet of gas and 68 barrels of condensate per day from an interval in the Lewis between 6,809 and 6,819 feet.

5. Stovall Oil completed a new discovery in NW SW section 16, T31N, R82W. The 3-16 Clarkson Hill-State well flowed 211 barrels of oil per day from the Cody between 4,618 and 4,648 feet.

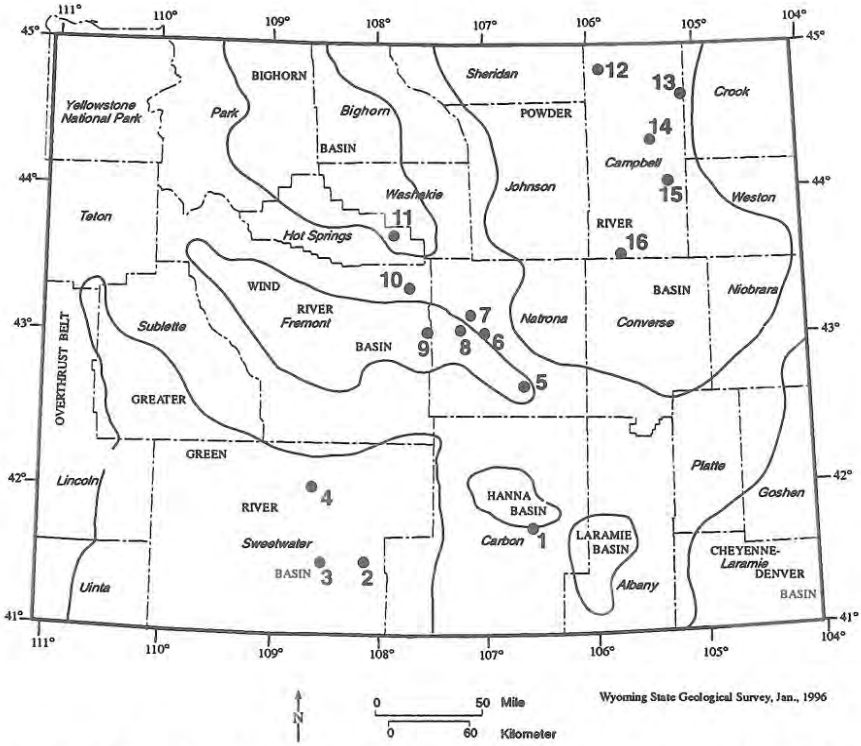

Figure 14. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 1995 (exclusive of coalbed methane activities).

6. Hunt Oil will drill a wildcat well to test the subthrust Frontier, Dakota, and Lakota. The 7 Boone Dome Unit well will be drilled in NW NW section 10, T35N, R85W to a projected depth of 10,600 feet.

7. Barrett Resources has a new Fort Union Formation producer in its Cave Gulch Unit. The 8 Cave Gulch Unit well in SW NW section 32, T37N, R86W flowed 20.3 million cubic feet of gas per day from perforations between 4,604 and 4,872 feet.

8. Intoil Inc. completed a new Fort Union Formation producer in Cooper Reservoir Field. The 7 Cooper Reservoir Unit well in SW SW section 3, T35N, R87W produced an average of 2.3 million cubic feet of gas, 33 barrels of condensate, and 158 barrels of water from an undisclosed depth during its first month of production.

9. Santee Inc. completed a discovery in the Lance Formation. The 1-7 Twiggy-Federal well in C NE section 7, T35N, R89W flowed 1.3 million cubic feet of gas from perforations between 6,680 and 6,690 feet.

10. Louisiana Land & Exploration Inc. began drilling its 4-36 Bighorn well in SW NE section 36, T39N, R91W to a projected depth of 24,697 feet in the Madison Limestone. The company is already processing 50 million cubic feet of sour gas per day from two other deep Madison wells at its Lost Cabin gas plant. The results of this test will help to determine the natural gas reserves in the Madison reservoir and may help the company decide if it will expand its gas processing plant.

11. Hallwood Petroleum completed another Phosphoria producer in the saddle between the northwest and southeast structures in Lake Ridge Field. The 1-24 Packsaddle-Federal well in NE NE section 24, T43N, R92W flowed 577 barrels of oil per day from a reservoir between 3,278 and 3,354 feet. This well is about a half mile west of Hallwood's earlier discovery in NW NW section 19, T43N, R91W, which was completed pumping 625 barrels of oil and 27,000 cubic feet of gas per day.

12. DCD Inc. plans to horizontally redrill a Muddy Sandstone producer at its 8-2H Werner-Wilson well from a surface location in NE SW section 35, T56N, R75W. The location is on the southwestern side of L-X Bar Field.

13. Ampolex completed two new Minnelusa producers. The 32-35 Howard well in SW NE section 35, T54N, R69W produced an average of 414 barrels of oil per day during September. The 23-26 Federal well in NE SW section 26, T54N, R69W produced an average of 298 barrels of oil and five barrels of water per day during its first 18 days on line.

14. Swift Energy also completed a new Minnelusa producer. During tests, the 1 K.M. Mines 41-17 well in NE NE section 17, T50N, R71W produced 240 barrels of oil per day from approximately 9,600 feet.

15. DCD Inc. also has plans to horizontally redrill two dual Muddy/Mowry producers in Big Hand Field. The 1-20H Conlin well will be drilled from a surface location in SE SW section 20, T47N, R70W to a true vertical depth of 8,292 feet. The 2-H Big Hand well will be drilled from a surface location in NE SE section 22, T47N, R71W to a true vertical depth of 8,676 feet.

16. The first horizontally-drilled Dakota producer was completed in North Buck Draw Field. The 24-13H North Buck Draw Unit well was drilled from a surface location in SE SW section 13, T41N, R74W. It produced an average of 1,058 barrels of oil and 583,000 cubic feet of gas per day during its first 11 days on line. True vertical depth of the well is about 12,845 feet.

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Minerals Management Service, 1995, Mineral revenues 1994: Report on receipts from Federal and Indian leases: U.S. Department of the Interior, Denver, Colorado, 132p.

COAL UPDATE

P. Daniel Vogler
Staff Geologist-Coal, Wyoming State Geological Survey

Wyoming coal deliveries continue to set a record pace in 1995, totaling almost 210 million tons through the first ten months (**Table 9**). Coupled with October, the third quarter of 1995 marked the first time in history that Wyoming's reported coal deliveries were over 21 million tons for four consecutive months (**Figure 15**). With this level of deliveries, Wyoming coal production for 1995 should equal or exceed 263.1 million tons. Of course, Campbell County has seen the greatest increase in production. **Figure 16** shows that spot sale deliveries in 1995 are tracking those in 1994, while contract deliveries continue to surpass those of 1994.

Production from Campbell, Converse, Lincoln, and Sweetwater Counties are also expected to grow over the next five years (**Table 10**). While coal production may be up for 1995, greater than 70% of the coal produced will be sold at F.O.B. prices below $5.00/ton. The Contracts section of this update shows some recent agreements that have been signed for coal deliveries.

Entech's Rocky Butte coal property in Campbell County is still up for sale. Entech is a subsidiary of Montana Power. The Rocky Butte property has reserves of approximately 625 million tons (Western Water Consultants and others, 1992).

The Utility Data Institute recently showed that the Laramie River power station, near Wheatland, is the lowest cost power producer among steam-electric power plants in the United States. This ranking marks the fourth consecutive year that Laramie River has had this distinction.

In other power plant news, one unit at the Dave Johnston power plant near Glenrock is out of service as the result of an accident that claimed the lives of two workers and injured a third on December 19, 1995. A high pressure steam pipe ruptured on the morning of the 19th, filling a three-story work area with 600 degree steam.

The Jim Bridger power plant laid off 11 workers in early November. In June, Pacific Power and Light Company announced that 49 positions at the plant might be cut. Officials at the power plant confirmed that these layoffs are part of the possible down-sizing described in June, but that the total number of job losses will probably be lower than expected.

The Interstate Commerce Commission is likely to grant approval for the merger of the Union Pacific and Southern Pacific Railways. There are reports that while the merger might eliminate over 3,500 jobs in the San Francisco area, it could create more than 70 jobs in Wyoming. Western Fuels Association's attempt to get trackage rights on Burlington Northern's (BN) rail line north of Gillette was refused in November. Western Fuels Association was seeking the

Table 9. Coal deliveries by month from Wyoming's mines.

	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative
JAN	16,407,150	16,407,150	15,931,150	15,931,150	19,326,770	19,326,770	21,586,303	21,586,303
FEB	14,604,480	31,011,630	14,646,090	30,577,240	17,171,910	36,498,680	20,839,926	42,426,229
MAR	14,429,650	45,441,280	17,112,970	47,690,210	19,178,990	55,677,670	21,707,422	64,133,651
APR	14,063,060	59,504,340	16,259,770	63,949,980	17,839,110	73,516,780	20,066,616	84,200,267
MAY	14,518,590	74,022,930	16,085,470	80,035,450	18,652,290	92,169,070	21,509,916	105,710,183
JUN	14,655,600	88,678,530	16,473,920	96,509,370	17,741,480	109,910,550	18,602,505	124,312,688
JUL	15,592,050	104,270,580	15,296,480	111,805,850	18,213,540	128,124,090	21,334,608	145,647,296
AUG	16,467,100	120,737,680	16,682,090	128,487,940	20,572,120	148,696,210	21,356,870	167,004,166
SEP	14,878,150	135,615,830	17,310,330	145,798,270	19,129,450	167,825,660	21,355,730	188,359,896
OCT	15,122,820	150,738,650	18,300,070	164,098,340	18,189,260	186,014,920	21,178,610	209,538,506
NOV	14,757,230	165,495,880	18,007,970	182,106,310	18,595,500	204,610,420		
DEC	16,096,150	181,592,030	19,034,530	201,140,840	20,866,710	225,477,130		
Total Tonnage Reported[1]		**181,592,030**		**201,140,840**		**225,477,130**		**209,538,506**
Total Tonnage Not Reported[2]		**7,878,226**		**8,784,986**		**11,430,937**		10,641,064[4]
Total Tonnage Produced[3]		**189,470,256**		**209,925,826**		**236,908,067**		220,179,570[4]

[1] COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities

[2] Includes estimates of residential, industrial, and exported coal, plus tonnages not reported on FERC's 423 forms

[3] State Mine Inspector's Annual Reports

[4] Estimate of total tonnage produced to date

Wyoming State Geological Survey, Coal Section, January 1996.

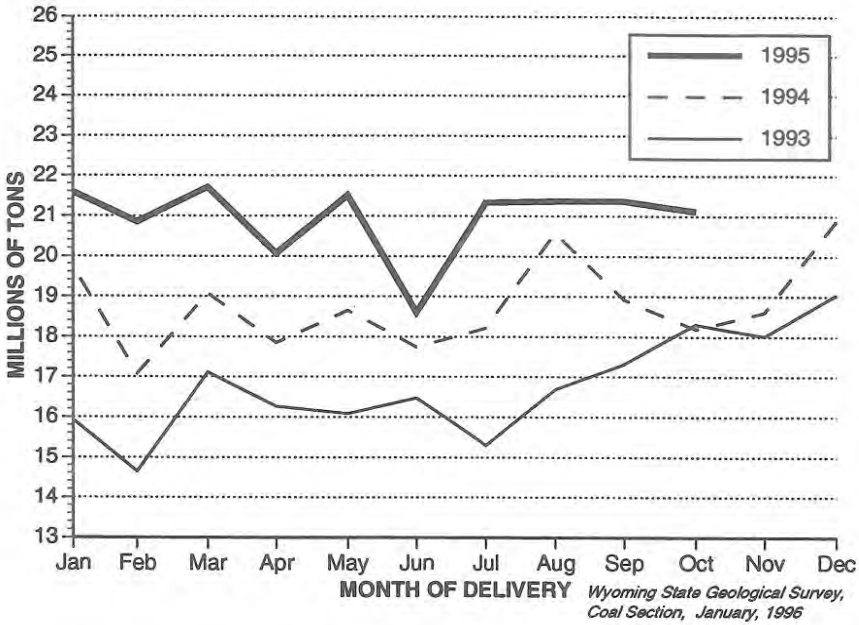

Figure 15. Reported deliveries from Wyoming coal mines (1993 through October, 1995). (From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).

right to use BN trackage to haul coal in their own cars from seven mines in the northern Powder River Basin.

There has been another coal mine closure in Colorado. The Golden Eagle mine announced that it would close its doors on New Years Eve, putting at least 149 miners out of work. Golden Eagle is owned by Basin Resources, Inc., a subsidiary of Montana Power. Earlier in 1995, the Empire mine closed.

Developments in the Powder River Basin

Texaco won a $24 million judgment in November in a "takings" lawsuit, involving its coal properties near Lake De Smet. The suit centered around a 1987 preliminary finding by the Wyoming Department of Environmental Quality, which determined that much of the 1200-acre Texaco property overlaid an alluvial valley floor (AVF) and therefore was unminable under Federal mining law. Texaco claimed it lost the value of 332 million tons of coal in that 1987 decision.

A Final Environmental Assessment (EA) for the Antelope Lease by Application (LBA), which was nominated by Kennecott Energy, was released in October. The first alternative mentioned in the EA is to approve the 462-acre tract as nominated. This tract is reportedly underlain by 57 million tons of coal.

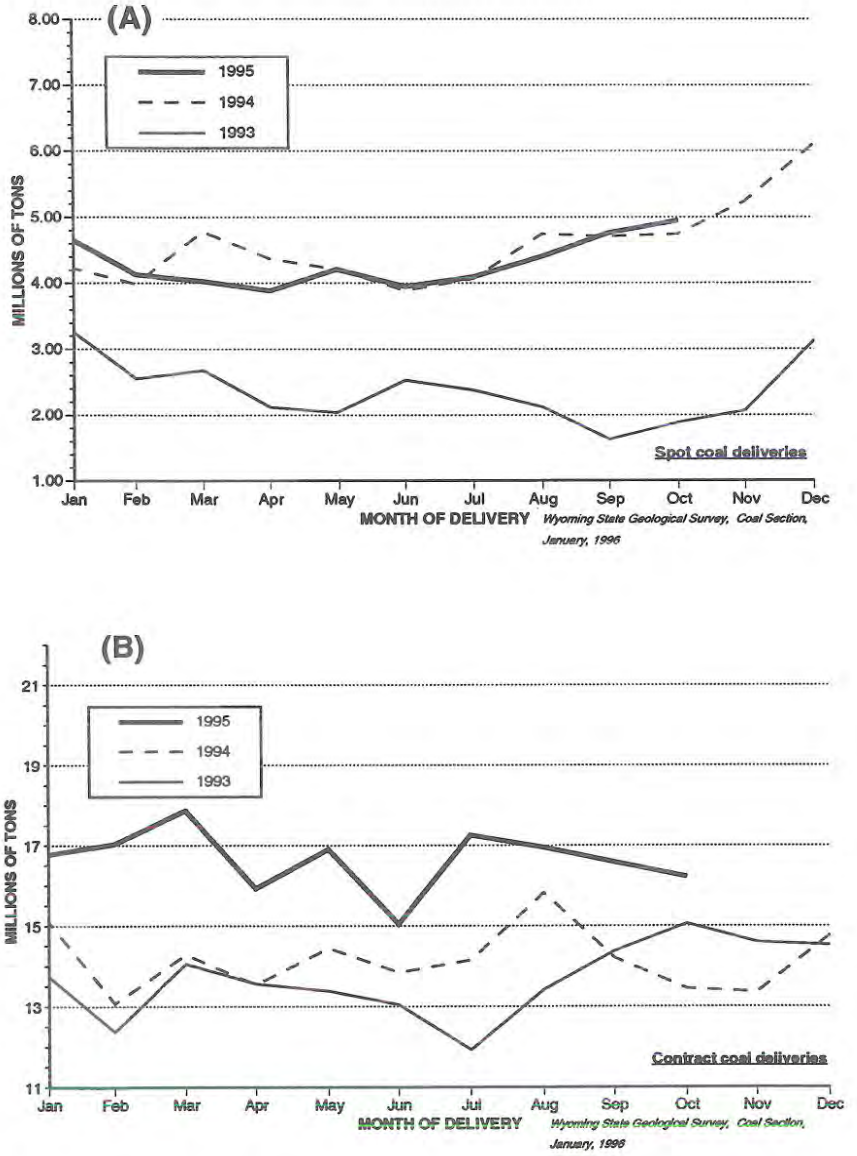

Figure 16. Monthly coal deliveries from Wyoming (1993 through October, 1995). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data International, Inc. compiled from the FERC Form 423 filed monthly by electric utilities).

Table 10 . Coal production (1992 to 1994) with forecast to 2002 (millions of tons).

	1992	1993	1994	1995[1]	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]
Campbell County	159.6	181.9	205.2	229.7	240.8	252.4	264.3	277.1	284.5	284.7	284.7
Converse County	8.5	10.2	11.7	13.0	13.2	13.8	14.9	15.6	16.0	16.3	16.6
Sheridan County	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Carbon County	4.1	4.4	4.4	4.2	4.1	3.8	3.6	3.3	3.0	3.0	3.0
Sweetwater County	12.6	9.2	11.2	11.5	11.5	11.7	12.0	12.2	12.4	12.2	12.2
Lincoln County	4.6	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.8	4.8	4.8
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming	189.5	209.9	236.9	263.1	274.9	287.1	299.9	313.3	321.1	321.1	321.1
Annual Change	-2.3%	10.8%	12.9%	11.1%	4.5%	4.4%	4.5%	4.5%	2.5%	0.0%	0.0%
Low-priced coal[2]	57%	64%	67%	74%	76%	78%	83%	87%	91%	94%	94%

[1]County estimates by the Wyoming State Geological Survey, January, 1996; [2]Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one-year duration], or through renegotiated, longer-term contracts all at prices under $5.00. M means minor tonnage (less than 0.1 million tons).

A second alternative would increase the tract size by 20 acres or 25 million tons of coal. Public comment on this EA ended on January 16, 1996.

A public scoping meeting on Ziegler Coal Company's North Roundup LBA was held in Gillette on December 5, 1995. This 1,439-acre tract contains approximately 150 million tons of coal. The U.S. Bureau of Land Management (BLM) has stated that an Environmental Impact Statement will be required for this tract (BLM, 1995). No dates have been set for the Thundercloud and North Antelope/Rochelle LBAs that were described on pages 25-26 in W*yoming Geo-Notes No. 48*.

Developments in Western and Southwestern Wyoming

In mid-November, a mine fire at the Cyprus Shoshone No. 1 underground mine near Hanna was extinguished with the help of personnel from the Mine Safety and Health Administration (MSHA). Mine officials had reported increased methane and carbon monoxide levels as well as smoke coming from a sealed area in the mine. After extensive testing, mine seals were reinforced and nitrogen was pumped into the sealed area to "starve" the blaze. MSHA officials continue to monitor the situation and cited spontaneous combustion as the cause for ignition.

The Carbon County Gasification Project was shut down December 21st, a victim of economics. Recent mechanical problems had been overcome, and the burn reignited in late September. It was estimated that it would take 6-8 weeks to extinguish the current burn. This was the only active underground coal gasification project in Wyoming.

Contracts

Table 11 and **Figure 17** depict coal marketing activity in Wyoming for the fourth quarter of 1995. A number of recent coal solicitations and their respective responses suggest that Powder River Basin coal prices in 1995 were below the $4.50-$5.50 prices seen in 1994.

The Lower Colorado River Authority (LCRA) recently finalized its 1996 coal supply agreements with some Powder River Basin producers. LCRA purchased 1.8 million tons of coal from Kennecott Energy's Cordero mine for $4.48/ton and 400,000 tons of coal from ARCO's Black Thunder mine for $4.10/ton.

A recent solicitation by the San Antonio Public Service Board (SAPSB) called for 2.5 million tons of coal for delivery in 1996, with options for up to five years. The bids that were submitted varied from a high of $5.05 for 8,800 Btu/lb coal from the North Antelope mine to a low of $3.35 from the Buckskin mine. SAPSB selected a $3.45 bid from Kennecott Energy's Cordero mine with annual deliveries of 2.6 million tons.

Table 11. Activities involving coal producers in Wyoming during the fourth quarter of 1995[1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	Central Power and Light	Coleto Creek	Black Thunder	T	200,000 t	
2.	Consumers Power	Cobb, Campbell, & Karn-Weadock	Powder River Basin coal	Sp	600,000 t	
3.	Hastings (NE) Utility Dept.	Whelan Energy Center	Caballo	Sp	50,000-200,000 t	
4.	Holnam Cement Co.	Fort Collins, CO, plant	Regional suppliers	So	30,000-40,000 t	
5.	Lower Colorado River Authority	Fayette	Cordero Black Thunder	Sp Sp	1,800,000 t 400,000 t	
6.	Omaha Public Power Disatrict	North Omaha North Omaha	Buckskin Buckskin	Sp Sp	800,000 t 700,000 t	 Supplemental coal.
7.	Public Service of Colorado	Arapahoe	Black Thunder	T	20,000 t	
8.	San Antonio Public Service Board	Deeley and Spruce	Cordero	C	2,600,000 t	Five-year contract.
9.	Springfield (MO) City Utilities	James River	Not specified	Sp	500,000 t	
10.	Texas Utilities Electric	Monticello	Supplied by either Black Thunder, Cordero, or Belle Ayr	Sp	500,000 t	
11.	Texas Municipal Power Agency	Gibbons Creek	Caballo Rojo Six Powder River Basin mines	C T	300,000 t 200,000 t	

[1] Data obtained from : Coal Week, trade journals, periodicals, FERC database, and personal contacts.
C =Contract coal; T =Test burn; Sp =Spot coal; So =Solicitation; t =short ton; MMTPY =Millions of tons per year.
Wyoming State Geological Survey, Coal Section, January 1996.

Wyoming State Geological Survey, Coal Section, January 1996

Figure 17. Coal Marketing activities related to Wyoming in the fourth quarter of 1995. [Numbers correspond to those in Table 11].

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Western Water Consultants, Mariah Associates, Inc., and Browne, Bortz & Coddington, Inc., 1992, Final Environmental Impact Statement, West Rocky Butte Coal Lease Application : U.S. Department of the Interior, Bureau of Land Management FES 92-11, p. 2-4.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

Figure 18 shows the location of many of the products, mines, and plants discussed below.

Bentonite

Bentonite is a clay mineral mined in the Black Hills of northern Wyoming, the Bighorn Basin, and west of Kaycee in the Powder River Basin. The major uses of bentonite are in making taconite pellets, foundry casting, drilling mud, and as an impermeable seal in pits or ponds to contain fluids. Bentonite is also effective in plugging seismic holes. Seismic holes are usually small-diameter, shallow

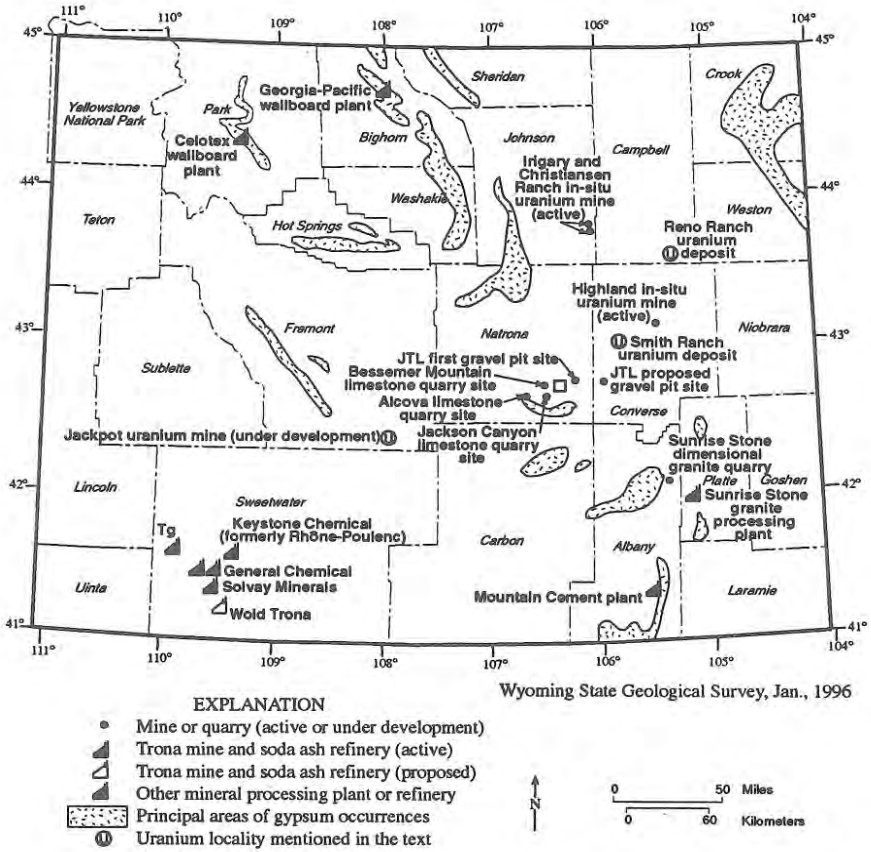

Fig 18. Industrial minerals and uranium activities in Wyoming during the fourth quarter of 1995.

holes in which small amounts of explosives are detonated. The reflections from the explosions are detected by an array of instruments. Either before or after the explosives are detonated, bentonite chips or pellets are poured into the hole. As the bentonite absorbs water from the surrounding rock, it expands, sealing or plugging the hole. It is preferable to put the bentonite in before the detonation, as it helps prevent the hole from blowing out. Blowouts are not as effective for the seismic survey, and they often leave a crater on the surface that must also be reclaimed.

Construction Aggregate

Construction aggregate is the sized gravel or crushed and sized rock used in many construction applications. It is a large-volume, but low-unit-cost mineral product. In early October, Bob Gaukel, the Executive Vice-president of the

Wyoming Contractors Association, noted that production of construction aggregate in Wyoming is expected to decline, both in 1995 and 1996. These declines reflect a general slowing down in heavy construction in Wyoming, both for buildings and highway projects.

Rissler McMurry has received a permit from the Natrona County Commissioners to operate a limestone aggregate quarry north of Alcova. Earlier attempts to permit an expanded quarry on Bessemer Mountain and a new quarry near Jackson Canyon were unsuccessful. Consumers will see an increase in price for this aggregate as the cost of construction aggregate goes up proportionately to the distance it is hauled.

JTL, which proposed a gravel pit in the alluvium of the North Platte River just east of Casper, was denied a permit at that site, and has now applied for a permit on a site about ten miles east of the initial location. If approved, JTL could operate a gravel pit and sizing facility at the new site. JTL's gravel prices will also reflect the increased haulage distance.

Dimension Stone

Sunrise Stone, which operates a dimension stone quarry in northern Albany County and a processing plant in western Platte County, has added an engraving machine to its equipment at the plant. Sunrise is now able to produce finished monuments out of their black granite (called Wyoming Raven), and their multicolored gneiss (called Fantastico).

After a few years of slowly dropping sales, the production of dimension stone in the United States increased by 7% in 1994. According to the U.S. Bureau of Mines one-half of this production was domestic granite, produced in Georgia, New Hampshire, Massachusetts, Minnesota, South Dakota, Texas, Wyoming, and a few other states. Production of dimensional limestone, which is produced primarily in Indiana, and marble, which is produced in Vermont, Tennessee, North Carolina, and elsewhere, also increased in 1994. Production of dimension stone probably increased slightly in 1995 as well.

Gypsum

Gypsum is mined in Wyoming by the Celotex Corporation near Cody, by the Georgia-Pacific Corporation between Lovell and Greybull, and by Mountain Cement south of Laramie. At the first two localities, gypsum is calcined and made into wallboard. Mountain Cement uses gypsum as a retarder in their cement.

Wallboard production from the plants in Wyoming is tied to construction in the Pacific Northwest because these plants are the closest domestic producers to that region. According to figures published by the Wyoming State Inspector of Mines, Wyoming's gypsum production for calcining increased from 355,792 tons mined in 1993 to 468,147 short tons mined in 1994. Construction activity in the Pacific Northwest is keeping both wallboard plants operating near

capacity. It is anticipated that gypsum production in Wyoming will remain at the current high levels or increase if the plants construct additional capacity.

Mountain Cement markets its products primarily in the Colorado Front Range, although its cement is sold in a wider area. While Mountain Cement's gypsum production has been relatively constant, expansion of the cement plant is scheduled for completion in early 1996. This expansion will almost double the plant's gypsum needs to around 100,000 tons per year.

Gypsum, a hydrated calcium sulfate mineral ($CaSO_4 \cdot 2H_2O$), is an important industrial mineral with several uses. It has the property of giving up and reacquiring water. Gypsum is usually calcined, which produces plaster of paris ($CaSO_4 \cdot 1/2\ H_2O$). When plaster of paris is mixed with water, it will set or harden, as the product returns to the dihydrate form. This semi-finished product, called stucco, is used to manufacture plasters, wallboard, and construction blocks. Uncalcined uses for gypsum include soil conditioners, mineral fillers and whiteners, and as a retardant in cement.

In Wyoming, gypsum is found at several localities, primarily in the Permian-Triassic Goose Egg and equivalent formations, the Triassic Chugwater and Spearfish formations, and the Jurassic Gypsum Spring formation. Although many of these gypsum deposits are mineable, competition from gypsum producers in nearby states make development of additional gypsum deposits in Wyoming unlikely.

Soil Conditioners (from phosphate rock and recovered sulfur)

The SF Phosphates plant southeast of Rock Springs produces soil conditioners from phosphate rock mined in Utah and sulfur recovered from natural gas in Wyoming. Due to a worldwide increase in prices for fertilizer and soil conditioners, SF Phosphates is constructing additional capacity at the plant. The plant's capacity will increase from 260,000 short tons per year to 300,000 short tons.

Trona

Trona, Wyoming's most important nonfuel mineral in terms of value, is mined and processed into soda ash and a variety of sodium compounds by five companies in southwestern Wyoming. An additional company, Wold Trona, is planning a sixth facility. In October, the Wyoming Department of Environmental Quality recommended approval of the permit for Wold's project.

In November, Rhône-Poulenc, a French-owned company, announced that it was selling its Wyoming trona mine and processing plant to Oriental Chemical Industry, a Korean-owned company. Oriental Chemical is planning to establish an American subsidiary called Keystone Chemical, which will be the name of the Wyoming operation. This mine and plant were originally developed by Stouffer Chemical in the late 1950s and early 1960s.

Uranium

Currently, all uranium extraction in Wyoming is through in-situ (solution-mining) methods. COMIN (a subsidiary of COGEMA) operates the Christiansen Ranch site, and Power Resources, the Highland site. Both companies continued drilling projects, expanding their production well fields.

Due to the increased demand for fertilizer and soil conditioners mentioned earlier, uranium recovered from phosphate rock in Florida has increased. Freeport Uranium Recovery, which mines the phosphate in Florida, but recovers the uranium from it in Louisiana, has increased its uranium production by almost 10%. Their production of recovered yellowcake has gone from 900,000 lbs/year to 1,026,000 pounds. This continues to be the largest single source of yellowcake produced in the United States. The two in-situ operations in Wyoming, however, collectively produce about 1,154,000 pounds of yellowcake each year, keeping Wyoming number one in domestic uranium production.

Companies continuing with plans for future uranium production include Kennecott Uranium at the Jackpot mine on Green Mountain south of Jeffrey City, Rio Algom at the Smith Ranch in the southern Powder River Basin, and Energy Fuels Nuclear at the Reno Ranch site. CAMECO continues exploration at some undisclosed locations in Wyoming.

METALS AND PRECIOUS STONES UPDATE

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

Tin Cup District

In 1994, the Wyoming State Geological Survey (WSGS) began field investigations in the Tin Cup district in the western Granite Mountains. Prior to 1994, no detailed study of the district was available. Previous investigations were made by Love (1970), who provided an overview on the mineralization and geology of the area, and Beeler (1907), who described the mines and mineralization of the district. More recently, Langstaff (1994) completed a detailed geologic map of the region.

Based on the report by Beeler (1907), the district appeared to have potential for significant gold and copper. However, the initial results of the WSGS's investigation do not support the earlier studies. Instead, the district appears to be a rock-hound's paradise, but with little or no precious metal potential. The author collected numerous samples of massive jasper, banded agate, jade, rubies, lapidary materials, and some massive pyrite in the district.

Beeler's report indicated that mineralized samples were found in the district that assayed from 0.08 ounce per ton to greater than 5.0 ounces per ton gold. It was also reported that some banded jaspers assayed 0.14 ounce per ton gold, and some prospects contained samples with as much as 15% copper. Addition-

ally, the prospectus of the Emigrant Mining Company (June 12, 1938) supported Beeler's work and reported that ore from the Sutherland mine south of Tin Cup Mountain assayed 0.04 to 0.46 ounce per ton gold. Samples collected from the bottom of the shaft purportedly assayed 0.4 ounce per ton gold and 23 ounces per ton silver.

The district, which lies in the western Granite Mountains, is underlain by amphibolite-grade Archean gneiss, schist, and amphibolite intruded by granite. Three prominent faults were mapped in the district (**Figure 19**), with a total strike length of nearly seven miles. All three contain several prospect pits along their length, and the southernmost structure also contains a couple of historical mines known as the Red Boy and Sutherland. An old foundation for a mill also occurs near the Sutherland shaft.

The Sutherland shaft was sunk in a gossan and intersected massive pyrite at a shallow depth. Samples of the massive pyrite and banded gneiss with stratiform pyrite were collected from the mine dump for assay. Another sample of jasperized breccia was collected from an adit driven on the same structure to the northeast of the shaft. These samples were quite disappointing as they contained no detectable gold. Only one sample along this structure (**Figure 19**, locality 19) contained trace amounts of silver (0.1 ounce per ton) and 1.71% copper. The sample was a copper-stained jasper with minor amounts of malachite, azurite, and tenorite, with a trace of chalcocite.

To the north of the Red Boy-Sutherland structure, some prominent jasperoids were found along the parallel faults. Red jaspers with jasperoid breccias and grey, banded, isoclinally folded jasperoids were found along these two structures. A sample of massive jasper with jasperoid breccia (**Figure 19**, locality 29) contained no detectable gold or silver.

Mineralization was lacking on these two structures, and while some of the samples contained more than 2% copper, the amount of copper-stained material found on the dumps was very restricted.

Gemstones and lapidary materials seemed to offer the greatest potential for economic possibilities. A ruby gneiss was traced along strike for 4,000 feet with widths of 20 to 50 feet in the southern portion of the district (**Figure 19**, locality 45). This gneiss contains common ruby porphyroblasts and fuchsite pseudomorphs after ruby. The rubies have a slight purple coloration possibly due to the presence of trace chromium. The stones range from two inches across to millimeter size. The great majority of the stones collected by the author are poor quality although some semi-translucent stones were recovered.

The gneiss continues south where the metamorphic grade decreases and the host rock is dominantly chloritic schist. The schist also contains ruby porphyroblasts.

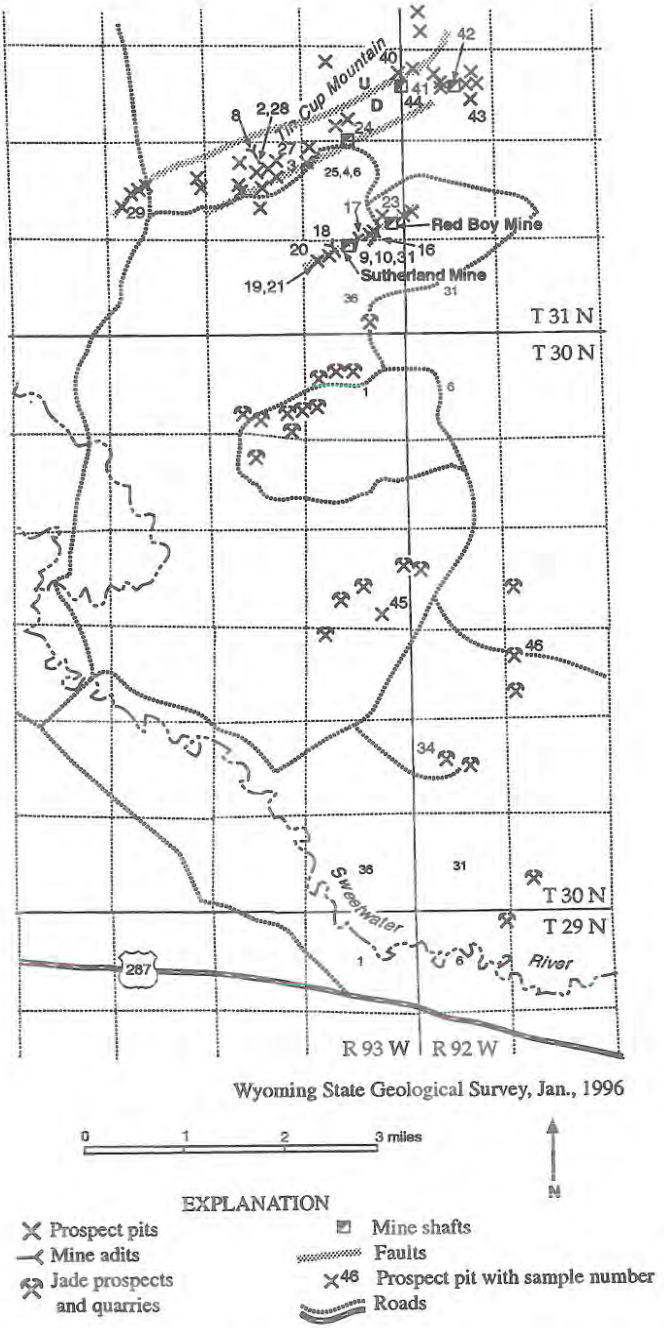

Figure 19. Schematic location map of the Tin Cup district, western Granite Mountains.

Several jade prospects also occur in the area (**Figure 19**). At locality 34, some bleached leucogranite with slight purple coloration was found in a worked-out jade prospect. The rock has a pleasing color and produces an attractive lapidary stone. XRD analysis of the aphanitic purple material in the rock resulted in a match with lepidolite, a lithum-bearing mica. At locality 46, jade was uncommon. However, some samples of nephrite jade were recovered that produced pseudomorphs after hexagonal quartz. A few of the other jade prospects in the area contained common narrow veins and veinlets of nephrite jade.

Golden Clover Mine

During July, the author visited the Golden Clover mine within the Big Creek district in the foothills of the Medicine Bow Mountains. The mine was developed by two 100-foot deep shafts located in section 26, T14N, R82W on the Barcus Peak Quadrangle (**Figure 20**). There is a mill adjacent to the shafts.

The mine was developed on a 2,000-foot-long quartz vein in sheared quartzofeldspathic gneiss country rock. The vein is 6 inches to 6 feet wide and contains free gold and auriferous pyrite in quartz. The values increase where the vein pinches, and some of the sheared wallrock yields values in gold. Several float samples collected in the region in the past were also anomalous in gold, suggesting the possibility of parallel vein sets. Highway 230 intersects an auriferous vein that was discovered nearby. Several assay certificates from the mine range from 0.2 to 20 ounces per ton gold (Ralph Platt, personal communication, 1995).

The author collected a grab sample of milky quartz with goethite after pyrite from the property. This sample yielded 0.323 ounce per ton gold and 14.9 ppm silver (0.43 ounce per ton). The Wyoming State Geological Survey will conduct detailed sampling and mapping studies of the area next summer.

Diamonds

Diamonds remained in the news with the scheduled commissioning of Redaurum Ltd.'s diamond mill at Kelsey Lake in the Colorado-Wyoming State Line district. The opening of this mine should attract some attention to the Colorado-Wyoming kimberlite province as the property has been producing some very high-quality diamonds (**Cover photo**).

According to the Northern Miner (8/21/95), production was to begin at the Kelsey Lake property in October, 1995, with the commissioning of the Kelsey Lake diamond mill. However, because of construction delays, the mill's commissioning was delayed. The January 1996 issue of the Northern Miner, however, reported that Redaurum Ltd. has begun processing a stockpiled, 70,000-tonne sample. The new mill is rated at a capacity of 250,000 tonnes per annum (Northern Miner, 8/21/95). Mining operations will reportedly resume in April (Northern Miner, 1/15/96).

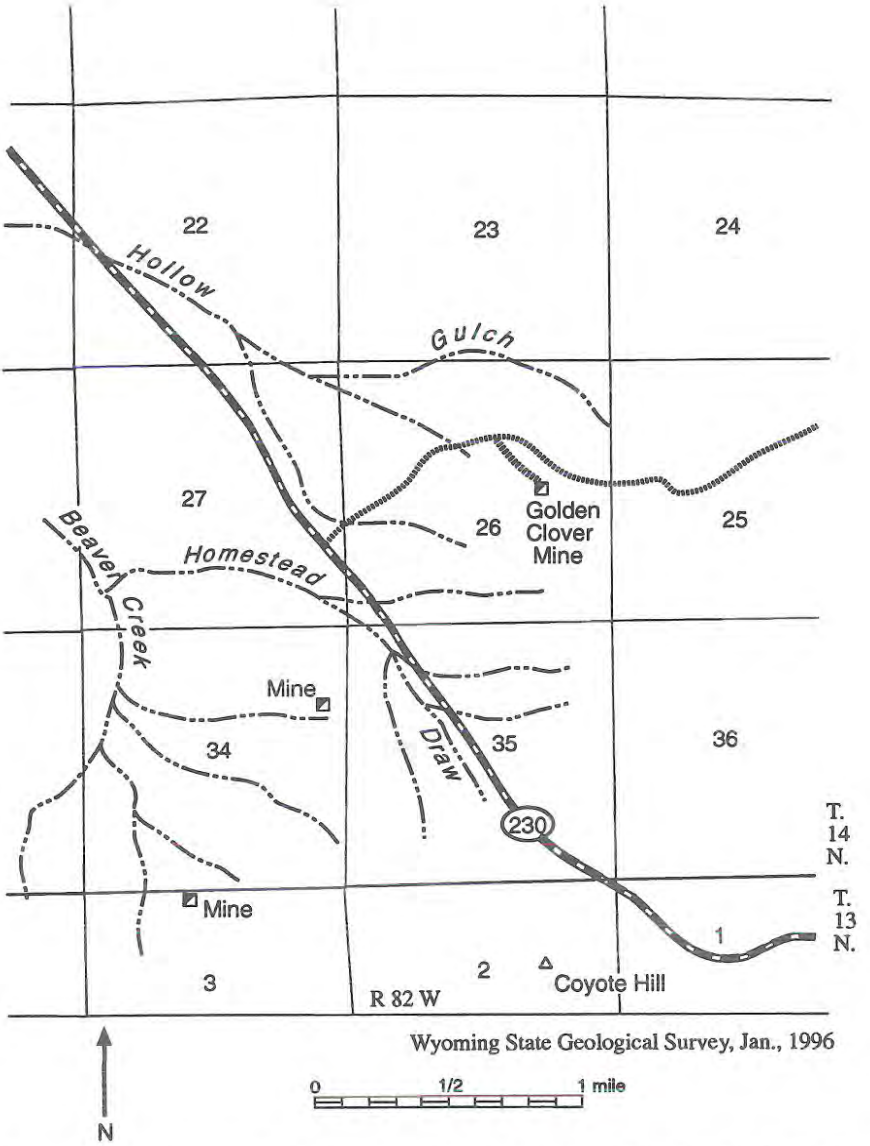

Figure 20. Location map of the Golden Clover mine, Barcus Peak Quadrangle, Wyoming.

According to the Casper Star-Tribune (12/30/95), Redaurum will recover about 25,000 carats of diamonds in its first year of production and plans to increase the capacity of the mill to 1.5 million tons per year in 1996-97. Full production will be about 150,000 carats of diamonds per year. According to the Northern Miner (8/21/95), the company's combined estimated tonnage for two of the four kimberlite pipes on their property was increased by 60% to 16.9 million tonnes.

Anvil Resources Ltd. of Canada has acquired four kimberlite 'blows' in the Chicken Park area in the southern part of the Colorado-Wyoming State Line district. The property has produced 306 diamonds in the past weighing a total of 19.73 carats at a grade of 6.67 carats/100 tonnes. The recovered diamonds included a 2.5-carat industrial diamond. The company reported drilling the property in August (Anvil Resources Ltd. company report, 1995). No results were available on the drilling.

During the Fall, diamond exploration activities expanded in Wyoming. In a November press release (11/7/95), Guardian Enterprises Ltd., announced that they had discovered a group of 10 "kimberlitic" diatremes and several associated dikes in the Green River Basin of southwestern Wyoming. This is the first report of kimberlites in this region, although "kimberlitic indicator minerals" have been known in the Cedar Mountain region for more than ten years. The kimberlites were discovered by the company's geologist, Richard Kuchera, as a follow-up to published reports on the widespread occurrence of the indicator minerals in the region (McCandless, 1982; Hausel and others, 1985; and McCandless and others, 1995). Based on the geology of the area, these kimberlitic pipes are Tertiary in age, rather than the Early Devonian age of the State Line kimberlites (Richard Kuchera, personal communication, 1995).

The area is of interest in that 10 detrital diamonds have been reported from the region in the past. Only one of the diamonds, however, has ever been verified. The Wyoming State Geological Survey is working with Guardian Enterprises Ltd. in assessing the diamond potential of these ultramafic breccia pipes. This is being done in the State Survey's diamond extraction laboratory. The Survey is currently conducting petrographic and geochemical studies of the host rocks and recently received a bulk sample from Guardian Enterprises for diamond extraction tests.

Late in 1995, Pay Dirt (11/95) reported that Royal Gold Inc. and Union Pacific Resources (UPR) had extended their exploration agreement to 1999. This agreement involves Royal Gold's right to explore for gold, diamonds, and other metals on UPR's lands in southern Wyoming

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GEOLOGIC MAPPING, STRATIGRAPHY, AND PALEONTOLOGY UPDATE

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

NEW GEOLOGIC MAP COMPLETED FOR LARAMIE COUNTY

The Wyoming State Geological Survey recently completed a new color geologic map for a large portion of Laramie County (Figure 21). The new, Cheyenne 1:100,000-scale map covers approximately 1,810 square miles and was compiled from existing maps of various scales with some new mapping to fill in gaps or replace outdated mapping. This map is one of a new series of maps at this scale specifically designed to aid city and county planners, industrial and mineral developers, as well as the general public by making regional geologic mapping available for the more populated areas in the State. These maps are intended to complement more detailed 1:24,000-scale maps, which the State Geological Survey is doing for the cities in Wyoming. Five other 1:100,000-scale maps (Nowater Creek, Recluse, Kinney Rim, Evanston, and Kemmerer Quad-

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Technically Recoverable Resources (January 1, 1995)	
Discovered (Includes oil, gas liquids, and condensate)	3.69 billion barrels[1]
Undiscovered	6.18 billion barrels[1]
Total	9.87 billion barrels
Remaining Reserve Base (January 1, 1995)	
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.05 billion barrels[2]
Indicated and inferred reserves (Reserve growth in conventional fields)	2.64 billion barrels[1]
Total	3.69 billion barrels

NATURAL GAS

Remaining Technically Recoverable Resources (January 1, 1995)	
Discovered (Includes 36.2 trillion cubic feet (TCF) of methane[1] and 121.8 TCF of CO_2[3])	158.0 trillion cubic feet
Undiscovered (Includes 15.72 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])	171.6 trillion cubic feet
Total	329.6 trillion cubic feet
Remaining Reserve Base (January 1, 1995)	
Measured reserves (Proved reserves) (Includes 10.2 TCF of methane[2] and 60.2 TCF of CO_2[3])	70.4 trillion cubic feet
Indicated and inferred reserves (Reserve growth in conventional fields)	26.0 trillion cubic feet
Total	96.4 trillion cubic feet

COAL

Remaining Resources (January 1, 1995)	
Identified and Hypothetical (Discovered)	1,427.8 billion tons[4]
Speculative (Undiscovered)	31.5 billion tons[4]
Total	1,459.3 billion tons
Remaining Reserve Base (January 1, 1995)	
Demonstrated strippable (Measured and indicated reserve base)	26.2 billion tons[5]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5 billion tons[5]
Total	68.7 billion tons

TRONA

Original Resources (1990 estimate)	
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[7]
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, 1994, U.S. crude oil, natural gas, and natural gas liquids reserves: 1993 Annual Report, 155 p.
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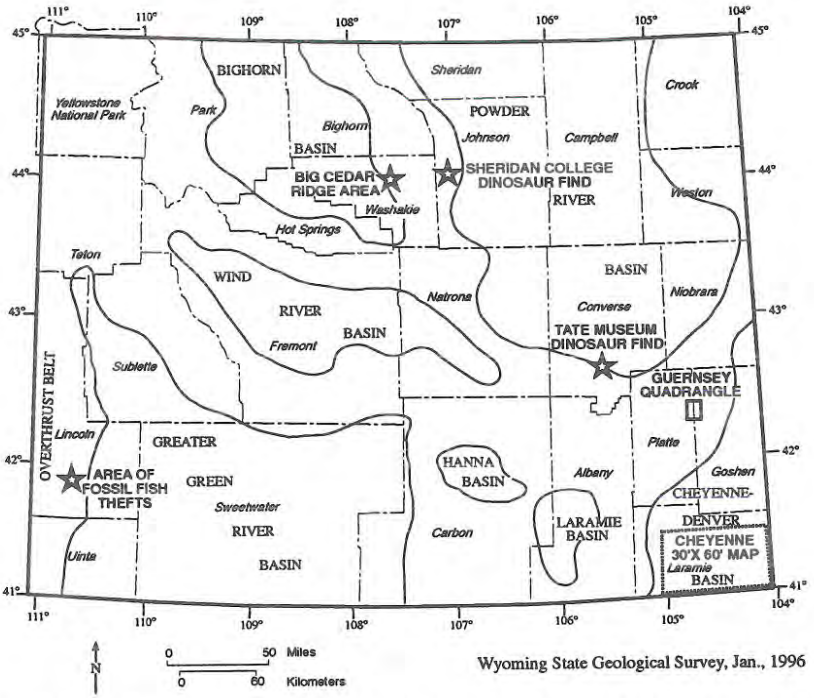

Figure 21. Index to selected reports, maps, or activities related to Wyoming geology.

rangles) have been completed by either the Wyoming State Geological Survey or the U.S. Geological Survey.

Sedimentary rocks ranging in age from Oligocene (38 million years before present) to Quaternary (2 million years or less before present) crop out within the boundaries of the quadrangle. Older Paleozoic and Mesozoic rocks occur in the subsurface beneath the Tertiary. In the subsurface, the structure is dominated by the axis of the Denver-Cheyenne Basin which crosses the quadrangle basically north to south just east of Cheyenne. The basin is asymmetrical with the steep limb on the west side. Several folds, which occur within the Paleozoic and Mesozoic rocks, contain significant oil and gas traps. Borie Field is an excellent example of one of these. Sand and gravel deposits, which are abundant within the area, are in great demand with numerous quarries already existing. The primary aquifers are the White River, Ogallala, and Arikaree Formations, as well as Quaternary terrace and alluvial deposits. There are also potential geologic hazards in this area related to windblown deposits. This map is available from the Wyoming State Geological Survey as Map Series 46 (MS-46). The map comes with an overview discussion that outlines the information included on the map and describes how the map can be used.

GUERNSEY AREA MAPPING PROJECT

The State Geologic Mapping Program (STATEMAP), which is part of a national program administered by the U.S. Geological Survey (USGS) and state geological surveys, recently awarded $8,499 to the Wyoming State Geological Survey for a geologic mapping project in northeastern Platte County and northwestern Goshen County (**Figure 21**). The proposal was developed by Ray Harris of the State Geological Survey's Industrial Minerals and Uranium Section. STATEMAP is a component of the National Mapping Act of 1992 in which states and the Federal government share equally in the cost of each funded project.

Harris, with assistance from the Mapping Section, will map the Guernsey Quadrangle (1:24,000-scale) during the 1996 field season. The proposed map area includes Archean and Proterozoic Precambrian rocks, Paleozoic and Tertiary rocks, and Quaternary sediments. The quadrangle is within the Hartville uplift and is crossed by the Wheatland-Whalen fault and numerous parallel and crosscutting structures. There is currently active production of industrial minerals and decorative stone in the area. The completed map will provide information useful for both the exploration and development of minerals as well as for the planning and siting of industrial and housing developments. The towns of Guernsey and Hartville are located within the quadrangle.

PALEONTOLOGICAL ACTIVITY

A field team from Sheridan College found fossilized bones of a rare, meat-eating, dinosaur identified as a *Ceratosaurus*. The specimen was found on a permitted, scientific-collecting site on State lands. According to Mike Flynn, a paleontologist and head of the Geology Department at Sheridan College, the find was made approximately 20 miles southwest of Buffalo, in the upper part of the 145-million-year-old Jurassic Morrison Formation (**Figure 21**).

Last summer, staff of the Tate Museum at Casper College and JPTA Summer Youth participants also discovered dinosaur remains in the Jurassic Morrison Formation. This fossil was found near Douglas (**Figure 21**). Later in the year, Dr. Robert Bakker identified the specimen as a plant-eating *Brachiosaurus*.

In 1990, Dr. Scott Wing of the Smithsonian Institute discovered well-preserved, fossilized remains of a 72-million-year-old plant community. The fossils occur in rocks of the Upper Cretaceous Meeteetsee Formation at a site south of Tensleep. A detailed study of the area during the summer of 1992 uncovered over 100 new plant species. As a result, the Worland office of the U.S. Bureau of Land Management has recommended that a 260-acre tract in the area be withdrawn for 20 years. They also are recommending retention of the current management of the area, which emphasizes scientific research, public education, and hobby collection of the fossils. These recommendations were out for public comment late in 1995.

Efforts to stop illegal collection of fossils on State, Federal, and private lands in the prolific fossil fish beds of the Green River Formation west of Kemmerer have increased (**Figure 21**). A representative of the Lincoln County Sheriff's Department recently testified before the Wyoming Board of Land Commissioners, regarding recent efforts of a local task force. He noted that periodic overflights of the area both during the day and at night have contributed to the discovery of 128 illegal digging operations and 29 felony convictions.

Currently, there are five permitted, commercial, fossil-collecting sites on State lands in that area of the State as well as numerous sites leased from private landowners. Commercial collecting is not permitted on Federal lands. The State permits, which are issued for five years at a cost of $1,000 a year, allow operators to collect and sell only seven common genera of fossil fish, while requiring them to turn over all other rare specimens to the State. In 1995, the Wyoming Board of Land Commissioners, which issues fossil-collecting permits for State lands, decided not to approve any new commercial permits until its staff thoroughly assessed the situation and brought its recommendations back to the Board. Existing permits were renewed for another five years.

CUTBACKS THREATEN SURVIVAL OF CORE RESEARCH CENTER

Federal budget cutbacks threaten the survival of the U.S. Geological Survey's (USGS's) Core Research Center in Lakewood, Colorado. Although the USGS has tried to maintain its historical funding level of about $1 million, recent cutbacks in funding have reduced their commitment to $600,000 for the current fiscal year. The cuts have sharply reduced staff activity at the center. Cores are no longer being slabbed and photographed. In addition, the staff has been reduced from eight to three and storage space reduced by 40%.

Currently the center maintains a library of about 1.4 million feet of core from about 8,000 wells. There are also cuttings from more than 50,000 wells, representing about 230 million feet of drilling. The majority of the cores and cuttings are from the Rocky Mountain states. Wyoming is well represented in the collection with 2,922 cores and 18,568 sets of cuttings. The library is used extensively by the petroleum industry, academia, and professional associations.

In an effort to support the center and more importantly, preserve the collections, the Rocky Mountain Association of Geologists (RMAG) established a Sample Preservation Committee. A major goal of this RMAG committee is raising $3.5 - 4 million for an endowment fund, with the interest going toward maintaining the center. For further information, contact the RMAG at (303) 573-8621.

NATIONAL GEOSCIENCE DATA REPOSITORY SYSTEM

In a somewhat similar vein, the American Geological Institute (AGI) is establishing a National Geoscience Data Repository System (NGDRS). The system was proposed as an effort to save literally billions of dollars of geological and geophysical data from eventual loss as the focus of the U.S. petroleum industry shifts to overseas. Previously, a variety of public and private geoscience collections received support directly and indirectly from petroleum companies. Recently, this support has significantly decreased.

NGDRS will be a system of regional data repositories developed in cooperation with existing state agencies and private organizations. It is envisioned as a integrated network of repositories, rather than one central data center. Data will include well logs (digital and hard copy), seismic data, rock core, and sample cuttings. Private companies, academia, and State and Federal agencies are expected to use this data for a wide variety of purposes, including mineral exploration, general research, environmental protection, hazard mitigation, and planning for various types of development. This system will make some data available to the entire geoscience community for the first time. For further information on this effort, AGI can be contacted at (703) 379-2480 or (FAX) (703) 379-7563.

EARTHQUAKE POTENTIAL IN SOUTHWESTERN WYOMING

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

Southwestern Wyoming has had an abundance of earthquakes, as seen in **Figure 22**. Fortunately, most have caused little damage, although the potential does exist for damaging earthquakes. In summary, the historic record shows that southwestern Wyoming is seismically active. Although some earthquake activity has been associated with mining or possibly exploration activities, most activity is related to movement on buried faults. Since there has been significant historic as well as current underground mining of both coal and trona in this area of Wyoming, there is the possibility that other mining-related seismic events could occur.

Figure 22 also shows active faults with a surficial expression in southwestern Wyoming. A comparison of the location of these faults to the historic epicenters in this figure indicates that few, if any, of the historic earthquakes in southwestern Wyoming have occurred on an exposed active fault. In other words, most historic events have occurred on buried faults with no surficial expression.

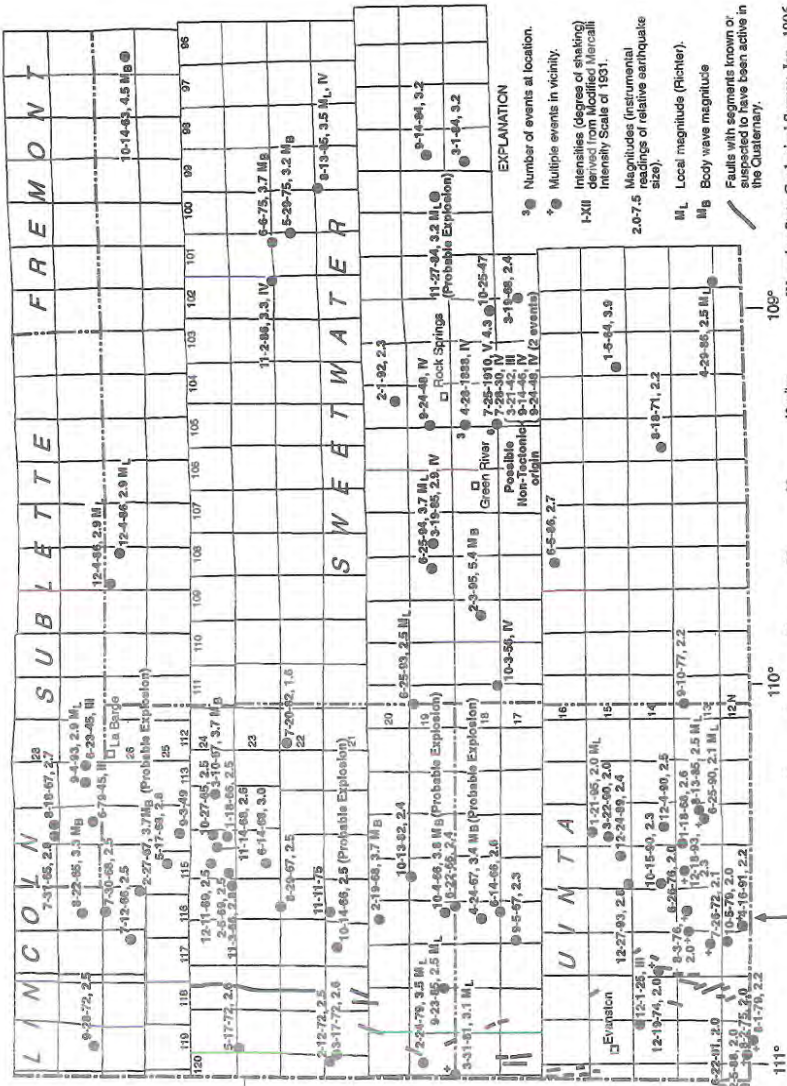

Figure 22. Earthquake epicenters and active faults with surficial expression in southwestern Wyoming.

When it comes to predicting the potential for future earthquakes, there are a few methods in use that can provide an estimate for an area. One method relies on an extrapolation of the historic record. If that method were applied to southwestern Wyoming, it would indicate there was only the potential for a few, relatively non-damaging events to occur in the future. Unfortunately, such methods of estimation are highly unreliable. The historic record only covers a period of a little more than one hundred years, and even that record is incomplete. This method of estimation does not account for large earthquakes that may occur every 2,000 years, even if 1,900 years have elapsed since the last large event.

A more accurate method of determining the seismic risk in an area is based on regional models of potential seismicity. These models, which are often used by the U.S. Geological Survey (USGS), take into account such factors as comparisons with similar geologic settings, with estimated maximum credible earthquakes assigned to those settings; historical seismicity; all available information on known active faults; and region-specific information on the seismic wave attenuation characteristics of the bedrock and soils in the region.

Using this approach, the USGS (Algermissen and others, 1982) has estimated that the largest earthquake likely to occur in the westernmost quarter of southwestern Wyoming (the Overthrust Belt) would have a magnitude of 7.3. The largest earthquake likely to occur in the rest of southwestern Wyoming would have a magnitude of 6.1. The USGS also has estimated that an intensity V earthquake would occur in the Wyoming Overthrust Belt every 10 years, and in the Green River Basin, every 62 years. An intensity V earthquake could break dishes and windows, crack plaster, and topple unstable objects.

The best way to estimate the earthquake potential of an area is derived from field studies of exposed active faults. Figure 23 shows that there are three exposed active fault systems in southwestern Wyoming: the Rock Creek, the Northern Bear River, and the Bear River fault systems.

The Rock Creek fault system, located just west of Fossil Butte National Monument in Lincoln County, has had a few limited studies done on it. The most recent study (McCalpin and Warren, 1992) indicates that the fault is capable of generating a magnitude 7.5 earthquake. The fault last activated between 3,280 and 3,880 years ago. The next most recent event was approximately 4,800 years ago (McCalpin, 1993). If a magnitude 7.5 earthquake did occur, it could be felt as an intensity X event in the vicinity of the fault, an intensity VIII-IX event in Kemmerer, an intensity VII-VIII event in Evanston, and an intensity VI-VII event in Green River. An intensity IX event would destroy much masonry construction, damage most foundations, and shift structures off their foundations. An intensity VIII event would cause considerable damage in ordinary substantial buildings, and an intensity VII event would cause slight to moderate damage in well-built ordinary structures. An intensity VI event would cause a few instances of fallen plaster or damaged chimneys.

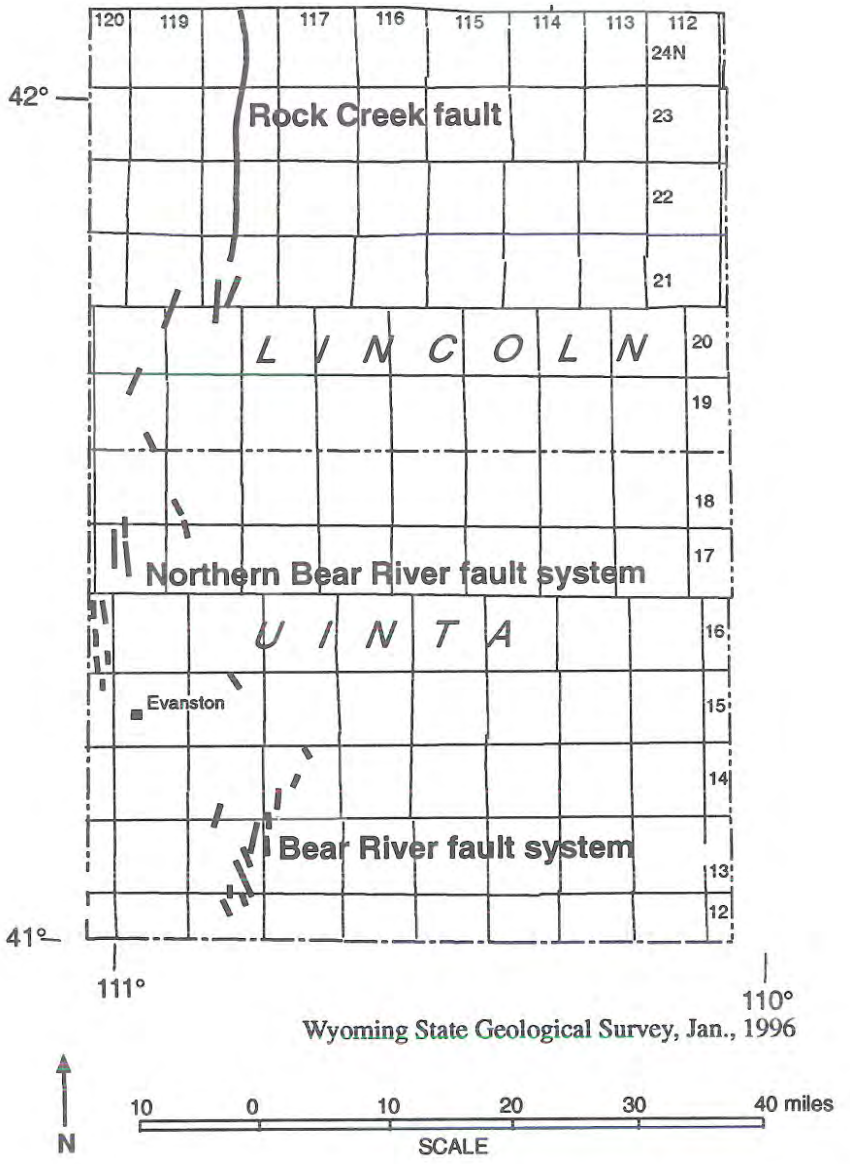

Figure 23. Active fault systems with surficial expression in southwestern Wyoming.

Very few studies have been conducted on the Northern Bear River fault system. It has been estimated that movement on one segment of the system, the Whitney Canyon fault, occurred between 1,200 and 2,400 years ago (Gibbons and Dickey, 1983).

The Bear River fault system is located approximately 12 miles southeast of Evanston. Based upon field studies by West (1989), a maximum credible earthquake of magnitude 7.5 has been estimated for the system. A minimum recurrence interval of 1,800 years has been inferred for the system. Since 2,320+/- years have elapsed since the last event, the system may be at or beyond the expected recurrence of a large earthquake. If the fault activates, damage could extend throughout southwestern Wyoming. A magnitude 7.5 earthquake originating on the Bear River fault system could be felt as an intensity IX event in Evanston, an intensity VII-VIII event in Kemmerer, and as an intensity VI-VII event in Green River.

In summary, one can roughly estimate the future earthquake potential of southwestern Wyoming based upon the above information. The three analytical techniques described above; however, are easily misunderstood and misused. Site-specific studies are still the best approach to take when determining the earthquake hazard of an area. Unfortunately, seismologists still cannot predict with any certainty when an earthquake will actually occur. The fault systems described above may not activate for thousands of years, or they may activate within the next one hundred years. We just don't know.

Recent research has uncovered some other geologic factors in southwestern Wyoming which may have a bearing on seismic events in this part of the State. Newly discovered shear zones (faults) as well as suspected regional uplift have been and are currently under investigation. Mr. Gordon Marlatt, a geologist at the Institute for Energy Research at the University of Wyoming, has discovered and delineated a series of east-west-trending shear zones scattered throughout the Green River Basin. The movements are post-Oligocene, although no evidence for Holocene-age activity has been found to date. Marlatt is continuing his research on the right-lateral shear zones. The relationship between the shear zones and future seismicity in the basin is unknown at this time.

In 1988, Mr. John Coyne completed a master's thesis at Cornell University titled "New Estimates of Crustal Motion in the Western United States". The thesis presents a comparison of precise leveling surveys conducted by the National Geodetic Survey, which used common benchmarks over time. First order leveling surveys were conducted from Ogden, Utah, to Green River, Wyoming, in 1958 and again in 1983. Based upon a comparison of the 1958 and 1983 data, Coyne found that an anomalous uplift, centered around Little America, Wyoming, had formed in that 25-year period. The uplift consisted of a centrally peaked uplift (3.7 inches high by 6 miles wide) with downwarped flanks (0.9 inches deep extending over 14.4 miles on each side). Coyne felt the uplift was too systematic to be local benchmark instability.

Coyne also described a southwest-northeast-trending shear zone that coincided spatially with the uplifted part of the anomaly, suggesting that aseismic creep on the shear zone may have contributed to the observed deformation. By the same token, the anomaly overlies thick trona deposits and is near some of the underground trona mines. As another possibility, Coyne suggests that the uplift may be due to flowage in trona, a process which is a matter of debate.

In summary, additional research would help to refine our knowledge of the seismic hazard in southwestern Wyoming. In addition, one or more seismic stations in this area of the State would improve the seismic record and provide valuable information in making estimates of the earthquake potential.

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ROCK HOUND'S CORNER

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

Many of Wyoming's gemstone deposits are unexplored, thus the weekend prospector and rock hound has a very good opportunity of making significant finds searching for gemstones in our State. To assist rock hounds and prospectors, the Wyoming State Geological Survey is in the initial stages of collecting information and photographs for a bulletin on the State's gemstones. If you would like to contribute to this bulletin, please contact W. Dan Hausel at the Wyoming State Geological Survey, P.O. Box 3008, University Station, Laramie, Wyoming 82071 (307/766-2286). Any information or photographs that we use in this bulletin will be properly credited.

Many rock hounds spend much of their field time searching for varieties of chalcedony (cryptocrystalline quartz). Such specimens of agate and jasper take a fine polish, and result in samples that anyone would be proud to display. For example, some agates found near Guernsey in the Hartville uplift of eastern Wyoming have attracted rock hounds and rock clubs for years. One of these agates is the Youngite agate. In geological terms, Youngite is a rehealed limestone breccia. But more specifically, the rock consists of pink- to cream-colored breccia clasts of Guernsey Limestone, rehealed, or cemented by light-grey to grayish blue, banded, drusy quartz. The drusy quartz fills fractures in the breccia completely encasing the limestone clasts. When polished, the contrasting colors of the quartz and breccia clasts provide an attractive lapidary stone often found in Wyoming and Nebraskian rock collections. Under long wavelength fluorescent light, samples yield a blue network of fluorescence following the bands of drusy quartz.

Another popular agate found in the same region is the Slater agate. The exact location of this agate has not been made available, but these agates produce concretionary masses covered with a white coating. When cut, the interior of the stone is a dark grey to black agate that surrounds milky agatized interiors containing small, fine, agatized dendrites. The surface of some of these agates is porous giving the impression of fossilized sponge or some similar material.

In addition to the agates of the Hartville uplift, agates and jaspers are found throughout the State. Some relatively attractive agates and jaspers are also described in the Metals and Precious Stones Update in this issue of *Wyoming Geo-notes*. Other agates are described by Hausel (1986) and Sutherland (1990).

Some of the more common gemstones found in Wyoming include rubies, sapphires, diamonds, aquamarine, and nephrite jade. There are probably other

gemstones in our State that have not yet been found. For instance, one Laramie prospector stopped in recently with some small unidentified mineral specimens collected from the Sierra Madre in southeastern Wyoming. One sample contained some small rubies: the other contained small emeralds. Prior to this time, emeralds were unknown in Wyoming.

Aquamarine is a another gemstone found in our State. The aquamarine in Wyoming is a light-blue, translucent beryl. Several years ago while working in the South Pass greenstone belt in the southern Wind River Range, Elmer Winters, a weekend prospector from Lander, found a large aquamarine in a pegmatite in the Anderson Ridge area. Luckily Mr. Winters had previous experience in single-jacking in a gold mine while growing up in the Depression. With his experience, he was able to work the stone out of solid pegmatite with minimal damage to the stone. Aquamarine has also been reported in the Bighorn, Owl Creek, and Laramie Mountains.

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Sutherland, W.M., 1990, Gemstones, lapidary materials, and geologic collectables in Wyoming: Wyoming State Geological Survey Open File Report 90-9, 53 p.

NEW PUBLICATIONS OF THE WYOMING STATE GEOLOGICAL SURVEY

*Publications available from the Wyoming State Geological Survey: 1995.-Free on request.

*Sixty-second annual report of the Wyoming State Geological Survey for Fiscal Year 1995, by G.B. Glass and S.G. Bruhnke: 1996.-Free upon request.

Geologic map of the Cheyenne 30' x 60' Quadrangle, southeastern Wyoming, western Nebraska, and northern Colorado, compiled and mapped by A.J. Ver Ploeg: Map Series 46, [scale 1:100,000], 1995.-$5.00 (folded), $6.50 (mailed rolled).

Triceratops, Wyoming State Dinosaur poster: miscellaneous publication, 1995.-$5.00 (over-the-counter), $6.50 (mailed rolled).

Triceratops, Wyoming State Dinosaur postcard: miscellaneous publication, 1995.- $0.25 or 5 for $1.00.

The Open File Report series of the Wyoming State Geological Survey was discontinued as of August, 1995. Each geologic section of the Survey now releases its own numbered reports and maps. Please contact the following Survey geologists for coverage, availability, prices, or further information on specific commodities or topics:

James C. Case - Geologic hazards and environmental geology

Rodney H. De Bruin - Oil and gas

Ray E. Harris - Industrial minerals and uranium

W. Dan Hausel - Metals and precious stones

Alan J. Ver Ploeg - Geologic mapping, paleontology, and stratigraphy

P. Daniel Vogler - Coal

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

The Wyoming State Geological Survey sells the *Atlas of Major Rocky Mountain Gas Reservoirs*, a publication jointly prepared by the New Mexico Bureau of Mines and Mineral Resources, the Colorado Geological Survey, the Utah Geological Survey, the Wyoming State Geological Survey, and the Gas Research Institute-$99.75. Available over-the-counter or PREPAID, by mail from the Wyoming State Geological Survey in Laramie. Checks, for this publication only, should be made payable to: New Mexico Bureau of Mines and Mineral Resources or NMBMMR. (Price includes postage and handling.)

Order these and other publications from: Wyoming State Geological Survey, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

PUBLICATIONS OF THE WYOMING GEOLOGICAL ASSOCIATION

By special arrangement with the Wyoming Geological Association (WGA), the Wyoming State Geological Survey sells all of WGA's Annual Field Conference Guidebooks as well as its Symposium Volumes. This includes the recently released Guidebook and Road Logs for the 1995 Field Conference on southwestern Wyoming ($75 + postage for WGA members, $85 + postage for nonmembers). These publications are available over-the-counter at the Survey's offices on the University campus in Laramie. Although they can be purchased by mail, prepayment is required. Call the Survey for book prices and postage costs. WGA sale prices will also be honored.

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The Wyoming State Geological Survey, an authorized sales agent for U.S. Geological Survey maps, was informed in August, 1995, that sales prices for U.S. Geological Survey maps were increased substantially, and that dealer discounts were also decreased. Because of these increased costs, we had to raise our prices for U.S. Geological Survey topographic maps. Effective October 1, 1995, the new prices for topographic maps are as follows:

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Mark your calendars and plan to attend the 32nd Forum on the Geology of Industrial Minerals. This international meeting will be held in Laramie, Wyoming, May 19-25, 1996. There will be one pre-meeting field trip, two days of technical sessions, and one-, two-, four-, and six-day post-meeting field trips to choose from.

Contacts:

Ray Harris for information on the content of the Forum: (307) 766-2286 or email: ray_harris@wsgs.uwyo.edu

Barbara Barnes for registration information: 1-800-448-7801, ext. 2 or (307) 766-2124 or email: bbarnes@uwyo.edu

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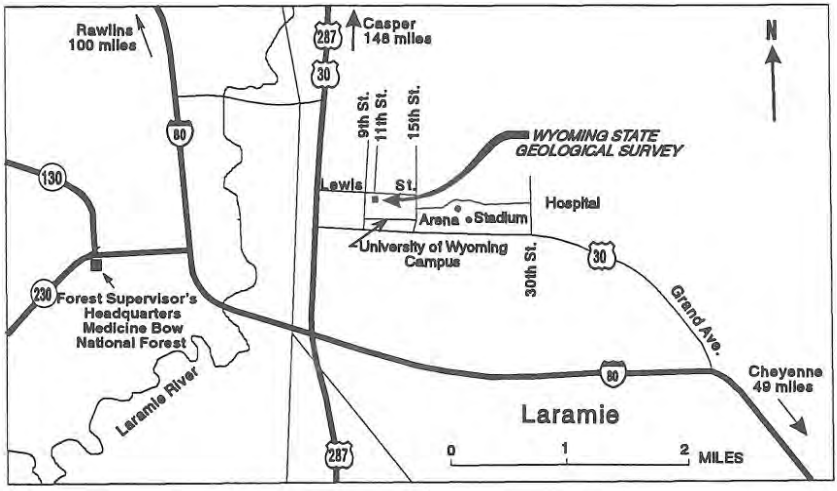

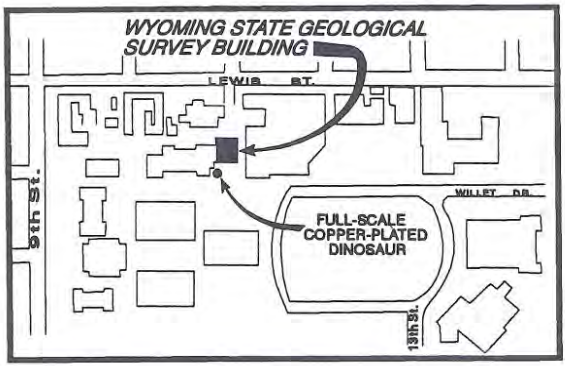

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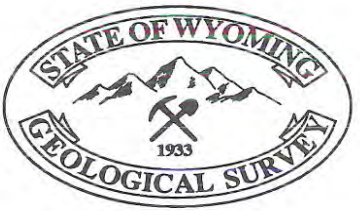
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