

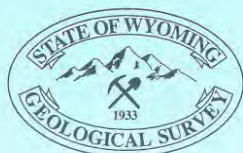
Wyoming Geo-notes

Number 63



Wyoming State Geological Survey
Lance Cook, State Geologist

Laramie, Wyoming
September, 1999



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Printed on 50% recycled fiber paper. 500 copies printed by Pony X-Press, Cheyenne, Wyoming.

Front cover: Left half of stereopair #90 - "Fountain Geyser" by H.B. Calfee of Bozeman, Montana ca. 1876. Lower Geyser Basin. Named during Hayden Survey, 1871. Height of eruption, 75 feet. Eruptions vary from 1-12 hours, with periods of dormancy. From the personal collection of Lance Cook.

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MINERALS UPDATE

OVERVIEW

By Gary B. Glass
Contributing Contract Editor

Oil production from Wyoming in 1998 was 65.7 million barrels, which is 6.4% below 1997 production (**Table 1** and **Figure 1**). This was somewhat better than expected after about a year of relatively low oil prices (**Table 2** and **Figure 2**). Production was also higher than the preliminary figure of 64.8 million barrels cited in the last issue of *Wyoming Geo-notes*.

On an even brighter note, the 11.9% decline in oil production through the first four months of 1999 should lessen as a result of the surprisingly higher oil prices that began in the second quarter of the year. Oil production in 1999 is now less likely to decline as much as the State's Consensus Revenue Estimating Group (CREG) forecast back in January (CREG, 1999).

In other good news, it also looks like the average price for Wyoming crude oil in 1999 will be considerably higher than CREG's (1999) January forecast. The optimistic prediction by some that the price of Light Sweet Crude would

Table 1. Wyoming mineral production (1985-1998) with forecasts to 2005¹.

Calendar Year	Oil ^{2,3}	Methane ^{3,4}	Carbon Dioxide ^{3,4}	Helium ^{4,5}	Coal ⁶	Trona ⁷	In-situ Uranium ^{7,8}	Sulfur ^{3,9}
1985	131.0	597.9	—	—	140.4	10.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	11.9	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3	1.20
1996	73.9	1,023.4	149.0	1.10	278.4	18.6	1.9	1.22
1997	70.2	1,040.7	151.0	1.10	281.5	19.4	2.2	1.23
1998	65.7	1,071.4	151.0	1.10	315.0	18.6	2.3	1.20
1999	55.3	1,064.8	151.0	1.10	338.5	18.2	2.5	1.20
2000	52.5	1,089.1	151.0	1.10	358.8	18.2	2.5	1.20
2001	49.9	1,113.9	151.0	1.10	371.0	18.4	2.5	1.20
2002	47.4	1,139.2	151.0	1.10	374.7	18.6	2.5	1.20
2003	45.0	1,165.1	151.0	1.10	378.5	18.8	2.5	1.20
2004	42.8	1,191.4	151.0	1.10	382.2	19.0	2.5	1.20
2005	40.7	1,218.3	151.0	1.10	386.1	19.2	2.5	1.20

¹Modified from CREG's Wyoming State Government Revenue Forecast, January, 1999; ²Millions of barrels; ³Wyoming Oil & Gas Conservation Commission, 1985-1998; ⁴ Billions of cubic feet; ⁵Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; ⁶Millions of short tons (Wyoming State Inspector of Mines, 1985-1998); ⁷Wyoming Department of Revenue, 1985-1998; ⁸Millions of pounds of yellowcake (not available [N/A] for 1985 and previous years because it was only reported as taxable value); ⁹Millions of short tons.

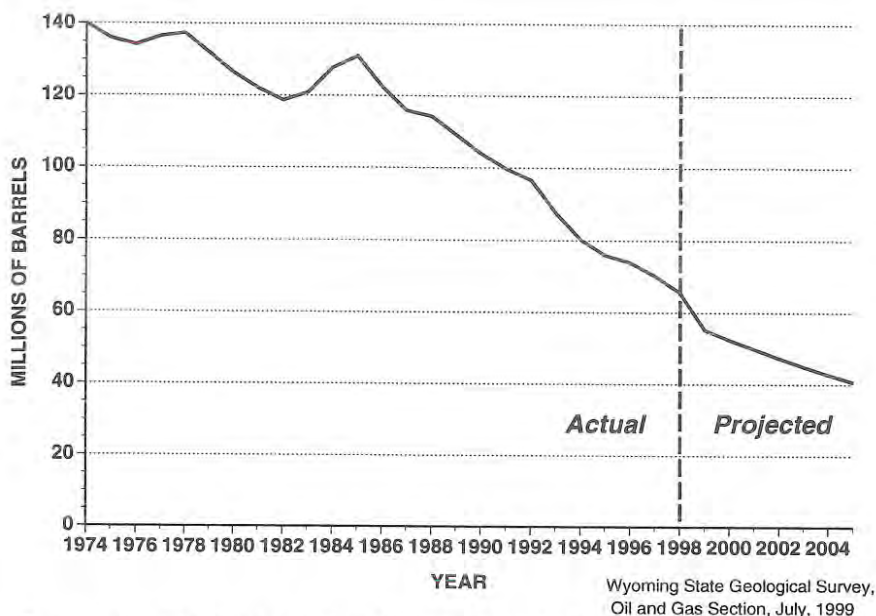


Figure 1. Annual oil production from Wyoming (1974 to 1998) with forecasts to 2005.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1998) with forecasts to 2005¹.

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	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.68	42.29
1998	10.67	1.81	5.41	41.29*
1999	9.50	1.75	5.27	39.91
2000	11.33	1.75	5.11	40.26
2001	13.16	1.75	4.94	41.24
2002	15.00	1.75	4.95	42.04
2003	15.00	1.75	5.01	42.53
2004	15.00	1.75	5.01	42.96
2005	15.00	1.75	5.04	43.15

¹ Modified from CREG, Wyoming State Government Revenue Forecast, January, 1999; ² First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1998; ³ Wellhead price in dollars per thousand cubic feet (MCF). Source: Wyoming Office of State Lands and Investments, 1989-1998 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); ⁴ Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-1998; ⁵ Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1998. * Still estimated

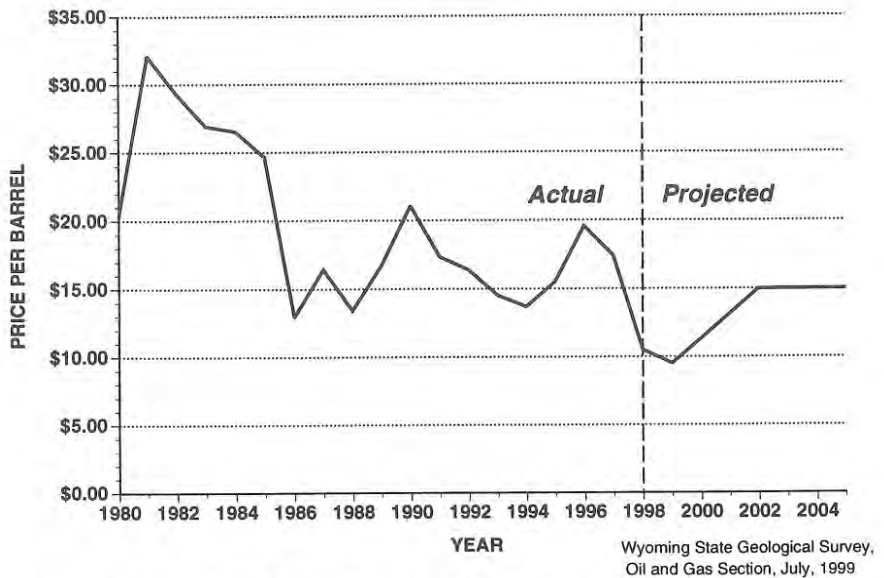


Figure 2. Average prices paid for Wyoming oil (1980 to 1998) with forecasts to 2005.

reach \$20.00 a barrel before the end of the year has come true. Oil Futures for Light Sweet Crude were holding at more than \$20.00 a barrel by the third quarter of the year. And in June, Wyoming crude oil prices averaged \$15.00 a barrel, up from \$9.20 for the first two months of the year (**Table 3 in the Oil and Gas Update**). **Table 2** and **Figure 2**; however, still reflect CREG's January forecast. They are expected to change when CREG meets again this fall.

As mentioned in the last issue of *Wyoming Geo-notes*, significantly higher oil prices could be a short-lived boon to some of Wyoming's oil producers. A reduced flow of Canadian oil into Wyoming's market area has been a direct function of low prices. As Canadian producers cut back their exports to the U.S., many Wyoming producers began receiving bonuses for their oil. However, as more Canadian oil starts to flow back into the area due to higher prices, those bonuses are likely to disappear. At least this gloomy possibility is tempered somewhat by the overall improvement in oil prices.

In regard to last year's natural gas production from Wyoming, the official figure is 1,223.5 billion cubic feet (BCF) (**Table 1** and **Figure 3**). This is 1.5% higher than predicted (CREG, 1999). It is also 2.9% higher than natural gas production in 1997.

After four months of production in 1999, natural gas production in Wyoming was only slightly ahead of 1998 production (**Table 6 in Oil and Gas Update**). Based on previous years; however, the production for the first four months of a year is not a particularly good indication of year-end production. If production increases by only 2%, it will reach 1,092.8 BCF in 1999. Although **Table 1**

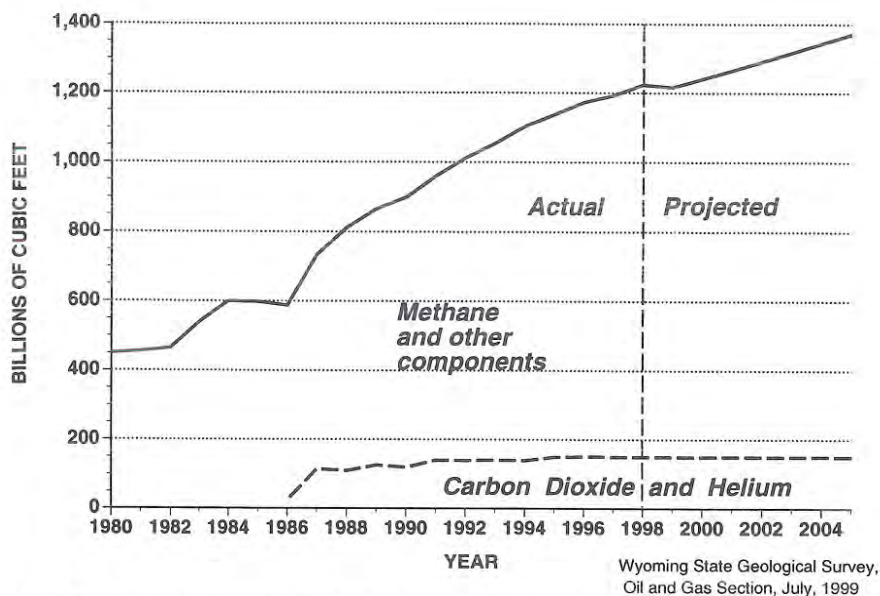


Figure 3. Annual natural gas production from Wyoming (1980 to 1998) with forecasts to 2005.

and **Figure 3** still show CREG's (1999) January forecast, CREG's forecast will likely be revised this fall.

Monthly reports from the American Gas Association and other sources indicate that spot sale prices of methane from Opal, Wyoming, averaged \$1.81 per thousand cubic feet (MCF) in 1998 (**Table 2** and **Figure 4**). In regard to methane prices this year, there is room for optimism. For 1999, CREG's (1999) estimate of \$1.75 per MCF of methane may be somewhat low, even though the six-month average for the State was only \$1.76 (**Table 5** in **Oil and Gas Update**). This is because methane prices increased to \$2.00 per MCF in May and June. If these higher prices continue for any length of time, the year-end average could equal or exceed that of last year.

In regard to coal production, there is also room for optimism. Production in the first quarter of the year is already 9.7% above that same quarter of 1998. This is actually a better start than the production record set last year. First quarter production in 1998 was only 7.4% above that in 1997. The forecast in **Table 1** currently shows a forecast overall increase of 7.5% in 1999. Forecasts in **Table 1** and **Figure 5** have been revised upward from the last issue of *Wyoming Geo-notes*. While the coal production forecasts are now significantly higher than CREG's January estimates, with the exception of 1999, they still reflect the same annual percentage increases as forecast by CREG (1999). Nearly all the additional tonnage will come from mines in Campbell and Converse Counties in the Powder River Basin.

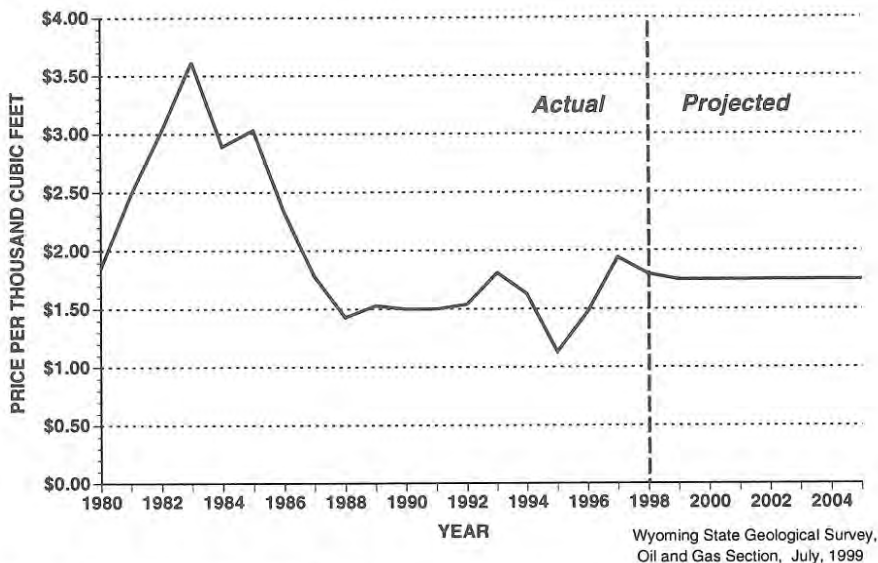


Figure 4. Average prices paid for Wyoming methane (1980 to 1998) with forecasts to 2005.

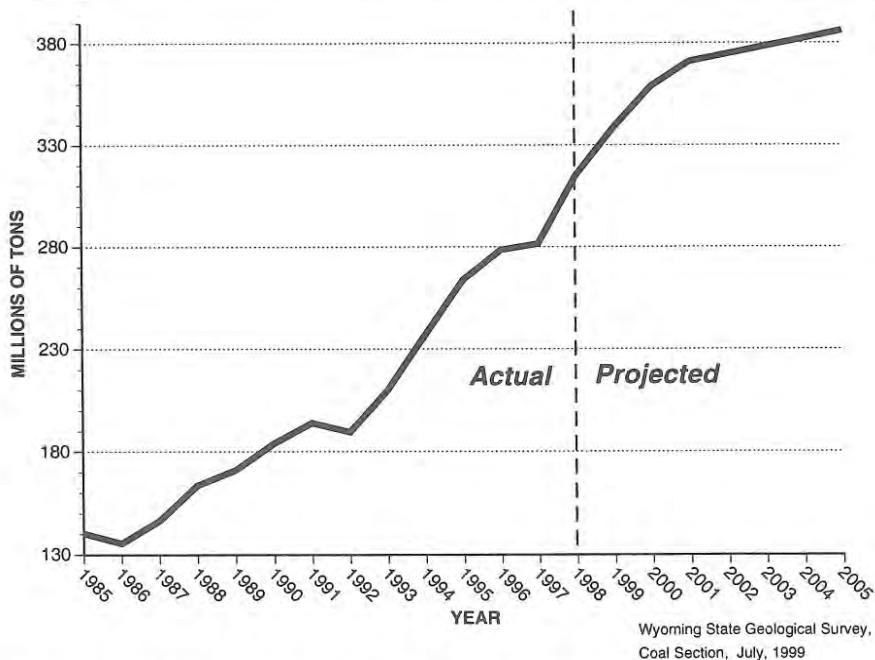


Figure 5. Annual coal production from Wyoming (1985-1998) with forecasts to 2005. Sources: Wyoming State Inspector of Mines (1985-1998) and Wyoming State Geological Survey (1999-2005).

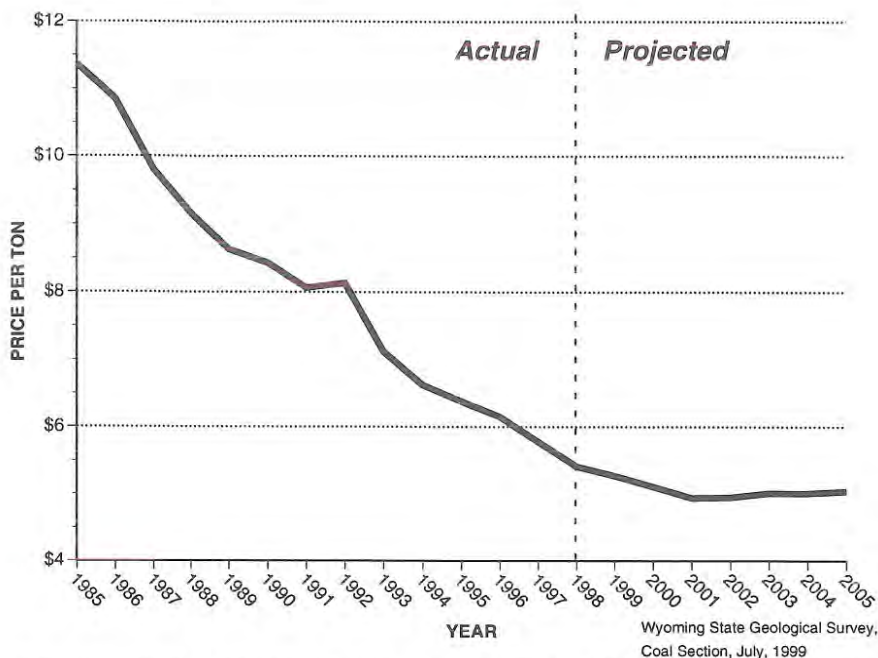


Figure 6. Average prices paid for Wyoming coal (1985 to 1998) with forecasts to 2005. Sources: U.S. Energy Information Administration (1985-1990); Wyoming Department of Revenue (1991-1998); and Wyoming State Geological Survey (1999-2005).

The forecast coal prices in **Table 2** and **Figure 6** are also no longer the same as those of CREG (1999). With the exception of the estimate for 2005, estimated average coal prices have been decreased by a few cents for each year. The estimate for 2005 remained unchanged. The lowered average prices for 1999 through 2004 reflect the increased production of low-cost, Powder River Basin coal, which sells for less than \$4.50 a ton.

Although no changes were made to the forecast production of other commodities in **Table 1**, the production of trona and uranium in 1998 were changed from what was in the last issue. Trona production for 1998 was increased slightly to 18.6 million tons. Uranium production was decreased slightly to 2.3 million pounds of yellowcake. The 1998 price for trona in **Table 2** remain unchanged from the last issue.

In addition to its second-quarter updates for oil, natural gas, coal, and other minerals, this issue of *Wyoming Geo-notes* includes a brief discussion of the State's Earthquake Program. There is also a description of a new fossil find, as well as citations to a number of new publications. The **Rock Hound's Corner** features garnet.

Reference Cited

Consensus Revenue Estimating Group (CREG), 1999, Wyoming State Government revenue forecast, Fiscal year 1999-Fiscal year 2004: Cheyenne, 14 p. (January).

OIL AND GAS UPDATE

Rodney H. De Bruin

Staff Geologist-Oil and Gas, Wyoming State Geological Survey

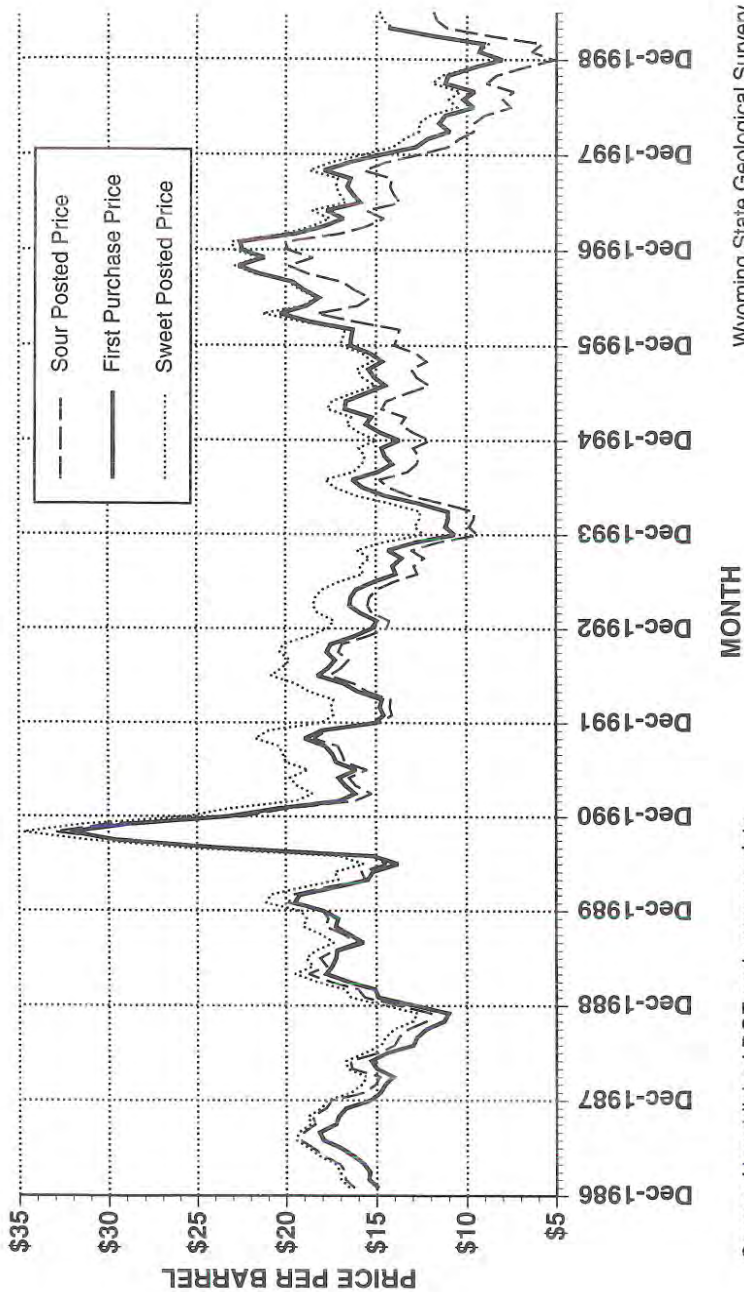
Figure 7 shows the posted Sweet and Sour crude prices and first purchase price for Wyoming oil averaged by month. Prices paid to Wyoming oil producers during the second quarter of 1999 averaged \$14.71 per barrel, which is \$4.67 higher than for the first quarter of 1999. As a result, the average for the first six months of 1999 was \$12.38, which is \$1.00 higher than for the first six months of 1998 (**Table 3**). The \$15.00 average price in June was the highest average monthly price since December, 1997.

Oil production in Wyoming for the first four months of 1999 was 19.7 million barrels (**Table 4**) according to figures from the Wyoming Oil and Gas Conservation Commission. This production is a drop of about 11.9% from the first four months of production in 1998, and reflects 15 months of low oil prices resulting from a worldwide oversupply of oil. The higher oil prices seen in the second and now the third quarter of the year should help slow the rate of decline in oil production. At least in part, production cutbacks by OPEC have reduced world supplies enough to affect prices.

Spot prices for methane at Opal, Wyoming, averaged \$1.87 during the second quarter of 1999. This is 22 cents higher than for the first quarter of 1999 and four cents higher than for the second quarter of 1998 (**Table 5** and **Figure 8**). The six-month average price for 1999 was \$1.76, which is 10 cents below that for the same period in 1998.

According to production figures from the Wyoming Oil and Gas Conservation Commission, production of natural gas in Wyoming for the first four months of 1999 was 400.4 billion cubic feet. This production is up only slightly from the first four months of 1998 (**Table 6**).

Jonah Gas Gathering Co. (JGGC) completed the \$8.5-million first phase of its expanded natural gas gathering system in southwestern Wyoming. This first phase was the construction of the Luman compressor station. The \$18.0-million second phase includes the installation of new compression at the Bird Canyon compressor station and construction of 50.5 miles of a 20-inch-diameter pipeline from the Bird Canyon station to the Opal gas processing plant.



Source: Unpublished DOE and company data

Wyoming State Geological Survey
Oil and Gas Section, July, 1999

Figure 7. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987, to June, 1999).

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1996 to June, 1999).

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	\$16.38	\$16.38	\$22.56	\$22.56	\$12.79	\$12.79	\$9.30	\$9.30
FEB	\$16.28	\$16.33	\$19.45	\$21.01	\$12.16	\$12.48	\$9.09	\$9.20
MAR	\$18.63	\$17.09	\$17.99	\$20.00	\$10.97	\$11.97	\$11.72	\$10.04
APR	\$20.29	\$17.90	\$16.81	\$19.20	\$11.54	\$11.87	\$14.34	\$11.11
MAY	\$18.85	\$18.08	\$17.74	\$18.91	\$11.19	\$11.73	\$14.80	\$11.85
JUN	\$18.15	\$18.10	\$15.90	\$18.41	\$9.63	\$11.38	\$15.00	\$12.38
JUL	\$18.98	\$18.22	\$16.29	\$18.11	\$10.20	\$11.21		
AUG	\$19.59	\$18.39	\$16.61	\$17.92	\$9.58	\$11.01		
SEP	\$21.48	\$18.74	\$16.42	\$17.75	\$11.19	\$11.03		
OCT	\$22.63	\$19.13	\$17.89	\$17.77	\$11.04	\$11.03		
NOV	\$21.19	\$19.31	\$16.51	\$17.65	\$9.64	\$10.90		
DEC	\$22.42	\$19.56	\$14.72	\$17.41	\$8.05	\$10.67		
Avg. yearly price	\$19.56		\$17.41		\$10.67			

Source: All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 1999 are estimated from various unpublished bulletins listing posted prices.

Wyoming State Geological Survey, Oil and Gas Section, July, 1999.

JGCC's pipeline capacity will increase by about 450 million cubic feet of gas per day. The project may be completed by late summer of this year.

In a related item, the U.S. Bureau of Land Management (BLM) approved both JGCC's and Mountain Gas Resources' proposals to build large pipelines. The JGCC proposal was for the second phase of the project discussed above. Mountain Gas Resources' proposed pipeline will carry gas from Jonah, Fontenelle, and Moxa arch fields to its Granger processing plant.

In May, the BLM called for comments on its Draft Environmental Impact Statement for the Continental Divide/Wamsutter II Projects (*Casper Star-Tribune*, 5/28/99). BP Amoco, Union Pacific Resources, Yates Petroleum, Snyder Oil, and others are proposing to drill up to 3,000 wells over the next 20 years in an area of about one million acres. Three-quarters of the project area is in eastern Sweetwater County. The remainder of the acreage is in Carbon County. The proposed action is for the drilling of 150-300 wells each year. The comment period on the draft was extended until July 15, 1999.

In May, the BLM announced their agreement with the final recommendation of the Southwest Wyoming Resource Evaluation study. The study, which began in 1995, concluded that a regional environmental review of the cumulative environmental impacts of growing mineral and oil and gas development in southwestern Wyoming was not warranted. The BLM's decision followed a period of public comment on the study's final report (*Casper Star-Tribune*, 5/26/99).

The BLM extended the public comment period for new rules that they first proposed last December (*Wyoming Geo-notes No. 61*, p. 12). Comments were extended until July 19, 1999. The rules would overhaul reclamation bonds for

oil and gas drilling, including an increase in statewide bonds to \$75,000. In addition, the rules revise the unitization process and the classification of regulatory violations. A public forum on the rules was held in Casper in April (*Casper Star-Tribune*, 6/13/99). The text of the rule is available on the Internet at: <http://www.blm.gov/gov/nhp/news/regul/3100p5.html>

In April, the Rocky Mountain Oil and Gas Association (RMOGA) decided to disband (*Casper Star-Tribune*, 5/15/99). With a history (as an organization) going back to 1920, the association decided depressed oil prices and the increasing number of corporate mergers and acquisitions had shrunk its financial support to a point where change was needed. Instead of having a regional association, there will now be state associations like the Petroleum Association of Wyoming (PAW). This will allow companies to home in on the states where their assets are located, and it should also result in some cost savings. Rick Robitaille, who is now the President and Chief Operating Officer of PAW, feels outward signs of the change in PAW will be minimal. PAW's offices are located in Casper, Wyoming.

Williams Energy Co. announced its purchase of properties owned by MCN Energy Group. The \$106 million deal involves properties in three states, including Wyoming. Williams said it could process the gas from the properties in its plant at Opal. The gas will be transported to West Coast markets via two of William's interstate pipelines. The purchase reportedly boosts Williams proved reserves by 26% (*Casper Star-Tribune*, 4/16/99).

Comments are being solicited on the U.S. Environmental Protection Agency's proposed new rules regarding the amount of allowable sulfur in gasoline. According to an official of Sinclair Oil Co., the rules could shut down Little America Refining Co.'s (LARCO's) Evansville refinery. Compliance with the new rules could cost LARCO upwards of \$15 million (*Casper Star-Tribune*, 5/23/99). Earlier, Sinclair officials said the rules could also cause financial setbacks at Sinclair Oil's Sinclair and Salt Lake City refineries if the rules go into effect at the end of the year (*Casper Star-Tribune*, 5/21/99). Although it is unclear what financial setbacks would have on Sinclair's earlier announcement that it planned to expand its refinery at Sinclair, large compliance expenses could affect at least the timing of those plans (*Wyoming Geo-notes No. 62*, p. 17).

In a related item, Sinclair Oil and Conoco have proposed a 248-mile-long, 12- to 16-inch-diameter pipeline from the Sinclair refinery to Croydon, Utah. For the most part, the Pioneer Pipeline Project would follow the same route as an existing 8-inch line. The pipeline is meant to serve anticipated market growth in Salt Lake City and other areas, with construction beginning in June of 2000. The BLM has reportedly begun an environmental assessment of the project (*Casper Star-Tribune*, 7/25/99).

Marathon Oil elaborated on their recent sale of several Wyoming properties. They sold interests in the Cody and Shoshone units, and in the Half-Moon, North Danker, Elk Basin, Little Sand Draw, and Walker Dome fields so that they could buy additional interests in Park and Hot Springs Counties (*Casper Star-*

Table 4. Monthly oil production from Wyoming in barrels (1996 to April, 1999).

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	6,153,037	6,153,037	5,964,848	5,964,848	5,846,364	5,846,364	5,104,137	5,104,137
FEB	5,693,084	11,846,121	5,459,518	11,424,366	5,233,502	11,079,866	4,630,162	9,734,299
MAR	6,176,805	18,022,926	6,014,780	17,439,146	5,759,176	16,839,042	5,204,739	14,939,038
APR	5,977,362	24,000,288	5,729,869	23,169,015	5,534,568	22,373,610	4,775,623	19,714,661
MAY	6,035,505	30,035,793	6,050,971	29,219,986	5,626,125	27,999,735		
JUN	5,916,019	35,951,812	5,761,549	34,981,535	5,335,463	33,335,198		
JUL	6,076,992	42,028,804	5,964,005	40,945,540	5,464,514	38,799,712		
AUG	6,414,850	48,443,654	5,868,789	46,814,329	5,287,415	44,087,127		
SEP	6,180,180	54,623,834	5,710,557	52,524,886	5,109,053	49,196,180		
OCT	6,186,019	60,809,853	5,949,974	58,474,860	5,274,269	54,470,449		
NOV	6,221,912	67,031,765	5,800,811	64,275,671	5,232,287	59,702,736		
DEC	6,330,701	73,362,466	5,900,791	70,176,462	5,078,909	64,781,645		
Total Barrels Reported ¹		73,362,466		70,176,462		64,781,645		
Total Barrels Not Reported ²		525,957		52,364		897,131		
Total Barrels Produced ³		73,888,423		70,228,826		65,678,776		

¹ Monthly production reports from Petroleum Information/Dwights LLC.

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

³ Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, July, 1999.

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of methane at Opal, Wyoming (1996 to June, 1999).

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	\$1.25	\$1.25	\$3.90	\$3.90	\$2.05	\$2.05	\$1.80	\$1.80
FEB	\$1.20	\$1.23	\$2.50	\$3.20	\$1.70	\$1.88	\$1.65	\$1.73
MAR	\$1.20	\$1.22	\$1.40	\$2.60	\$1.90	\$1.88	\$1.50	\$1.65
APR	\$1.05	\$1.18	\$1.45	\$2.31	\$1.90	\$1.89	\$1.60	\$1.64
MAY	\$0.95	\$1.13	\$1.60	\$2.17	\$1.95	\$1.90	\$2.00	\$1.71
JUN	\$1.10	\$1.13	\$1.35	\$2.03	\$1.65	\$1.86	\$2.00	\$1.76
JUL	\$1.20	\$1.14	\$1.45	\$1.95	\$1.60	\$1.82		
AUG	\$1.25	\$1.15	\$1.40	\$1.88	\$1.75	\$1.81		
SEP	\$1.20	\$1.16	\$1.50	\$1.84	\$1.60	\$1.79		
OCT	\$1.30	\$1.17	\$2.05	\$1.86	\$1.65	\$1.78		
NOV	\$2.45	\$1.29	\$3.00	\$1.96	\$2.00	\$1.80		
DEC	\$3.50	\$1.47	\$1.95	\$1.96	\$2.00	\$1.81		
Avg. yearly price		\$1.47		\$1.96		\$1.81		

Source: American Gas Association's monthly reports, except for the average yearly price, which comes from Wyoming's Office of State Lands and Investments.

Wyoming State Geological Survey, Oil and Gas Section, July, 1999.

Tribune, 5/19/99). So far the sale only resulted in the loss of five employees, rather than the 15 mentioned in the last issue of *Wyoming Geo-notes*.

Texaco has asked the BLM for a modification of its drilling program at the Stagecoach Draw Unit near Farson, Wyoming. The BLM originally approved the drilling, testing, and completion of 72 natural gas wells. Texaco is asking for 65 additional wells so that they could do some in-fill drilling. The BLM's original approval in 1995; however, is still under appeal although BLM officials believe a decision is close at hand. The unit produces from the Almond Formation at depths of 8,000-9,000 feet (*Casper Star-Tribune*, 6/20/99).

McMurry Oil has asked the BLM for permission to drill a specific, 20,000-foot, gas well in the Jonah Field. The request is required because the Record of Decision for the Jonah II Project only allows eight wells per section. This well would be the ninth well on a particular section. As a result, an additional environmental analysis is needed. Because the Record of Decision is under appeal, the BLM can start the process, but it cannot make a decision until a decision on the appeal is rendered (*Casper Star-Tribune*, 7/6/99). The well would be the first test of the Frontier Formation in the Jonah Field.

Joining others that are downsizing, Enron Oil and Gas Co. recently laid off seven employees at its Big Piney facility. The cut was part of a company-wide plan to reduce the number of employees by 50. As a reason, the company cited lower prices, especially for oil (*Casper Star-Tribune*, 6/21/99).

BP Amoco has announced that its Bairoil facilities, including the Lost Soldier and Wertz oil fields, are for sale. The company hopes to have them sold before the end of year. According to a company spokesperson, BP Amoco wants to sell these oil-related facilities so it can better focus on its natural gas opera-

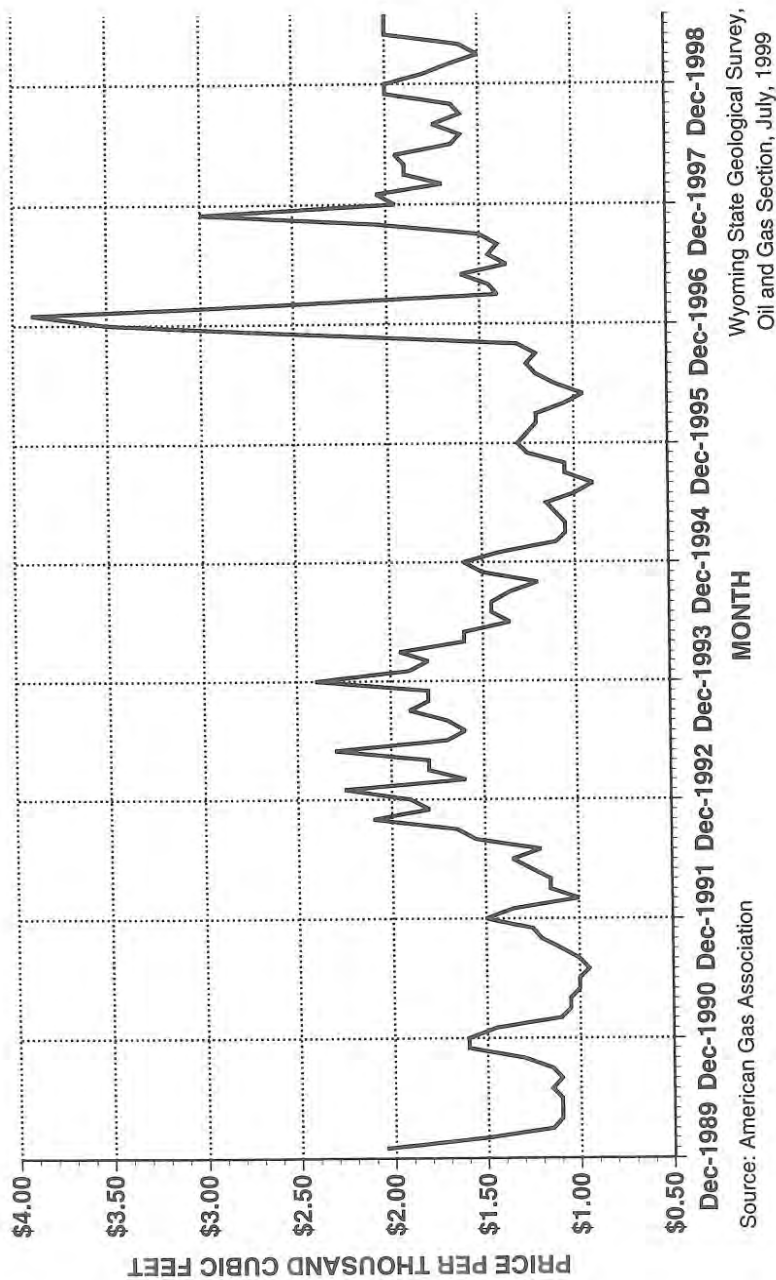


Figure 8. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990, to July, 1999).

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1996 to April, 1999).

	1996			1997			1998			1999		
	monthly	cumulative	monthly	monthly	cumulative	monthly	monthly	cumulative	monthly	monthly	cumulative	cumulative
JAN	101,359,648	101,359,648	99,579,818	99,579,818	99,579,818	103,640,214	103,640,214	103,640,214	101,294,975	101,294,975	101,294,975	101,294,975
FEB	96,303,300	197,662,948	91,766,159	91,766,159	191,345,977	94,501,819	94,501,819	198,142,033	90,165,550	90,165,550	191,460,525	191,460,525
MAR	103,541,127	301,204,075	104,157,578	104,157,578	295,503,555	103,906,999	103,906,999	302,049,032	108,950,112	108,950,112	300,410,637	300,410,637
APR	99,479,609	400,683,684	99,459,039	99,459,039	394,962,594	98,201,007	98,201,007	400,250,039	99,990,891	99,990,891	400,401,528	400,401,528
MAY	97,900,963	498,584,547	101,070,371	101,070,371	496,032,965	96,741,237	96,741,237	496,991,276				
JUN	87,069,612	585,654,159	91,905,308	587,938,273	587,938,273	98,413,520	98,413,520	595,404,796				
JUL	100,219,275	685,873,434	100,129,497	688,067,770	688,067,770	102,055,968	102,055,968	697,460,764				
AUG	99,874,019	785,747,453	97,673,622	785,741,392	785,741,392	105,378,334	105,378,334	802,839,098				
SEP	93,510,551	879,258,004	100,028,888	885,770,280	885,770,280	98,474,782	98,474,782	901,313,880				
OCT	95,441,022	974,699,026	102,206,875	987,977,155	987,977,155	96,470,624	96,470,624	990,880,952				
NOV	94,015,007	1,068,714,033	100,752,128	1,088,729,283	1,088,729,283	103,445,859	103,445,859	1,101,230,363				
DEC	99,141,298	1,167,855,331	103,415,430	1,192,144,713	1,192,144,713	99,339,043	99,339,043	1,200,569,406				
Total MCF Reported¹	1,167,855,331		1,192,144,713		1,192,144,713			1,200,569,406				
Total MCF Not Reported²	5,663,874		683,432		683,432			22,955,142				
Total MCF Produced³	1,173,519,205		1,192,828,145		1,192,828,145			1,223,524,548				

¹ Monthly production reports from Petroleum Information/Dwights LLC.

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

³ Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, July, 1999.

tions in Wyoming (*Casper Star-Tribune*, 7/14/99). This announcement complements a later announcement that BP Amoco would cut its expenses by \$4 billion over the next three years. As part of this downsizing, BP Amoco is selling one-third of its oil-refining capacity, including its third largest U.S. oil refinery, which is the Alliance plant in Louisiana (*Casper Star-Tribune*, 7/16/99).

Leasing activity at the U.S. Bureau of Land Management's (BLM's) April sale was concentrated in the Hanna Basin and in the Greater Green River Basin (**Figure 9**). The significant leasing in the Hanna Basin is most likely a renewal of an earlier coalbed methane play in that basin. The leasing along the southern border of the Greater Green River Basin is in the area of deep Vermilion Creek discoveries. Paul Sawyer made the sale's high per-acre bid of \$280 for a 204.65-acre lease that covers parts of sections 20 and 29, T47N, R69W (location **A**, **Figure 9**). The lease is 1-3 miles south of Minnelusa production at Dillinger Ranch Field. There were a total of 14 parcels at this sale that received bids of \$50 or more per acre.

Leasing activity at the Wyoming Office of State Lands and Investments' April sale centered on the western area of the coalbed methane play in the

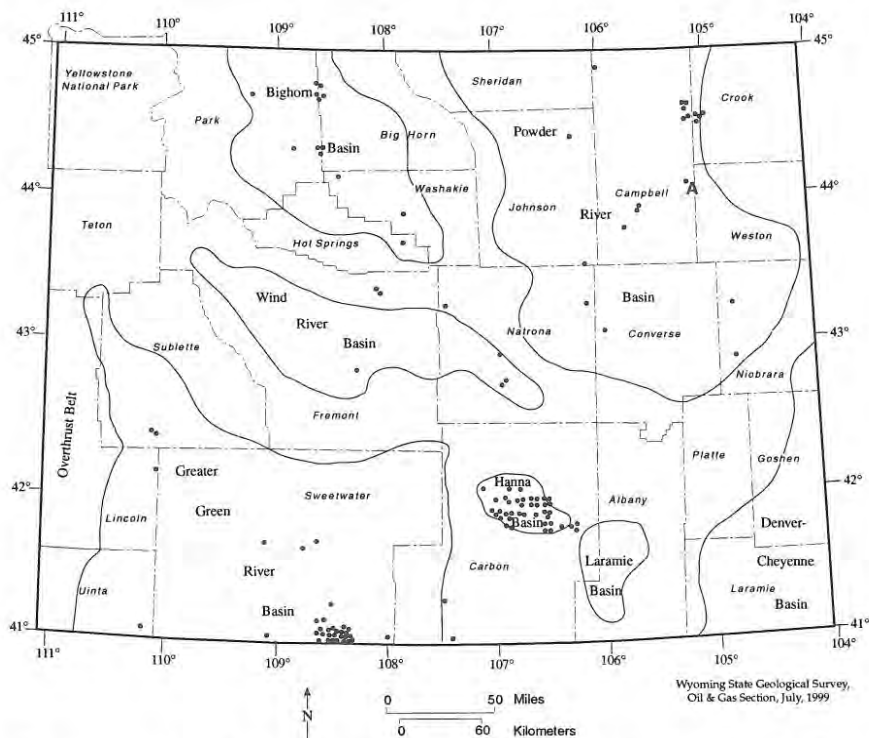


Figure 9. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at its April, 1999, sale.

Powder River Basin (**Figure 10**). This lease sale also saw much heavier than usual leasing in the Hanna Basin. Tab McGinley made the high per-acre bid of \$890 for a 320-acre parcel that covers the NE and SW section 16, T47N, R73W (location **A**, **Figure 10**). The lease is 2-3 miles east of Parkman oil production at Pleasantdale Field and 3-4 miles southwest of coalbed methane development in the Fort Union Formation. Meany Land & Exploration made the second high per-acre bid of \$425 for a 640-acre lease that includes all of section 36, T45N, R75W (location **B**, **Figure 10**). The parcel is about two miles south of five staked locations for coalbed methane exploratory tests in section 23, T45N, R75W. There were a total of 14 parcels at this sale that received bids of \$50 or more per acre.

Leasing activity at the June BLM sale was predominantly in the Greater Green River Basin and was most intense in an area east of Jonah Field. The sale's top per-acre bid of \$32,000 by Santa Fe Snyder Corp. doubled the previous record bid offered at one of these sales. This bid alone accounted for over \$4.5 million of the \$8.4 million in total revenue from the sale (**Table 7**). The 141.81-acre parcel covers part of section 1, T28N, R109W (location **A**, **Figure 11**) and is just west of Lance gas and condensate production in Jonah Field.

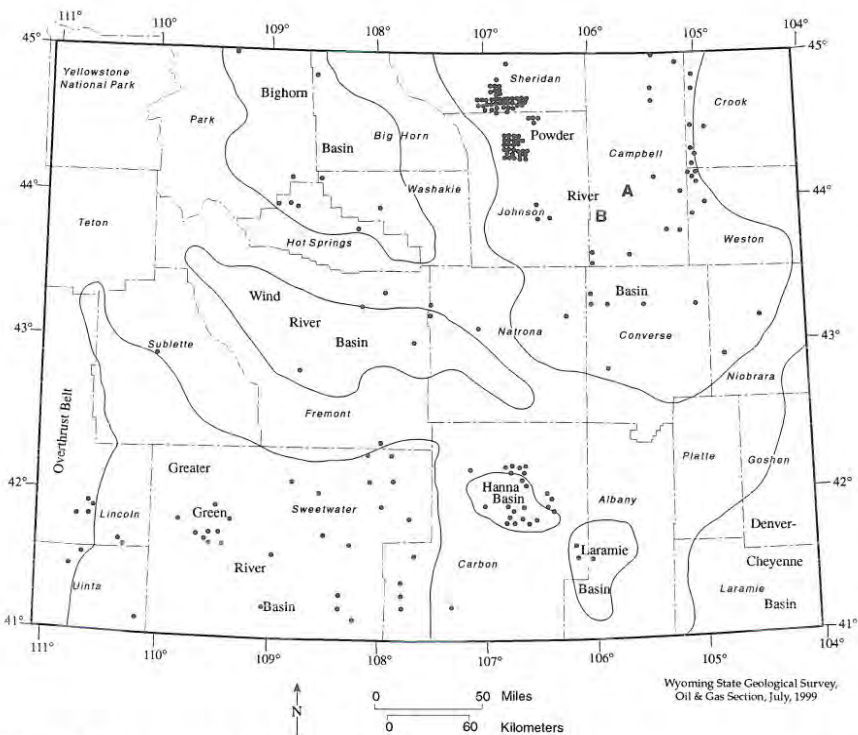


Figure 10. Locations of State oil and gas tracts leased by the Office of State Lands and Investments at its April, 1999, sale.

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

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)								STATE SALES (OFFICE OF STATE LANDS AND INVESTMENTS)							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1996								1996							
TOTAL	\$11,487,567	1,828	1,125	1,403,444	739,505	\$15.53	\$1,450.00	TOTAL	\$2,325,497	1049	508	418,111	206,814	\$11.24	\$206.00
1997								1997							
TOTAL	\$31,976,603	1,787	1,485	1,578,938	1,206,642	\$26.50	\$600.00	TOTAL	\$3,151,020	1198	704	438,296	263,230	\$11.97	\$340.00
1998								1998							
February	\$5,262,908	369	285	366,787	241,654	\$21.78	\$415.00	April	\$1,203,792	300	161	115,646	63,848	\$18.85	\$320.00
April	\$10,287,111	247	227	192,561	162,393	\$63.35	\$395.00	June	\$1,660,438	300	148	108,654	52,501	\$31.63	\$600.00
June	\$14,737,117	463	367	498,339	368,816	\$39.96	\$430.00	October	\$1,313,792	298	178	98,856	65,212	\$20.14	\$590.00
August	\$8,033,029	306	245	349,605	278,095	\$28.89	\$500.00	December	\$1,045,447	300	187	121,551	77,852	\$13.43	\$215.00
October	\$10,251,074	455	308	421,900	293,141	\$34.97	\$430.00	TOTAL	\$5,223,469	1198	674	444,707	259,413	\$20.14	\$600.00
December	\$15,229,257	407	278	388,783	277,538	\$54.87	\$800.00	1999							
TOTAL	\$63,800,496	2,247	1,710	2,217,975	1,621,637	\$39.34	\$800.00	February	\$2,734,442	170	138	157,779	124,880	\$21.90	\$325.00
1999								April	\$2,121,220	124	116	129,358	121,421	\$17.47	\$280.00
February	\$2,734,442	170	138	157,779	124,880	\$21.90	\$325.00	June	\$1,002,039	300	190	108,310	69,858	\$14.34	\$400.00
April	\$2,121,220	124	116	129,358	121,421	\$17.47	\$280.00								
June	\$8,358,363	179	155	233,599	207,978	\$40.19	\$32,000.00								

Sources: Wyoming Office of State Lands and Investments, Petroleum Information/Dwights LLC - Rocky Mountain Region Report, and U.S. Bureau of Land Management.

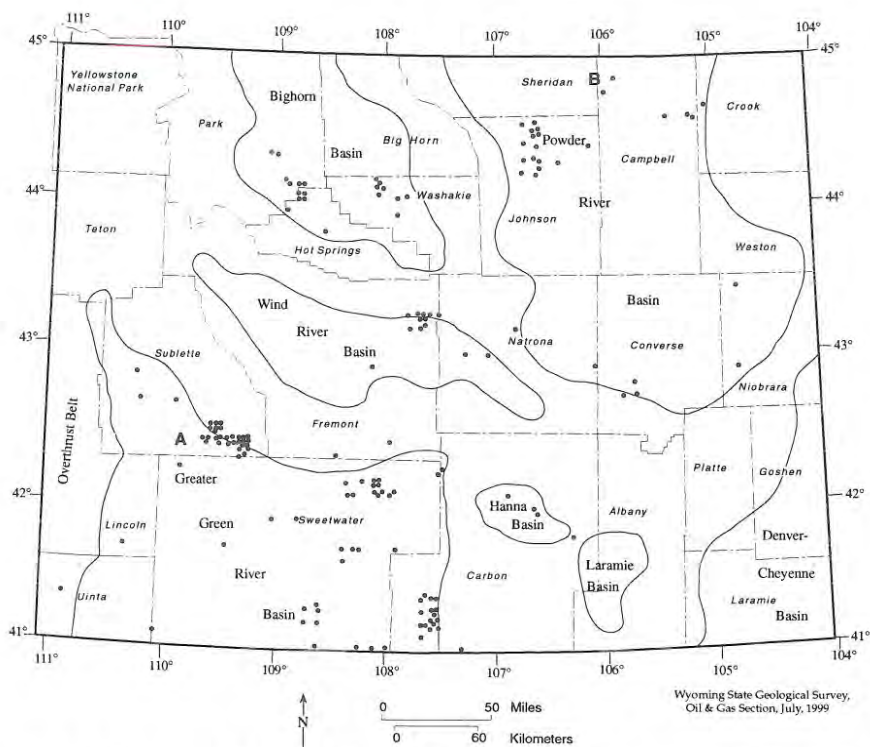


Figure 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at its June, 1999, sale.

Santa Fe Snyder has already received drilling permits for two tests on the lease. Pennaco Energy made the second high per-acre bid of \$350 for a parcel that covers N/2 NW section 33, T55N, R76W (location **B**, **Figure 11**). A number of locations for coalbed methane tests have been staked about six miles south of this lease. The sale had 15 parcels that received bids of \$50 or more per acre.

Leasing activity at the Wyoming Office of State Lands and Investments' June sale centered on the Powder River and Greater Green River Basins. Pennaco Energy made the sale's high per-acre bid of \$400 for an 80-acre tract that covers W/2 SE section 36, T53N, R76W (location **A**, **Figure 12**). The lease is about two miles northwest of Pennaco and CMS Oil & Gas' drilling program for coalbed methane in the Fort Union Formation. Pennaco also made large bids for three other coalbed methane tracts in western Campbell County. The company paid \$390 per acre for a parcel that covers the SW NW section 25, T50N, R74W; \$380 per acre for a tract that covers SW NE and NE SE section 17, T50N, R74W; and \$290 per acre for a parcel that covers E/2 NW section 12, T50N, R74W (location **B**, **Figure 12**). This sale had 20 parcels that received bids of \$50 or more per acre.

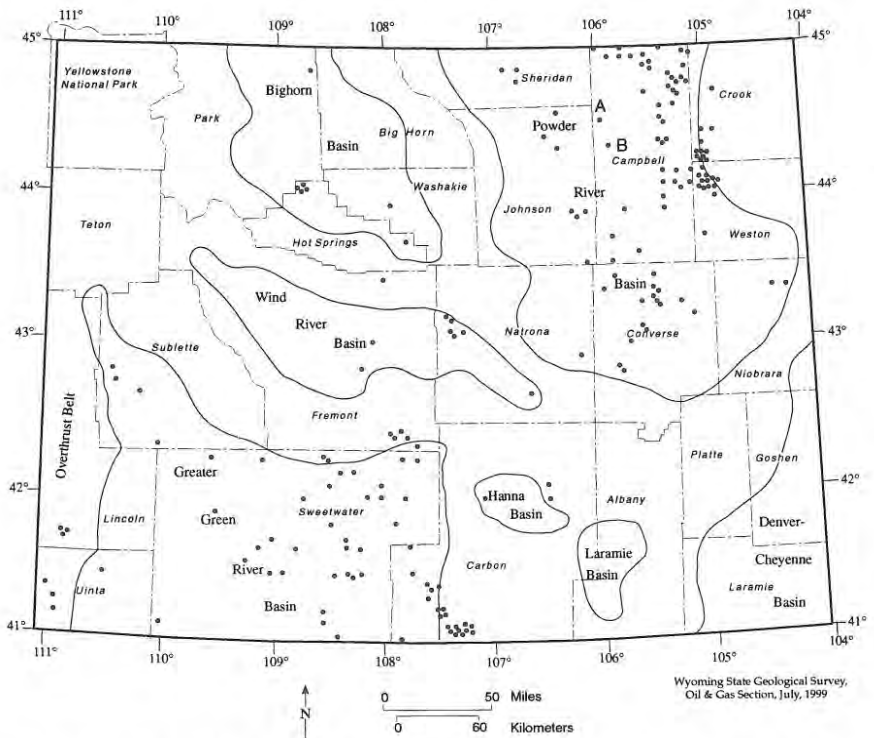


Figure 12. Locations of State oil and gas tracts leased by the Office of State Lands and Investments at its June, 1999, sale.

The Wyoming Oil and Gas Conservation Commission (WOGCC) approved 1,865 Applications for Permit to Drill (APDs) in the first half of 1999 (**Table 8**). This is the largest number of APDs approved by the WOGCC in the first half of a year since the drilling boom of the early 1980s, and is more than for the entire years of 1995 or 1996. Campbell County again led with 77.4% of the total approved APDs. Sheridan and Johnson counties combined for another 7.2% of the total approvals. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

The WOGCC only permitted 10 seismic projects in the first half of 1999 (**Table 9**). For comparison, there were 34 permits for seismic projects during the first quarter of 1998. Exploration for any targets other than coalbed methane has slowed considerably as evidenced by these statistics.

The average daily rig count for the first quarter of 1999 was 24. This average is 11 less than in the first quarter of 1998, but does not include rigs drilling for coalbed methane. Most drilling presently is for natural gas. **Figure 13** shows the Wyoming daily rig count averaged by month.

Table 8. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1996 through June, 1999).

County	1996 APDs	1997 APDs	1998 APDs	1999 APDs
Albany	1	0	0	0
Big Horn	53	59	13	1
Campbell	554	941	1586	1444
Carbon	77	84	96	36
Converse	20	16	6	9
Crook	37	26	29	3
Fremont	26	58	76	37
Goshen	0	0	0	0
Hot Springs	24	42	1	1
Johnson	16	6	49	69
Laramie	2	3	2	0
Lincoln	55	122	105	29
Natrona	74	59	36	19
Niobrara	7	8	8	0
Park	30	25	11	0
Platte	0	0	0	0
Sheridan	0	2	35	65
Sublette	118	179	230	93
Sweetwater	136	210	181	49
Teton	0	0	0	0
Uinta	10	27	26	8
Washakie	30	36	9	0
Weston	10	5	6	2
Totals	1280	1908	2505	1865

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, July, 1999.

Exploration and Development

Company data, news releases, and information compiled and published by Petroleum Information/Dwights LLC indicate the following significant exploration and development events occurred in Wyoming during the second quarter of 1999. The numbers preceding discussions refer to locations on **Figure 14**.

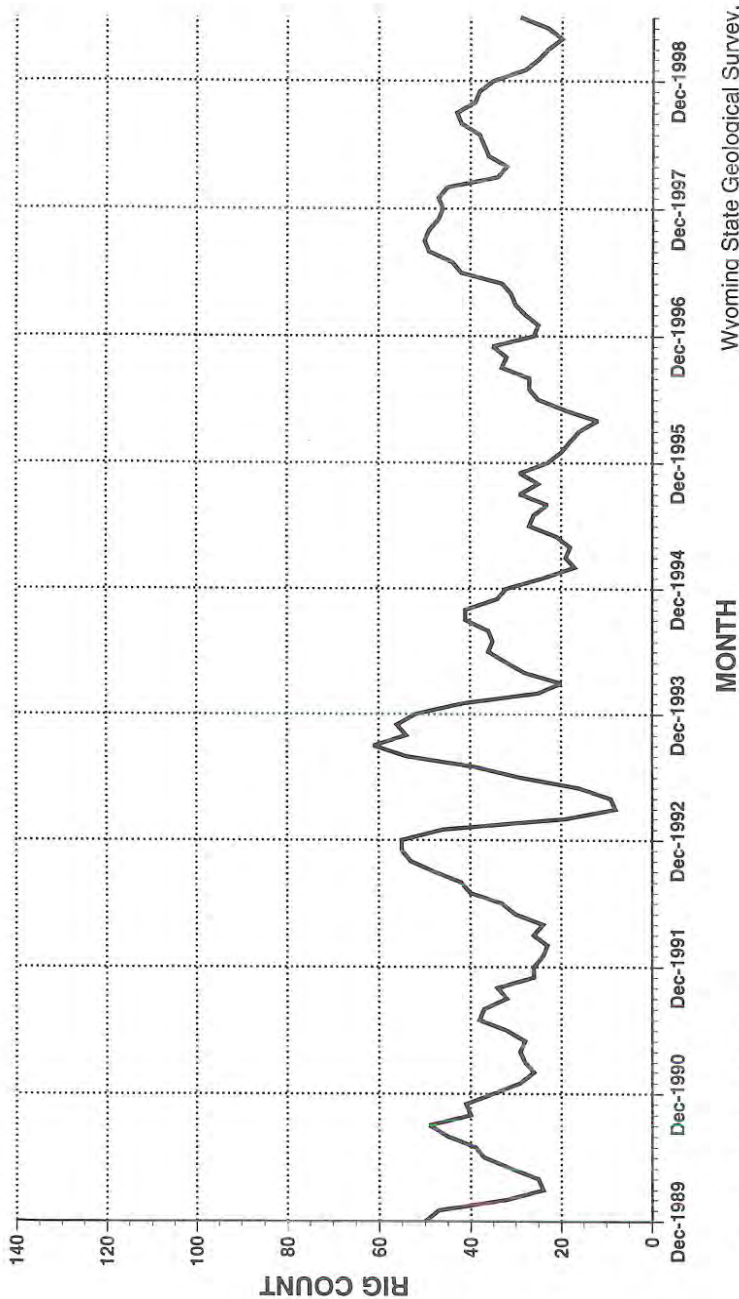
1. Mid Central Production began completion of a wildcat well drilled in NE NW section 12, T12N, R120W. They were swab testing the D101 Danielson well in an undisclosed interval in the Frontier Formation. The well was cased to a total depth of 6,267 feet after the company reported encountering 114 feet of oil and gas pay in a highly fractured Frontier zone.

2. BP Amoco completed a delineation well to its Session Mountain discovery well, completed in 1982. The 3-1 Cummings-Federal well in SW NW section 3, T18N, R120W flowed 3.7 million cubic feet of gas, two barrels of condensate, and 134 barrels of water per day from the Mission Canyon Limestone between 13,292 and 14,080 feet and from the Bighorn Dolomite between 15,098 and 15,347 feet.

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission ('1996 through June, 1999).

County	Permits	1996			1997			1998			1999		
		Conventional	3-D Sq		Permits	Conventional	3-D Sq	Permits	Conventional	3-D Sq	Permits	Conventional	3-D Sq
		Miles	Miles			Miles	Miles		Miles	Miles		Miles	Miles
Albany	1	18	0	0	0	0	0	0	0	0	0	0	0
Big Horn	2	3	66	2	2	0	45	1	0	16			
Campbell	32	56	220	20	20	52	79	14	18	182			
Carbon	2	5	18	3	3	7	190	4	0	318	1		57
Converse	1	4	0	1	1	5	0	0	12	239			
Crook	5	3	20	7	7	8	18	2	2	4			
Fremont	2	5	15	6	6	43	126	2	100	0			
Goshen	0	0	0	2	2	227	0	0	0	0			
Hot Springs	4	17	29	1	1	8	0	4	19	0			
Johnson	0	0	0	2	2	7	17	1	4	0			
Laramie	0	0	0	0	0	0	0	0	0	0			
Lincoln	0	0	0	3	3	7	116	1	10	0			
Natrona	0	0	0	5	5	14	101	6	12	214	1		130
Niobrara	2	0	23	0	0	0	0	0	0	0	1	7	
Park	6	20	82	4	4	56	58	0	16	132	2	17	32
Platte	0	0	0	0	0	0	0	0	0	0			
Sheridan	1	5	0	0	0	0	0	1	14	0			
Sublette	2	21	52	1	1	0	61	2	1	115	1		54
Sweetwater	8	17	670	4	4	66	296	6	214	66	4		111
Teton	0	0	0	0	0	0	0	0	0	0			
Uinta	1	0	40	0	0	0	0	2	0	147			
Washakie	0	0	0	3	3	36	0	4	41	35			
Weston	1	0	16	1	1	0	17	1	0	35			
Totals	70	174	1251	65	65	536	1124	58	463	1503	10	24	384

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, July, 1999.



Wyoming State Geological Survey,
Oil and Gas Section, July, 1999

Source: Hughes Rig Count

Figure 13. Wyoming daily rig count averaged by month (December, 1989, to June, 1999).

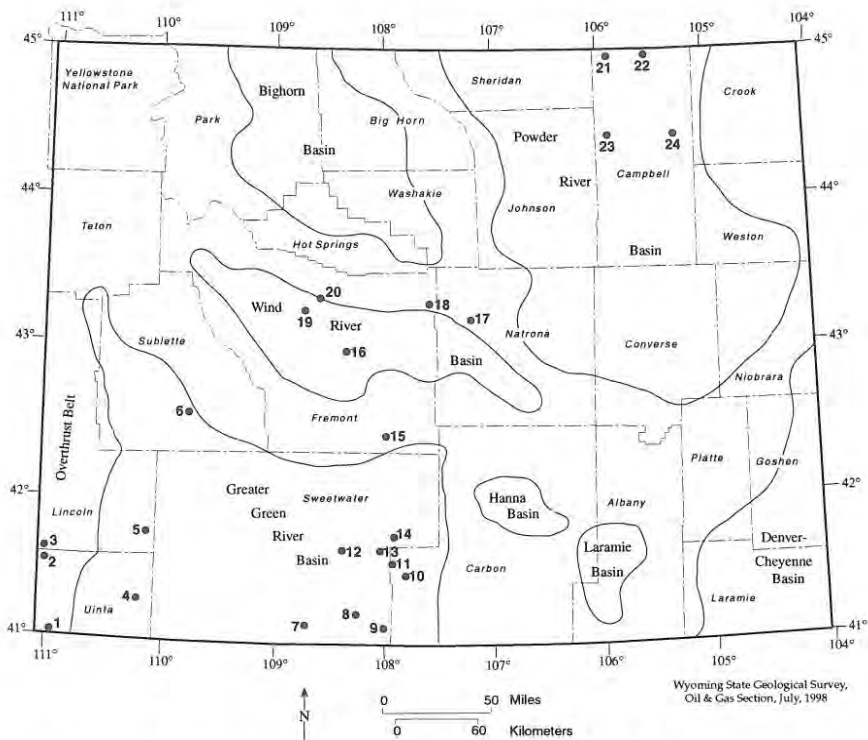


Figure 14. Oil and gas exploration and development activities in Wyoming during the second quarter of 1999 (exclusive of coalbed methane activities).

3. A consortium of Canadian 88 Energy, Prize Energy, and Redwood Energy encountered over 600 feet of highly fractured dolomite in the Mission Canyon Limestone at their 1-10P Chevron et al well in NE SW section 10, T19N, R120W. The well was directionally drilled to an estimated true vertical depth of 12,000 feet. This well was originally drilled and completed by Chevron USA as a dry hole. The well is about four miles northwest of Mission Canyon production on the northern end of Whitney Canyon-Carter Creek Field.

4. Forest Oil completed an exploratory well in C NW section 15, T15N, R113W. The 20-15 Douglas well flowed 1.9 million cubic feet of gas, 43 barrels of condensate, and 26 barrels of water per day from the Muddy Sandstone between 12,870 and 12,880 feet.

5. Belco Energy completed a new producer in Whiskey Buttes Field. The 2 Champlin 288 "C" well in SW SE section flowed 2.4 million cubic feet of gas per day from the Frontier Formation between 11,208 and 11,300 feet.

6. There is still a lot of activity in the Jonah Field/Pinedale anticline area. Western Gas Resources completed its 9-21 Stud Horse Butte well in NE SE

section 21, T29N, R108W. The well flowed 7.3 million cubic feet of gas, 41 barrels of condensate, and 84 barrels of water per day from undisclosed Lance intervals above 11,621 feet. Ultra Petroleum completed its 3-23 Stud Horse Butte well in NE NW section 23, T29N, R108W. The well flowed 8.7 million cubic feet of gas, 81 barrels of condensate, and 43 barrels of water per day from five zones in the Lance between 9,321 and 11,980 feet. Ultra also completed a new well on the northeastern flank of Jonah Field. The 13-14 Stud Horse Butte well in SW SW section 14, T29N, R108W flowed 1.2 million cubic feet of gas, 15 barrels of condensate, and two barrels of water per day from four intervals in the Lance between 9,518 and 11,905 feet. Ultra completed its 9-24 Stud Horse Butte well on the eastern flank of Jonah Field in NE SE section 24, T29N, R108W. The well flowed 2.5 million cubic feet of gas, 17 barrels of condensate, and 33 barrels of water per day from five Lance intervals between 9,736 and 12,096 feet. Ultra also announced that it was selling about 8% of its acreage in the Green River Basin to Anschutz Wyoming for \$13.2 million in cash and work commitments. The sale represents half of Ultra's interest in the Mesa area on the northern part of the Pinedale anticline. Ultra will retain more than one-third working interest in this part of its acreage. McMurry Oil discovered gas and condensate at its 13-19 Pinedale-Federal well in SW SW section 19, T31N, R108W. The well flowed 3.4 million cubic feet of gas, 16 barrels of condensate, and 69 barrels of water per day from an undisclosed interval in the Lance Formation.

7. Wexpro discovered gas at its 13-1 Kinney well in NE NE section 13, T13N, R100W. The well flowed a combined rate of 8.8 million cubic feet of gas per day from the Morrison, Curtis, Entrada, Carmel, and Nugget formations between 14,328 and 15,396. The new well is about a mile south of Marathon Oil's 1 Vermillion Creek Deep discovery well completed in the Entrada and Nugget in 1997.

8. Basin Exploration and Tom Brown discovered gas at their 34-26X Powder Mountain-Federal well in SW SE section 26, T14N, R96W. The well was to evaluate a basin-centered tight gas sand play in the Lance. Although the well logged potential pay in the Lance, the well is producing gas without stimulation from an undisclosed secondary tight gas sand objective below the Lance. That zone has been production-tested at rates in excess of 5.0 million cubic feet of gas per day. The companies plan to limit production to about 3.5 million cubic feet of gas per day once permanent production facilities are installed.

9. Enron Oil & Gas completed a new discovery in NW NE section 5, T13N, R94W. During its first 11 days of production, the 31-5 Cedar Chest well flowed an average of 3.1 million cubic feet of gas per day from an undisclosed interval in the Almond Formation.

10. Snyder Oil has a new producing well in Baldy Butte Field. The 7-10-17-92 Baldy Butte well in SW NE section 10, T17N, R92W flowed 3.6 million cubic feet of gas, 47 barrels of condensate, and 39 barrels of water per day from the Almond Formation between 7,393 and 7,411 feet.

11. BP Amoco completed four new wells in Standard Draw Field. The 4 Champlin 261 Amoco "D" well in NE NW section 21, T18N, R93W flowed 4.0 million cubic feet of gas per day from Almond Formation intervals between 8,999 and 9,061 and between 9,084 and 9,220 feet. The 3 Champlin Amoco 261 "F" well in NW SE section 29, T18N, R93W flowed 3.6 million cubic feet of gas per day from the Almond between 9,159 and 9,217 and between 9,244 and 9,353 feet. The 3 Champlin 222 Amoco "H" well in C SE section 5, T18N, R93W flowed 2.5 million cubic feet of gas per day from the Almond between 9,098 and 9,249 feet. The 4 Champlin 222 Amoco "H" well in C NW section 5, T18N, R93W flowed 902,000 cubic feet of gas per day from the Almond between 9,157 and 9,358 feet.

12. Union Pacific Resources (UPR) is producing 14 million cubic feet of gas per day at its 4-H Rock Island Unit well in SW SW section 4, T19N, R97W. The horizontally-drilled well is the first to produce from the naturally fractured and overpressured Frontier Formation and is one of the deepest of its kind in the world. The well is producing from measured depths between 15,000 and 17,000 feet. This well is the result of five years of research by UPR and the U.S. Department of Energy's (DOE's) Federal Energy Technical Center. The DOE's Greater Green River Basin Production Improvement Project was designed to explore technologies that could make production of gas resources from the tight sands of the Frontier Formation technically and economically feasible to exploit. UPR plans to drill three horizontal offsets in the third quarter of 1999.

13. Flying J Oil & Gas completed a new well in W/2 SW section 32, T19N, R94W. The 1 Red Lakes well flowed 2.8 million cubic feet of gas per day from the Almond Formation between 9,838 and 10,010 feet.

14. Santa Fe Snyder Corp. completed a new producer on the north side of Echo Springs Field. The 12-14-20-93 Latham well in NW SW section 14, T20N, R93W flowed 4.4 million cubic feet of gas, 10 barrels of condensate, and 20 barrels of water per day from the Almond Formation between 10,115 and 10,119 and between 10,148 and 10,152 feet.

15. Flying J Oil & Gas completed a new producer in Happy Springs Field. The 39 Happy Springs Unit well in SW SW section 16, T28N, R93W pumped 300 barrels of oil per day from the Dakota Sandstone between 6,687 and 6,698 feet.

16. Santa Fe Snyder Corp. completed a stepout from the north end of Riverton Dome Field. The 54 Riverton Tribal well in S/2 NW section 19, T1S, R5E flowed 2.8 million cubic feet of gas per day from the Muddy Sandstone between 10,076 and 10,086 feet.

17. Activity continues in the Waltman Field area. Barrett Resources completed its 1-36 West Cave Gulch-State well in NW NE section 36, T37N, R87W. The well flowed 3.7 million cubic feet of gas, 60 barrels of condensate, and 20 barrels of water per day from the Lance Formation between 5,987 and 6,300 feet. W. A. Moncrief, Jr. recovered 741,000 cubic feet of gas per day from a

subthrust Muddy Sandstone zone at its 16-1 Teepee Flats Unit well in NE SW section 16, T37N, R86W. The well was tested through perforations between 19,428 and 19,440 feet.

18. Burlington Resources Oil & Gas is drilling below 17,000 feet at a proposed 25,000-foot Madison test in Madden Field. The 5-6 Bighorn well in SW NW section 6, T38N, R89W is 2.5 miles east of the closest of three Madison producers in the field.

19. Tom Brown Inc. has a new producing well in Pavillion Field. The 33-10 Tribal-Pavillion well in NW SE section 10, T3N, R2E flowed 3.5 million cubic feet of gas per day from five Fort Union intervals between 5,126 and 5,490 feet.

20. Tom Brown also completed two new producers in Muddy Ridge Field. The 25-41M Tribal-MR well in NE NE section 25, T4N, R2E flowed 3.8 million cubic feet of gas, 18 barrels of condensate, and 55 barrels of water per day from the Lance Formation between 9,576 and 9,608 feet; the Meeteetse Formation between 9,702 and 10,871 feet; and the Mesaverde Formation between 11,616 and 12,218 feet. The 30-22M Tribal-MR well in SE NW section 30, T4N, R3E flowed 4.0 million cubic feet of gas, 24 barrels of condensate, and 46 barrels of water per day from the Lance between 9,538 and 9,634 feet; from the Meeteetse between 9,648 and 10,816 feet; and from the Mesaverde between 11,395 and 12,694 feet.

21. Three new wells were completed in SA Creek Field. Termo Co. completed its 1-1 SA Draw-Federal well in NW NW section 1, T56N, R75W. The well is producing an average of 212 barrels of oil per day from an undisclosed Minnelusa interval. Termo also completed its 1-13 BJB-Federal well in SW NW section 13, T56N, R75W. The well initially produced oil at a calculated rate of 408 barrels of oil and 408,000 cubic feet of gas per day from the Muddy Sandstone between 7,656 and 7,662 feet and between 7,682 and 7,694 feet. Ensign Operating completed its 1-35 State well in SE SE section 35, T57N, R75W. During its first month online, the well produced an average of 63 barrels of oil and 20 barrels of water per day from an undisclosed interval in the Muddy.

22. Bellevue Resources produced an average of 550 barrels of oil per day at its 2 True Grit-Federal 22-18 well in SE NW section 18, T57N, R72W. The well is producing from the Minnelusa in Ute Field at about 8,200 feet. DCD Inc. has plans to reenter 12 vertical wells in Ute Field and drill several small-diameter laterals in the Muddy Sandstone. These wells are in sections 3, 4, and 10, T57N, R72W and in sections 34 and 35, T58N, R72W.

23. Prima Oil & Gas completed a new well in Cedar Draw Field. The 15-21 Cedar Draw-Federal well in NE NW section 15, T51N, R75W flowed 898,000 cubic feet of gas and 69 barrels of condensate per day from the Muddy Sandstone between 9,628 and 9,636 feet.

24. Samedan Oil discovered oil at its 44-13 Kuehne well in SE SE section 13, T51N, R70W. The well pumped 215 barrels of oil and 18 barrels of water per day from the Minnelusa between 7,980 and 8,000 feet.

COAL UPDATE

Robert M. Lyman

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According to figures available from the Federal Energy Regulatory Commission (FERC), the State's coal producers are off to a record-setting start in the first quarter of 1999 (FERC, 1999). First quarter deliveries of coal from Wyoming totaled 80,728,282 short tons (**Table 10**). This is an increase of 9.7% over the 73,593,841 tons delivered in the same period of 1998. Coal deliveries from Wyoming for the first quarter of 1999 also remained the highest in the Nation (FERC, 1999). **Figure 15** shows monthly coal deliveries from January through March, 1999. **Figure 16** breaks these monthly deliveries into spot sales and contract sales.

Table 11 depicts historic coal production by county as well as a new forecast of county production through 2005. It also provides an estimate of Powder River Basin coal, which sells for more than \$5.00/ton. The tonnage sold at these higher prices is the remaining; older, long-term contracts that had escalation clauses built into them. **Table 12** shows a breakdown of the average prices for coal produced in northeastern Wyoming and southern Wyoming over the past 11 years as well as a revised forecast of average prices through 2005.

Table 13 shows Wyoming's 1998 coal production by mine as reported by the Wyoming State Inspector of Mines (Stauffenberg, 1999). A copy of the full report is available from the office of the State Inspector of Mines in Rock Springs, Wyoming. The office phone number is (307) 362-5222.

Developments in the Powder River Basin (PRB)

At the end of June, Cyprus Amax Minerals Co. announced the sale of its subsidiary, Cyprus Amax Coal Co. The purchaser is RAG International Mining GmbH (RAG). The sale price was reportedly \$1.1 billion, and includes the purchase of three Wyoming mines. These are the Belle Ayr and Eagle Butte surface mines located in the Powder River Basin (PRB) and the Shoshone No. 1 underground mine in the Hanna Basin. Cyprus Amax's Australian coal holdings were not included in the sale.

Coal Week (7/5/99) reported the transaction not only includes a cash payment from RAG to Cyprus Amax, but also the assumption of debt. In addition, RAG is assuming other long-term obligations and is acquiring related assets. RAG, which is based in Germany, has mines in South America, Australia, and North America. RAG acquired the Cyprus Amax holdings by merging them into its wholly-owned subsidiary, RAG American Coal Co.

Following an earlier announcement by its owner, Rio Tinto PLC/Ltd (*Wyoming Geo-notes* No. 62, p. 33-34), Kennecott Energy Co. has announced its reorganization to improve and streamline work responsibilities as well as build synergies throughout the company. Quoting Greg Boyce, President and CEO of the company, "Because of Kennecott Energy's size and number of opera-

Table 10. Monthly coal deliveries from Wyoming's mines in short tons (1996-March, 1999)

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	21,793,387	21,793,387	25,165,405	25,165,405	26,536,217	26,536,217	26,970,936	26,970,936
FEB	20,374,055	42,167,442	20,743,224	45,908,629	23,196,152	49,732,369	25,675,015	52,645,951
MAR	22,507,800	64,675,242	22,566,012	68,474,641	23,861,472	73,593,841	28,082,331	80,728,282
APR	22,579,959	87,255,201	20,961,008	89,435,649	24,768,989	98,362,830		
MAY	22,216,016	109,471,217	23,102,867	112,538,516	25,278,960	123,641,790		
JUN	20,698,814	130,170,031	20,862,610	133,401,126	24,450,835	148,092,625		
JUL	24,842,971	155,013,002	24,074,929	157,476,055	25,663,577	173,756,202		
AUG	24,421,537	179,434,539	23,002,254	180,478,309	26,591,950	200,348,152		
SEP	23,339,792	202,774,331	22,452,566	202,930,875	26,041,099	226,389,251		
OCT	22,615,721	225,390,052	21,623,057	224,553,932	26,659,121	253,048,372		
NOV	21,421,085	246,811,137	21,695,072	246,249,004	25,620,216	278,668,588		
DEC	22,105,530	268,916,667	24,695,740	270,944,744	26,102,620	304,771,208		
Total Tonnage Reported¹		268,916,667		270,944,744		304,771,208		
Total Tonnage Not Reported²		9,508,289		10,536,772		10,190,883		
Total Tonnage Produced³		278,424,956		281,481,516		314,962,091		

¹From Federal Energy Regulatory Commission (FERC) Form 423, 1996-1999.

²Includes estimates of residential, industrial, and exported coal, plus tonnage not reported on FERC's Form 423.

³Wyoming State Mine Inspector's Annual Reports.

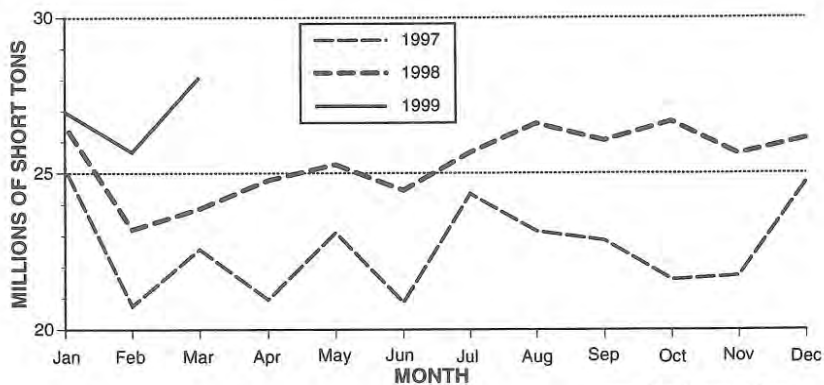


Figure 15. Reported monthly deliveries from Wyoming coal mines (1997 through March, 1999). Derived from data on the Federal Energy Regulatory Commission's Internet bulletin board.

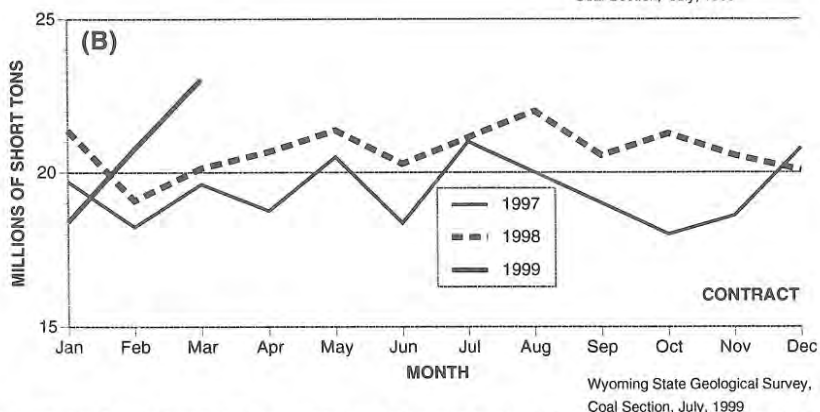
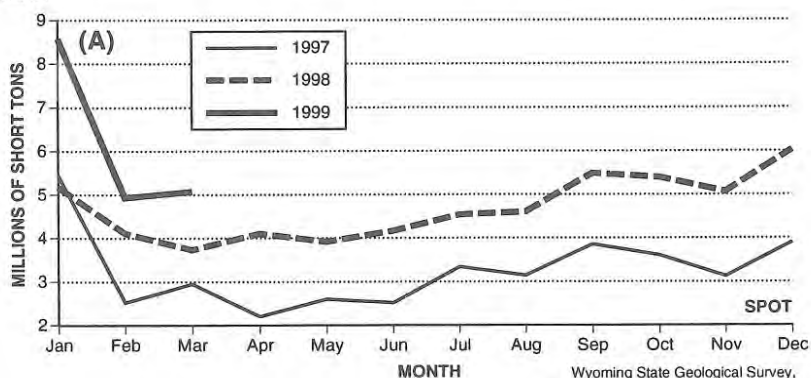


Figure 16. Monthly coal deliveries from Wyoming (1997 through March, 1999). (A) Coal sold on the spot market and (B) coal sold on contract. Derived from data on the Federal Energy Regulatory Commission's Internet bulletin board.

Table 11. Wyoming coal production by county (in millions of tons), from 1995 to 1998 with forecasts to 2005.

	1995 ¹	1996 ¹	1997 ¹	1998 ²	1999 ²	2000 ²	2001 ²	2002 ²	2003 ²	2004 ²	2005 ²
Campbell County	232.4	245.3	246.3	274.1	296.8	313.8	328.0	331.7	333.5	342.2	345.1
Converse County	14.1	15.8	17.8	23.4	25.0	30.0	30.0	30.0	30.0	25.0	25.0
Sheridan County	M	M	M	M	M	M	M	M	M	M	M
Carbon County	3.8	4.7	5.0	3.5	3.7	2.0	M	M	2.0	2.0	3.0
Sweetwater County	9.1	8.2	7.8	9.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.5	4.4	4.6	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Wyoming	263.9	278.4	281.5	315.0	338.5	358.8	371.0	374.7	378.5	382.2	386.1
Annual Change	11.4%	5.5%	1.1%	11.9%	7.5%	6.0%	3.4%	1.0%	1.0%	1.0%	1.0%
Higher-priced coal ³	26%	24%	22%	17%	13%	9%	6%	4%	4%	4%	4%

¹Tonnage from the Wyoming State Inspector of Mines, 1995-1998.

²County estimates by the Wyoming State Geological Survey, July, 1999.

³Estimated percentage of Powder River Basin coal production that is sold at prices above \$5.00/ton (older long-term contracts that have not yet expired).

[M means minor tonnage (less than 50,000 tons)].

Table 12. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1998) with forecasts to 2005.

Year	Northeastern	Southern	Statewide
1988	\$7.35	\$21.45	\$9.16
1989	\$6.94	\$19.76	\$8.63
1990	\$6.86	\$19.36	\$8.43
1991	\$6.58	\$18.81	\$8.06
1992	\$6.61	\$18.84	\$8.13
1993	\$6.02	\$17.72	\$7.12
1994	\$5.62	\$17.42	\$6.62
1995	\$5.60	\$17.35	\$6.38
1996	\$5.40	\$17.30	\$6.15
1997	\$5.03	\$17.19	\$5.78
1998	\$4.73	\$17.15	\$5.41
1999	\$4.66	\$17.11	\$5.27
2000	\$4.61	\$16.63	\$5.11
2001	\$4.51	\$16.89	\$4.94
2002	\$4.52	\$16.79	\$4.95
2003	\$4.52	\$16.91	\$5.01
2004	\$4.53	\$16.81	\$5.01
2005	\$4.54	\$16.70	\$5.04

Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1998 are derived from Wyoming Department of Revenue information; estimates for 1999-2005 and for all regional breakdowns are by the Wyoming State Geological Survey (July, 1999).

tions, it is in the best interest of the company to consolidate certain functions between the operations to avoid unnecessary duplication of efforts".

The company's news release (5/27/99) said that approximately 30 salaried positions would be eliminated, but added that employees affected by the action would be offered other positions within the company. Kennecott's coal operations in Wyoming include Antelope Coal Co., the Cordero Rojo Complex, and Jacobs Ranch Coal Co.

Thunder Basin Coal Co. has applied for a new mine permit to connect their Black Thunder mine to their Coal Creek mine (*Gillette News Record*, 6/17/99). The new permit area would be approximately 22 miles long and would be used to facilitate the transfer and movement of various pieces of mining equipment between the two operations. The company said there would be no mining on the new permit area. In about twenty years, the corridor area would be returned to its pre-mining uses.

In May, SGI International completed acquisition of all assets and interests associated with the liquids-from-coal (LFC) technology that SGI had formerly developed with Zeigler Coal Holding Co. Under the agreement, SGI will pay Zeigler's successor, AEI Resources Inc., \$2 million over five years in exchange for AEI's 50% interest in the LFC technology and the LFC demonstration plant in Gillette, Wyoming. The plant was owned by AEI's Bluegrass Coal Development Co. (*Coal Daily*, 5/7/99).

Table 13. 1998 coal production from Wyoming by mine

Mine	County	Employees	Tons Produced
Belle Ayr	Campbell	280	22,479,368
Black Thunder	Campbell	445	42,683,014
Buckskin	Campbell	145	17,290,730
Caballo	Campbell	333	25,984,949
Coal Creek	Campbell	114	7,068,322
Cordero Rojo Complex	Campbell	361	36,979,025
Dry Fork	Campbell	9	1,030,718
Eagle Butte	Campbell	184	18,074,546
Jacobs Ranch	Campbell	358	29,078,333
KFx	Campbell	1	48,945
North Antelope			
Rochelle Complex	Campbell	605	64,639,932
North Rochelle	Campbell	70	41,083
Rawhide	Campbell	63	5,390,400
Wyodak	Campbell	43	3,280,157
Antelope	Converse	178	19,418,684
Dave Johnston	Converse	159	3,964,694
Big Horn	Sheridan	14	65,909
Powder River Subtotal		3,362	297,518,809
Medicine Bow	Carbon	46	1,100,970
Seminole II	Carbon	42	463,501
Shoshone No. 1	Carbon	108	1,903,000
Kemmerer	Lincoln	259	4,736,245
Black Butte	Sweetwater	123	2,800,000
Jirn Bridger	Sweetwater	383	6,439,566
Southern Wyoming Subtotal		961	17,443,282
Wyoming Total Production		4,323	314,962,091

Source: Office of the State Inspector of Mines, 1999.

Now that SGI fully owns the LFC technology, it plans to restart the plant by mid-2000. Coal feedstock may come from the Buckskin mine, but a long-term agreement has not yet been structured. At full production, the plant would consume 350,000 tons/year.

SGI International also announced an agreement to sell most of its enhanced coal product to Illinois Power Co. (5/25/99). Under the terms of a five-year contract ending in 2004, Illinois Power reportedly has the right to all but a possible 100,000 tons/year of SGI's production. SGI apparently retained an option to sell up to that amount to other parties that wish to test-burn the enhanced fuel. The agreement also provides Illinois Power with an option to purchase up to 500,000 tons/year of the coal product from a larger LFC plant that SGI hopes to build in the future near the North Rochelle mine (*PR Newswire*, 5/26/99).

Cordero Mining Co. and Powder River Coal Co. have each filed applications with the U.S. Bureau of Land Management (BLM) to explore tracts of Federal coal reserves near their respective mines. This exploration would obtain information on the coal such as overburden thickness, coal thickness, and coal quality (*Coal Daily*, 5/27/99). Cordero Mining wants to explore approximately 7,000 acres located west and south of the Cordero-Rojo mine complex near Reno, Wyoming. Cordero hoped to begin drilling sometime in August.

Powder River Coal Co. hoped to begin drilling by mid-July. It wants to explore about 11,000 acres of land that surrounds its North Antelope/Rochelle mine complex and extends south to the northern tip of Kennecott's Antelope lease boundary.

Developments in Southern Wyoming

In July, Chevron Corp. had apparently nearly completed the sale of its Pittsburg & Midway (P&M) coal holdings (*Coal Week*, 7/19/99). The sale includes the Kemmerer mine, located in Lincoln County, Wyoming. The buyer is reportedly the Renco Group of New York, which is the parent company of Lode-star Energy. The companies have entered into a confidentiality agreement and are saying very little about the terms of the sale. Last year, the Kemmerer mine produced 4,736,245 tons of coal.

The U.S. Bureau of Land Management (BLM) released its Record of Decision on Arch Coal Inc.'s (Arch's) Elk Mountain lease application, clearing the way for a Federal coal lease sale this fall. According to the BLM, the Federal coal lands in the application contain an estimated 150 million tons of recoverable coal.

Arch nominated the Elk Mountain lease area in Carbon County in hopes that it would support a replacement mine for Arch's nearby Medicine Bow and Seminoe II mines, which are slated for closure by 2001. Arch announced earlier that it planned to delay the development of the mine complex until 2003 due to the current market conditions for southern Wyoming coal (*Coal Daily*, 4/14/99). Despite this delay in the new mine's development, the lease sale is expected to go forward.

If Arch wins the lease, it intends to combine the Federal coal with 230 million tons of private coal under Arch's control. The lease area, which is in the Carbon Basin, is approximately 18,000 acres in size. Long-term plans call for the development of both surface and deep mines, with annual production of up to 7.7 million tons (*Coal Daily*, 6/25/99).

Ashland Inc. (6/23/99) has retained Goldman Sachs to explore strategic alternatives for its investment in Arch Coal, Inc. Ashland owns 58% of Arch and is "reviewing the fit between the strategic goals of Ashland and of Arch in order to enhance the prospects for each to achieve more focused and company-specific business objectives as well as to facilitate both managements' concentration on achieving those goals." Arch has mines in both the Hanna Basin (Medi-

cine Bow and Seminole II) and the Powder River Basin (Black Thunder and Coal Creek).

In-state Power Plants

Black Hills Generation, a subsidiary of Black Hill's Corp., is moving forward with its plans to build an air-cooled, 80-megawatt, coal-fired power plant next to its Neil Simpson Unit 2 near Gillette, Wyoming (*Coal Daily*, 6/16/99). Using the same type of equipment as the Unit 2 plant, it plans to burn approximately 500,000 tons of coal a year from its parent company's Wyodak mine. Known as the Wygen No. 1, construction on the plant could begin as early as August of this year. Plans call for Wygen to be online by the second quarter of 2002.

The first foreign takeover of an American utility moved one step closer when the Federal Energy Regulatory Commission gave their approval to ScottishPower's \$7.9 billion bid to buy PacifiCorp (*Casper Star-Tribune*, 6/18/99). The sale has also cleared hurdles in Australia and the United Kingdom. Although Wyoming and several other states were still holding hearings on the proposed purchase, company officials felt the sale could be concluded later this year. PacifiCorp operates four major coal-fired power plants in Wyoming. They are the Dave Johnston and Wyodak plants in the Powder River Basin and the Naughton and Jim Bridger plants in southern Wyoming.

Transportation

Toward the end of June, rail congestion again created some transportation problems in the Powder River Basin (PRB) of Wyoming. Railroads and coal producers reportedly pointed fingers at each other as the number of idled, empty, coal trains increased. The Burlington Northern/Santa Fe (BNSF) railroad was apparently holding up to 20 empty trains per day for PRB mines, up from a more normal 8 to 9 trains per day (*Coal Daily*, 7/16/99). The Union Pacific/Southern Pacific (UPSP) railroad was also reportedly staging some trains. Because the railroads are working on expedited dispatching at the same time that the mines are expanding and speeding up their loadout facilities, there is a good chance that the congestion will be a short-lived problem (*Wyoming Geo-notes* No. 62, p. 34-35).

The BNSF railroad has developed four new marketing groups. To streamline its business units, it has created a new coal group, as well as an agricultural group, an industrial products group, and a consumer products group (*Coal Daily*, 6/9/99). The new coal group will replace the existing coal business unit, but will perform the same tasks.

In May, the Dakota, Minnesota, & Eastern railroad (DM&E) announced that it planned to build a new \$100 million operations center in Huron, South Dakota. The project is contingent on getting the necessary regulatory approvals. The cost of the operations center is included in DM&E's proposed \$1.4 billion rail line into the PRB of Wyoming. The new facility would also house DM&E's primary locomotive and railcar repair shop, and serve as the line's main switch-

ing yard (*Coal Daily*, 5/28/99). In regard to its proposed new line into the PRB, DM&E has provided the Surface Transportation Board (STB) with preliminary data on crew districts, proposed sidings, yard facilities, grades and river crossings, design parameters, operating schedules, environmental and community impact mitigation, and interchanges with other carriers (*Coal Daily*, 6/24/99).

Coalbed Methane Developments

In the second quarter of 1999, the biggest story concerning coalbed methane was the U.S. Supreme Court's ruling on the ownership of coalbed gas. At issue was the language used in the 1909 and 1910 Coal Lands Acts, which allowed homesteaders to acquire Federal lands, but reserved the rights to the coal under those lands to the Federal government.

Last year, the U.S. Court of Appeals for the Tenth Circuit, in the case of the Southern Ute v. Amoco, reversed a lower court decision by saying that the coal reserves covered under the Federal Coal Lands Acts of 1909 & 1910 included the coalbed gas. Prior to that ruling, a 1981 Solicitor's opinion ruled that a coal lease would not include coalbed methane (*Wyoming Geo-notes* No. 57, p. 35).

This year, the U.S. Supreme Court, in a June 7th decision, overruled the Court of Appeals and ruled coal and coalbed methane (CBM) were not part of the same mineral estate. In its ruling, the Court said, "Including the CBM gas in the coal reservation would; therefore, create a split gas estate that would be at least as difficult to administer as a split coal/CBM gas estate. There is no reason to think Congress would have been more concerned about the creation of a split coal/CBM gas estate than the creation of a split gas estate."

Another significant action in the second quarter was Congress' appropriation of \$1 million to help the U.S. Bureau of Land Management process drilling permits for coalbed methane wells in the Powder River Basin (PRB) (*Casper Star-Tribune*, 5/28/99 and 6/23/99). While the first million dollars will help, many feel that it may take two or three times that much to expedite the drilling in northeastern Wyoming alone. It is expected that virtually thousands of coalbed methane wells will be drilled over the next ten years.

The coalbed methane play has also impacted the Water Quality Division (WQD) of the Wyoming Department of Environmental Quality. As a result the WQD has finalized a general water discharge permit to help them keep up with the play in northeastern Wyoming (*Casper Star-Tribune*, 5/26/99). The new permit should reduce permitting time to 30 days for qualifying discharges. It had often taken as long as 90 days. The general permit, which removes the public comment period, only applies to water discharges into dry draws. And the landowner on which the drilling occurs must also give approval before the general permit can be used.

Since the coalbed methane play began, the Wyoming Oil and Gas Conservation Commission (WOGCC) has issued 4,724 applications for permits to drill coalbed methane wells. Through June of 1999, 1,760 coalbed methane wells

have been completed, with 1,109 producers and 481 wells shut-in waiting for pipeline connections.

In a related item, both the Federal and State oil and gas lease sales in April saw a large number of leases in the Hanna Basin of south-central Wyoming (**Figures 9 and 10 in the Oil and Gas Update**). This leasing suggests a renewed interest in coalbed methane in that basin. The State's April oil and gas lease sale and the June Federal sale saw significant leasing for coalbed methane on the west side of the PRB (**Figures 10 and 11 in the Oil and Gas Update**).

The BLM released the Draft Environmental Impact Statement (DEIS) for the Wyodak Coalbed Methane Project. Under the preferred alternative, coalbed methane operators in study area could drill 3,000 new wells (*Casper Star-Tribune*, 5/22/99). Comments on the draft were due to the BLM by June 29, 1999. This DEIS covers the main fairway of the current coalbed methane play in north-eastern Wyoming. Already; however, the play is spreading westward and north-westward outside the area of this DEIS.

While the first Coalbed Methane Gas Fair for northeastern Wyoming is now history, organizers are already looking toward a second fair. Although the first fair brought many interested company, government, and private parties together, the second is expected to be much larger. The first fair was held at Gillette on July 9 and 10. The date and place for the next fair; however, are not yet set.

In late April, Pennaco Energy, Inc. sold its first coalbed methane production from wells drilled in the South Gillette area (*PR Newswire*, 5/29/99). By the end of May, Pennaco estimated production from its working interests would approximate 11 million cubic feet per day. Pennaco has drilled 175 wells. This includes 157 wells in its South Gillette area, and 18 wells in the Pennaco/CMS joint venture area. Approximately 205 additional wells are scheduled for completion by the end of year. Pennaco currently has five drilling rigs working in the PRB. Fifty-one percent of Pennaco's wells are producing while the remainder are undergoing completion, testing, and hookup. Further increases in production will be limited until the Fort Union Gas Gathering System begins operation. Its completion is expected near the end of the third quarter of this year.

In a related development, Pennaco Energy's Board of Directors approved a 44% or \$26.5 million increase in the company's budget for capital expenditures in 1999. Pennaco will use the increased funding for the development of its coalbed methane project in the Powder River Basin. The company plans to spend \$18 million in drilling approximately 460 wells in the play. Pennaco also plans to spend an additional \$8.5 million on the acquisition of leases.

Regulatory Developments

The U.S. Court of Appeals for the District of Columbia, in response to a suit lodged by the National Mining Association (NMA), made several decisions in

favor of the NMA. The NMA had challenged U.S. Office of Surface Mining (OSM) practices that resulted in the denial of mining permits on the basis of unresolved environmental violations. The court decision ruled that an applicant company cannot be denied a permit merely on the basis that it is owned or controlled by another firm with an outstanding violation; that a permit cannot be denied merely on the basis that an officer of the company is associated with a firm with an outstanding violation; and that an applicant company cannot be denied a permit merely on the basis that a 10-50% stockholder has an ownership interest in a firm with an outstanding violation (*Coal Daily*, 5/31/99).

Market Developments and Opportunities

Oklahoma Gas & Electric Co.'s Muskogee plant was damaged by a tornado on the evening of June 1, 1999. The storm knocked out two of the plant's three coal-fired generating units (*Coal Daily*, 6/4/99). The twister, the center of which passed through the facility between its coal yard and generating units, did not injure any of the plant's employees. While the damaged units will be down from two to four weeks, coal procurement should not be impacted. In 1998, Muskogee burned about 5.84 million tons of coal from the Powder River Basin (PRB) of Wyoming.

A March test burn at Southern Illinois Power Coop. (SIPC) is reportedly helping the utility determine the optimal percentage of PRB coal it will use under Phase II of the Clean Air Act. Depending on test results, the company's 272-MW plant at Marion, Illinois, expects it may burn up to 30% PRB coal (*Coal Daily*, 4/7/99). Currently, the plant only uses coal from the Illinois Basin.

Illinois Power reports that its test burn of 100% PRB coal was so successful that they are going to switch their 306-MW plant at Hennepin, Illinois, to PRB coal later this year. The test coal was from Arch's Black Thunder mine. The Hennepin plant traditionally burned coal from the Illinois Basin (*Coal Week*, 6/14/99).

Illinois Power also settled on Southern Coal Handling Co.'s Havana Terminal on the Illinois River to handle the estimated 0.8-1.0 million tons of PRB coal slated to move to the Hennepin plant each year. The terminal has a transfer capacity of 10 million tons per year, with storage for up to 140,000 tons. Served by the Illinois & Midland railroad, the terminal is accessible from both the Union Pacific/Southern Pacific and the Burlington Northern/Santa Fe railroads (*Coal Daily*, 5/24/99).

Table 14 is a tabulation of some of the contracts, spot sales, tests, and solicitations for Wyoming coal announced during the second quarter of 1999.

Table 14. Marketing activities for Wyoming coal producers during the second quarter of 1999.¹

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	American Electric Power Service	Unspecified	PRB	Sp	Unspecified	Delivered over terms of 3-12 months
2.	Central and Southwest Services	Unspecified	Kennecott/PRB	Sp	1.5 million t	From monthly electronic bid
3.	Dairyland Power Coop.	Genoa and Alma	PRB	So	up to 1.9 million t	8300-8800 Blu/lb for 2000 delivery
4.	Detroit Edison Co.	Trenton Channel	New Rochelle/PRB	T	40,000 t	Test burn of PRB & eastern blend
5.	FirstEnergy	Bayshore, Avon, and Eastlake	PRB	Sp	300,000 t	Fourth quarter 1999 delivery
6.	Houston Lighting & Power	Parish	PRB	C	1.75 million t/y	Delivery over next two years
7.	Illinois Power	Wood River & Havana	SGL enhanced coal/PRB	C	Unspecified	Delivery early 2000 to end of 2004
8.	Lansing Board of Water & Light	Erickson and Ekert	8800 Blu/lb PRB	So	0.75 to 1 million t/y	Delivery in 2000 and possibly 2001
9.	The Lower Colorado River Authority	System System	Arch & Kennecott mines/PRB	C	500,000 t/y each Co.	3 years with option for up to 600,000 t more
			PRB	Sp	300-350 thousand t	Delivery in third quarter of 1999
10.	MidAmerican Energy Co.	System	PRB	C	Unspecified	Multi-year starting January 1, 2000
11.	Northern Indiana Public Service	System	Unspecified	So	500,000-1 million t/y	1-4 years beginning in 2000
12.	Ontario Power Generation	System System	Triton/PRB Arch/PRB	Ex	300,000 t	Delivery through end of lake shipping season
				Ex	120,000 t	Delivery through end of lake shipping season
13.	PacifiCorp	Dave Johnston	PRB	So	up to 4 million t/y	Starting fourth quarter of 1999
14.	Public Service of Colorado	Arapahoe	Black Thunder from Illinois Power	Sp	80,000 t	Delivery in third quarter of 1999
15.	Salt River Project	Coronado	North Antelope/PRB	T	30,000 t	Test burn of PRB coal & Arizona coal blend
16.	St. Joseph Light & Power Co.	Lake Road	Arch & Kennecott mines/PRB	C	200,000 t	Delivery by end of 1999
17.	TXU Electric & Gas	Big Brown & Martin Lake	PRB	So	3-3.5 million t/y	Delivery on BNSF for 2000 & 2001

¹Data obtained from: *Coal/Week, Coal Age*, FERC database, and personal contacts.

Note: C = contract coal; Sp = spot coal; So = solicitation; Ex = export coal; T = test burn; t = short ton; t/y = short tons per year; PRB = Powder River Basin; and BNSF = Burlington Northern/Santa Fe railroad. *Wyoming State Geological Survey, July, 1999.*

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INDUSTRIAL MINERALS AND URANIUM UPDATE

Ray E. Harris

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Trona

According to the Wyoming Department of Revenue, the production of trona fell 5% in 1998, to 18,619,616 short tons. This decline was due to a softening of the Asian economy with a corresponding drop in orders for sodium products from that region. Production of sodium products is expected to rebound slightly in 1999.

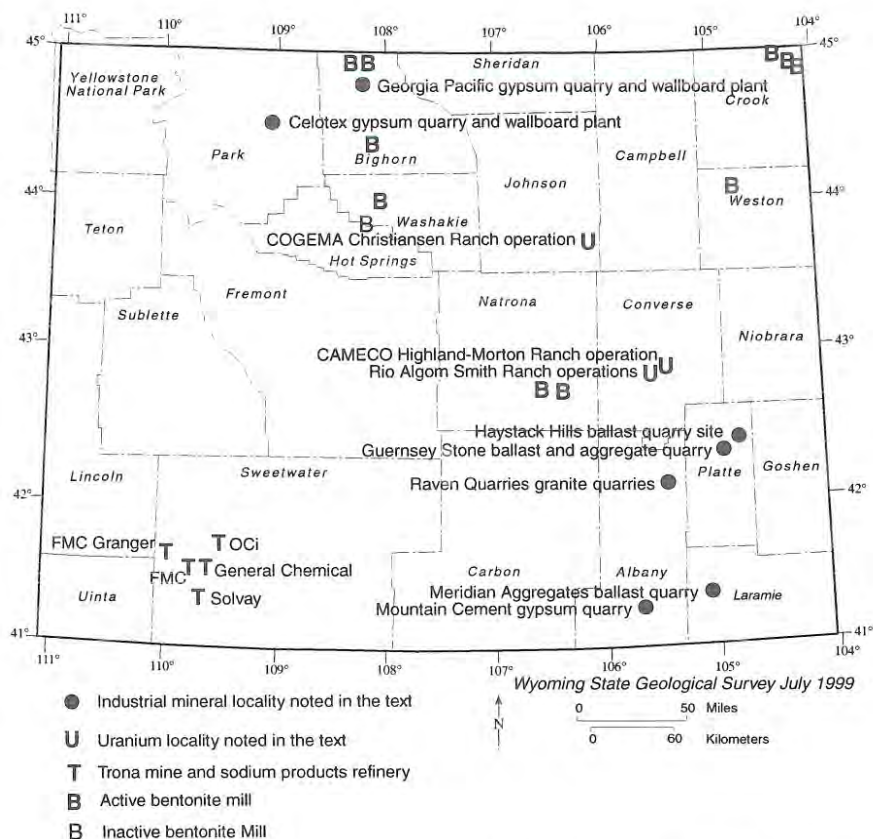
FMC Corp. completed its acquisition of Tg Soda Ash's trona mine and soda ash refinery. Its purchase of the Tg operation, which is now called FMC Granger, is not expected to have any significant impact on the production of either trona or soda ash. The combined workforce at FMC's two operations is now estimated at between 1,300 and 1,400 employees.

There are now five separate trona mines and plants that refine sodium products in Wyoming. Four producers operate them: FMC, General Chemical Soda Ash Partners, OCi, and Solvay Minerals (**Figure 17**).

Bentonite

According to the Wyoming State Inspector of Mines, while bentonite mine production decreased 3% in 1998, to 4,528,161 short tons, plant outputs increased about 1%, to 3,606,176 short tons. Bentonite production in 1999 is currently ahead of production in 1998.

In Wyoming, bentonite is mined near each of the ten operating bentonite plants. These plants are located in the Black Hills, the Bighorn Basin, and in Casper (**Figure 17**). One mill, at Lucerne in Hot Springs County, remains inactive.



Gypsum

The demand for gypsum products, particularly wallboard, is increasing in the western U.S. At the end of June, Colorado and Wyoming suppliers were announcing 6 to 8 week delays in deliveries of wallboard to customers due to a shortage of this product. The delays point out a need for additional production capacity in the region and may provide a target of opportunity for Wyoming producers.

Construction Aggregate

The production of construction aggregate in Wyoming has traditionally been dependent on highway construction augmented by significantly large construction projects, such as new natural gas processing plants or power plants. In 1998, 11,246,477 short tons of construction aggregate were produced, a 7% increase over 1997. This year, additional Federal funds are available for construction and reconstruction of highways, and some significant construction projects are underway.

For several years, the demand for aggregate in the construction of railroad grades, base, and ballast has also been increasing. To provide for increased coal transportation out of the Powder River Basin (PRB) of northeastern Wyoming, the Burlington Northern/Santa Fe as well as the Union Pacific/Southern Pacific railroads have been upgrading many of their routes. This includes the construction of double- and even triple-tracked line where single or double tracks were formerly located, widening of railroad cuts, and the daylighting and widening of tunnels (**Figure 18**). And the Dakota, Minnesota, and Eastern railroad is proposing a new line from eastern South Dakota into the PRB, where it would serve the Basin's large coal mines. This new trackage would help supply markets in the upper Midwest.

As a result, aggregate production from Meridian Aggregates' quarry west of Cheyenne and Guernsey Stone's dolomitic marble quarry near Guernsey has increased (**Figure 17**). In addition, several companies have been conduct-



Figure 18. A double-tracked cut has recently replaced the Burlington Northern/Santa Fe's single-track tunnel east of Guernsey, Wyoming.

ing exploration programs and acquiring property for future ballast quarries. One such site is located in the Haystack Range northeast of Guernsey (**Figure 17**). Production of construction aggregate in 1999 will likely far exceed the production for any of the past five years.

Dimensional Stone

Plans continue for the expansion of the dimensional stone industry in Wyoming. Raven Quarries, LLC is now quarrying pink and black granite blocks in northern Albany County (**Figure 17**). These blocks are trucked to Tijuana, Mexico, for processing into finished tile and slab. Production figures released by the Wyoming State Inspector of Mines show that Raven Quarries increased production to over 166,000 tons of product in 1998.

Uranium

According to the Wyoming State Inspector of Mines, uranium production in Wyoming increased 4% in 1998, to 2,327,463 pounds of yellowcake. Larger production from Rio Algom's Smith Ranch operations accounted for most of the increase. Other producers are CAMECO at the Highland-Morton Ranch operation and COGEMA at Christiansen Ranch near the Pumpkin Buttes (**Figure 17**). All production from Wyoming is by in-situ, solution-mining methods.

METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel

Senior Economic Geologist- Wyoming State Geological Survey

During the past quarter, the Wyoming State Geological Survey (WSGS) responded to dozens of inquiries from the general public, companies, government agencies, and various educational institutions searching for information on Wyoming's mineral resources. The majority of the inquiries were in regard to gold, platinum, palladium, iron, titanium, diamond, and other gemstone occurrences. Due to efforts of the WSGS, the South Pass area, in particular, has been receiving considerable activity by gold prospectors. One prospector, using a metal detector, reported finding more than 150 nuggets. Prior to the WSGS' mapping of this region, the area had generally only received historical interest (Hausel, 1991). Currently, there is no gold production from Wyoming other than by individual prospectors and recreational panning and sluicing.

And despite low gold prices, there is still interest in gold exploration in Wyoming. The low prices for gold; however, are causing concern in gold-producing states as well as in other gold-producing countries. Exacerbating the concern was the Bank of England's recent sale of 25 metric tons of gold (*Casper Star-Tribune*, 7/8/99). That was followed by the International Monetary Fund's announcement that it planned to sell as much as \$2.6 billion worth of its gold

reserves (*Casper Star-Tribune*, 7/10/99). The price of gold in early May was \$257.70/ounce. In early August, it was still quoted between \$256 and \$258 an ounce.

Several companies and prospectors were searching for platinum and palladium. The economics of these two precious metals suggest that a significant shortfall will occur sometime in the near future. Because Wyoming is a significant province for these metals, it can expect continued exploration for these metals.

Diamonds and other gemstones were also attracting interest in the State. Work by the WSGS has identified the State as a significant diamond province (Hausel, 1998). The WSGS continued its fieldwork in the Iron Mountain kimberlite district, where it has already identified a small group of probable diamondiferous kimberlites.

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Technically Recoverable Resources (January 1, 1998)	
Discovered (Includes oil, gas liquids, and condensate)	3.47 billion barrels ¹
Undiscovered	6.18 billion barrels ¹
Total	9.65 billion barrels

Remaining Reserve Base (January 1, 1998)	
Measured reserves (Proved reserves) (Includes: 0.627 billion barrels of oil and 0.600 billion barrels of gas liquids and condensate)	1.23 billion barrels ²
Indicated and inferred reserves (Reserve growth in conventional fields)	2.41 billion barrels ¹
Total	3.64 billion barrels

NATURAL GAS

Remaining Technically Recoverable Resources (January 1, 1998)	
Discovered (Includes 35.6 trillion cubic feet (TCF) of methane ¹ and 121.5 TCF of CO ₂ ³)	157.1 trillion cubic feet
Undiscovered (Includes 14.72 TCF of conventional methane ¹ ; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO ₂ ³)	170.6 trillion cubic feet
Total	327.7 trillion cubic feet
Remaining Reserve Base (January 1, 1998)	
Measured reserves (Proved reserves) (Includes 13.6 TCF of methane ² and 59.8 TCF of CO ₂ ³)	73.4 trillion cubic feet
Indicated and inferred reserves (Reserve growth in conventional fields)	22.8 trillion cubic feet
Total	96.2 trillion cubic feet

COAL

Remaining Resources (January 1, 1999)	
Identified and Hypothetical (Discovered)	1,426.3 billion tons ⁴
Speculative (Undiscovered)	31.5 billion tons ⁴
Total	1,457.8 billion tons
Remaining Reserve Base (January 1, 1999)	
Demonstrated strippable (Measured and indicated reserve base)	24.7 billion tons ⁵
Demonstrated underground-minable (Measured and indicated reserve base)	42.5 billion tons ⁵
Total	67.2 billion tons

TRONA

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

URANIUM

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

OIL SHALE

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

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

² Modified from Energy Information Administration, 1998, U.S. crude oil, natural gas, and natural gas liquids reserves: Advance Summary, 1997 Annual Report: Washington D.C., 12 p.

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

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⁵ Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 p.

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

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

GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE

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NEW BLACK AND WHITE GEOLOGIC MAP OF THE LARAMIE AREA

The Wyoming State Geological Survey (WSGS), with funding assistance from the STATEMAP Program, recently completed the compilation and mapping of the geology for the 1:100,000-scale Laramie Quadrangle. STATEMAP is a cooperative, jointly-funded, Federal-State effort created by the National Geologic Mapping Act of 1992 (*Wyoming Geo-notes* No. 62, p. 64-65).

As a result of several identified needs, the Laramie Quadrangle was chosen as a focus for mapping efforts that began in 1994. Firstly, very little in the way of published, larger scale, geologic mapping existed for much of the area. Secondly, the city of Laramie was the only larger city in Wyoming without a published, larger scale, geologic map to cover it. Thirdly, with expanding construction in Laramie and surrounding areas, accurate up-to-date geologic mapping was needed to assist the construction and concrete industries in locating sand, gravel, gypsum, and limestone resources. Fourthly, the map was needed to aid in identifying and mitigating potential geologic hazards. Fifthly, accurate geologic information was needed to enhance the chances for siting good water wells in the area.

The Laramie Quadrangle is located in southeastern Wyoming, on the Colorado/Wyoming border (**Figure 19**). The quadrangle includes Precambrian to Upper Miocene bedrock. The Laramie structural basin underlies the western half of the quadrangle, with the Laramie Mountains and the western flank of the Cheyenne-Denver Basin on its eastern half. High-angle reverse faulting bounds the western side of the Laramie Basin and the western side of the Cheyenne-Denver Basin. Northwest trending anticlines parallel the reverse faulting on the western side of the Laramie Basin. On the eastern flank of the Laramie Basin, mapping revealed previously unidentified faulting with indications of lateral motion. Unique geomorphic features such as the Big Hollow blowout in the Laramie Basin and the Gangplank on the east side of the Laramie uplift also occur on the quadrangle.

The new map is entitled, *Preliminary geologic map of the Laramie 30' X 60' Quadrangle, Albany and Laramie Counties, southeastern Wyoming*, and is available through the WSGS's Publications Section as Preliminary Map Series PGM 99-1. The black-line map comes with a pamphlet that describes the map units and map symbols and lists the sources of geologic information used to compile the map. The map will be digitized as part of STATEMAP 99 and made available as a plotted color map by August of 2000.

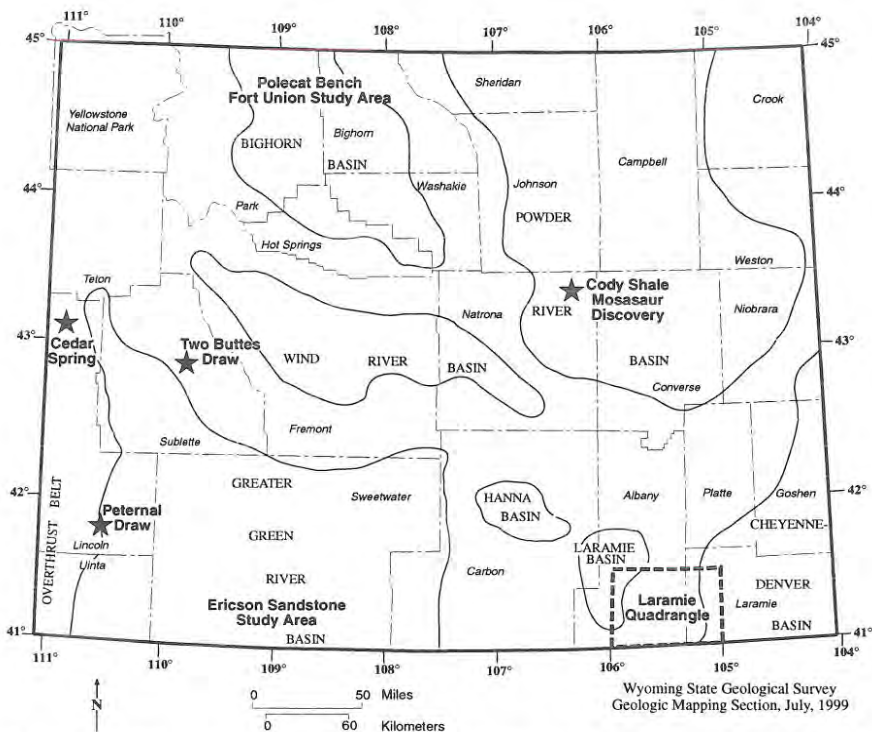


Figure 19. Index to selected paleontologic and geologic mapping activities in Wyoming.

In producing this map, the WSGS mapped and published three, 1:24,000-scale quadrangles to fill gaps in existing mapping and to correct outdated mapping. The Laramie quadrangle (partially funded by STATEMAP 94) and the Red Buttes Quadrangle (solely funded by the WSGS) were mapped and field checked during the 1994 field season. The Howell Quadrangle was completed in 1996 with some funding from STATEMAP 95. Under STATEMAP 98, the WSGS also completed an additional eight, 1:24,000-scale, reconnaissance/photogeologic maps. These unpublished maps include the Best Ranch, Dale Creek, Downey Lakes, Hutton Lake, Johnson Ranch, King Mountain, Pilot Hill, and Sherman Mountains West quadrangles. These maps are available for viewing at the WSGS' offices at Laramie. Citations to previously published, 1:24,000-scale maps are listed below:

- Ver Ploeg, A.J., 1995, Preliminary geologic map of the Red Buttes Quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Preliminary Geologic Map Series PGM-95-2, scale 1:24,000.
- Ver Ploeg, A.J., 1996, Preliminary geologic map of the Howell Quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Preliminary Geologic Map Series PGM-96-1, scale 1:24,000.

Ver Ploeg, A.J., 1998, Geologic map of the Laramie Quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Geologic Map Series MS-50, scale 1:24,000.

FOSSILIZED MOSASAUR DISCOVERED

Jim and Linda Schmiedt discovered a nearly complete mosasaur skeleton in a 70- to 80-million-year-old Cody Shale outcrop near Midwest, Wyoming (**Figure 19**). The Schmiedts are teachers who enjoy spending their spare time looking for fossils. Bill Wahl, Director of the Tate Geological Museum, and Bill Larson of the Black Hills Geological Institute, verified the skeleton was a mosasaur. Rick Hebdon of Warfield Fossils near Thayne, Wyoming, excavated the fossil skeleton and encased it in plaster for removal to his laboratory where he will spend up to two years preparing the fossil. The find was on private land, and the skeleton will be sold commercially when its preparation is complete. The Schmiedts hope it is sold to a museum and properly displayed.

This find is significant in that it is one of the first mosasaur finds in the Upper Cretaceous Cody Shale in this region. Mosasaurs are extinct lizard-like dinosaurs, which somewhat resembled the present day Komodo dragon. During their prominence in Upper Cretaceous time and beginning about 87 million years ago, mosasaurs were the dominant carnivore of the time. They fed on fish, squid, ammonites, and even other mosasaurs.

NEW WYOMING GEOGRAPHIC NAMES APPROVED

The U.S. Board on Geographic Names recently approved names for three geographic features in Wyoming. The three features are Cedar Spring, Peternal Draw, and Two Buttes Draw (**Figure 19**). Cedar Spring is a spring located along an unnamed stream between Corral Canyon and Birch Creek, 2.7 miles northeast of Etna in Lincoln County. In 1907, the Crook brothers originally named the spring for its close proximity to a cedar tree. Peternal Draw is a stream that flows into the Hams Fork of the Green River, four miles north of Kemmerer in Lincoln County. It was named for the Peternal family, who made improvements on the land on which the stream is situated. Two Buttes Draw is a stream, which flows into the New Fork River, south of Pinedale in Sublette County. It is named for Two Buttes, a nearby summit.

NEW PUBLICATIONS ON WYOMING GEOLOGY

An article by Kraus and Wells (1999) discusses the facies architecture of Paleocene floodplain deposits in the Fort Union Formation of the Polecat Bench area in the Bighorn Basin (**Figure 19**). The researchers used described and measured sections, petrologic analyses, and paleobotanical studies to define the alluvial architecture of the Fort Union Formation in that area.

The Upper Cretaceous Ericson Sandstone in the Glades/Clay Basin area on the Wyoming/Utah border is the subject of a paper by Petersen and Steel (1999). They examined the sequence stratigraphy, fluvial architecture, and spe-

cifically, the unconformity bounded sequences of the Ericson Sandstone in the study area (**Figure 19**). Results indicate uplift was actively occurring during the deposition of the Ericson, allowing less sediment accommodation along the western edge of the present uplift, compared to off-structure areas farther to the east and south. Evidence points to thinning of the formation over a slightly positive area, in contrast to the demonstrated thickening over the same area during the deposition of the earlier Rock Springs Formation and later Fort Union Formation.

The Rocky Mountain Association of Geologists recently released their July issue (v. 36, no. 3) of the *Mountain Geologist*, which is a bibliography of published articles on Rocky Mountain oil and gas fields. The bibliography is organized with field listings by state (Arizona, Colorado, Montana, western Nebraska, Nevada, northern New Mexico, North Dakota, South Dakota, Utah, and Wyoming). It also contains a listing of the articles organized by author. M.W. Longman and M.S. Johnson edited this issue of the *Mountain Geologist*. D.S. Anderson, S.M. Clark, E.G. Griffith, M.L. Hendricks, M.S. Johnson, M.W. Longman, J.C. Osmond, J.W. Robinson, and J.P. Rogers compiled the bibliography.

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THE EARTHQUAKE PROGRAM IN WYOMING

By James C. Case

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The Wyoming State Geological Survey (WSGS) has been participating in the Federal Emergency Management Agency's Earthquake Program since last December (*Wyoming Geo-notes* No. 62, p.68). Summaries of the Program's projects and their current status are presented below.

HAZUS

HAZUS is a computer program, which helps estimate, both in dollars and lives, potential losses associated with earthquakes of various magnitudes. The WSGS is currently assembling data for HAZUS computer models applicable to Teton, Fremont, and Lincoln Counties. A detailed analysis is being developed

for Teton County. This analysis will emphasize the effects that earthquakes will have on shelters and on utility and lifeline systems. The analysis will include an evaluation of the effects of a magnitude 7.5 earthquake on the Teton fault. The analysis for Teton County will also incorporate the potential for and damage from seismic-induced landslides.

Initially, the analyses for Fremont and Lincoln Counties will use available default data already in the HAZUS software. The default data will be replaced with detailed analyses during the next contract period.

EARTHQUAKE WEB PAGE

Using contract funds, the WSGS has subcontracted with the Water Resources Data System at the University of Wyoming for an interactive search page for earthquakes. The page will enable a user to define search parameters by date, resulting in a plot of all earthquakes that occurred between selected dates. The earthquake epicenters will plot on a Wyoming map showing county boundaries. The data for the page come from the U.S. Geological Survey's National Earthquake Information Center, the University of Utah Seismograph Stations, the U.S. Bureau of Reclamation, and the WSGS. The web page, which will be served through the Water Resources Data System, will be updated weekly, and will contain detailed information on recent damaging earthquakes. The page should be operational in August of this year.

PUBLICATIONS AND BROCHURES

The WSGS has begun work on two brochures and a publication related to earthquakes and seismic safety. One brochure will explain how to make your Wyoming home more earthquake resistant. It will include instructions for attaching the frame of your home to its basement, for the strengthening of walls, for the proper anchoring of a water heater, and for the stabilization of bookshelves and valuables. Another brochure will contain information on Wyoming earthquakes, on preparation for earthquakes, and on what to do during an earthquake.

The planned publication will discuss historic seismicity and known and suspected active faults in Wyoming. It will be a significant update and expansion of *Earthquakes and active faults in Wyoming* (Preliminary Hazards Report 97-2).

WORKSHOPS

An important goal of the Earthquake Program is to inform and educate residents about the earthquake hazard in Wyoming. Even though the U.S. Geological Survey and the Federal Emergency Management Agency (FEMA) have classified Wyoming as having a very high seismic hazard, many residents of the State do not feel that the hazard is significant. Part of the reason for this is that damaging earthquakes do not occur every year. Through education, resi-

dents, public officials, builders, teachers, and schoolchildren will become more aware of the potential for earthquakes and begin to take appropriate action.

FEMA and the National Science Teachers Association have developed two train-the-trainer workshops for teachers. *Tremor Troop* is designed for teachers of grades K-6 and *Seismic Sleuths* is designed for teachers of grades 7-12. Workshops are being developed for later this year in western Wyoming. While these planned workshops are being designed for western Wyoming, they can benefit any school system.

FEMA has also developed a workshop on how to rapidly assess a building's probable performance during an earthquake. A workshop on this rapid, visual, screening technique is scheduled for September 17, 1999, in Casper, Wyoming. The workshop is offered during the joint annual meetings of the State Fire Marshals and the Wyoming Conference of Building Officials.

EARTHQUAKE SHELTERS

There are a variety of emergency shelters located in Wyoming. In the case of earthquakes; however, shelters must be designed or retrofitted to not only withstand an earthquake, but also to serve displaced persons after an earthquake. The WSGS has begun working with the Red Cross, cities, and counties on the selection of suitable earthquake shelters. Using HAZUS, the WSGS can analyze a potential shelter for its ability to withstand a design earthquake.

ROCK HOUND'S CORNER

by W. Dan Hausel

Senior Economic Geologist- Wyoming State Geological Survey

GARNETS

Garnet is a common mineral found in many metamorphic environments, particularly where the rocks have been metamorphosed to amphibolite grade and are aluminum-rich. Such rocks contain abundant black mica and may also contain some amphibole with scattered grains of red garnet. These latter, speckled rocks have been described as resembling plum pudding.

Within Wyoming, the metamorphic environments described above are common in essentially all the Precambrian-cored mountain ranges. The only major mountain ranges in Wyoming without an exposed Precambrian core are those in the Overthrust Belt and the Absaroka Mountains in western Wyoming. Thus the possibility of finding garnets is excellent, particularly in mica schists and granite pegmatites. Detrital garnet, derived from the erosion of these rocks,

has been found in anthills and in some streams that drain these uplifts. Although most garnets found in the State have been industrial quality, gem-quality and specimen-quality garnets do occur (Hausel and Sutherland, 1998).

There are several varieties of garnet. In fact, mineralogists recognize six garnet end-members. These vary in color, specific gravity, chemistry, and index of refraction. The end-members include pyrope [$\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3$], almandine [$\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$], spessartite [$\text{Mn}_3\text{Al}_2(\text{SiO}_4)_3$], grossularite [$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$], andradite [$\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$], and uvarovite [$\text{Ca}_3\text{Cr}_2(\text{SiO}_4)_3$] garnet. However, these pure, end-member garnets are rare in nature. Most garnets occur as mixtures of two or more of the end-members. Since these mixtures are solids, the mineralogist refers to them as solid-solutions. For example, a garnet containing both magnesium and iron is called a pyrope-almandine garnet, and so forth.

Garnets crystallize in the isometric crystal system (they are equal-dimensional). They have no cleavage, but may show parting. Most garnets are translucent. Gemologists sometimes cut the less common transparent garnets into semi-precious gemstones. Other garnets with well-formed dodecahedral or trapezohedral crystal habits are sought by mineral collectors. Garnets may be purplish-red, yellow-orange, reddish-brown, black, white, or green in color.

Garnets have relatively high specific gravity (3.5 to 4.3) and hardness (6.5 to 7.5). The high specific gravity accounts for garnets ending up in the heavy black sand concentrates in stream deposits. The high hardness makes garnet useful as an abrasive.

Some specimen-quality garnets (garnets with excellent crystal shape or unusual characteristics) that have been found in Wyoming include translucent to opaque almandine garnets from the Teton Range and chlorite pseudomorphs after almandine from the Sierra Madre mountains. These latter pseudomorphs exhibit excellent dodecahedral habit, but are opaque and completely or nearly completely replaced by chlorite mica, even though they retain the garnet crystal habit. Some extraordinary megacrysts of pyrope-almandine garnet from the Colorado-Wyoming State Line district have been found in diamondiferous kimberlites in that district. While some of these translucent, reddish-brown garnets are 5 to 6 inches across, they are highly fractured and rounded.

Although transparent, flawless, semi-precious, gem garnets are uncommon in Wyoming, several gem-quality stones have been found in breccia pipes in the Greater Green River Basin near Cedar Mountain and in anthills near Butcherknife Draw. These are small, transparent, pyrope and pyrope-almandine garnets (typically less than 6 millimeters in diameter). They are found in anthills in association with emerald-green chromian diopside and chromian enstatite. Faceted stones cut from these garnets have produced some very attractive yellow-orange and reddish-purple gems.

Other transparent, gem-grade garnets have been reported in an area 20 miles northeast of Guernsey (Cheyenne Gem and Mineral Society, 1965). Many of the garnets from the Guernsey area were cut, polished, and sold as gems several years ago.

REGIONS OF INTEREST

Topographic maps are helpful for finding the best route to the garnet localities discussed below. The U.S. Geological Survey's 1:100,000-scale, metric, topographic maps work well for this purpose. One should also check out surface ownership, as some of these localities are on private land. The U.S. Bureau of Land Management's 1:100,000-scale, Surface Land Status maps are useful for this purpose. The topographic and land status maps are available from the Wyoming State Geological Survey and from some sporting goods stores in the State. Also, remember that many of these sites could have mineral claims on them, which puts them off-limits to collecting without permission of the claimant.

Granite Mountains

The Granite Mountains are in central Wyoming. These ancient mountains are formed of Archean (>2.5 billion years old) metamorphic rocks (schists and gneisses) intruded by granites. Tertiary sedimentary rocks surround the Precambrian rocks. Much of this region is relatively unexplored.

The Wyoming State Geological Survey's (WSGS') recent investigations in the Barlow Gap area identified several garnet amphibolite schists found near banded iron formation. The garnets in these schists are poor quality, opaque, and reddish-brown. However, there is a potential for the discovery of better quality garnets in this region.

Some excellent, dodecahedral garnets have been found near Jeffrey City. These garnets were found in the vicinity of the Graham Ranch on the Sweetwater River in the southern Granite Mountains (Robert Odell, personal communication, 1997). The source for these garnets, which were larger than one inch in diameter, has not been found.

Greater Green River Basin

Numerous pyrope and pyrope-almandine garnets have been found in anthills, in the Bishop conglomerate, in road cuts, and in a small group of breccia pipes in the Greater Green River Basin. This area extends as far north as Interstate 80 near Moss Agate Cut and Mud Spring Hollow to the east of Lyman, and as far south as the Cedar Mountain area east of Lonetree. Many of these garnets are gem quality, as they are translucent to transparent, and red to purple-red to yellow-orange in color. The majority of the garnets found in the anthills are small (1-6 millimeters across) although larger stones have been recovered from road cuts, the Bishop Conglomerate, and the DK pipes along the southwestern margin of Cedar Mountain.

One of the better areas to collect garnets is the Butcherknife Draw area north of Cedar Mountain. In this area, many garnets are found in anthills. A few diamonds have also been reported from this area.

Hartville Uplift

The Hartville uplift in eastern Wyoming is known for both gem and industrial quality garnets. The uplift is a metamorphic-cored structure containing mica schists with some garnet pegmatites. Some interesting localities include the following:

Crystal Palace pegmatite (NE section 34 & 35, T28N, R65W). The Crystal Palace pegmatite lies along the section line between sections 34 and 35. This is a 6- to 18-foot-wide pegmatite that has some beryl with feldspar, quartz, muscovite, tourmaline, and garnet (Sterrett, 1923).

Haystack pegmatite (section 1, T27N, R65W). This pegmatite is six miles northeast of Guernsey, just south of Garnet Hill. The Haystack pegmatite was originally staked for feldspar found in the granite pegmatite. The pegmatite contains quartz, feldspar, mica, and garnet. Some of the garnets were reportedly one inch in diameter and euhedral (Hanley and others, 1950).

McGinnis Pass area (section 11, T27N, R65W). McGinnis Pass is in the Haystack Range of the Hartville uplift. Several hundred, clear, garnet crystals found on this property were cut, polished, and sold as semi-precious gems (Osterwald and others, 1966).

Jay Em area. Large fractured garnets are reported in outcrops 12 miles west and 8 miles north of Jay Em, and to the northwest of Rawhide Creek (Osterwald and others, 1966).

Laramie Mountains

Several garnet localities are reported in the Laramie Mountains although no gemstone garnets are reported from this region. Some interesting localities include the following:

Cooney Hills (section 8, T23N, R69W). A large deposit of garnet was found in the Cooney Hills west of Wheatland (Osterwald and others, 1966). The deposit, known as the MacDougal vermiculite, occurs in garnet-biotite schist (Hagner, 1944). Some of the garnet crystals were as large as two inches in diameter.

Iron Mountain district (T19N, R70W). Several kimberlite dikes, sills, and blows in the Iron Mountain district contain pyrope and pyrope-almandine garnet, as well as picroilmenite and some chromian diopside.

In addition to garnet, this is a good place to search for hand specimens of kimberlite, as some kimberlite crops out. A few kimberlite outcrops also have relatively well-preserved megacrysts of olivine. The kimberlites are found on private, State, and Federal lands (Smith, 1977, and Hausel and others, 1997).

Owen Creek area (sections 9 & 16, T25N, R71W). In the NW section 16, 0.25-inch-diameter garnets were found in a gully draining into Owen Creek (Osterwald and others, 1966). These garnets were derived from the adjacent biotite schist country rock.

A nearby amphibolite reportedly contained pyrope-almandine garnets (Osterwald and others, 1966). The Owen Creek area is near Wheeler Flat, which is several miles west of Wheatland and north of Palmer Canyon.

Colorado/Wyoming State Line district (T12N, R72W). Several kimberlites in the State Line district south of Tie Siding and west of U.S. Highway 287 host a variety of rounded (anhedral) garnets (Hausel, 1998). The minerals include pyrope, pyrope-almandine, almandine, and pyrope-grossular garnets of millimeter size. However, some metacrysts of pyrope-almandine garnet megacrysts have been fist-size (5 to 6 inches across). These megacrystal garnets are reddish-brown, translucent, and highly fractured.

Other garnets found in the district are red to reddish-purple to orange yellow, to pink. These are associated with emerald-green chromian diopside and some industrial and gem-quality diamonds.

Tie Siding area (section 11, T12, R72W). During the 1940s, several small pegmatites were quarried for feldspar along U.S. Highway 287 on the eastern edge of the State Line diamond district. Locally, these pegmatites contain uncommon euhedral to subhedral, opaque to translucent garnet (Osterwald and others, 1966). At one quarry, about 500 feet east of U.S. Highway 287, the author found a fractured, fist-size, opaque, euhedral, reddish-brown garnet.

Medicine Bow Mountains

Some relatively large, poorly-formed, translucent to opaque, almandine garnets have been found in pegmatites southwest of Foxpark in the Medicine Bow Mountains. Much of this area lies within the National Forest and is fairly accessible.

Big Creek district (T13N, R81W). At least three types of pegmatites occur in this district, which is in the flats along the southwestern margin of the Medicine Bow Mountains. One type is a feldspar-quartz pegmatite with accessory biotite, garnet, muscovite, magnetite, and ilmenite (Houston, 1961). These pegmatites occur conformable to the strike of the amphibolite gneiss and schist country rock. A second type of pegmatite crosscuts the foliation of the country rock, and is poorly zoned with a quartz-rich core and an outer border of graphic granite. These pegmatites consist of feldspar and quartz with accessory garnet, tourmaline, biotite, muscovite, and fluorite, and rare monazite, allanite, euxenite, and columbite (Houston, 1961). A third pegmatite, found at the Big Creek mine (NW section 9), is conformable to the country rock, but contains significant copper mineralization with common, transparent, euhedral quartz (Ralph Platt, personal communication, 1999).

Lone Prospect (*section 32, T13N, R78W*). Located southwest of Foxpark, this prospect is a Precambrian pegmatite, which intrudes schist. The pegmatite is comprised of quartz, microcline, and muscovite with accessory albite feldspar. Some large garnets, weighing as much as two pounds, were found in this pegmatite. The garnets were poorly crystallized and not gem quality (Osterwald and others, 1966).

Many Values prospect (*SE section 32, T13N, R78W*). This prospect is southwest of Foxpark and about one mile west of Wyoming Highway 230 in the Medicine Bow Mountains. The Many Values pegmatite strikes N50°E and dips 85°NW, and has a surface exposure of 15 by 150 feet. Prospect pits in the pegmatite have exposed a feldspar-rich core zone.

About 75 feet north of the main prospect is a second pegmatite. This pegmatite is a feldspar-quartz-mica pegmatite that strikes northerly and has a vertical dip.

Muscovite is abundant near the hanging wall of the main pegmatite. Some of the muscovite books are speckled light green due to the presence of magnetite. Several tons of mica along with two tons of industrial quality beryl were mined from the Many Values property prior to 1942. The pegmatite also contains small tantalite crystals (hard, black, submetallic minerals often with an iridescent tarnish and a short, prismatic or tabular habit), minor accessory fergusonite (a rare-earth tantalite), and pink euhedral and orange subhedral garnets (Osterwald and others, 1966).

Muscovite pegmatite (*section 32, T13N, R78W*). The Muscovite pegmatite lies west of the Many Values prospect. The Muscovite deposit consists of a granitic pegmatite dike, which strikes N50°E and dips vertically, cutting Precambrian metadiabase, hornblende schist, and gneiss. The pegmatite averages 40 feet wide and has a 600-foot strike length.

Green beryl is found along fractures in the wallrock associated with tantalite-columbite crystals. In places, quartz and feldspar show graphic textures. The pegmatite contains microcline crystals several inches in diameter and muscovite books up to one-foot wide. Andradite garnet is reported as a minor accessory mineral (Osterwald and others, 1966).

Sierra Madre

There are several garnet localities in the Sierra Madre mountains west of the Medicine Bow Mountains. This area lies within the National Forest and contains numerous historical mines and prospects that were developed primarily for copper, gold, zinc, and lead. When searching the district for garnets, a copy of a map by Houston and Graff (1995) is helpful. This map shows the location of the Silver Lake Metavolcanics, which hosts biotite-garnet schist.

Oldman property (*NE section 14, T14N, R84W*). This property is 1.5 miles west of Encampment along the Copper Creek road. A narrow chlorite schist

(typically less than 10 feet wide) continues on both sides of the road and trends northwesterly about 0.5 mile southwest of the Oldman Ranch. The garnet-chlorite schist was traceable for approximately 2,000 feet. The garnets include large, dodecahedral, chlorite pseudomorphs after garnet (Osterwald and others, 1966). Many of the garnet pseudomorphs are 0.5 inch to 3 inches across and easily separated from the schist (the author and Grace Dyck, personal communication, 1991). Portions of the interior of the pseudomorphs contain preserved almandine garnet.

Section 8 mine (*SE section 8 & NE section 17, T14N, R85W*). Sometime near the turn of the last century, a shaft was sunk on an exhalative massive copper-sulfide. Samples from this historic mine consist of banded chert with alternating layers of massive sulfide (pyrite, chalcopyrite, bornite, and cuprite). The massive sulfide is hosted by mafic (amphibolite) schist and garnet biotite schist of the Silver Lake Metavolcanics. The amphibolite contains large 'turkey track', bladed, radiating amphibole in a muscovite-sericite schist with 1/8- inch-diameter almandine garnets. Other nearby biotite schists contain large, 0.25- to 0.5- inch-diameter porphyroblasts of opaque, fractured, reddish-brown, subhedral to euhedral almandine garnet (Hausel, 1997).

Owl Creek Mountains

The Owl Creek Mountains lie north of Shoshoni and south of Thermopolis in northwestern Wyoming. The Copper Mountain portion of the range hosts several pegmatites that contain garnet.

Copper Mountain (*sections 22, 27 & 28, T40N, R93W*). Archean metamorphic rocks intruded by granite and granitic pegmatite underlie the Copper Mountain district. The metamorphic rocks include amphibolite, banded iron formation, quartzofeldspathic gneiss, biotite-chlorite-epidote schist, quartzite, quartz-mica schist, and porphyroblastic mica schist. The porphyroblasts include andalusite, cordierite, sillimanite, and garnet although none of these have been reported as gem quality.

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