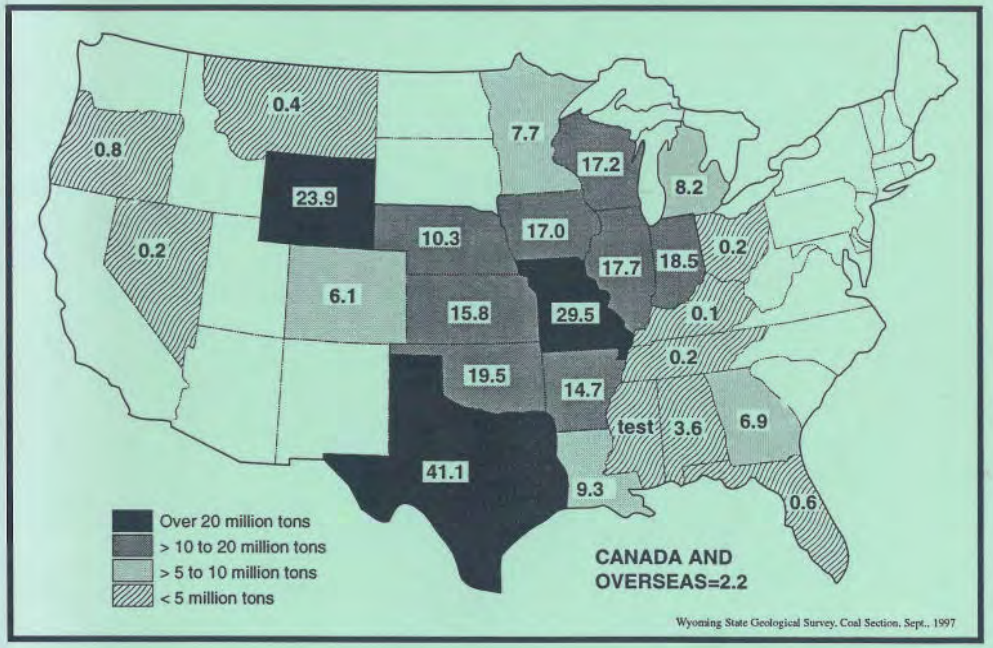
Wyoming Geo-notes

Number 56



Wyoming State Geological Survey
Gary B. Glass, State Geologist

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December, 1997

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WYOMING GEO-NOTES
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Cover: Map showing deliveries of Wyoming coal to electric generating plants in 1996 (tonnages in million of tons). See p. 22 of this issue for a more detailed explanation.

Table of Contents

MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

The forecasts of energy and other mineral production in **Table 1** of this issue have been updated to reflect the October estimates of the Consensus Revenue Estimating Group (CREG). As a result, forecast oil production has been increased somewhat from their most recent previous estimate, which was made in April of 1997. **Table 1** and **Figure 1** depict forecast oil production. The forecast decline in annual production remains between 5.0-5.5%. CREG noted that the full effect of the Express Pipeline on Wyoming production, remains uncertain. Express now brings Canadian oil through Casper.

CREG revised its forecasts for the production of natural gas to slightly below their April estimates. In addition, based on some late revisions, corrections were made to the production of natural gas (methane), carbon dioxide, and helium in 1995. Estimated production of carbon dioxide and helium have been increased over previous forecasts, as has methane production. Overall, natural gas production is forecast to increase every year (**Table 1**; **Figure 2**). After an estimated 6.7% increase in 1998, production is forecast to increase by approximately 2% a year. The higher increase in 1998 reflects an increase in pipeline capacity.

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

Calendar Year	Oil[2,3]	Natural Gas[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[6]	In-situ Uranium[7,8]	Sulfur[3,9]
1985	131.0	597.9	—	—	140.4	11.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	987.5	148.8	1.11	263.9	18.1	1.3	1.20
1996	*73.9	*1,023.4	*149.0	*1.10	278.4	17.5	1.9	*1.20
1997	70.0	1,044.9	149.0	1.10	288.3	19.4	2.4	1.20
1998	66.3	1,124.9	149.0	1.10	302.2	20.0	3.5	1.20
1999	62.8	1,150.4	149.0	1.10	319.4	21.1	3.5	1.20
2000	59.5	1,176.4	149.0	1.10	339.9	21.8	3.5	1.20
2001	56.3	1,203.3	149.0	1.10	346.7	22.6	3.5	1.20
2002	53.3	1,230.0	149.0	1.10	350.2	23.5	3.5	1.20
2003	50.5	1,257.6	149.0	1.10	353.7	24.4	3.5	1.20
2004	47.8	1,285.8	149.0	1.10	357.2	25.9	3.5	1.20

*Estimated until official figures are available.
[1]Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2004, October, 1997; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1985-1995; [4] Billions of cubic feet; [5]Based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; [6]Millions of short tons (Wyoming State Inspector of Mines, 1985-1996); [7]Wyoming State Inspector of Mines, 1985-1996; [8]Millions of pounds of yellowcake (not available [N/A] for 1985 and previous years because it was only reported as taxable value); [9]Millions of short tons.

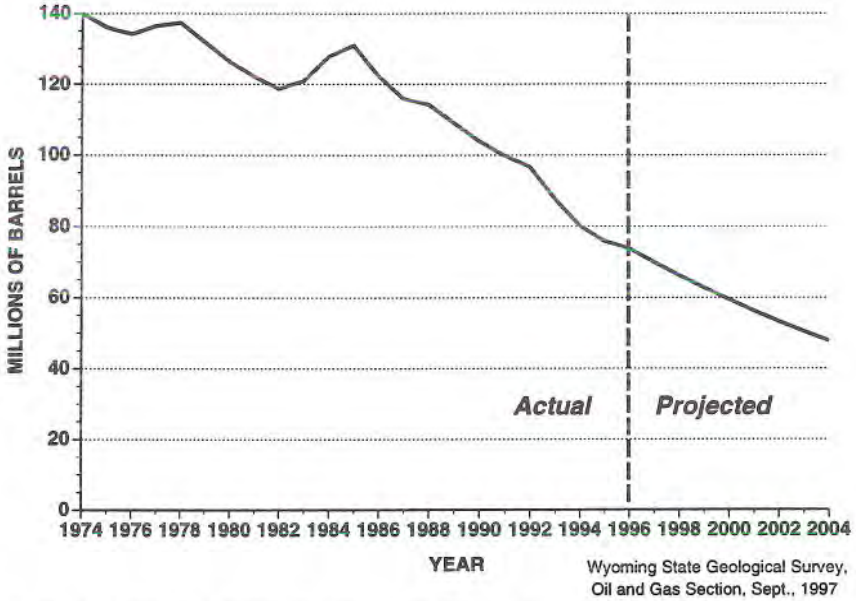

Figure 1. Annual oil production from Wyoming (1974 to 1996) with forecasts to 2004.

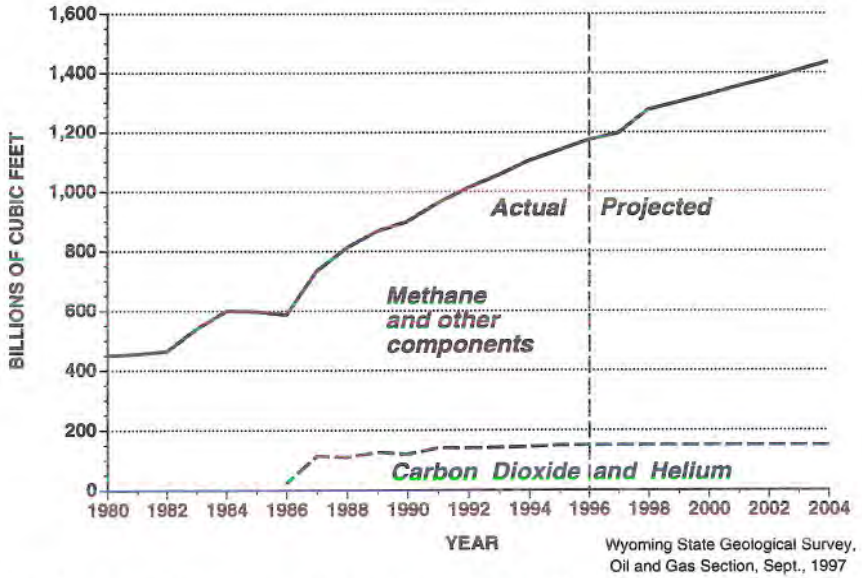

Figure 2. Annual natural gas production from Wyoming (1980 to 1996) with forecasts to 2004.

Estimates of coal production has been lowered somewhat in all the projected years. However, gains in annual production are still forecast to increase each year between 1997 and 2004 (**Table 1**; **Figure 3**). However, after Phase II of the Clean Air Act in 2000, production gains are projected to taper off to about 1-2% a year. And the forecasts for at least this year and next could turn out slightly high because of delivery problems currently plaguing the Union Pacific/Southern Pacific railroad. As it is, coal production in 1997 is only forecast to increase 3.6% over that in 1996.

Although CREG reduced its April forecasts for trona production, especially in the next two years, production is projected to increase each year through 2004 (**Table 1**). Estimates of uranium production are reduced in 1997, but not changed in the following years. In addition, the production of uranium in 1996 is revised downward to 1.9 million pounds (**Table 1**). It had been shown as 2.4 million pounds.

CREG made fewer changes from its forecast prices of April than it did in its production estimates. The estimated price of oil is increased to $17.30 in 1997, which is 30 cents above CREG's earlier estimate. It continued to forecast $15.00 between 1998 and 2004 (**Table 2**; **Figure 4**). The lower price after 1998 reflects uncertainty about what effect Express Pipeline will ultimately have on Wyoming prices.

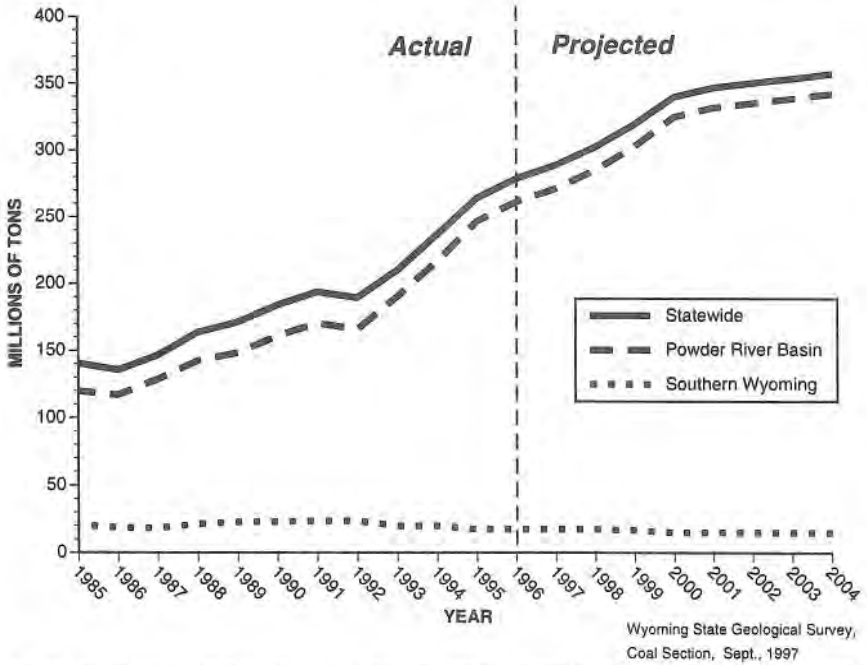

Figure 3. Annual coal production from Wyoming (1985-1996) with forecasts to 2004. Data from Wyoming State Inspector of Mines (1985-1996) and Wyoming Consensus Estimating Group (1997-2004).

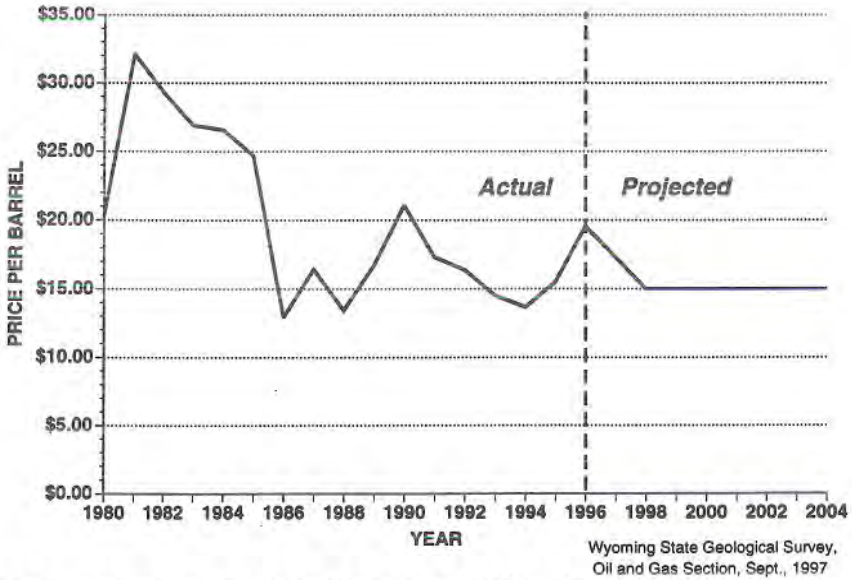

Figure 4. Average prices paid for Wyoming oil (1980 to 1996) with forecasts to 2004.

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

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	41.86
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	44.50
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.47	6.15	45.86
1997	17.30	1.74	6.11	42.62
1998	15.00	1.50	5.97	43.34
1999	15.00	1.50	5.82	42.93
2000	15.00	1.50	5.64	43.25
2001	15.00	1.50	5.55	43.44
2002	15.00	1.50	5.48	43.92
2003	15.00	1.50	5.40	44.24
2004	15.00	1.50	5.32	44.45

* Estimated until official figures are available.
[1] Modified from CREG, Wyoming State Government Revenue Forecast FY97-FY2004, October, 1997; [2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1996; [3] Wellhead price in dollars per thousand cubic feet (MCF). Source: Wyoming State Land and Investment Office, 1989-1996 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); [4] Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-1996; [5] Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1996.

The forecast price for natural gas (methane) this year is increased to $1.74, which is up from the previous forecast of $1.60. Between 1998 and 2004, CREG continues to forecast a price of $1.50 (**Table 2**; **Figure 5**). CREG cited a slow growth in the national demand rate coupled with an influx of considerable Canadian gas as the reasons for not escalating gas prices.

In comparison to CREG's April forecasts, its coal price forecasts in October are increased slightly for the years 1997 though 2001. The price estimates for 2002 to 2004, however, are lower than the earlier estimates. **Table 2** and **Figure 6** show that CREG now forecasts the average price of Wyoming coal declining each year through 2004. The average price paid for Wyoming coal continues to fall as more and more coal is sold on the spot market at prices below $4.00 a ton.

The forecast prices for trona are also changed from the estimate CREG made in April. The price forecast reflects an anticipated decline in price between 1996 and 1997, followed by a gradual increase in price (**Table 2**). The growth in price is not as great as predicted in the earlier forecast.

As you may have noticed, there are fewer tables and charts in this overview than in the past. All of these missing illustrations are in this edition of *Wyoming Geo-notes*, but they are in the appropriate commodity discussions.

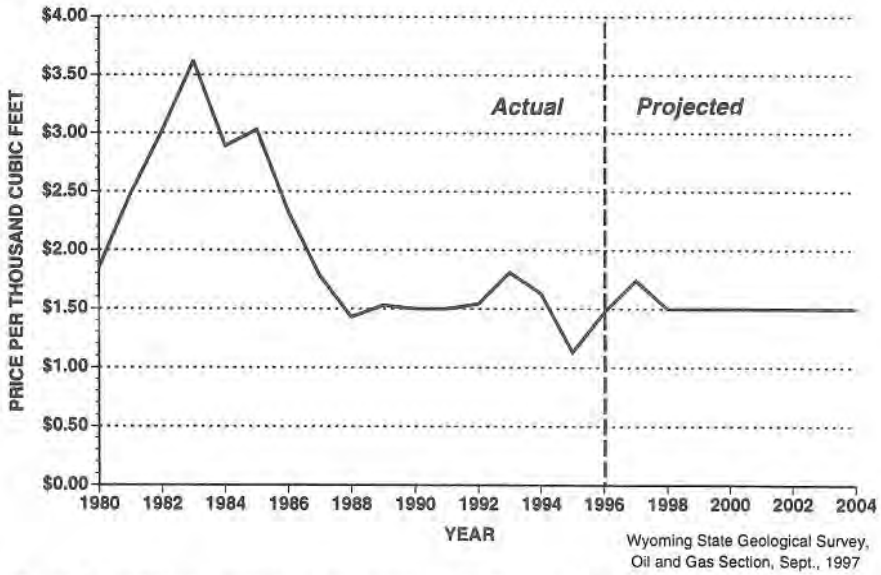

Figure 5. Average prices paid for Wyoming methane (1980 to 1996) with forecasts to 2004.

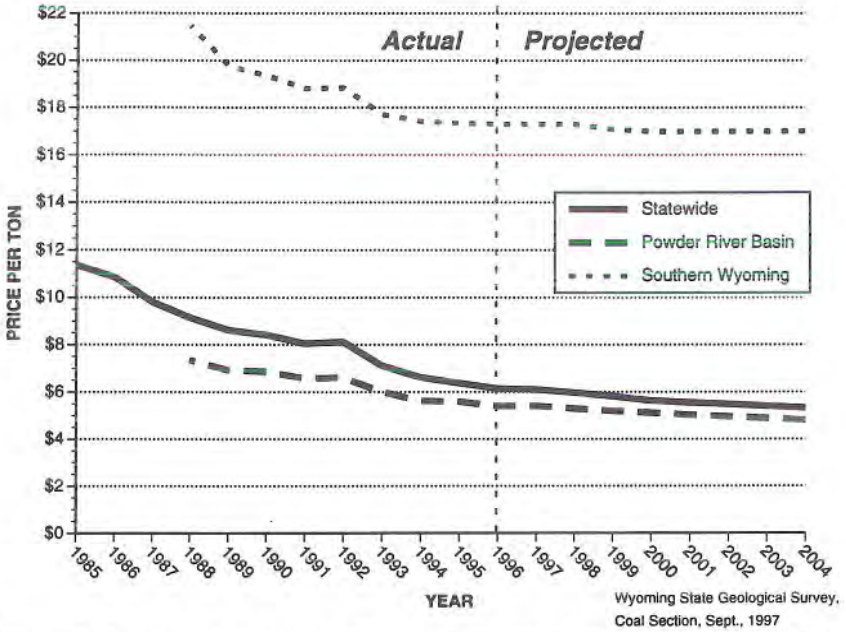

Figure 6. Average prices paid for Wyoming coal (1985 to 1996) with estimates to 2004. Source: U.S. Energy Information Administration (1985-1990); derived from the Wyoming Department of Revenue (1991-1996); and the Consensus Revenue Estimating Group (1997-2004).

Reference cited

Consensus Revenue Estimating Group, 1997, Wyoming State Government revenue forecast for FY1998-FY2004: Cheyenne, October, 22 p.

OIL AND GAS UPDATE

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

Prices paid to Wyoming oil producers at the end of the third quarter of 1997 averaged $16.40 per barrel (**Table 3**). The average price for the first nine months of 1997 is $1.00 lower than for the first nine months of 1996, but is higher than it was in the first nine months of 1992-1995. **Figure 7** shows that monthly posted prices for Wyoming's Sweet and Sour crude as well as the first purchase price are now coming off a high that has lasted about a year.

Oil production in Wyoming for the first half of 1997 was an estimated 34.8 million barrels (**Table 4**) according to preliminary figures from Petroleum Infor-

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

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	$ 11.15	$ 11.15	$ 14.77	$ 14.77	$16.38	$16.38	$22.56	$22.56
FEB	$ 11.01	$ 11.08	$ 15.55	$ 15.16	$16.28	$16.33	$19.45	$21.01
MAR	$ 11.04	$ 11.07	$ 15.26	$ 15.19	$18.63	$17.09	$17.99	$20.00
APR	$ 12.59	$ 11.45	$ 16.73	$ 15.58	$20.29	$17.90	$16.81	$19.20
MAY	$ 14.53	$ 12.07	$ 16.65	$ 15.79	$18.85	$18.08	$17.74	$18.91
JUN	$ 15.73	$ 12.68	$ 15.52	$ 15.75	$18.15	$18.10	$15.90	$18.41
JUL	$ 16.31	$ 13.20	$ 14.50	$ 15.57	$18.98	$18.22	**$16.30**	**$18.11**
AUG	$ 14.89	$ 13.41	$ 15.09	$ 15.51	$19.59	$18.39	**$16.50**	**$17.91**
SEP	$ 14.10	$ 13.49	$ 15.41	$ 15.50	$21.48	$18.74	**$16.40**	**$17.74**
OCT	$ 14.53	$ 13.59	$ 14.67	$ 15.42	$22.63	$19.13		
NOV	$ 14.68	$ 13.67	$ 15.32	$ 15.41	$21.19	$19.31		
DEC	$ 13.71	$ 13.67	$ 16.43	$ 15.50	$22.42	$19.56		
Average yearly price		**$ 13.67**		**$ 15.50**		**$19.56**		

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

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

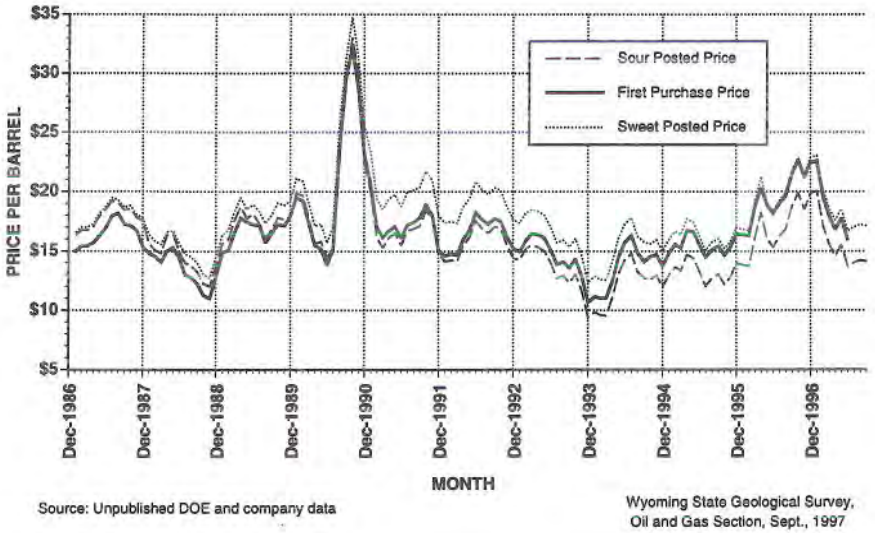

Figure 7. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

mation Inc. This production is a drop of about 3.2% from last year's first half oil production.

Spot prices for natural gas at Opal, Wyoming, averaged $1.45 during the third quarter of 1997 (**Table 5**; **Figure 8**). This is the highest third quarter average price since 1993.

Natural gas production in Wyoming for the first quarter of 1997 was an estimated 568.6 billion cubic feet according to preliminary production figures from Petroleum Information Inc. Production is about 15 billion cubic feet low because of a reporting omission by a major gas producer (**Table 6**). Even with an added 15 billion cubic feet of production, the total for the first half is lower than for the first half of 1996. Production should increase later in the year when pipeline capacity out of the State increases.

KN Energy's Pony Express pipeline began free-flow operations in August. Free-flow operations allow up to 60 million cubic feet of gas per day to travel through the line. The 900-mile line will transport natural gas from Wyoming to the Kansas City area. The pipeline's full capacity of 255 million cubic feet of gas per day should be reached in the fourth quarter of 1997.

Coastal Corporation's subsidiaries, Colorado Interstate Gas and Wyoming Interstate, finished construction in August on the expansion of their pipeline systems in Wyoming. The new compression facilities increased Wyoming Interstate's capacity by 193 million cubic feet of gas per day and Colorado Interstate Gas' capacity by 68 million cubic feet per day.

Table 4. Monthly oil production from Wyoming in barrels (1994 to present).

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	7,115,472	7,115,472	6,700,000	6,700,000	6,153,037	6,153,037	5,955,032	5,955,032
FEB	6,387,147	13,502,619	6,100,000	12,800,000	5,693,084	11,846,121	5,453,263	11,408,295
MAR	6,984,248	20,486,867	6,300,000	19,100,000	6,176,805	18,022,926	6,007,454	17,415,749
APR	6,672,207	27,159,074	6,200,000	25,300,000	5,977,362	24,000,288	5,689,334	23,105,083
MAY	6,847,709	34,006,783	6,300,000	31,600,000	6,035,505	30,035,793	6,032,578	29,137,661
JUN	6,594,914	40,601,697	6,200,000	37,800,000	5,916,019	35,951,812	5,646,501	34,784,162
JUL	6,773,956	47,375,653	6,300,000	44,100,000	6,076,992	42,028,804		
AUG	6,685,423	54,061,076	6,100,000	50,200,000	6,414,850	48,443,654		
SEP	6,446,719	60,507,795	6,100,000	56,300,000	6,180,180	54,623,834		
OCT	6,525,817	67,033,612	6,300,000	62,600,000	6,186,019	60,809,853		
NOV	6,257,924	73,291,536	6,100,000	68,700.000	6,221,912	67,031,765		
DEC	6,236,204	79,527,740	6,300,000	75,000,000	6,330,701	73,362,466		
Total Barrels Reported[1]		**79,527,740**		**75,000,000**		**73,362,466**		
Total Barrels Not Reported[2]		**651,400**		**554,113**		**525,957**		
Total Barrels Produced[3]		**80,179,140**		**75,554,113**		**73,888,423**		

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

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

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

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

Source: American Gas Association's monthly reports

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

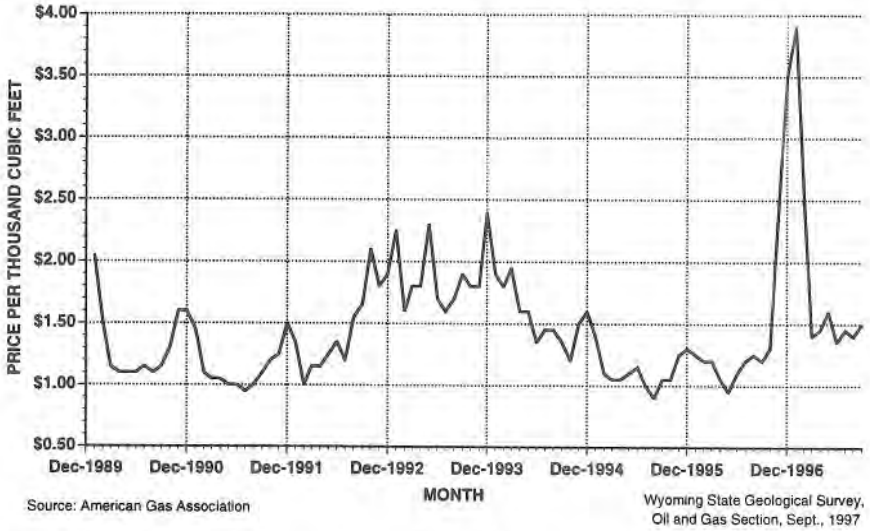

Figure 8. Spot sale price for methane at Opal, Wyoming, averaged by month (1989 to present).

The U.S. Department of Energy (1997) released its new reserve estimates for crude oil, natural gas liquids, and natural gas. **Table 7** shows Wyoming's relative ranking among the top ten states in proved reserves of natural gas and crude oil. At the end of 1996, Wyoming ranked fourth in natural gas reserves and seventh in crude oil reserves. **Table 8** shows that Wyoming's natural gas reserves increased in 1996 to their highest level ever, despite record production. Condensate and natural gas liquids reserves also increased and crude oil reserves only decreased by two million barrels.

The Solicitor General for the U.S. Department of the Interior has criticized the U.S. Bureau of Land Management (BLM) for failing to collect up to $8 million annually by failing to recover the cost of processing mineral-leasing documents. As a result, producers may face new fees at nearly every stage of the Federal leasing process. New fees may be charged for each inspection or enforcement visit, each noncompliance violation issued, each request to post a given parcel for sale, processing of bonds, filing drilling applications, applications for lease suspension or relinquishment, and requests for review of decisions by the BLM State Director.

In the third quarter of 1997, there was only one lease sale. Leasing activity at the August U.S. Bureau of Land Management (BLM) sale was concentrated in the Powder River Basin, the Greater Green River Basin, and the Bighorn Basin (**Figure 9**). The high per-acre bid was $600 by Thomas J. Noonan for an 80-acre parcel covering SW NE and SE SE section 4, T45N, R74W (location A, **Figure 9**). The lease is about a mile and a half west of Sussex oil production at House Creek Field. The second high per-acre bid was $370 by Thomas J. Noonan for a 320-acre lease that covers parts of sections 17 and 20,

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

	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative	1997 Monthly	1997 Cumulative
JAN	93,146,775	93,146,775	100,224,249	100,224,249	101,359,648	101,359,648	99,433,887	99,433,887
FEB	85,623,666	178,770,441	86,691,577	186,915,826	96,303,300	197,662,948	74,475,904	173,909,791
MAR	94,388,052	273,158,493	94,344,991	281,260,817	103,541,127	301,204,075	104,043,342	277,953,133
APR	92,362,726	365,521,219	93,929,323	375,190,140	99,479,609	400,683,684	99,810,172	377,763,305
MAY	93,886,923	459,408,142	95,791,327	470,981,467	97,900,863	498,584,547	101,021,889	478,785,194
JUN	81,764,661	541,172,803	92,140,614	563,122,081	87,069,612	585,654,159	89,859,615	568,644,809
JUL	94,998,414	636,171,217	92,796,301	655,918,382	100,219,275	685,873,434		
AUG	93,743,790	729,915,007	90,393,416	746,311,798	99,874,019	785,747,453		
SEP	88,476,703	818,391,710	92,589,092	838,900,890	93,510,551	879,258,004		
OCT	95,232,646	913,624,356	98,386,458	937,287,348	95,441,022	974,699,026		
NOV	95,312,491	1,008,936,847	94,939,660	1,032,227,008	94,015,007	1,068,714,033		
DEC	87,115,084	1,096,051,931	99,314,617	1,131,541,625	99,141,298	1,167,855,331		
Total MCF Reported[1]		**1,096,051,931**		**1,131,541,625**		**1,167,855,331**		
Total MCF Not Reported[2]		**6,879,705**		**6,448,396**		**5,663,874**		
Total MCF Produced[3]		**1,102,931,636**		**1,137,990,021**		**1,173,519,205**		

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

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

Table 7. Wyoming's 1996 ranking in proved reserves of crude oil (billions of barrels) and dry natural gas (trillions of cubic feet).

State	Crude Oil	State	Dry Natural Gas
Texas	5.736	Texas	38.270
Alaska	5.274	New Mexico	16.485
California	3.437	Oklahoma	13.074
New Mexico	0.744	**Wyoming**	12.320
Louisiana	0.658	Louisiana	9.543
Oklahoma	0.632	Alaska	9.294
Wyoming	0.603	Kansas	7.694
Kansas	0.275	Colorado	7.710
North Dakota	0.248	Alabama	5.033
Utah	0.237	West Virginia	2.703

Source: U.S. Department of Energy, 1997.

Table 8. Comparison of Wyoming's proved reserves of crude oil (billions of barrels), dry natural gas (trillions of cubic feet), and condensate and natural gas liquids (billions of barrels) for the years 1980 through 1996.

Year	Crude Oil	Dry Natural Gas	Condensate and Natural Gas Liquids[1]
1980	0.928	9.100	0.239
1981	0.840	9.307	0.269
1982	0.856	9.758	0.477
1983	0.957	10.227	0.552
1984	0.954	10.482	0.602
1985	0.951	10.617	0.664
1986	0.849	9.756	0.665
1987	0.854	10.023	0.647
1988	0.825	10.308	0.808
1989	0.815	10.744	0.627
1990	0.794	9.944	0.568
1991	0.757	9.941	0.524
1992	0.689	10.826	0.462
1993	0.624	10.933	0.420
1994	0.565	10.789	0.395
1995	0.605	12.166	0.415
1996	0.603	12.320	0.505

Source: U.S. Department of Energy, 1997.
[1]Estimated from U.S. Department of Energy figures.

T44N, R73W (location B, **Figure 9**). The lease is also about a mile and a half west of Sussex oil production at House Creek Field. The third high per-acre bid was $355 by Forest Oil for a 75.35-acre parcel that covers parts of section 30, T21N, R112W (location C, **Figure 9**). The lease is about a mile west of Frontier oil and gas production at Whiskey Butte Field. At this sale, there were 52 parcels that sold for $50 or more per acre. The total revenue from the first four BLM sales this year has already exceeded the total revenue from the BLM sales in 1995 and in 1996 (**Table 9**).

There were 1,451 Applications for Permit to Drill (APDs) in the first nine months of 1997 (**Table 10**). APDs for the first nine months have already exceeded the total number of APDs in each of the last five years. Nearly 50% of the applications were for Campbell County, and a large percentage of those permits were for shallow coalbed methane tests.

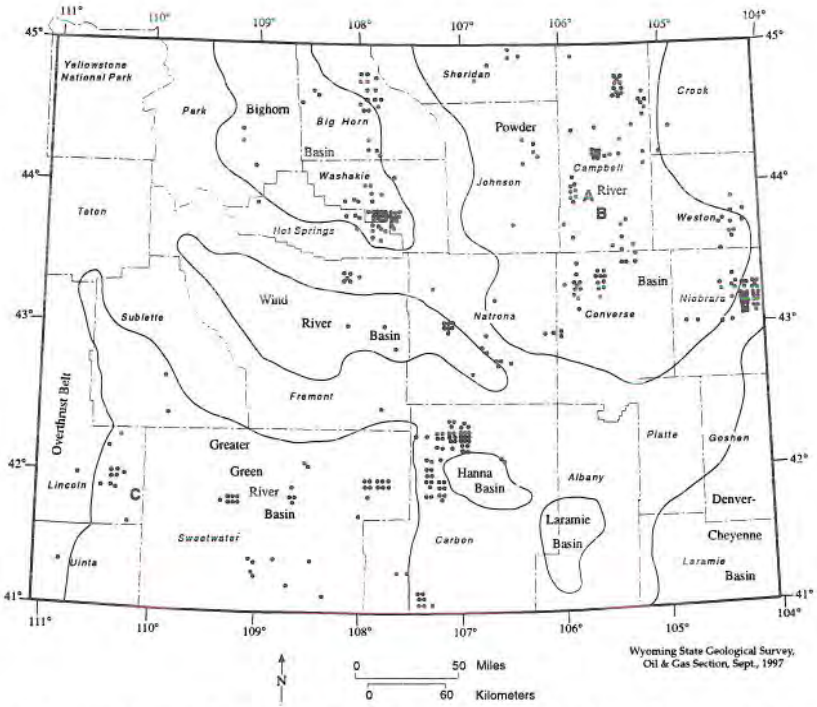

Figure 9. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the August, 1997, sale.

The number of seismic projects permitted by the Wyoming Oil and Gas Conservation Commission was 54 in the first nine months of 1997 (**Table 11**). Over half of the seismic projects permitted in the first nine months of 1997 were in counties in the Powder River Basin.

The average rig count for the third quarter of 1997 was 47, which is the highest average count for a quarter since the fourth quarter of 1993. The average rig count of 50 for September is the highest average for a month since December of 1993 (**Figure 10**). The rig count is currently on the upswing and has increased every month from February through September.

Exploration and Development

Company data, news releases, and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the third quarter of 1997. The numbers preceding discussions below refer to locations on **Figure 11**.

1. Chevron USA staked a location for a horizontally-drilled Nugget test in Painter Reservoir Field. The 14-8AHPRU well will be drilled from a surface location in SE SW section 8, T15N, R119W, to a true vertical depth of 12,207 feet. The planned well is a mile east of Chevron's 14-18AHPRU well, a

Table 9 . Federal and State competitive oil and gas lease sales in Wyoming.

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1993							
TOTAL	$12,942,008	2,769	1,469	2,065,942	995,344	$13.00	$400.00
1994							
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.00
1995							
February	$3,252,668	533	332	473,177	290,046	$11.21	$425.00
April	$1,591,709	531	206	483,826	189,003	$8.42	$160.00
June	$3,499,604	393	246	384,746	238,863	$14.65	$660.00
August	$1,105,381	488	165	420,189	149,025	$7.41	$160.00
October	$2,761,689	477	227	384,683	174,453	$15.83	$1,100.00
December	$836,195	205	88	180,367	68,321	$12.24	$316.00
TOTAL	$13,047,246	2,649	1,264	2,326,988	1,109,711	$11.76	$1,100.00
1996							
February	$1,635,668	455	192	358,478	137,901	$11.86	$220.00
June	$1,438,325	460	282	337,440	181,338	$7.93	$210.00
August	$2,021,488	289	182	261,321	118,267	$17.09	$145.00
October	$3,058,248	363	255	280,434	163,054	$18.76	$270.00
December	$3,333,838	261	214	165,771	138,945	$23.99	$1,450.00
TOTAL	$11,487,567	1,828	1,125	1,403,444	739,505	$15.53	$1,450.00
1997							
February	$2,463,137	267	210	222,486	148,148	$16.63	$250.00
April	$2,612,013	145	137	98,865	90,948	$28.72	$400.00
June	$4,642,113	285	249	313,519	262,682	$17.67	$310.00
August	$4,636,555	426	365	430,213	327,172	$14.17	$600.00

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

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

Table 10. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1993 to present).

County	1993 APDs	1994 APDs	1995 APDs	1996 APDs	1997 APDs
Albany	0	0	1	1	0
Big Horn	17	3	16	53	37
Campbell	126	105	151	554	698
Carbon	35	135	50	77	58
Converse	34	74	29	20	12
Crook	29	9	15	37	24
Fremont	16	46	30	26	55
Goshen	0	0	0	0	0
Hot Springs	12	4	13	24	29
Johnson	18	16	6	16	7
Laramie	33	15	10	2	2
Lincoln	135	103	64	55	78
Natrona	36	63	80	74	49
Niobrara	5	4	4	7	7
Park	22	18	20	30	26
Platte	0	2	0	0	0
Sheridan	7	3	0	0	3
Sublette	80	113	61	118	159
Sweetwater	156	204	153	136	149
Teton	0	0	0	0	0
Uinta	48	11	11	10	16
Washakie	17	12	31	30	36
Weston	23	6	10	10	6
TOTALS	**849**	**946**	**755**	**1280**	**1451**

Source: All data are from the Wyoming Oil and Gas Conservation Commission (1997 data are through September 22, 1997).

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

horizontally-drilled Nugget Producer that was completed in August, 1996. That well had produced 511,000 barrels of oil, 2.3 billion cubic feet of gas, and 8,400 barrels of water through June, 1997.

2. Celsius Energy completed a wildcat on the Moxa Arch. The Reynard Federal Exploratory Unit well in NE SE section 14, T20N, R113W, flowed 1.8 million cubic feet of gas per day from the Frontier between 11,222 and 11,236 feet and 11,290 and 11,308 feet. The new well is about two miles west of Dakota and Frontier production in Wilson Ranch Field.

3. Alpine Gas has an apparent gas discovery at its 32-33 Cottonwood-Federal well in SW NE section 33, T32N, R111W. The well was drilled to a total

Table 11. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1994 to present).

	1994			1995			1996			1997		
County	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	1	18	0	0	0	0
Big Horn	5	24	4	1	16	0	2	3	66	2	0	45
Campbell	13	17	50	12	24	43	32	56	220	17	50	69
Carbon	11	117	86	1	0	16	2	5	18	3	7	190
Converse	0	0	0	4	39	20	1	4	0	1	5	0
Crook	3	3	2	1	0	5	5	3	20	7	8	18
Fremont	6	12	104	6	32	56	2	5	15	4	43	66
Goshen	0	0	0	0	0	0	0	0	0	2	227	0
Hot Springs	1	9	0	2	70	9	4	17	29	1	8	0
Johnson	0	0	0	1	4	0	0	0	0	2	7	17
Laramie	3	57	0	0	0	0	0	0	0	0	0	0
Lincoln	0	0	0	2	18	110	0	0	0	3	7	116
Natrona	1	0	17	3	27	3	0	0	0	3	8	15
Niobrara	1	0	11	0	0	0	2	0	23	0	0	0
Park	1	0	7	0	0	0	6	20	82	3	56	43
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	0	0	0	1	5	0	0	0	0
Sublette	5	4	145	2	0	162	2	21	52	1	0	61
Sweetwater	4	59	0	9	17	497	8	17	670	2	1	100
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	2	0	89	0	0	0	1	0	40	0	0	0
Washakie	0	0	0	0	0	0	0	0	0	2	13	0
Weston	0	0	0	1	13	0	1	0	16	1	0	17
TOTALS	**56**	**302**	**515**	**45**	**260**	**921**	**70**	**174**	**1251**	**54**	**440**	**757**

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

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

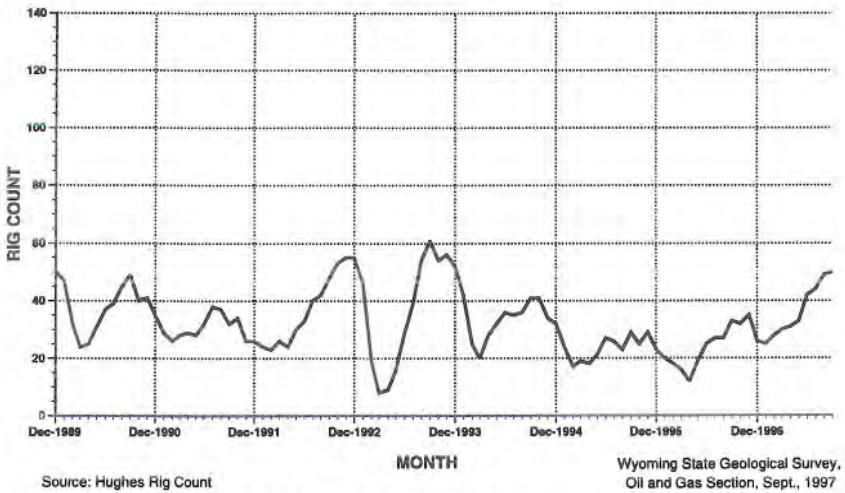

Figure 10. Wyoming daily rig count averaged by month (1979 to present).

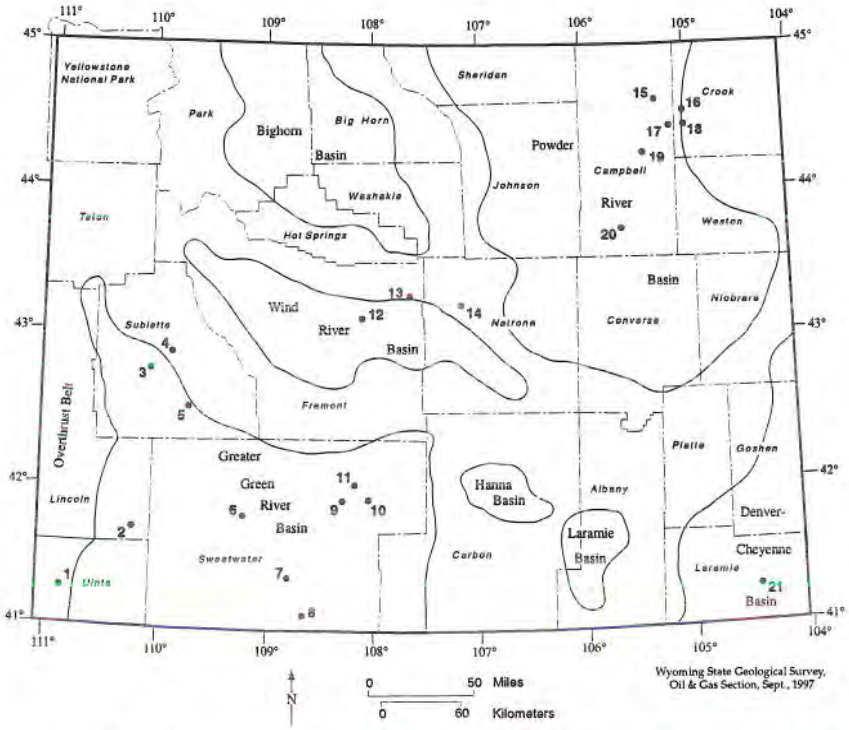

Figure 11. Oil and gas exploration and development activities in Wyoming during the third quarter of 1997 (exclusive of coalbed methane activities).

depth of 11,960 feet and geophysical logs indicated multiple potential pay zones in overpressured Lance sandstones.

4. Ultra Petroleum staked eight new wildcats that will target the Mesaverde in an area south and west of Pinedale. The new wells are projected to depths from 12,500 to 15,000 feet and are located in T34N, R111W; T33N, R109W; T32N, R109W; T31N, R108W; T30N, R108W; and T30N, R107W.

5. Three new wells were completed in Jonah Field. McMurray Oil completed its 1-13 Yellow Point well in NE NE section 13, T28N, R109W. The well flowed 5.5 million cubic feet of gas and 80 barrels of condensate per day from an undisclosed interval in the Lance above 10,712 feet. Western Gas Resources completed its 13-23 Stud Horse Federal well in SW SW section 23, T29N, R108W. The well flowed 10.1 million cubic feet of gas and 247 barrels of condensate per day from six intervals in the Lance between 8,938 and 11,676 feet. Snyder Oil completed its 4-30 Cabrito Federal Unit well in NW NW section 30, T29N, R107W. The well flowed 1.7 million cubic feet of gas, 20 barrels of condensate, and five barrels of water per day from the Lance between 9,428 and 10,796 feet.

   In a related item, BLM officials said that comments by the Environmental Protection Agency (EPA) have stalled completion of an environmental impact statement for the Jonah Field II project. The EPA said that the draft document did not adequately consider the cumulative effects that several projects in the area would have on visibility in the nearby Bridger-Teton Wilderness Area. The Jonah Field II project would have resulted in the drilling of up to 450 wells over 10-15 years and would have created an estimated 135 to 200 full-time jobs during that period. Estimates for the amount of recoverable natural gas in Jonah Field are between one and three trillion cubic feet.

6. Yates Petroleum completed a wildcat on the Rock Springs uplift. The 1 Roundhouse-State well in NE NE section 36, T21N, R104W, produced an average of 34 barrels of oil, 28,000 cubic feet of gas, and 134 barrels of water per day during its first month on line. The well is producing from an undisclosed interval in the Dakota.

7. Union Pacific Resources completed a horizontally-drilled development well in Brady Field. The 41P-H Brady Federal Unit well was drilled from a surface location in SE NW section 11, T16N, R101W, to a true vertical depth of approximately 14,100 feet. The well flowed 18.0 million cubic feet of gas and 2,600 barrels of condensate per day from the Phosphoria Formation.

8. Marathon Oil completed its 1 Vermillion Creek Deep well in SW NE section 12, T13N, R100W. The well is producing an average of 11.8 million cubic feet of gas per day from the Entrada and Nugget formations between 14,118 and 14,850 feet.

9. Yates Petroleum completed a wildcat in the Almond Formation. The 2 Wabash Cannonball Federal Unit well in SW NE section 18, T22N, R96W, flowed 1.6 million cubic feet of gas per day through perforations between 8,830 and 9,158 feet.

10. Union Pacific Resources completed a stepout from Siberia Ridge Field. The 3-30 Mansfield well in C section 30, T22N, R94W, flowed 2.3 million cubic feet of gas per day from the Almond between 11,042 and 11,300 feet. The well is a mile west of current Almond production in Siberia Ridge Field.

11. Yates Petroleum completed a wildcat in NW NW section 14, T23N, R95W. The 1 Harvest Federal Exploratory Unit well produced an average of 2.4 million cubic feet of gas per day from an undisclosed interval in the Lewis and an average of 1.1 million cubic feet of gas per day from an undisclosed interval in the Almond during its first nine days on line.

12. Petroleum Resources Management reentered and deepened a well in Fuller Reservoir Field. The 2 Esther Fuller well in NE NE section 26, T36N, R94W, flowed 3.0 million cubic feet of gas per day from an undisclosed lower Fort Union interval.

13. Louisiana Land & Exploration (LL&E) completed a new producer in Madden Field. The 27 Madden Deep Unit well in SE SW section 2, T38N, R90W, flowed 3.3 million cubic feet of gas and 18 barrels of condensate per day from between 7,579 and 7,590 feet in the Fort Union Formation. LL&E also entered into purchase and sale agreements with BHP Petroleum and Coastal Oil & Gas to acquire additional working interests in natural gas reserves in the Madden Field area. The purchases will increase LL&E's working interest in the Madison Limestone in the Madden anticline and will also increase its interest in the Lost Cabin gas plant, which processes sour gas from the Madison in Madden Field. The purchases also include additional working interests in shallower producing reservoirs in Madden Field. As a matter of information, LL&E was recently purchased by Burlington Resources.

14. Chevron USA completed a dual producer in Waltman/Cave Gulch Field. The 43 Bullfrog Unit well in SW NE section 31, T37N, R86W, flowed 11.6 million cubic feet of gas, 95 barrels of condensate, and 67 barrels of water per day from the Fort Union between 4,601 and 4,902 feet and from the Lance between 5,084 and 9,104 feet. Barrett Resources also completed a new well in the area. The 16 Cave Gulch Unit well in NE NW section 32, T37N, R86W, flowed 10.2 million cubic feet of gas per day from an undisclosed interval in the third Frontier. Tests also indicated that the Muddy should sustain flows of three to four million cubic feet of gas per day and that the first, fourth, and fifth Frontier sands are also capable of production. Plans call for producing those other zones after the third Frontier's pressure declines. Barrett also announced plans to test lower zones with two deep wells to the Madison Limestone at Waltman/Cave Gulch.

15. Lario Oil & Gas recovered 1,240 feet of oil and 110 feet of oil-cut-mud on a drillstem test of the Minnelusa between 7,417 and 7,447 feet at its 2 Sagebrush-Federal well in NW SW section 14, T53N, R70W. The well is only about 1,000 feet south of the 1 Sagebrush-Federal well, also in NW SW section 14, T53N, R70W. That well is producing an average of 210 barrels of oil per day from the Minnelusa at about 7,440 feet.

16. Fancher Oil discovered oil at its 18-8A well in SE NE section 18, T52N, R68W. The well pumped 408 barrels of oil per day from the Minnelusa between 7,290 and 7,296 feet.

17. Westech Energy completed a new discovery. The 11-35 Doane well in NE SW section 35, T51N, R69W, produced an average of 129 barrels of oil per day from an undisclosed interval in the Muddy Sandstone during its first 16 days on line. The nearest current Muddy production is about three miles west at Windmill Field.

18. Hunt Oil completed a new well in SW NW section 2, T51N, R68W. The 1 New Guthery Unit well pumped 137 barrels of oil per day from the Minnelusa between 6,916 and 6,920 feet and between 6,924 and 6,932 feet.

19. Conley P. Smith Operating discovered oil at its 8-9 Renee-Federal well in NE SE section 8, T49N, R71W. The well produced 130 barrels of oil and 21 barrels of water per day from the Muddy between 8,160 and 8,183 feet, during its first 27 days on line.

20. Yates Petroleum completed two new discoveries in the Turner. The 1 Bunn-Federal well in SE NE section 13, T43N, R73W, produced an average of 47 barrels of oil and 58 barrels of water per day from an undisclosed interval, during its first seven days on line. The 6 Rocky Butte-Federal well in NW NW section 4, T43N, R73W produced an average of 34 barrels of oil, 50,000 cubic feet of gas, and 42 barrels of water per day from an undisclosed interval, during its first month on line.

21. Union Pacific Resources completed a new horizontally-drilled producer on the southeastern flank of Silo Field. The 1H Razorback 41-21 well, drilled from a surface location in NE NE section 21, T15N, R63W, flowed 319 barrels of oil and 100,000 cubic feet of gas per day from the Niobrara at a true vertical depth of 7,504 to 7,558 feet.

Reference cited

U.S. Department of Energy, 1997, U.S. crude oil, natural gas, and natural gas liquids reserves: Advance summary, 1996 Annual Report: Washington, D.C., 12 p.

COAL UPDATE

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Coal delivery figures, as reported on the Federal Energy Regulatory Commission's (FERC's) Form 423, show Wyoming leading the nation in steam coal deliveries through the second quarter of 1997. Wyoming deliveries for the period totaled 133.4 million tons (**Table 12**). Compared to the 130.2 million tons from the same period in 1996, 1997 coal deliveries in Wyoming were up 2.46 percent at mid-year. This compares to a 4.7% increase at mid-year in 1996. **Figure 12** shows monthly coal deliveries over the last three years. **Figure 13** breaks these monthly deliveries into spot sales and contract sales.

Table 13 depicts projected coal production by county. It also shows the percentage of coal from the Powder River Basin which sells for more than $5.00/ton. The tonnages sold at these higher prices are the remaining older long-term contracts that had escalation clauses built into them.

Figures published by the Energy Information Administration (EIA), show that utilities in 26 states, as well as Canada and Spain, consumed Wyoming coal in 1996 (EIA, 1997) (**Figure 14**). In 1996, new markets were tested in Ohio, Kentucky, Mississippi, and Tennessee. Of special note, Illinois utilities increased their use of Wyoming coal and are now the sixth largest consumer. They were the tenth largest in 1995.

In addition, 97% of the coal produced in Wyoming in 1996 was used to generate electricity (**Figure 15**). When combined with coal exports, at least 271.6 million tons were used by electric utility companies. Documented industrial, residential, and commercial usage accounted for another 6.1 million tons (EIA, 1997). There was an additional 2.9 million tons of coal produced in Wyoming that was not accounted for by the EIA. This tonnage is the difference between the yearend production total published by EIA and the total published by the Wyoming State Inspector of Mines (Stauffenberg, 1997). This unclassified tonnage is probably an aggregate of smaller purchases, perhaps in all of the consumer categories listed above.

Table 14 is a revised version of Table 13 in the last issue of *Wyoming Geo-notes*. The production of coal from the North Rochelle mine has been corrected in this revised table.

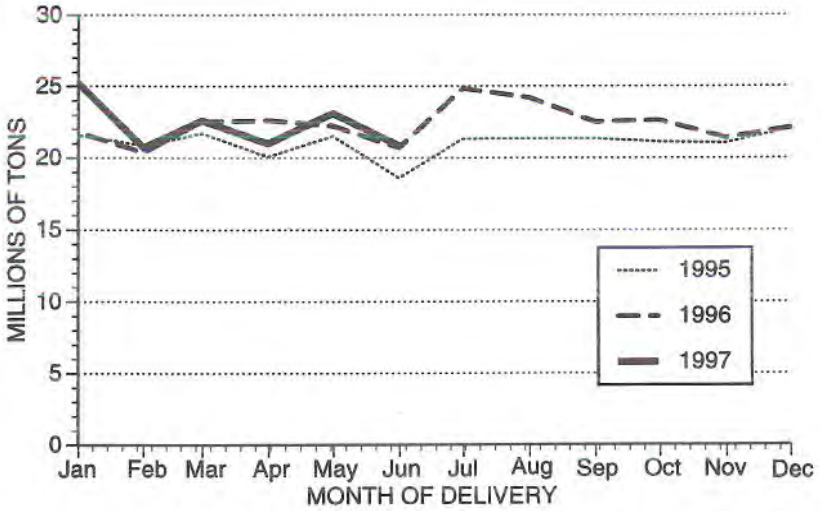
In the second quarter, there were numerous reports of delivery problems on the Union Pacific/Southern Pacific railroad. Some utilities were encountering delays in receiving coal from Wyoming as well as from other states. These delays were not limited to coal shipments as there were also complaints from many other customers.

Fieldston's *Coal Market Bulletin (CMB)* showed spot sale coal prices firmed toward the end of the third quarter. At the start of September, CMB showed the Powder River Basin's (PRB's) higher Btu spot sale price moving toward a $4.50/

Table 12. Monthly coal deliveries from Wyoming's mines in short tons (1994-1997).

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

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



Wyoming State Geological Survey, Coal Section, Sept., 1997

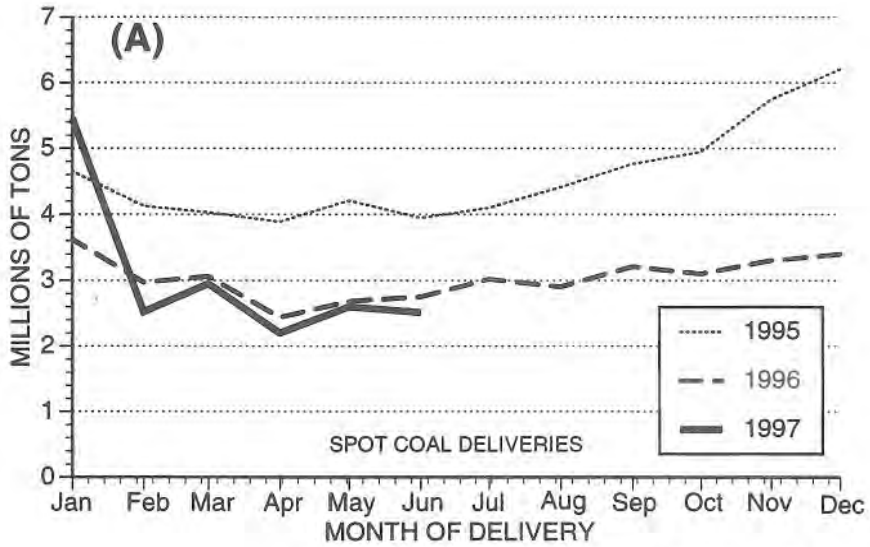
Figure 12. Reported monthly deliveries from Wyoming coal mines (1995 through 1997). From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997.

ton average. The spot sale price for lower Btu PRB coal was pushing $3.20/ton. Near the end of the month, CMB (9-29-97) reported that several producers were "sold up to a comfortable point for 98, and prices appear to be rising." For deliveries in the first quarter of 1998, CMB reported that the higher Btu coal in the PRB was inching up into the $4.50 to $5.00 range while the lower Btu product was heading for $3.50.

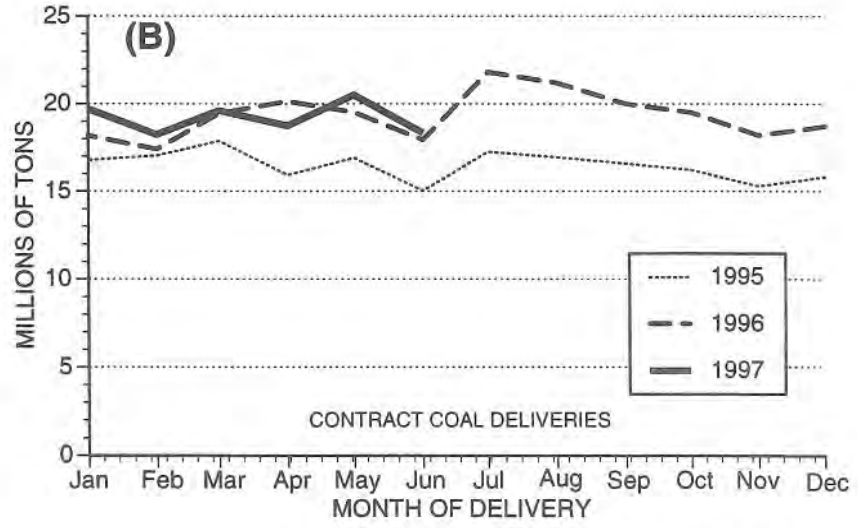
Developments in the Powder River Basin

The Powder River Regional Coal Team, which is comprised of the governors of Montana and Wyoming and U.S. Bureau of Land Management (BLM) officials, approved consideration of two new Federal coal lease sales: Kennecott's 178-million-ton, 1,470-acre Horse Creek Lease by Application (LBA) at its Antelope mine and Cyprus-Amax's 200-million-ton, 1,578-acre LBA at its Belle Ayr mine (**Table 15**). Upon successful acquisition of these maintenance tracts, each of these applicants would add an additional eight years onto the life of their mines.

After rejecting Triton Coal Co.'s July bid of 17 cents/ton, the BLM accepted Triton's September 26 offer of $19.4 cents/ton for the lease rights to the 1,482-acre, North Rochelle LBA coal tract near Wright, Wyoming (**Table 15**). Estimated to contain 157,610,000 tons of coal in two minable coal beds within the Wyodak coal zone (*Wyoming Geo-Notes No. 55*, p. 31), the total of the bid was approximately $30.6 million. Triton Coal Co. is a subsidiary of Zeigler Coal Holding Co.



Wyoming State Geological Survey, Coal Section, Sept., 1997



Wyoming State Geological Survey, Coal Section, Sept., 1997

Figure 13. Monthly coal deliveries from Wyoming (1995 through 1997). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data International, Inc. (1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996 and 1997).

Table 13. Wyoming coal production by county (in millions of tons), from 1993 to 1996 with forecasts to 2004.

	1993	1994	1995	1996	1997[1]	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]	2004[1]
Campbell County	181.9	205.2	232.4	245.3	256.5	270.0	287.4	309.6	316.4	319.9	323.4	326.9
Converse County	10.2	11.7	14.1	15.8	14.5	15.0	15.3	15.3	15.3	15.3	15.3	15.3
Sheridan County	0.1	0.1	M	M	M	M	M	M	M	M	M	M
Carbon County	4.4	4.4	3.8	4.7	4.3	4.2	3.7	2.0	2.0	2.0	2.0	2.0
Sweetwater County	9.2	11.2	9.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.1	4.3	4.5	4.4	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Wyoming	209.9	236.9	263.9	278.4	288.3	302.2	319.4	339.9	346.7	350.2	353.7	357.2
Annual Change	10.8%	12.9%	11.4%	5.5%	3.6%	4.7%	5.7%	6.4%	2.0%	1.0%	1.0%	1.0%
Higher-priced coal[2]	36%	33%	26%	24%	22%	17%	13%	9%	6%	4%	4%	4%

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

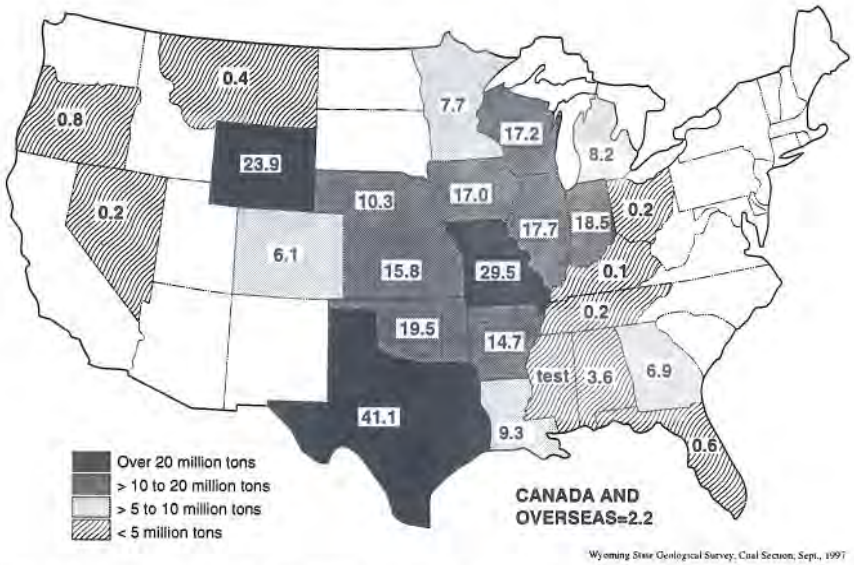


Figure 14. Wyoming coal deliveries to electric generating plants in 1996 in millions of tons (adapted from EIA, 1997).

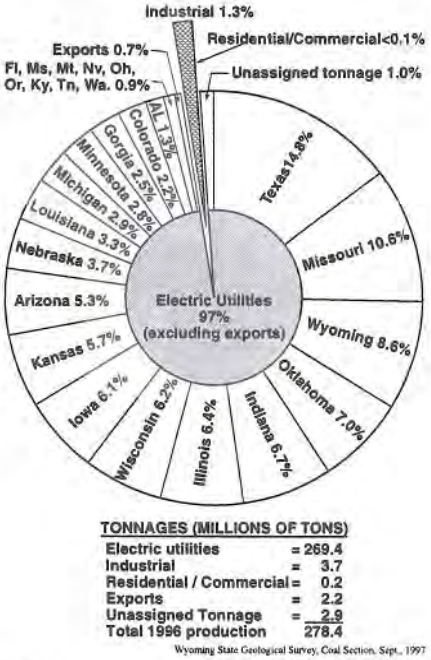


Figure 15. Utilization of Wyoming coal in 1996 in percentage and tonnage (adapted from EIA, 1997). Total 1996 production is from Stauffenberg (1997).

Table 14. Wyoming coal production and employment by coal field and mine, 1995 and 1996 (revised).

Company	Mine Name		1995 Employees	1995 Production(tons)	1996 Employees	1996 Production(tons)	Production Difference 1995-1996	Percentage Increase/ Decrease
	POWDER RIVER COAL FIELD							
Kennecott Energy, Inc.	Antelope Coal Co.	(surface)	128	10,866,880	152	12,047,801	1,180,921	10.87
Cyprus-AMAX Coal Co.	Belle Ayr	(surface)	224	18,771,977	261	19,970,300	1,198,323	6.38
Big Horn Coal Co.	Big Horn	(surface)	17	37,472	18	15,129	-22,343	-59.63
Thunder Basin Coal Co.	Black Thunder	(surface)	449	36,149,282	486	39,174,599	3,025,317	8.37
Triton Coal Co.	Buckskin	(surface)	146	11,600,000	148	11,951,798	351,798	3.03
Powder River Coal Co.	Caballo	(surface)	232	18,357,087	237	22,003,064	3,645,977	19.86
Drummond Coal Co.	Caballo Rojo	(surface)	186	16,808,549	183	15,082,891	-1,725,658	-10.27
Kerr-McGee Coal Corp.	Clovis Point	(surface)	5	408,994	14	199,825	-209,169	-51.14
Thunder Basin Coal Co.	Coal Creek	(surface)	64	4,199,587	78	5,804,419	1,604,832	38.21
Kennecott Energy, Inc.	Cordero	(surface)	210	14,607,000	184	13,071,242	-1,535,758	-10.51
Glenrock Coal Co.	Dave Johnston	(surface)	183	3,268,961	185	3,792,706	523,745	16.02
Phillips/Western Fuels	Dry Fork	(surface)	47	3,603,453	39	2,945,662	-657,791	-18.25
Cyprus-AMAX Coal Co.	Eagle Butte	(surface)	180	16,942,000	184	15,642,744	-1,299,256	-7.67
Drummond Coal Co.	Fort Union	(surface)	6	450	14	1,004,887	1,004,437	2,232.08
Kerr-McGee Coal Corp.	Jacobs Ranch	(surface)	381	24,645,109	373	24,522,960	-122,149	-0.49
Powder River Coal Co.	North Antelope	(surface)	241	21,248,991	247	28,623,177	7,374,186	34.70
Triton Coal Co.	North Rochelle	(surface)	2	677,409	1	380,521	-296,888	-43.80
Powder River Coal Co.	Rawhide	(surface)	168	15,355,000	166	15,068,358	-286,642	-1.87
Powder River Coal Co.	Rochelle	(surface)	276	26,035,555	271	26,248,241	212,686	0.82
Wyodak Resources	Wyodak	(surface)	51	2,984,000	47	3,198,544	214,544	7.19
TOTAL			3,196	246,567,756	3,288	261,198,868	14,631,112	5.93%
	HANNA COAL FIELD							
Arch of Wyoming	Medicine Bow	(surface)	68	1,699,106	73	1,791,046	91,940	5.41
Rosebud Coal Sales Co.	Rosebud	(surface)	16	Reclamation	16	Reclamation	0	0.00
Arch of Wyoming	Seminoe No. 2	(surface)	8	113,991	13	224,368	110,377	96.83
Cyprus Shoshone Coal Co.	Shoshone No. 1	(deep)	141	1,990,114	138	2,640,912	650,798	32.70
TOTAL			233	3,803,211	240	4,656,326	853,115	22.43%

Table 14 Wyoming coal production and employment by coal field and mine, 1995 and 1996 *(continued)*.

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

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

Table 15. Summary of Leases by Application (LBA) in the Powder River Coal Field of Wyoming.

LBA/Company Applicant	Application Date	Applied for Acreage	Applied for Tons	Offered for Bid Acreage	Offered for Bid Tons	Status	Total of Bid	Cents/ton
Jacobs Ranch/Kerr-McGee	10/10/89	1,465	123 MM	1,709	147.4 MM	Accepted 9/26/91	$20,114,930	13.6
West Black Thunder/ Thunder Basin Coal Co.	12/22/89	3,225	400 MM	3,492	429 MM	Accepted 8/12/92	71,909,282	16.8
North Antelope & Rochelle/ Powder River Coal Co.	03/02/90 (2 applications)	954 1,196	120 MM 150 MM	3,064 (Offered as 1 Tract)	403.5 MM	Accepted 9/28/92	86,987,765	21.6
West Rocky Butte/ Northwestern Resources Co.	12/04/90	390	50 MM	463	56.7MM	Rejected 12/3/92 Accepted 1/07/93	14,200,000 16,500,000	25.8 29.1
Eagle Butte/AMAX Land Co.	07/21/91	915	150 MM	1,059	166.4 MM	Accepted 4/05/95	18,470,400	11.1
North Rochelle/Ziegler Coal Co.	07/22/92	1,440	144 MM	1,482	157.6 MM	Rejected 7/29/97 Accepted 9/26/97	26,800,000 30,600,000	17.0 19.4
Antelope/Antelope Coal Co.	12/29/92	617	60 MM	617	60.4 MM	Rejected 9/18/96 Accepted 12/4/96	6,645,045 9,064,600	11.0 15.0
Powder River/Powder River Coal Co.	03/23/95	4,0200	550 MM	na	na	~~Draft EIS prepared~~	FINAL EIS done	
Thundercloud/Kerr-McGee	04/14/95	3,396	427 MM	na	na	~~Draft EIS prepared~~	FINAL EIS done	
New Keeline/ Evergreen Enterprises	05/13/96 (New Mine Proposal)	7,841	675 MM	na	na	PRRCT reviewed 4/23/97 and recommended this LBA not be considered		
Horse Creek/ Antelope Coal Co.	02/14/97	1,471	177.5 MM	na	na	4/24/97 PRRCT reviewed & approved to proceed		
Belle Ayr/AMAX Land Co.	03/20/97	1,032	200 MM	na	na	4/23/97 PRRCT reviewed & approved to proceed		

Adapted from 1997 Draft EIS, Powder River & Thundercloud Leases, prepared by the U.S. Bureau of Land Management.. MM =millions; PRRCT =Powder River Regional Coal Team.

In its second quarter earnings announcement, Zeigler Coal noted that progress continued on their North Rochelle project, a 10- to 12-million-ton-per-year mine, which is in the development stage. The company anticipates beginning full-scale production at the mine by the second half of 1998. Currently, they are erecting a dragline, and site work is underway for coal handling and other facilities.

Lightning struck twice, or at least heavy thunderstorms did, as Thunder Basin Coal Co.'s Black Thunder mine suffered its second flood of the year. Heavy rains in late July caused disrupted production as runoff from a storm filled the mine's three pits with water to depths upwards of thirty feet. However, unlike the earlier May flood (*Wyoming Geo-Notes No.55*, p. 30), this flood did not damage any mining equipment.

Although recovery from the latest storm was quicker than the earlier one, the mine reportedly lost another million tons of production. This caused the company to declare force majeure with some of its customers. Black Thunder's management remained optimistic that lost production resulting from the two floods would not prevent the mine from reaching its 1997 production target of nearly 50 million tons. The Black Thunder mine is the largest producing coal mine in the country. Thunder Basin Coal Company is a subsidiary of ARCO.

Following its earlier announced plans to exit the coal mining business, ARCO has sent an information package to a list of parties interested in buying ARCO Coal Co. Early in the fourth quarter, the company expects to have a short list of prospective bidders. Those companies on ARCO's short list will get access to additional information prior to finalizing their bids. With bids in hand, ARCO can compare them to the possible financial advantages of spinning the coal business off in a public stock offering. The decision whether to sell or spin off the coal company is expected by the end of the year.

Kerr-McGee Coal Co.'s Jacobs Ranch mine has completed its coal preparation plant ahead of schedule. The new facility consists of another truck dump, crusher, and single conveyor belt to the mine's loadout silos. The new plant will help the mine increase its capacity to 39 million tons per year. (*Wyoming Geo-Notes No.55*, p. 27)

Montana Power's Rocky Butte Federal coal reserves are apparently for sale. It was rumored in *Coal Outlook* (9-9-97) that Peabody Holding Co. was close to buying the 6,800-acre block of reserves. In July, the Land Quality Division (LQD) of the Wyoming Department of Environmental Quality said the mine permitting process for the lease had stopped. The Rocky Butte coal reserves adjoin Powder River Coal Co.'s Caballo mine. Powder River Coal is a subsidiary of Peabody.

Prior to this development, PacifiCorp had announced its plans to acquire Peabody Holding Co. (*Wyoming Geo-Notes No.55*, p. 30). The effect this acquisition will have on any of Peabody's plans is unknown at this time. Rumors that PacifiCorp and Peabody might shut down the Rawhide mine, however, were confirmed in November when Peabody announced they would idle the

mine on April 1, 1998. Rawhide's longer term contracts will be shifted to other Peabody mines in the Powder River Basin.

Zeigler Coal Holding has put its ENCOAL (liquids-from-coal) plant on hold. Mitsubishi International Corp. had been contracted to build the $460 million plant at the site of Triton Coal Co.'s North Rochelle mine in Campbell County, Wyoming. The plant was designed to transform six million tons of coal per year into a solid process-derived fuel and liquids suitable for fuel or chemical feed stocks. In a further development, Zeigler will apparently idle the project's demonstration plant at least until next spring.

Developments in southern Wyoming

In an article from the *Casper Star-Tribune* (9/2/97), Arch of Wyoming said it was looking at the feasibility of the company's plan to go underground at its proposed new Elk Mountain mine in the Carbon Basin. This proposed mine was previously called the Carbon Basin mine. Preliminary plans call for the opening of a surface mine in the year 2000. Apparently, underground mining would only begin if studies show that there is enough coal left to make it worthwhile.

Because of anticipated production rates of 5-6 million tons per year for 25 years, Arch now plans to build a rail spur to the mine. Originally the coal was to be trucked through Hanna.

It was reported that Cyprus-Amax is undecided about whether it will extend its Shoshone No. 1 deep mine beyond a fault line, which the mine will reach by the end of 1999. The longwall in this Hanna Basin mine currently operates under about 500 feet of cover. Cover on the other side of the fault reportedly starts at 1,000 feet and rapidly increases to over 2,000 feet in thickness. Mining at those increased depths would require a new mine plan. The company has apparently asked the BLM to stop processing their application to add 160 acres of Federal coal lands to their lease on the far side of the fault. Also, the company is rumored to have had discussions with Northern Indiana Public Services Co., the mine's main contract customer, in regard to substituting other coal for the last two years of their contract.

Transportation developments

The Union Pacific/Southern Pacific railroad (UP/SP) is having trouble with slow turn-around times on their trains. In the middle of August, UP/SP officials said the slowdown was a result of congestion in the southern part of the system, particularly from Fort Worth southward. The slowdown was reportedly due in large part to a shortage of train crews. Adding to UP/SP's crew shortage, in the Grand Junction area of Colorado, the Burlington Northern-Santa Fe railroad (BNSF) reportedly offered a $20,000 dollar signing bonus and hired away approximately 40 of the UP/SP's skilled employees.

In an August 29 meeting in Houston, UP/SP officials and representatives from over 300 of their shippers discussed the problem of traffic delays along

the UP/SP line, including turn-around times for coal trains from the Powder River Basin (PRB). The UP/SP acknowledged that the delays could continue well into next year. There have been some complaints that the average shipment on the UP/SP nationwide was up to twice as long as it had been. To solve the problem, the UP/SP announced plans to add 327 locomotives to its system by January, and to hire 400 engineers and conductors to ease the current congestion. In addition, a recent safety review by the Federal Railroad Administration (FRA) indicated that 90-hour work weeks were common for some UP/SP employees, and the FRA expressed concern about fatigue on the job.

By the end of September, UP/SP unveiled what they called a "Service Recovery Plan" aimed at eliminating congestion on their system, and restoring normal service. While UP/SP again acknowledged widespread service problems, the carrier contended they were making progress. They said that while the steps outlined in the plan would not produce miracles, they should lead to concrete and significant improvements in the coming weeks.

Western Fuels Service Corporation (WFS), in a complaint filed with the Surface Transportation Board (STB) in 1996, is seeking rail access as a prospective rail carrier to the PRB mines north of Gillette. These mines are currently served by the Burlington Northern-Santa Fe (BNSF) railroad. Despite low contract price offerings from these mines, WFS claims the increased demand for PRB coal is going almost exclusively to those mines on the joint line (UP/SP and BNSF line) where the presence of a second carrier creates more favorable transportation costs.

KFx, Inc. is in support of trackage rights for WFS. In an August 12 filing with the Surface Transportation Board (STB), they said the rail pricing polices of the BNSF are hurting efforts to sell upgraded coal from their KFx plant in Wyoming. KFx claims that its sales have been limited to utilities that have older haulage contracts. Most of these agreements expire within the next three years. KFx said that BNSF has been putting provisions into its new haulage contracts that preclude hauls of upgraded coal at the same price as raw PRB coals. KFx produces a high-Btu coal product by reducing the moisture content of the subbituminous coal that it processes.

Dakota, Minnesota, and Eastern Railway Corp. (DM&E) announced that they have sidelined their proposed "middle route" for a new rail line they hope to build into the eastern Powder River Basin. This route would have run from just south of Belle Fourche, South Dakota, southwest to the middle group of the PRB mines south of Donkey Creek. DM&E felt this route would have entailed a higher per-mile cost, affected the greatest number of landowners, and raised the most environmental questions.

Coalbed methane developments

In their Environmental Impact Statement for the Gillette South coalbed methane project, the U.S. Bureau of Land Management (BLM) notes that 400 new coalbed methane wells are proposed in a 685-square-mile area between

Gillette and Wright over the next five years. The wells would be adjacent to 140 coalbed methane wells already producing south of Gillette. One hundred ninety of the wells would be on Federal mineral lands with the rest on State and private lands.

Regulatory developments

In August, the U.S. Bureau of Land Management (BLM) issued a final rule that modifies regulations governing the formation of Logical Mining Units (LMUs) in areas where mining companies lease Federal coal reserves. The new rule prohibits Federal coal leases, which have not produced commercial quantities of coal within the first eight years of their due-diligent period, from being included in a new LMU. The rule does allow a lessee, as a result of "standard business practice" to interrupt coal mining for brief periods and still remain qualified to receive additional leases. It also establishes specific criteria for LMU approval. The final LMU rule, published in the *Federal Register* (8/20/97), was effective as of 9/19/97.

The U.S. Department of the Interior's Office of Surface Mining, Reclamation, and Enforcement (OSM) has issued a new rule amending regulations used in calculating the coal tonnage subject to reclamation fees pursuant to the Surface Mining Control and Reclamation Act (SMCRA). The regulations 1) Define terms and phrases related to the collection and testing of coal samples used to determine moisture content; (2) Identify acceptable ASTM test methods; (3) Establish frequencies for collecting and testing samples of high- and low-rank coals; and (4) Provide coal operators with formulae for calculating moisture allowances for the purpose of reducing the weight of coal subject to the Abandoned Mine Land Reclamation Fee.

A Denver hearing on the Environmental Protection Agency's (EPA's) new regulations aimed at reducing haze in 156 national parks and wilderness areas drew mixed reviews. As reported in the *Casper Star-Tribune* (9/20/97), the new rules are meant to reduce the amount of visible air pollution in regions with "Class I" air quality as defined under the 1977 Clean Air Act. Included in the regulations is a requirement for states to evaluate the need for more efficient pollution controls, known as best available retrofit technology (BART). The BART provisions would, for example, require the Wyoming Department of Environmental Quality to consider whether or not PacifiCorp's Naughton power plant near Kemmerer should install scrubbers for their three units. At the meeting, it was pointed out that BART language in the rules would require the state to review the economics of retrofitting. This review could reportedly cost a state upwards of $100,000 per pollution source.

Awards and honors

Marking the twentieth anniversary of SMCRA, Triton's Buckskin mine was named a winner of the "Excellence in Surface Coal Mining and Reclamation Award", and Kerr-McGee's Jacobs Ranch mine was awarded the "Reclamation Hall of Fame Award". Kerr-McGee's Jacobs Ranch mine also was honored by the U.S. Mine Safety and Health Administration and the National Mining Asso-

ciation as the safest surface coal mine in the country. Last year the mine's 373 workers put in 768,297 hours and produced 24.5 million tons of coal with no lost work days or employee work restricted due to a mine related injury.

The safety and mine rescue team from Kennecott Energy's Cordero-Rojo mine complex returned from the Safety Olympiad held in Elko, Nevada, with a first place award in the first-aid division and a second place over-all finish. Twenty teams from across the country competed in events including first-aid, fire fighting, rescue and rigging, hazardous material response, and field operations.

The June 1997 issue of *Coal Age* magazine included an article titled, "Women's Roles Grow in Western Coal". Powder River Coal Co.'s Amy Hetzer, Wanda Burget (Gillette), and Karen Werner (Rochelle mine), along with Pittsburg and Midway Coal Co.'s Lynn Sessions (Kemmerer mine) were highlighted in the magazine's cover story. While women make up five percent of the nation's mining work force, the bulk of professional women in coal are working in the west.

Market developments and opportunities

There apparently is not much coal from the Powder River Basin (PRB) still available this year. *Coal Outlook* (9/15/97) reported that mines with higher Btu coal are essentially sold out. Delivery problems make any spot sales via the UP/SP railroad difficult at best. Some utilities served by the UP/SP have apparently curtailed their coal burn to conserve inventory or have seen their stockpiles decline dramatically due to ongoing delays in deliveries.

Officials with KFx, Inc. and the Dry Fork mine met in Denver in early September to discuss the potential of KFx purchasing 800,000 tons of coal per year from the Dry Fork mine. KFx would use the coal as feedstock for its coal drying project located at the Fort Union mine. Use of Dry Fork coal in the beneficiation project could begin as early as next year. The Dry Fork mine is owned by Phillips and Western Fuels Association.

Lansing Board of Water and Light (LBWL) has contracted with a consulting firm to determine the cost-effectiveness of switching coals in seven coal-fired boilers at two of its power plants. The LBWL is looking for the most economic way to switch from low-sulfur Kentucky coal to even lower sulfur Wyoming coal.

Market analysts note that PacifiCorp's acquisition of Peabody's parent company, Energy Group, PLC, may provide a new twist in marketing coal throughout the nation, including Wyoming. As pointed out in the September issue of *Coal Age*, PacifiCorp has shown a willingness to renegotiate coal contracts held by the newly acquired Peabody Coal. While renegotiations of coal contracts are far from novel in Wyoming, some of PacifiCorp's terms are unlike traditional contract renegotiations. They have reportedly sought the right to sell additional electricity produced by the plants bound by their coal contracts. In other words, lowering coal prices to acquire access to prime generating capacity will allow PacifiCorp to increase its generating capacity without the capi-

tal expense of building or buying generation units. This concept adds a new dimension to the leveraging of coal contracts.

Table 16 is a tabulation of some of the contracts, tests, and solicitations for Wyoming coal announced during the third quarter of 1997.

References cited

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

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

INDUSTRIAL MINERALS AND URANIUM UPDATE

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Bentonite

Wyoming's bentonite production continues to increase in response to both new products and increased production of long-established products. Much of Wyoming's production of bentonite goes to the manufacture of kitty litter with four of Wyoming's eleven bentonite plants dedicated to producing this product. However, the use of other bentonite based products, such as clay barriers, environmental cleanup material, mineral fillers, and oil well drilling mud are increasing as well.

Construction Aggregate

Construction aggregate production increased to its seasonal maximum in the third quarter of 1997. Construction aggregate is crushed and sized stone (such as limestone, granite, scoria [clinker] or other materials), which is used without processing in railroad ballast, erosion control rip-rap, traction sand, or many other uses. Construction aggregate is also mixed with asphalt to form road surfacing material, asphalt shingles, etc., or mixed with cement to form concrete. Several large highway projects have consumed thousands of tons of this material this year, including reconstruction projects along Interstate Highways 80 and 90. A large project reconstructing US Highway 26 in the Fort Laramie-Lingle-Torrington area is expected to commence next year. Sources of crushed limestone for this project are being sought.

Table 16. Marketing activities for Wyoming coal producers during the third quarter of 1997[1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	American Electric Power Co.	Clifty City Rockport	Powder River Basin	So	Unspecified	Unspecified volume of spot coal.
2.	Central Louisiana Electric Co.	Rodemacher	Powder River Basin	So	up to 300,000 t	Spot for 1998 on UP/SP.
3.	Central & South West Corp. Central Power & Light Public Service of OK Southwestern Power Co. West Texas Utility Co.	4 unnamed plants	Buckskin Caballo Rojo Jacobs Ranch North Antelope/Rochelle	C C C C	1.3 million t	Awarded for 1998 delivery beginning in January.
4.	Georgia Power	Wansley	Jacobs Ranch	T	150,000 t	Test burn of PRB coal.
5.	Grand Island Electric	Platte	Powder River Basin	So	200,000-400,000 t	Seeking bids from PRB mines on the UP/SP.
6.	Houston Lighting and Power Co.	Parish	Jacobs Ranch	C	0.5 to 5 million t	For 1998 delivery.
7.	Lower Colorado River Authority	Unnamed	Cordero Rojo complex	C	1.5 million t	300,000 tons per month for 5 months beginning Aug. to Dec., 1997.
8.	Mid-American Energy (broker)	Several in Iowa	Powder River Basin	So	1 to 5 million t	Over 1 to 10 years.
9.	Minnesota Power & Light Co.	Boswell & Laskin	Powder River Basin	So	2.5 million t/y	For 5 years, starting in 2000.
10.	Nebraska Public Power District	Gentleman	Black Thunder	C	1.0 million t	
11.	Northern Indiana Public Service Co.	Unspecified	Powder River Basin	So	1.0-1.5 million t/y	For 2 to 4 years, delivery to start in April, 1998.

Table 16 . Marketing activities for Wyoming coal producers during the third quarter of 1997[1] (*continued*).

	Utility	*Power Plant*	*Coal Mine/Region*	*Activity*	*Tonnage*	*Comments*
12.	Omaha Public Power District	Unspecified Unspecified	Powder River Basin Powder River Basin	T So	Undisclosed 1.5-2.0 million t	Test burn before making award. For 1998 delivery.
13.	Ontario Hydro	Nanticoke	Kennecott Energy	C	200,000 t	1997 delivery.
14.	Portland General Electric	Boardman	Powder River Basin	So	1.2 million t 5 million t 8 million t	1998 delivery. 1998 to 2000 delivery. 1998 to 2002 delivery.
15.	Southern Company	Scherer	Powder River Basin	So	2.4 millon t/y	For 1, 3, or 5 years starting in 1998.
16.	Southwestern Public Service Co.	Harrington	Antelope	C	2.5 million t/y	For three years starting in 1998.
17.	Springfield City Utilities	Dallman	Powder River Basin	So	0.6-1.2 million t	For two years starting in 1998.
18.	Tennessee Valley Authority	Unspecified	Black Thunder	C	1.5 million t/y	Six years with reopener in the middle.
19.	Wisconsin Power & Light	Columbia	Powder River Basin	So	1.5 million t	For 1998 delivery.

[1]Data obtained from : Coal Week©, Coal Outlook©, Coal Market Bulletin©, FERC database, and personal contacts.
C =contract coal; Sp =Spot coal;So =solicitation; T =Test burn; t =short ton; t/y =short tons per year; PRB =Powder River Basin
Wyoming State Geological Survey, Coal Section, September, 1997.

Decorative Stone

Sunrise Stone continues to produce custom decorative stone blocks from its Raven quarry in Albany County west of Wheatland. Production from this quarry is increasing as more experience in quarrying this particular black granite is acquired.

Industrial Consulting and Marketing (ICM) continues to conduct feasibility studies for quarries and fabricating plants for the production of dimensional granite, marble, and limestone in Wyoming. Dimensional stone consultants from Italy were in Wyoming in October doing detailed site studies at several locations identified by ICM with assistance from the Wyoming State Geological Survey.

Trona

Wyoming's most important industrial mineral in terms of production value, trona, is mined at five localities in the Green River Basin west of the town of Green River. The operators, FMC Wyoming, General Chemical Partners, OCi, Solvay Minerals, and Tg Soda Ash, are all planning or constructing increased sodium product capacity. Several other companies, including Church & Dwight, Occidental, Rock Springs Realty Corporation, and Wold Trona, have leased trona reserves, and Wold is in the process of planning a mine and refining plant.

Trona is a naturally occurring sodium carbonate-bicarbonate mineral. It is refined into sodium-based products, primarily soda ash, and also other chemicals. Soda ash has numerous uses. Its primary use is in the manufacture of glass. Baking soda is pure soda ash. Most of the baking soda used in the U.S. was originally in a trona bed 1,500 feet beneath the sagebrush in southwestern Wyoming.

Zeolites

U.S. Zeolite (USZ) reports increased sales of its refined zeolite product from its plant in Aurora, Utah. The zeolite ore came from USZ's mine southeast of Bitter Creek, in Sweetwater County. USZ sells its product, called Sweetwater Zeolite, as sized material in bulk and in 60 & 50 lb. bags. Individual 50 lb. bags sell for $5.00 each.

The U.S. Geological Survey's Minerals Information Service reports that the world production of natural zeolites has increased to over 3.5 million short tons. The product is used mostly in pozzolanic cements and as a soil conditioner. However, natural zeolites have an opportunity for growth, replacing synthetic zeolites in some applications. These applications are where an ion exchange material is needed. In these cases the zeolite-based product substitutes desirable ions for undesirable ions in the cleanup of toxic material, odor control, or the refining of industrial products.

Uranium

The price of domestic yellowcake increased in the third quarter of 1997, reversing a decline that began in September, 1996. As reported by Bob Odell in the September edition of the *Rocky Mountain Scout*, the October 2 price of restricted uranium was $11.00 per pound, up from $10.50 per pound at the end of the second quarter (**Figure 16**).

Uranium production continues at three in-situ localities in Wyoming: CAMECO's Highland and Morton Ranch operations, COMIN's Christiansen Ranch operation, and Rio Algom's Smith Ranch operation (**Figure 17**).

Many former uranium mining districts in Wyoming are being reclaimed. Mining in these areas occurred from the 1950s into the early 1980s. All of these projects have cost many millions of dollars each. American Nuclear (ANC) is completing reclamation of the former Federal American Partners site in the Gas Hills. ANC is also initiating studies for future reclamation of some open pit mines and haul roads in the Gas Hills. Bear Creek Uranium is working on a $54 million reclamation project at the Bear Creek open pit mine in central Converse County. COGEMA is continuing reclamation of mines and mill sites in the Gas Hills. Pathfinder Mines, the reclamation subsidiary of COGEMA, reports that the current project should be completed in 1999, with a new project, the construction of radon barriers, to begin in 1998. Petrotomics is doing reclamation at the Texaco mine site in the Shirley Basin. This project may cost

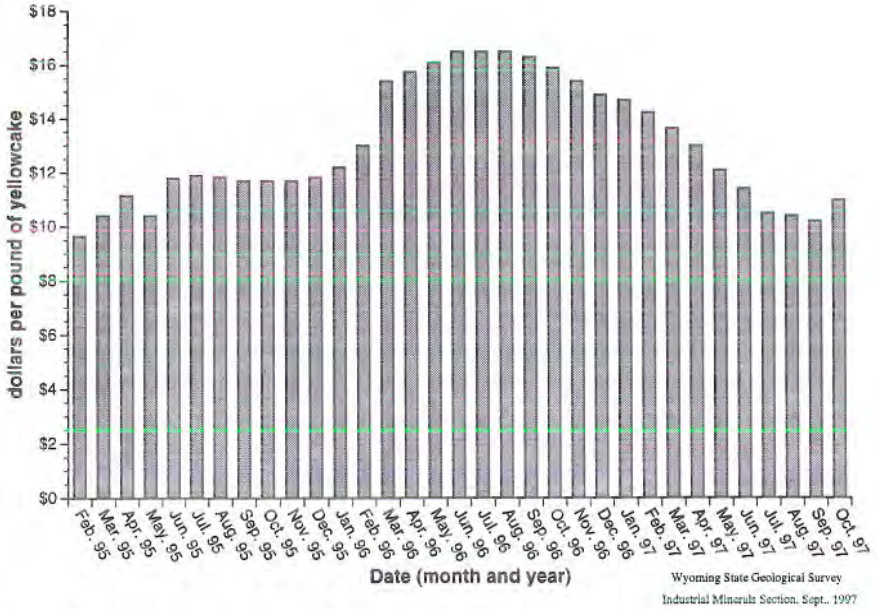

Figure 16. Domestic yellowcake prices, February 1995 through October 1, 1997.

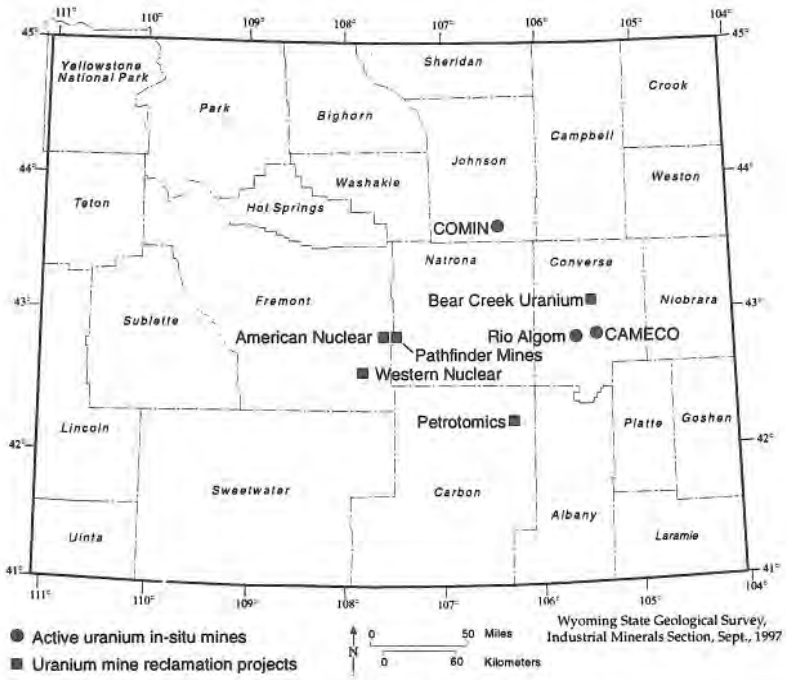

Figure 17. Uranium mining and reclamation activities in Wyoming.

$23 million. Finally, Western Nuclear, which operated in the Jeffrey City area from 1954 until 1981, has almost completed the reclamation of the Split Rock mill. Only 60 acres of the original 270 remain to be reconstructed, and seeding of the site will begin in 1998.

METALS AND PRECIOUS STONES UPDATE

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Ferris-Haggarty Mine

Recently, the authors had the opportunity to visit part of the underground workings of the Ferris-Haggarty mine in the Grand Encampment district of the Sierra Madre. The mine visit was made possible by Tim Richmond of the Department of Environmental Quality, Jim Gusek of Knight Piesold, and Terry Hankins, property owner. The authors are indebted to all three individuals including members of the Knight Piesold and Harrison Western crews working at the mine.

The Ferris-Haggarty mine was last worked in 1908 following a few years of successful mining of rich copper ores. The available records indicate production of copper from 1899 to 1908 amounted to more than 21 million pounds of copper, with some gold and silver (Hausel, 1997). According to Short (1958), the mine was the 27th largest copper producer in the world during its operation.

Historical accounts indicate the deposit was discovered in 1897 after a prospector named Ed Haggarty found a gossan along the northwest-facing hillside, which overlooked a creek later named in his honor. The gossan, was reported to be very limited in surface exposure, with little to no evidence of copper (Spencer, 1904).

Pieces of the gossan are still found near the upper adit above Haggarty Creek. The gossan consists of spongy limonite and goethite with some boxworks. Copper stains are notably absent. The historic shaft sunk on this gossan exposed copper sulfides at a depth of 35 feet (Spencer, 1904). Lakes (1904) and Beeler (1905) indicated that the shaft intersected solid bornite (copper iron sulfide) at a depth of 39 feet.

The lack of copper stains in the gossan is an eye-opener. During field reconnaissance in the Sierra Madre over the past few years, the author has found and sampled several gossans. Many of the gossans have been prospected in the past although most only have shallow pits. Similar gossans to the Ferris-Haggarty would not provide many clues to the underlying mineralization as they would be poor in both base and precious metals, and the only indication of underlying mineralization may be the presence of a limited, massive boxworks produced from the leaching of former copper sulfides.

The mine, which was initially known as the Rudefeha, later became known throughout the West as the Ferris-Haggarty mine following the purchase of the property by the Penn-Wyoming Copper Company. The company constructed a mill and smelter complex at Riverside, Wyoming, and hauled the ore on a 16.25-mile-long tramway which ran from the mine portal, over the continental divide to the smelter works at Riverside. At the time of construction, the tramway was the longest aerial tramway in the world (Short, 1958).

For many years, much of the mine has been inaccessible, and the only geologic report on the mine was written by Spencer (1904) during the early years of its operation. However, 1,400 feet of the lower production adit, known as the Osceola tunnel (located about 400 feet below the discovery shaft), was recently opened and retimbered to identify the source of cupriferous waters draining from the tunnel into the adjacent Haggarty Creek. The Osceola adit was apparently developed after Spencer had visited the mine because Spencer reported the mine as only 250 feet deep.

The Ferris-Haggarty mine occurs in a steeply dipping mineralized zone along a contact between footwall quartzite and hanging wall phyllite of the Magnolia Formation (Proterozoic). Although the mine workings have a vertical

depth of about 400 feet from the upper shaft located at 9,900 feet elevation, to the Osceola tunnel along Haggarty Creek at an elevation of about 9,500 feet, the true length of the mineralized zone is probably on the order of 600 to 800 feet along the dip plane. Based on Spencer's (1904) report, the ore shoot in the upper workings had a strike length of 250-300 feet, and the width of the ore ranged from 30 feet or more, to a few inches near the ends of the shoot. Messerschmidt (1972) and Vandenberge (1906), reported that some ore shoots were as much as 65 feet thick yielding an average grade of 6-8% Cu. Low-grade ore extended beyond the mine excavations (Spencer, 1904).

In the recently opened Osceola tunnel, the ore zone was intersected in a crosscut about 1,200 feet from the portal. The mineralization at this depth is still strong, and occurs in quartzite breccia and metaconglomerate. According to Spencer (1904) the ore breccia was ubiquitous in the upper workings; however, no mention was made of the cupriferous metaconglomerate.

The ore zone has a minimum strike length of 250 feet in the Osceola tunnel, and may extend to an even greater length. The true extent of the ore shoot could not be determined as the eastern extent of the mineralized zone is still buried under a collapsed portion of the mine workings. Indications are that the collapsed workings may extend another 100 feet to the mine face.

The ore zone in the Osceola tunnel consists of stratabound cupriferous metaconglomerate and quartzite breccia in the footwall, capped by a hanging wall of limonite-stained phyllitic schist. The host quartzite trends east-west, and dips at about 30°S near the No. 6 chute in the Osceola tunnel. About 200-250 feet to the east near a winze, the ore dips about 60°S, supporting the presence of a flexure fold suggested by Short (1958). Near the winze, the ore occurs in quartzite breccia formed of angular quartzite clasts surrounded by massive copper. There is also a hint of small scale, third order, isoclinal folding at this point. On the surface, looking south across the Haggarty Creek valley from the No. 1 shaft, a second order, large scale, isoclinal fold is visible. The presence of isoclinal folding in the vicinity of the mine suggests the possibility of a nearby, undiscovered, mineralized fold limb similar to the mineralization in the mine.

Near the No. 6 chute, the mineralization occurs in sheared metaconglomerate. In several places, the metaconglomerate is relatively undeformed with rounded quartzite pebbles supported by a matrix replaced by massive copper sulfides and silicates.

Samples collected in the ore zone are slated for mineralogic, petrographic, and geochemical studies by the Wyoming State Geological Survey (WSGS) over the winter. Based on hand samples, the ore assemblage includes chalcopyrite and covellite, with lesser chalcocite, copper silicates, and bornite. Samples of waste rock collected from the mine dump several years ago, also contained some cuprite, pyrite, malachite, and chrysocolla (Hausel, 1986).

In addition to mineralogical studies, the WSGS will also examine trace metals associated with the ore to search for potential by-products, and for potential source rocks for the ore. For example, Lakes (1904) and Beeler (1905) reported ore shipped from the mine contained 30- 40% Cu with 0.1-0.4 opt Au and some silver. Although these values may be inflated, it suggests a potential for significant by-product precious metal content. Waste rock collected from the mine dump yielded 3.95% Cu with a trace of silver, 4.6% Cu with 0.06 opt Ag, and 3.23% Cu and 0.61 opt Ag (Hausel, 1986).

In the late 1980s, Exxon Minerals sampled the upper adit of the Ferris-Haggarty mine and reportedly identified significant copper, gold, and silver resources. However, only a small portion of the mine was accessible to Exxon.

It is obvious that the Ferris-Haggarty mine was important in Wyoming's early mining history. But possibly even more significant, the Ferris-Haggarty deposit may be unique with few other analogs in the world. It is hoped that more of the mine workings will become accessible so that concepts on genesis and exploration models can be developed. Exploration for similar undiscovered copper deposits in the Sierra Madre is worthy of consideration.

South Pass gold

Several prospectors have found gold in the historic South Pass-Atlantic City district in the Wind River Mountains in the recent past. Possibly, one of the more significant finds in the past few years was the recovery of a walnut-size, 7.5-ounce nugget reportedly found by a part-time prospector from the Green River-Rock Springs area. The South Pass region has produced several large nuggets in the past including one piece of quartz found near the turn of the last century that contained an estimated 630 ounces of gold. There is also a report of a large gold nugget recovered from the district, which now resides in the Los Angeles National Museum (Ralph E. Platt, personal communication, 1997).

Diamonds, kimberlite, and lamproite

The Wyoming State Geological Survey (WSGS) sampled and mapped the Leucite Hills during this past field season, and are currently testing samples for their geochemistry as well as for the possibility of diamonds. One interesting find was the recovery of possible gem character, olivine (peridot) grains up to 0.5 inch across. These came from a few of the lamproites.

The WSGS also sampled kimberlites in the Iron Mountain district during the past field season. The samples will be tested for diamonds, and indicator minerals are being recovered for geochemical analysis.

During the field investigation, one small new kimberlite was discovered. The WSGS also located a group of structurally-controlled depressions west of the Iron Mountain district. Both EM and magnetic surveys were conducted over a few of the depressions in an attempt to determine their origin.

The *Denver Post* (9/25/97), recently highlighted what it called the largest cut diamond recovered in North America. The cut diamond weighed 16.8 carats and was cut from a 28.2-carat gem-quality stone recovered from the Kelsey Lake mine in the Colorado-Wyoming State Line district. To date, the Kelsey Lake mine has produced some of the largest diamonds found in the U.S. (**Table 17**).

Table 17. Reported diamonds in the United States greater than two carats in weight (modified from Hausel, 1995a, b).

Diamond	weight (carats)	State	Diamond	weight (carats)	State
Uncle Sam	40.42	Arkansas	Williams Ferry	>6.00	Georgia
Punch Jones	34.46	West Virginia	Milford	6.00	Ohio
Star of Murfreesburo	34.25	Arkansas	Unnamed	5.90	Arkansas
Doubledipity	32.99	California	Unnamed	5.76	Arkansas
Kelsey Lake	28.30	Colorado	Unnamed	5.63	Arkansas
Kelsey Lake	28.18	Colorado	Unnamed	5.58	Arkansas
Howell	27.31	Arkansas	Sloan	5.51	Colorado
Dewey	23.75	Virginia	Unnamed	5.19	Arkansas
Terresa	21.25	Wisconsin	Unnamed	5.15	Arkansas
Rock Flat	19.50	Idaho	Unnamed	5.08	Arkansas
Enigma	17.83	California	Unnamed	5.00	Arkansas
Amarillo Starlight	16.37	Arkansas	Unnamed	5.00	Arkansas
Kelsey Lake	16.29	Colorado	Stanley	4.88	Indiana
Eagle	15.37	Wisconsin	Lee	4.61	Alabama
Star of Arkansas	15.24	Arkansas	Shelby	4.37	Alabama
Serendipity	14.33	California	Dysortville	4.33	North Carolina
Kelsey Lake	14.20	Colorado	Daniel Light	4.25	Georgia
Lewis & Clark	14.00	Montana	Skamania	>4.00	Washington
Kelsey Lake	11.85	Colorado	Brown County	4.00	Indiana
Dowagiac	10.875	Michigan	Peru	3.93	Indiana
Kelsey Lake	10.48	Colorado	Devine	3.87	Wisconsin
Kelsey Lake	9.40	Colorado	Jeopardy	3.90	California
Unnamed	8.82	Arkansas	Columbus	3.50	Georgia
Unnamed	8.61	Arkansas	Chicken Craw	3.15	Oregon
Unnamed	7.95	Arkansas	Salt Creek	3.06	Indiana
Ashley	7.75	Illinois	Little Indian Creek	3.00	Indiana
French Corral	7.25	California	Union Crossroads	3.00	Tennessee
Shell Bluff	7.11	Georgia	Chicken Park	2.60	Colorado
Unnamed	6.75	Arkansas	Malheur	2.50	Oregon
Saukville	6.57	Wisconsin	Prescott Siding	2.41	Alabama
Gary Moore	6.43	Arkansas	McDowell	2.38	North Carolina
Unnamed	6.30	Arkansas	Gold Creek	2.28	Indiana
Unnamed	6.25	Arkansas	Mary	2.27	California
Unnamed	6.20	Arkansas	Moore	2.25	California
Kelsey Lake	**6.20**	**Wyoming**	George Creek	2.14	Colorado
Eisenhower	6.11	Arkansas	Burlington	2.11	Wisconsin
Unnamed	6.07	Arkansas			

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

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

Remaining Reserve Base (January 1, 1997)
- Measured reserves (Proved reserves) (Includes: .605 billionb barrels of oil and 4.15 billion barrels of gas liquids and condensate) ..... 0.95 billion barrels[2]
- Indicated and inferred reserves (Reserve growth in conventional fields) ..... 2.61 billion barrels[1]
- Total ..... 3.56 billion barrels

NATURAL GAS

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

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

COAL

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

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

TRONA

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

URANIUM

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

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

OIL SHALE

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

[1] Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 1118, 20 p.
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GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE

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VOLUNTEERS AID THE GEOLOGIC MAPPING PROGRAM

The Wyoming State Geological Survey (WSGS) is presently working on 1:24,000- and 1:100,000-scale mapping initiatives with an emphasis on the more populated areas of Wyoming. The maps are designed to aid in land-use evaluation and planning, as well as in exploration and development of potential mineral and water resources.

In February of this year, the WSGS issued a second request for volunteer assistance from qualified geologists in an effort to accelerate geologic mapping in Wyoming. To date, eight new volunteers have come forward, committing to compilation of the Yellowstone National Park North, Yellowstone National Park South, Lander, Rock Springs, Powell, and Riverton 1:100,000-scale geologic maps; the Cody, Spence, North Emblem Reservoir, and Green River 1:24,000-scale geologic maps; and a tentative commitment for the Rock Springs 1:24,000-scale geologic map (**Table 18**). These projects are all in the beginning stages with volunteers having been given basemap materials and copies of existing maps for their specific map areas. In addition, the WSGS has begun work on the Laramie 1:100,000-scale map.

A similar request in June of 1995, was answered by eight geologists, who volunteered to compile the Cody, Sheridan, Casper, Thermopolis, and Worland 1:100,000-scale quadrangles, and the Thermopolis 1:24,000-scale quadrangle (**Table 18**). These maps are in various stages of preparation with the first drafts for the Casper and both Thermopolis maps approaching completion.

Demand for geologic maps is increasing. Recent and projected population growth in many of Wyoming's cities has increased the need for geologic information to assist planning entities in those areas. As a result of these needs, the Survey continues to solicit the aid of any qualified geologists willing to volunteer their efforts in compiling geologic maps. Geologists with expertise and interest in a desired map area are encouraged to contact Alan Ver Ploeg at the Wyoming State Geological Survey at (307) 766-2286 or by e-mail at <averpl.@wsgs.uwyo.edu>.

WORKSHOP FOR TOPOGRAPHIC MAP USERS

Topographic maps provide essential geographic information for planners, policy makers, legislators, farmers, foresters, mining and drilling companies, engineers, surveyors, builders, and pipeline and powerline companies, to name just a few. The list of topographic map users is even longer, including law enforcement officials, emergency management officials, archeologists, histori-

Table 18. Listing of volunteer geologic mapping projects included in the Wyoming State Geological Survey's mapping initiative.

Quadrangle/Scale	Volunteer	Affiliation
Casper-1:100,000	John and Alison Hunter	Power Resources/Tate Museum Casper, WY
Thermopolis-1:100,000	Tim McCutcheon	Consultant Casper, WY
Cody-1:100,000	Dr. David Malone	Illinois State University Normal, IL
Sheridan-1:100,000	Louise Kiteley	USGS-retired Sheridan, WY
Thermopolis-1:24,000	Gretchen Hurley	Consultant Thermopolis, WY
	Dan Wychgram	Consultant Thermopolis, WY
Worland 1:100,000	Barb Vietti	Consultant Danville,CA
Rock Springs-1:100,000	Deborah Deibler Steele	Consultant Cody, WY
Buffalo-1:100,000	Remelle Burton Olsen	Consultant Sheridan, WY
N. Emblem Reservoir-1:24,000 Spence-1:24,000 Powell-1:100,000	Dr. Gary D. Johnson	Dartmouth College Hanover, NH
Cody-1:24,000	Dr. Tim Clarey	Delta College University Center, MI
Riverton-1:100,000 Worland-1:100,000	Kent Chamberlain	Consultant Worland, WY
Green River-1:24,000	John Dyni	USGS Denver, CO
	Bill Culbertson	USGS-retired Denver,CO
Riverton-1:100,000	Tom Zeiner	Mobil Oil Co. Bakersfield, CA
Rock Springs 1:24,000 Rock Springs 1:100,000	John Stout	Retired Geologist Englewood, CO
Yellowstone National Park North Yellowstone National Park South 1:100,000-scale	Don Browne	University of California Los Angeles, CA

ans, tax assessors, wildlife managers, geologists, hydrologists, hunters, fishermen, and recreationists, etc. These maps serve as the base for mapping bedrock and surficial geology and even provide information essential to subsurface and geophysical mapping.

In an attempt to address concerns expressed by several groups of topographic map users, especially members of the American Association of State Geologists (AASG), the U.S. Geological Survey's (USGS) National Mapping Division (NMD) has recently held two Topographic Map Users Workshops. The AASG's concerns center around proposed changes in map content, quality, availability, and cost. The NMD designed these workshops to survey topographic map user needs and concerns and to inform users of the current status and direction of the National Mapping Program.

At the most recent workshop, which was held in Denver, participants were divided into smaller groups with common interests and asked to address identified topographic map program issues, which included map content, map revision, map access, map media, maps-on-demand, and any other map-related issues. In addition the participants discussed and ranked in order of importance the following map revision factors: accuracy, completeness of coverage, level of detail, currentness, and consistency.

The groups ranked the importance of the revision factors in the following order: 1) accuracy, 2) detail, 3) currentness, 4) completeness of coverage, and 5) consistency with some variation in the order of the lower two. None of the groups felt there were any map features they could do without, ranking cultural and topographic/hydrological features as most critical. All felt it was critical that paper copies continue to be available, but that digital versions were also needed.

Most groups had a problem with the maps-on-demand program, noting that quality and accuracy were lacking and that cost was a significant factor. To be successful, these factors would need addressing. Several of the groups noted that the NMD needs to seek out complementing sources of topographic map data and to streamline a method to allow digital and other types of data available through various state entities to be added into NMD map coverages. The state entities and other sources of data would need educated with respect to standards for digital map data.

Users indicated a concern over the current method of revising maps including city/urban areas, where only roads are shown along with a shaded pattern to depict areas of revision, and where all buildings, structures, etc., which were depicted on the previous version of the map, are removed. Concerns raised by these groups were very similar to those raised at an earlier workshop in Reston, VA. The NMD indicated that they would take these concerns into consideration and that these workshops would continue as a method to keep in touch with the needs and concerns of their users.

NATIONAL MAPPING ACT OF 1992 REAUTHORIZED

In early August, President Clinton signed the National Geologic Mapping Reauthorization Act of 1997, reauthorizing the National Geologic Mapping Act of 1992. The bill authorizes spending for the U.S. Geological Survey's National Cooperative Geologic Mapping Program, which funds Federal, state, and university mapping projects, including the STATEMAP and EDMAP Programs. The bill authorizes funding of $26 million in Fiscal Year (FY) 1998, $28 million in FY1999, and $30 million in FY2000. However, for FY1998 both the House and Senate Appropriations Committees voted a $21.9 million funding level, the same as in FY1997, which is $1.7 million more than the President requested. Bill supporters, led by the Association of American State Geologists, hope that passage of the reauthorization bill will encourage the Administration and Congress to increase support for the program in the coming years.

Funding through the National Geologic Mapping Act by way of the STATEMAP Program has been invaluable to the Wyoming State Geological Survey (WSGS) in maintaining a much needed geologic mapping program. Funding has already directly led to the completion of three 1:24,000-scale quadrangles in the Laramie and Guernsey areas over the past three years. Another Guernsey area map is scheduled for completion during the next field season.

In addition, STATEMAP is funding some of the WSGS's efforts to produce digitized surficial and bedrock geologic maps at 1;100,000-scale, including the Casper, Cheyenne, Rawlins, and Laramie Quadrangles. Digital information and maps are currently being requested by county and city planning entities in the State and the STATEMAP funding source has been instrumental in getting this digitizing effort off the ground.

WYOMING GEOLOGIC DATABASE NOW AVAILABLE ON THE WWW

As a cooperative effort, the University of Wyoming's Institute for Energy Research (IER) recently completed the first phase of their Wyoming Geologic Database (WGDB) as a World Wide Web (WWW) site. Working with geologic map indices for Wyoming generated by the Wyoming State Geological Survey (WSGS), the site allows a user to select an area and determine what geologic maps exist in the WGDB for that area. Currently, the WGDB returns a bibliographic listing of geologic maps in a user specified area of interest. If desired, the user can print the retrieved data using their browser print command. The address of the WWW site is: www.wgdb.sdvc.uwyo.edu

The geologic map data is a GIS-coverage created from nineteen index maps, which were updated and provided by the WSGS in the Fall of 1996. Each index map corresponds to a particular type or source of geologic map. On each map, regions are outlined corresponding to indexed maps. The regions on each index map were digitized with attributes (citations). The results were then entered into the database. There are plans to add geothermal and oil shale data as well as satellite images to the database.

PALEONTOLOGICAL ACTIVITY

The Wyoming Office of State Lands and Investments recently released proposed changes to rules for Exclusive Commercial as well as Non-Exclusive Scientific Fossil Removal Permits. Hearings were held on these and other proposed rule changes in a number of cities and towns. The comment period for these proposed rule changes ended on November 8. Copies of the proposed rule changes can be obtained at the following address:

Harold Kemp
Office of State Lands and Investments
122 West 25th Street
Herschler Building
Cheyenne, WY 82002-0600
Phone: 307-777-6643

Some proposed changes of note include: 1) treating exclusive commercial and non-exclusive scientific permits the same with respect to size (no more than 5 acres), a 5-year duration, and an application fee of $50; 2) for commercial permits, a minimum annual royalty payment of $1,000; 3) a sliding scale royalty rate on all sales (based on sales price), which may be offset against the minimum annual royalty payment; 4) possible sale of rare and unusual specimens with the approval the Office of State Lands and Investments or its agent; 5) a minimum bond of $600 required for commercial permittees, which can be increased by the Board of Land Commissioners if the existing bond is not in their opinion adequate; and 6) a requirement that all fossil permittees (commercial and scientific) submit a complete list of all specimens collected during the year.

NEW REPORTS ON WYOMING STRATIGRAPHY AND PETROLEUM GEOLOGY

Ahlbrandt and Fox (1997) used outcrop and subsurface information to study the depositional environment and history of two sandstone members of the Sundance Formation on the east flanks of the Powder River Basin. These sandstone members were deposited as incised valley fill in the Triassic Spearfish Formation, forming excellent hydrocarbon reservoirs, manifested in both stratigraphic and structural traps.

Montgomery and Robinson (1997) profile pertinent stratigraphy and production history of Jonah Field, a Lance Formation gas producer in the northwestern corner of the Green River Basin. Jonah Field contains nearly one trillion cubic feet of reserves in overpressured fluvial Lance Formation, which only recently became fully commercial with the advent of improved fracturing techniques.

Oldham (1997) describes recent shallow gas production from the Tongue River Member of the Fort Union Formation in the northcentral Powder River Basin. Coal-sourced bacterial gas appears to have accumulated in localized structural highs in these sand bodies, which occurred as a result of differential compaction in the underlying sediments.

Tyler and others (1997) define a model to predict the occurrence of coalbed methane at the northwest end of the Cedar Mountain fault system in the Sand Wash Basin, on the eastern margin of the Washakie Basin, and around the northeast flank of the Rock Springs uplift. The proposed exploration model targets the Mesaverde coals in these areas.

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HISTORICAL SEISMICITY OF SOUTH-CENTRAL AND SOUTHEASTERN WYOMING

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Damaging earthquakes have occurred and will continue to occur in south-central and southeastern Wyoming. The first recorded earthquake that was felt in that part of the State occurred in 1882, and the last recorded earthquake occurred in 1993. While the seismic hazard in southeastern Wyoming does not compare to the hazard in western Wyoming, it is, nonetheless, a very real hazard.

The historical earthquakes presented below are organized by region. The area encompassed by this discussion includes Laramie County, the southern two-thirds of Albany, Carbon, Goshen, and Platte Counties, and the far eastern part of Sweetwater County. In addition, significant earthquakes in northern Colorado that were strongly felt in southeastern Wyoming are discussed.

LARAMIE AREA

Two of the first earthquakes to be felt and recorded in southeast and south-central Wyoming, occurred between Laramie, Wyoming, and Estes Park, Colorado, on November 7-8, 1882. The first and largest earthquake, which occurred on November 7, 1882, was estimated to have a magnitude of 6.2 and a maximum intensity of VII. It was felt over most of Colorado, the southern half of Wyoming, and northeastern Utah (Kirkham and Rogers, 1985). The second earthquake, which occurred on November 8, 1882, was only felt from Denver to Laramie. In Laramie, the first event caused considerable apprehension, and some people ran out into the streets. Clocks were stopped, plaster was cracked, and some glass in windows was broken (Case, 1993). Kirkham and Rogers (1985) documented that the earthquake was felt as an intensity VI event in Laramie.

The earliest recorded earthquake that actually originated in the Laramie area, occurred on January 13, 1898. The intensity IV event shook buildings and rattled dishes, windows, and loose objects in Laramie. Before the shock waves were felt, many Laramie residents reported that they "heard a noise similar to that which a heavy wagon would make moving at a good speed a block or two away" (*The Daily Boomerang*, January 14, 1898). As the earthquake occurred at 11:45 p.m., a number of people were awakened by the shaking of their beds.

The next two earthquakes recorded in the Laramie area occurred in the 1930s. On September 20, 1931, an earthquake with a maximum intensity of IV was felt in Laramie and at the Summit Tavern, located east-southeast of Laramie in the Laramie Mountains. There were reports from Laramie that windows and dishes rattled, and some residents ran from their homes (*The Laramie Repub-*

lican-Boomerang, September 21, 1931). This event was followed by another intensity IV earthquake on November 10, 1935. This earthquake, thought to have an epicenter in Laramie, was felt in Laramie, Rawlins, and Rock River. In Laramie, buildings shuddered slightly, dishes rattled, and a low rumbling sound was heard. The earthquake lasted less than ten seconds (*The Laramie Republican-Boomerang*, November 11, 1935).

The most recent earthquake originating in the Laramie area occurred on January 20, 1954. The earthquake had a maximum intensity of V, and occurred approximately twelve miles north-northeast of Laramie. In Wyoming, the earthquake was felt in Laramie, Fox Park, Albany, Centennial, Jelm, Tie Siding, and Ryan Park. In Colorado, it was felt near Cowdrey. In fact, Murphy and Cloud (1956) estimated that the earthquake was felt over 2,000 square miles. In Laramie, a roaring noise was heard, and buildings shook and dishes fell from tables. One Laramie resident thought that the earthquake was an explosion, and alerted the local fire department. The local newspaper reported that stories "were getting more colorful by the hour" (*The Laramie Republican and Boomerang*, January 21, 1954). At Fox Park, a slow motion was observed by all residents. Doors and dishes were rattled, and a post supporting the roof of one house was shifted. At Albany, a rapid motion was felt, with furnishings shifted and windows rattled. The earthquake was reported to have been felt for two minutes at Albany. In Centennial, the earthquake was described as being similar to a heavy dynamite blast (Murphy and Cloud, 1956). In Jelm, a rapid motion that lasted for ten seconds was felt by all residents. An east-to-west motion was described in Jelm. At Tie Siding and Ryan Park, a slow motion was felt for a short period of time. In Cowdrey, Colorado, a rapid motion was felt for fifteen seconds, and hanging objects swung. A few aftershocks were reported in Fox Park and Jelm.

In 1983 and 1984, a series of earthquakes that originated in northern Albany County were felt in the Laramie area. On February 13, 1983, a magnitude 4.0, intensity IV event was felt in Laramie, Casper, Wheatland, and Medicine Bow. No damage was reported. On October 18, 1984, a magnitude 5.5, intensity VI earthquake was also felt in Laramie. A wall in a local school was slightly cracked by the earthquake.

FOX PARK, JELM, AND WOODS LANDING AREA

A series of earthquakes occurred in the Fox Park, Jelm, and Woods Landing area in the 1950s. The first earthquake recorded in the area, an intensity IV event, occurred on January 22, 1954. The earthquake resulted in a very strong but brief shock felt in Jelm (Murphy and Cloud, 1956). On May 22, 1955, an intensity V earthquake near Jelm and Woods Landing caused considerable concern. Many area residents reported hearing a loud rumbling noise which was followed by shaking. Dishes, windows, and cupboards were rattled in many cabins in the Woods Landing area. Reflecting the fears of the time, one Jelm resident thought that an atomic bomb had dropped on Denver. A group of fishermen camping near Woods Landing reported that they were rolled around

in their tent. The earthquake was not felt in Laramie (*The Laramie Republican and Boomerang*, May 23, 1955; Murphy and Cloud, 1957).

On August 6, 1958, an intensity IV earthquake near Fox Park was felt in Fox Park, Laramie, and Centennial. Windows rattled and dishes shook in Fox Park, and one Laramie resident thought there was an explosion in his basement (*The Laramie Daily Boomerang*, August 7, 1958). This earthquake was followed on August 13, 1958, by an intensity III event in the same general area. Residents in the Centennial area reported that buildings shook (*The Laramie Daily Boomerang*, August 15, 1958). In Fox Park, a light tremor was felt (Brazee and Cloud, 1960).

The most recent earthquake recorded in the area occurred near Fox Park and Jelm on December 25, 1959. The magnitude 4.3, intensity V event was felt in Fox Park, Jelm, and Laramie. In Fox Park, slight cracks formed in a concrete block building under construction. Many residents of Fox Park felt the earthquake and described it as a pretty strong jolt. At Jelm, the earthquake was felt by all residents, with many reports of creaking walls (Eppley and Cloud, 1961).

MEDICINE BOW AREA

Three earthquakes have been recorded in the Medicine Bow area. The first occurred on February 5, 1938. The intensity III earthquake was felt as a slight shock in Medicine Bow (Neumann, 1940). On August 28, 1952, an intensity IV earthquake occurred in Medicine Bow. The event was felt by several residents. There were reports of buildings creaking and loose objects rattling (Murphy and Cloud, 1954). On August 17, 1973, a small earthquake, with no assigned magnitude, occurred approximately ten miles west of Medicine Bow. The earthquake was not felt (Reagor, Stover, and Algermissen, 1985).

The most significant earthquake-related damage in the Medicine Bow area occurred as a result of an October 18, 1984, event in northern Albany County. The magnitude 5.5, intensity VI earthquake cracked the exterior brick walls of a public school in Medicine Bow. The earthquake also cracked some chimneys and exterior brick or cinder block walls in Rock River.

SEMINOE RESERVOIR AREA

A series of earthquakes have occurred in the vicinity of the Seminoe Reservoir, with episodes of activity confined to 1973, 1975, 1991, and 1993. Small earthquakes, with no assigned magnitudes, were detected on April 13, 1973, May 30, 1973, and June 1, 1973. They were all located approximately six miles west of Hanna. On August 3, 1973, a magnitude 4.1 earthquake was recorded on the southeastern margin of Seminoe Reservoir. The earthquake has been identified as a probable explosion (Coffman and von Hake, 1975). This event was followed by another probable explosion in the same area on August 10, 1973. The probable explosion was assigned a magnitude of 3.6 by the U.S. Geological Survey (Coffman and von Hake, 1975). A small earth-

quake, with no assigned magnitude occurred in the same area on August 17, 1973. The U.S. Geological Survey did not report this event as an explosion although the record was so weak that a definite origin is uncertain (Reagor, Stover, and Algermissen, 1985). On November 21, 1973, another earthquake that was a probable explosion was recorded on the western side of Seminoe Reservoir. No magnitude was assigned to the event (Coffman and von Hake, 1975). The last reported earthquake of the 1970s occurred on July 11, 1975. The earthquake occurred on the southeastern margin of Seminoe Reservoir, and was felt as an intensity II event in Rawlins (Coffman and Stover, 1977) .

Four earthquakes occurred in the vicinity of Seminoe Reservoir in the 1990s. The first, a magnitude 3.2 event, occurred on April 13, 1991, and the second, a magnitude 2.9 event, occurred on April 19, 1991. The earthquakes, which occurred near the center of Seminoe Reservoir, were not felt (Case, 1994). On December 18, 1991, a magnitude 3.1 earthquake occurred to the southwest of Seminoe Reservoir. As with the other earthquakes in 1991, the event was not felt (Case, 1994). The last earthquake reported in the area occurred on August 23, 1993. The magnitude 3.0 earthquake, which occurred near the center of Seminoe Reservoir, was not felt (Case, 1994).

RAWLINS AREA

One of the first earthquakes recorded in south-central and southeast Wyoming occurred near Rawlins on March 28, 1896. The intensity IV earthquake shook for about two seconds, causing windows to rattle in Rawlins. Lamps swayed and dishes were rattled by the event, which seemed to originate in the southwest (Case, 1993). The local newspaper also reported that "Several years ago a similar disturbance was felt here, but at that time it was considerably more severe" (*The Rawlins Republican*, April 3, 1896). The earlier earthquake may have been the November 7, 1882, event described in the Laramie Area section of this report.

On March 10, 1917, another intensity IV earthquake occurred in the Rawlins area. The earthquake was felt as a distinct shock which caused wooden buildings to vibrate quite noticeably. Stone buildings were not affected by the event (*Rawlins Republican*, March 15, 1917.

On September 11, 1964, a magnitude 4.1 earthquake occurred in eastern Sweetwater County, approximately thirty miles west of Rawlins. One Rawlins resident reported that the earthquake caused a crack in the basement of his home in Happy Hollow. No other damage was reported (*The Daily Times*, September 11, 1964).

On January 27, 1976, a magnitude 2.3, intensity V earthquake occurred approximately twelve miles north of Rawlins. Dishes were rattled, pictures fell from walls, lamps were knocked off tables, and one wall in a residence was reportedly cracked. Many reports came from the Park Drive area, and several people reported that they were thrown out of bed. (*Daily Times*, January 28, 1976).

SIERRA MADRE

Two earthquakes have been recorded in the Sierra Madre mountains, between Baggs and Saratoga, in the 1970s and 1980s. On March 3, 1977, a magnitude 4.2, intensity V earthquake rattled doors and dishes in southern Carbon County homes. No significant damage was reported (*The Laramie Daily Boomerang*, March 6, 1977). On November 1, 1989, a magnitude 3.0 earthquake occurred in the area. It was felt in Saratoga (U.S. Geological Survey, 1989)

CHEYENNE AREA

A few earthquakes have occurred in the Cheyenne area although none have caused damage. On March 24, 1927, an intensity III earthquake occurred approximately five miles north of Cheyenne. The event was felt by at least five residents who described a rapid trembling that lasted five seconds. The earthquake was felt by two persons on the fourth floor of a building. Some reports indicated that two shocks were felt, and that the ground "trembled and bumped" (Neumann, 1929).

A very small earthquake, located approximately ten miles west-southwest of Cheyenne, was recorded by the U.S. Geological Survey on June 5, 1967. No magnitude or intensity have been associated with the event. On September 12, 1980, a magnitude 3.2 non-tectonic earthquake occurred approximately sixteen miles west of Cheyenne. The event was identified as an explosion of 150 tons of dynamite which was felt twenty miles west-northwest of Cheyenne (Stover and von Hake, 1982).

SUMMARY

Earthquakes are fairly common in south-central and southeastern Wyoming. Based upon the November 7, 1882, earthquake that occurred between Laramie and Estes Park, Colorado, it must be assumed that earthquakes in the magnitude 6.2-6.5 range are possible in southeastern Wyoming.

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ROCK HOUND'S CORNER

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Silver, an important precious metal, has been overlooked in Wyoming because of the lack of historic production of the metal. In the past, silver has been produced as a by-product of gold and copper mining. Based on the available records (which are very incomplete), at least 157,000 ounces of silver were recovered from mines in the historic past.

According to Parkhurst (1991) there are at least 55 recognized silver minerals. Some of the more important minerals include native silver; electrum (gold-silver alloy); argentite (silver sulfide) also known as "silver glance"; cerargyrite (silver arsenic sulfide) also known as "horn silver"; proustite "ruby silver" (silver arsenic sulfide); pyargyrite "dark ruby silver" (silver antimony sulfide); silvanite (gold-copper tellurium); argentiferous galena (silver-bearing lead sulfide); stephanite (silver antimony sulfide); polybasite (silver-copper antimony sulfide); stromeyerite (silver copper sulfide); freibergite (copper-silver antimony-arsenic sulfide), which is a silver-bearing tetrahedrite; and tennantite (copper-arsenic sulfide). Silver is often found in association with lead and copper, and as a metal is malleable, ductile, and has a very high specific gravity ranging from 10 to 11.

Silver has many important uses because of its high electrical and thermal conductivity. This precious metal has many uses in the photography industry and is used in mirrors, jewelry, and coinage. Recently, the Silver Institute reported that silver is also a natural bactericide, which inactivates bacteria on contact. This might account for why ancient civilizations often stored water, wine, and vinegar in silver vessels.

Even though we generally do not think of silver when we think of Wyoming, this could have changed a few decades ago when AMAX Mining Company explored the Bald Mountain porphyry at Kirwin. The Bald Mountain porphyry is a large copper-silver deposit in the Absaroka Mountains in northwestern Wyoming. If that property had been placed in production, Wyoming would be a significant producer of silver as well as a producer of copper, gold, zinc, and lead.

However, because the Kirwin deposit was not developed, the district still has several old mines with very high-grade silver. Some of the mines were reported to contain ore-grade and specimen-grade silver (**Table 19**). The more interesting reports include the Oregon, Little Johnnie, Galena Ridge tunnel, and Byron mines.

The Oregon vein, for example, was reported to yield an average of 17.8 opt (ounces per ton) Ag with 0.08 opt Au across 3-foot widths. The nearby Little Johnnie vein yielded samples that assayed 64.7 opt Ag and 0.12 opt Au across widths of 1.5 feet. One select sample from the mine dump assayed 156.0 opt Ag! According to Rostad (1982), the best values on these veins were

Table 19. Assay results from samples collected from various mines in the Kirwin district (from Rostad, 1983; Wilson, 1964; Hausel, 1997).

Claim	Au (opt)	Ag(opt)	Cu (%)	Pb(%)	Zn(%)	Mo(%)	Sample Type
Bryan	0.04	4.2	-	-	-	-	Dump-grab
Bryan	0.25	30.5	2.33	tr	-	tr	Dump-grab
Bryan #2	0.13	29.6	0.73	-	-	-	Average 98 ft of vein in portal
Wolf shaft	tr	tr	-	tr	-	0.55	Dump-grab
Oregon	0.03	10.8	-	0.1	-	-	Vein-channel
Oregon	0.11	28.9	0.2	2.5	-	-	Dump-grab
Oregon	0.05	9.32	-	-	-	-	Average 120 ft of vein
Oregon	0.07	15.85	-	-	-	-	Dump-ore
Smuggler	0.06	8.1	0.8	-	-	-	Opencut-grab
Smuggler	0.07	4.8	0.2	-	-	-	Dump-grab
Pickwick	0.09	1.5	-	-	-	-	Dump-grab
Pickwick	0.04	4.3	-	-	-	-	Vein-channel
Pickwick	0.03	2.2	-	-	-	-	Vein-channel
Pickwick	0.15	28.0	tr	tr	-	-	Large general sample
Tumlum	0.02	17.6	-	3.2	-	-	Dump-grab
Tumlum	0.07	41.1	-	31.9	-	-	Dump-grab
Illonies	0.02	0.2	-	-	-	0.51	Dump-grab
Illonies	tr	tr	0.5	tr	-	0.14	Dump-grab
Anaconda shaft	0.03	1.4	-	20.6	-	-	Dump-grab
Anaconda shaft	0.04	11.9	-	61.8	-	-	Shaft-grab
Anaconda shaft	0.02	7.3	tr	39.9	-	-	Dump-grab
Anaconda shaft	0.03	6.71	-	23.4	-	-	1 ft down
Anaconda shaft	0.03	3.87	-	9.7	-	-	9 ft down
Anaconda shaft	0.01	1.37	-	-	-	-	19 ft down
Black Prince	0.06	6.0	0.2	3.1	-	-	Outcrop
Black Prince	0.10	1.22	-	-	-	-	Average 44 ft of vein
Little Johnnie	0.01	1.5	-	1.1	-	-	Vein-grab
Little Johnnie	0.19	111.8	0.03	-	1.2	-	Dump-bulk
Little Johnnie	0.07	29.5	-	-	-	-	Average 82 ft of vein in portal
Little Johnnie	0.12	64.7	-	-	-	-	Mine face
Little Johnnie	nd	156.0	-	-	-	-	Specimen from dump
Little Johnnie	0.09	43.1	-	-	-	-	Shipment-(small lot)
Mendota	0.04	14.7	-	0.55	-	-	Dump-grab
Mendota	0.08	21.2	-	-	-	-	Second cut.
Mendota	0.04	2.38	-	-	-	-	Face-upper tunnel
Mendota	0.28	101.0	-	-	-	-	High grade
Manilla	0.06	5.86	-	-	-	-	Face-upper tunnel
Iowa	0.06	3.84	-	-	-	-	Lower cut
Iowa	0.02	2.66	-	-	-	-	Main adit at face
Iowa	0.12	8.76	-	-	-	-	Second cut
Krachy	0.10	7.10	-	-	-	-	Ore dump
Krachy	0.10	4.14	-	-	-	-	Cut
Krachy	0.10	0.64	-	-	-	-	Outcrop on summit north of shaft
Krachy	0.15	4.55	-	-	-	-	Outcrop on summit north of shaft
Krachy	0.15	17.68	-	-	-	-	Outcrop 100 ft north of shaft

obtained at or next to the mine faces (end of the tunnels), where work had ended.

At the Byran mine on nearby Spar Mountain, 31 samples were taken over a strike length of 98 feet. These samples averaged 0.13 opt Au, 29.5 opt Ag and 0.73% Cu (Rostad, 1982). Some unbelievable samples were collected from the Mendota vein in the Galena Ridge tunnel. A select sample collected across a half-foot of the vein averaged 101.35 opt Ag and 0.283 opt Au! Based on these samples, significant silver mineralization still exists in the Kirwin district.

Other places in Wyoming that have yielded samples with high-grade silver include the Sunlight district several miles north of Kirwin, the Lake Alice district in the Overthrust Belt of western Wyoming, and the Mineral Hill district in northeastern Wyoming.

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