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WYOMING GEO-NOTES
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Cover: A 240-ton dump truck hauls coal out of the Cordero mine in Wyoming's Powder River Basin.

Table of Contents

	Page
Minerals Update	1
Overview	1
Reference cited	12
Oil and Gas Update	12
Exploration and Development	22
Coal Update	26
Developments in the Powder River Basin	27
Developments in southern and western Wyoming	29
Power plants	30
Coal contracts and solicitations	31
Coalbed methane	31
Industrial Minerals and Uranium Update	36
Decorative and dimensional stone	36
Trona	36
Uranium	37
Zeolites	37
References cited	39
Metals and Precious Stones Update	39
Diamonds	39
Colorado-Wyoming State Line District	40
Green River Basin	40
Lonetree geophysical anomalies	42
Bighorn Mountains	42
Central Wyoming	43
Gold	44
Copper	44
References cited	44
Mineral Resource and Reserve Base Estimates for Wyoming	46
Overview of Historical Seismicity in Yellowstone National Park	47
Overview of earthquakes in the late 1800s	47
Overview of earthquakes in the early- to mid-1900s	49
Overview of earthquakes in the 1950s	50
Overview of earthquakes in the 1960s	50
Overview of earthquakes in the 1970s	51
Overview of earthquakes in the 1980s	52
Overview of earthquakes in the 1990s	52
Summary	53
References cited	53
Rock Hound's Corner	55

Page

New publications of the Wyoming State Geological Survey 56
Section reports recently made available 57
Gas atlas still available 57
Recreational map purchasers! 58

Wyoming State Geological Survey location maps 59

MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

Late in the third quarter of 1996, staff of the Wyoming State Geological Survey prepared new production and price forecasts for the various minerals produced in Wyoming. These forecasts were for the calendar years 1996 through 2003. As in the past, the State's Consensus Revenue Estimating Group (CREG) used these estimates and those made by the Wyoming Oil and Gas Conservation Commission and the Department of Revenue to reach consensus in their forecasts of mineral revenue. The CREG's October report, which was provided to the Governor and the Legislature, contains these mineral production and price forecasts for the State of Wyoming (CREG, 1996).

Tables 1 and **2** of this issue of *Wyoming Geo-notes* reflect the CREG's new forecasts.

Table 1. Wyoming mineral production (1985-1995) with forecasts to 2003[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	994.3	*142.6	*1.07	263.9	18.1	1.3	1.20
1996	71.7	1,019.4	142.6	1.07	273.5	18.8	2.0	1.20
1997	67.8	1,045.1	142.6	1.07	282.8	21.0	2.0	1.20
1998	64.0	1,072.4	142.6	1.07	296.9	21.0	2.5	1.20
1999	60.5	1,100.4	142.6	1.07	313.7	21.0	2.9	1.20
2000	57.2	1,129.0	142.6	1.07	334.6	22.6	2.9	1.20
2001	54.0	1,167.2	142.6	1.07	341.3	22.6	2.9	1.20
2002	51.1	1,206.5	142.6	1.07	344.7	24.4	2.9	1.20
2003	48.3	1,247.0	142.6	1.07	348.2	24.4	2.9	1.20

*Estimated until official figures are available.
[1]Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2003, October, 1996; [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, 1985-1995); [7]Wyoming State Inspector of Mines, 1985-1995; [8]Millions of pounds of yellowcake (not available [NA] for 1985 and previous years because it was only reported as taxable value); [9]Millions of short tons.

Table 2. Average prices paid for Wyoming oil, methane, coal, trona, and uranium (1985-1995) with forecasts to 2003[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	18.40	1.20	6.23	44.09
*1997	16.00	1.25	6.07	44.49
*1998	15.00	1.30	5.95	44.60
*1999	15.00	1.30	5.80	44.97
*2000	15.00	1.30	5.65	45.57
*2001	15.00	1.30	5.54	45.96
*2002	15.00	1.30	5.50	46.20
*2003	15.00	1.30	5.50	46.44

*Estimated until official figures are available.
[1] Modified from CREG's Wyoming State Government Revenue Forecast FY97-FY2003, October, 1996; [2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1995; [3] Wellhead price in dollars per thousand cubic feet (MCF). Sources: Wyoming State Land and Farm Loan Office, 1989-1995 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); [4] Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Wyoming Department of Revenue, 1991-1995; [5] Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1995.

In regard to oil, the annual decline in production is increased to 5.5%, as compared to the previously estimated 4%. This rate of decline is consistent with trends over the last ten years (**Table 1** and **Figure 1**). A slowing of this decline is unlikely in view of new competition from Canadian crude, which will soon flow into Casper on the Express Pipeline from Alberta. Express expects to complete most of the construction of this new pipeline in the fourth quarter of this year.

While the estimated price of oil in 1996 and 1997 is higher, it falls back to the previous forecast after 1997 (**Table 2** and **Figure 2**). This reflects the current higher prices for crude (**Figure 3**) as well as concern over the impending competition from Canadian oil. For example, the bonuses now paid to some Wyoming producers for sour, and sometimes sweet crude, are likely to decrease or disappear after the Canadian pipeline into Casper increases the supply of oil.

Production of natural gas is slightly greater in the new forecast (**Table 1** and **Figure 4**). It is still predicted to increase at 2-3% a year, which is higher than the 1.5% national growth rate. But the oversupply of domestic and Canadian natural gas into Wyoming's market area, as well as some transportation bottlenecks, are going to remain well into the forecast period.

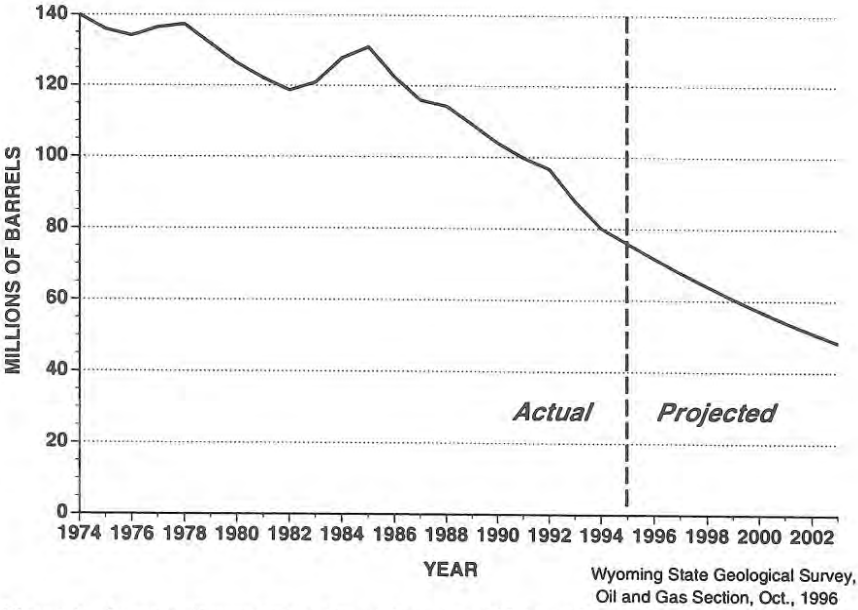


Figure 1. Annual oil production from Wyoming (1974 to 1995) with forecasts to 2003.

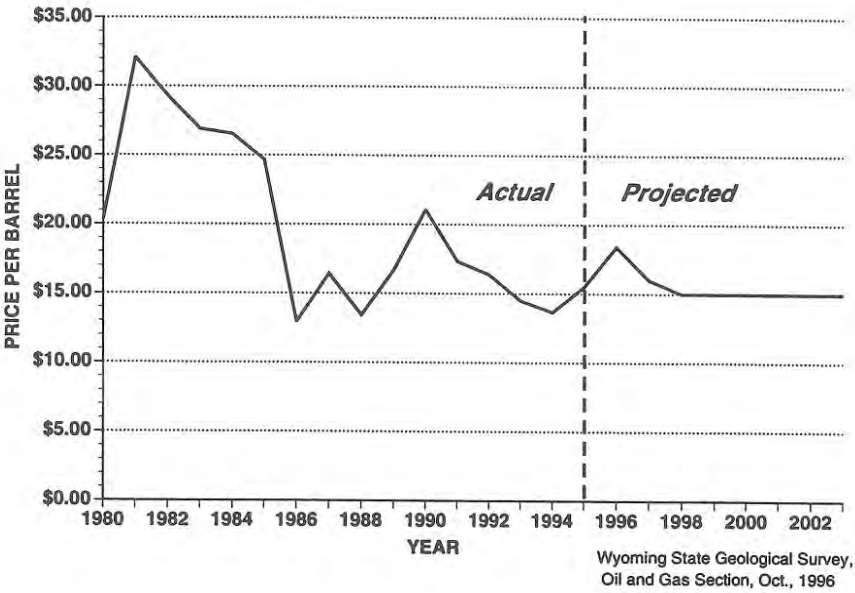


Figure 2. Average prices paid for Wyoming oil (1980 to 1995) with forecasts to 2003.

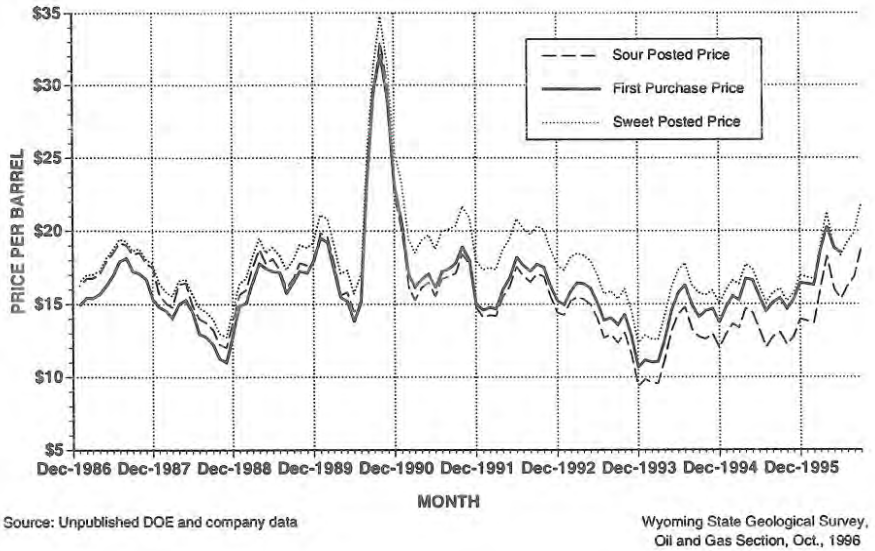


Figure 3. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

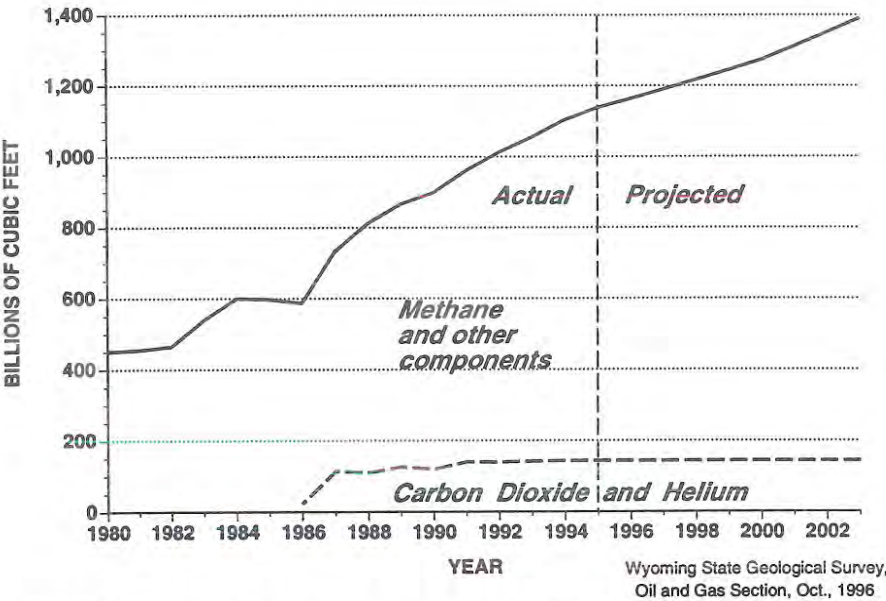


Figure 4. Annual natural gas production from Wyoming (1980 to 1995) with forecasts to 2003.

The forecast natural gas prices are lower than previous estimates (**Table 2** and **Figure 5**). This reflects the need to keep prices down if natural gas from Wyoming is going to compete in an oversupplied market. **Figure 6** shows the spot sale price received for natural gas at Opal, Wyoming, averaged by month for the last several years.

Although the predicted annual coal production over the next four years is slightly less than previous forecasts, predictions are substantially greater after 1999, nearly reaching 350 million tons a year by 2003 (**Table 1** and **Figure 7**). The current forecast indicates a relatively slow rate of growth in 1996 and 1997, increasing as the deadline for compliance with Phase 2 of the 1990 Clean Air Act approaches (**Table 3**). That deadline is the year 2000. After 2000, production will continue to increase but again at a slower pace. By July of 1996, coal deliveries from Wyoming producers were only 6.4% above the same period in 1995 (**Table 4** and **Figure 8**). Monthly spot sale tonnages, however, were still well below last year's levels **Figure 9**.

While the forecast average price for coal is slightly higher for 1996, it is lower in the years beyond that, and the new forecast does predict a flattening of the price, beginning at the year 2001 (**Tables 2** and **5**; **Figure 10**). By 2001, the market price is expected to reflect the contract and spot sale prices received at that time, since nearly all of the older, higher priced, longer term contracts will have expired (**Table 3**). It is these older contracts that have been propping up the average price for many years.

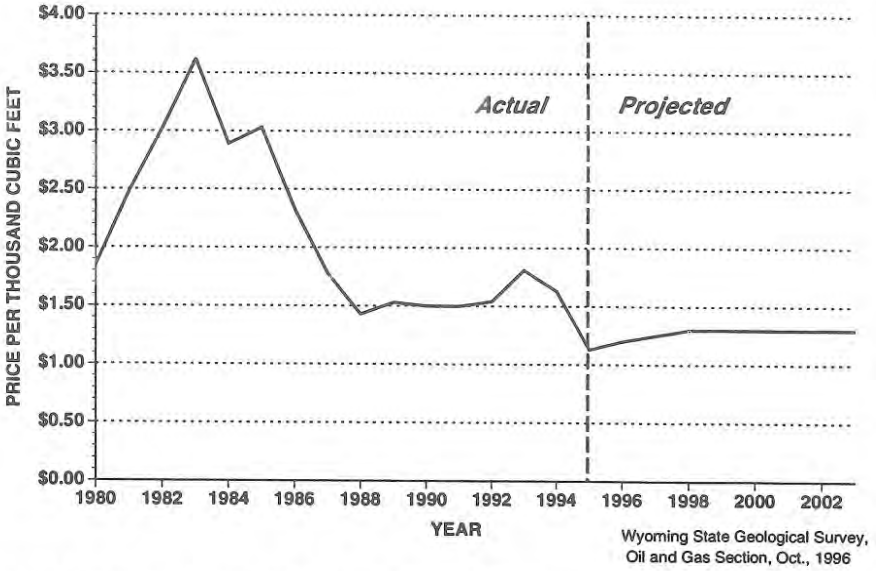


Figure 5. Average prices paid for Wyoming methane (1980 to 1995) with forecasts to 2003.

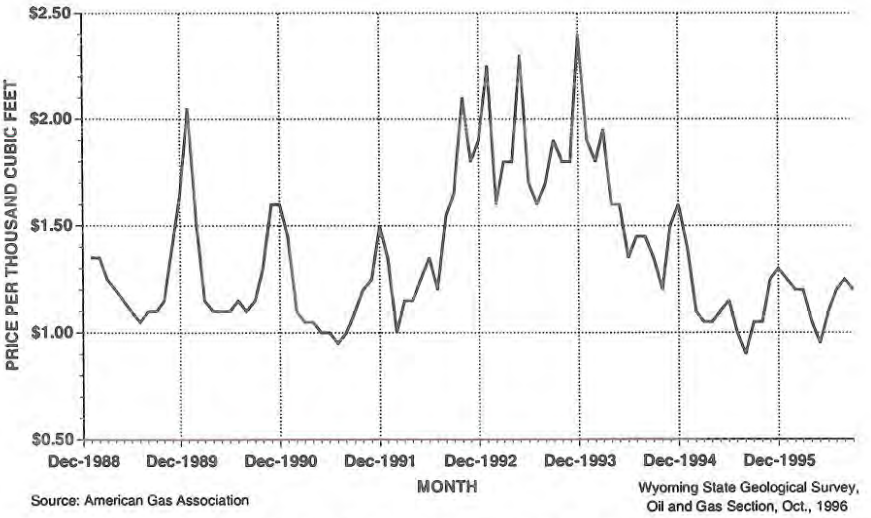


Figure 6. Spot sale prices for methane at Opal, Wyoming, averaged by month (1989 to present).

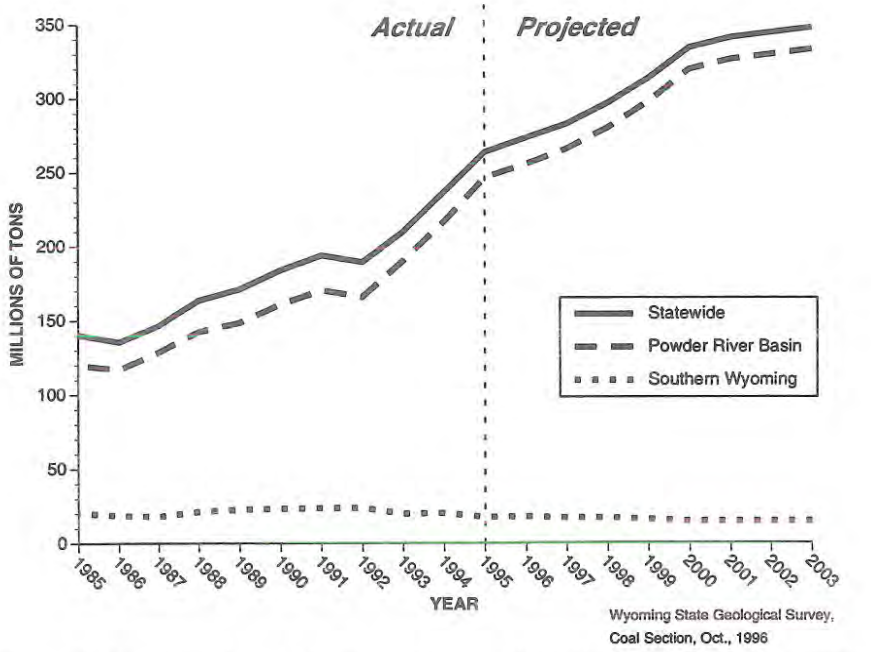


Figure 7. Annual coal production from Wyoming (1970-1995) with forecasts to 2003. Data from Wyoming State Inspector of Mines (1970-1995) and Wyoming Consensus Revenue Estimating Group (1996-2003).

Table 3. Wyoming coal production by county (in millions of tons), from 1992 to 1995 with forecasts to 2003.

	1992	1993	1994	1995	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]	2001[1]	2002[1]	2003[1]
Campbell County	159.6	181.9	205.2	232.4	255.7	251.5	265.1	282.6	304.6	311.3	314.7	318.2
Converse County	8.5	10.2	11.7	14.1	14.3	14.5	15.0	15.3	15.3	15.3	15.3	15.3
Sheridan County	0.1	0.1	0.1	M	M	M	M	M	M	M	M	M
Carbon County	4.1	4.4	4.4	3.8	4.1	3.8	3.8	2.8	1.7	1.7	1.7	1.7
Sweetwater County	12.6	9.2	11.2	9.1	9.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.6	4.1	4.3	4.5	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming	189.5	209.9	236.9	263.9	273.5	282.8	296.9	313.7	334.6	341.3	344.7	348.2
Annual Change	-2.3%	10.8%	12.9%	11.4%	3.6%	3.4%	5.0%	5.7%	6.7%	2.0%	1.0%	1.0%
Low-priced coal[2]	57%	64%	67%	74%	76%	78%	83%	87%	91%	94%	96%	96%

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

Wyoming State Geological Survey, Coal Section, October, 1996

Table 4. Monthly coal deliveries from Wyoming's mines in short tons (1993-1996).

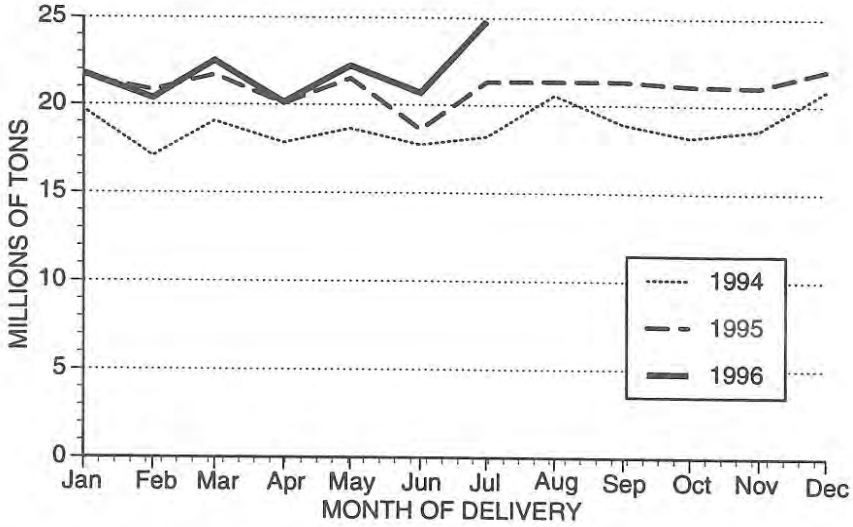
	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative
JAN	15,931,150	15,931,150	19,326,770	19,326,770	21,586,303	21,586,303	21,793,387	21,793,387
FEB	14,646,090	30,577,240	17,171,910	36,498,680	20,839,926	42,426,229	20,374,055	42,167,442
MAR	17,112,970	47,690,210	19,178,990	55,677,670	21,707,422	64,133,651	22,507,800	64,675,242
APR	16,259,770	63,949,980	17,839,110	73,516,780	20,066,616	84,200,267	22,579,959	87,255,201
MAY	16,085,470	80,035,450	18,652,290	92,169,070	21,509,916	105,710,183	22,216,016	109,471,217
JUN	16,473,920	96,509,370	17,741,480	109,910,550	18,602,505	124,312,688	20,698,814	130,170,031
JUL	15,296,480	111,805,850	18,213,540	128,124,090	21,334,608	145,647,296	24,842,971	155,013,002
AUG	16,682,090	128,487,940	20,572,120	148,696,210	21,356,870	167,004,166		
SEP	17,310,330	145,798,270	19,129,450	167,825,660	21,355,730	188,359,896		
OCT	18,300,070	164,098,340	18,189,260	186,014,920	21,178,610	209,538,506		
NOV	18,007,970	182,106,310	18,595,500	204,610,420	21,042,260	230,580,766		
DEC	19,034,530	201,140,840	20,866,710	225,477,130	22,032,910	252,613,676		
Total Tonnage Reported[1]		**201,140,840**		**225,477,130**		**252,613,676**		
Total Tonnage Not Reported[2]		**8,784,986**		**11,430,937**		**11,324,347**		
Total Tonnage Produced[3]		**209,925,826**		**236,908,067**		**263,938,023**		

[1] COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities (1993-1995); From bulletin board of the Federal Energy Regulatory Commission in 1996.

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

[3] Wyoming State Mine Inspector's Annual Reports.

Wyoming State Geological Survey, Coal Section, October, 1996.



Wyoming State Geological Survey, Coal Section, Oct., 1996

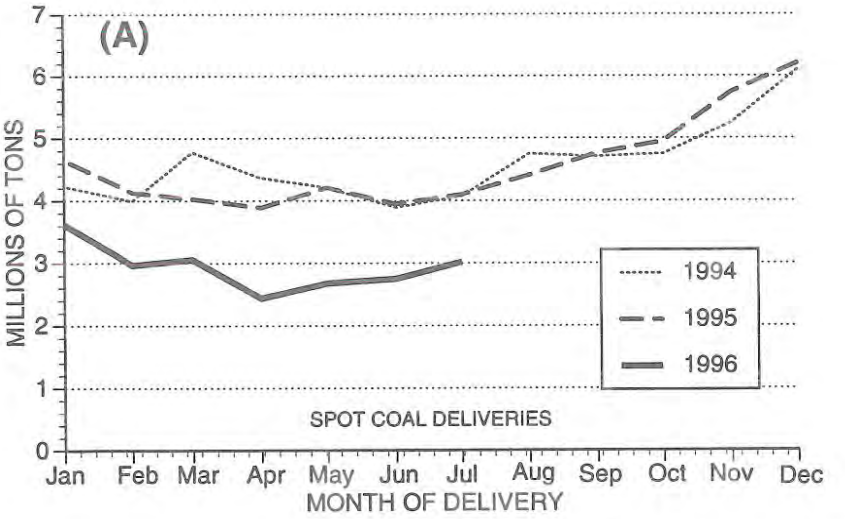
Figure 8. Reported monthly deliveries from Wyoming coal mines (1994 through July, 1996). From COALDAT Marketing Report by Resource Data International, Inc., (1994 and 1995), and from the Federal Energy Regulatory Commission's bulletin board in 1996.

In the Powder River Basin (PRB), the current contract and spot sale prices remain in the $3.00-$4.20 range. Competition among producers in the PRB, coupled with deregulated utilities shopping around for the best bargains, suggests the price will not improve soon. So far this year, the continued low prices in the PRB have at least contributed to the sale of the Clovis Point mine, the idling of the Dry Fork mine, and the delayed startup of the North Rochelle mine (p. 27 and 28). In addition, they have started speculation about the possible sale of the Caballo Rojo and Fort Union mines as well as some other mines in the PRB.

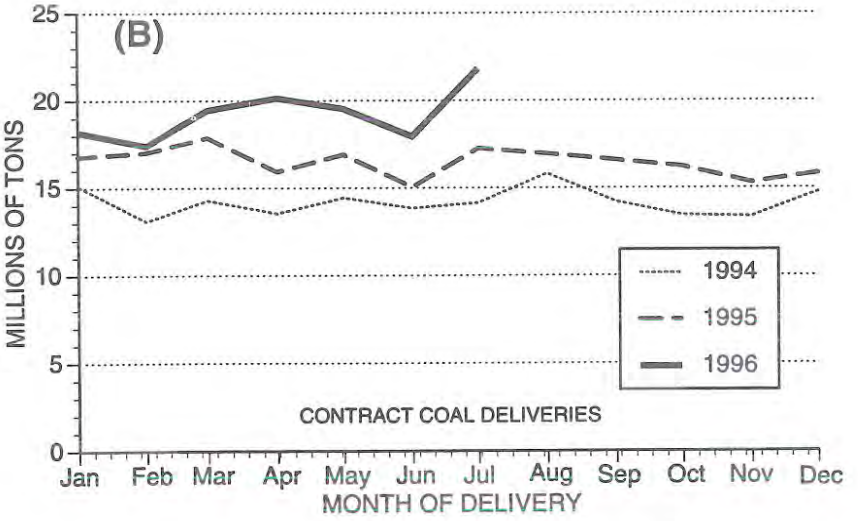
The new forecasts also indicate greater production of trona than previous estimates (**Table 1**) and higher prices (**Table 2**). Also, the long term health of the trona industry was somewhat reinforced by the recent leasing of an estimated 545.5 million tons of trona in this year's two Federal lease sales (p. 36).

The spot sale price of uranium has increased over the last year and a half and is now over $15.00 per pound of yellowcake (**Figure 14**, p. 38). As a result, forecast production of solution-mined uranium is also higher than previous estimates (**Table 1** and **Figure 15**, p. 38).

Exploration for diamond in Wyoming remains strong with activity reported in both the Colorado-Wyoming State Line district in southeastern Wyoming and the Green River Basin in the southwestern corner of the State (p. 40).



Wyoming State Geological Survey, Coal Section, Oct., 1996



Wyoming State Geological Survey, Coal Section, Oct., 1996

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

Table 5. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1995) with forecasts to 2003[1].

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

[1]Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1995 are derived from Wyoming Department of Revenue information; estimates for 1996-2003 are from the Consensus Revenue Estimating Group's report of October, 1996; and all regional breakdowns are estimated by the Wyoming State Geological Survey.

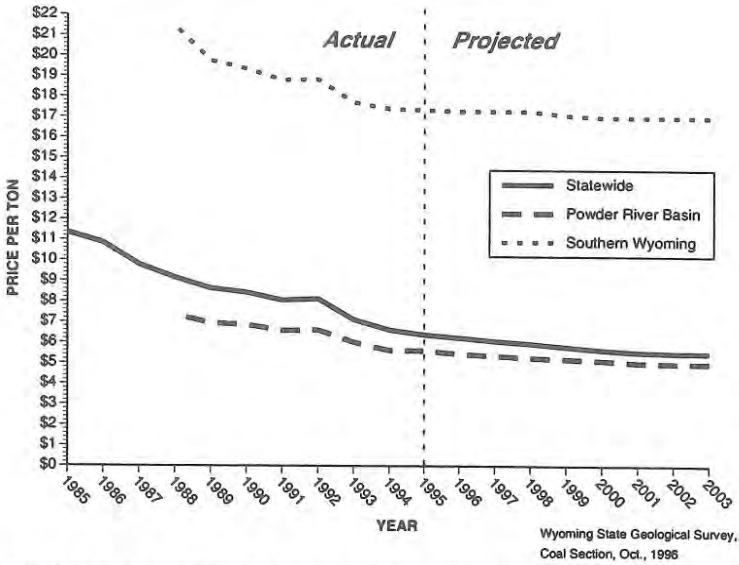


Figure 10. Average prices paid for Wyoming coal (1970 to 1995) with estimates to 2003. Sources: U.S. Energy Information Administration (1970-1990); derived from the Wyoming Department of Revenue (1991-1995); and the Consensus Revenue Estimating Group (1996-2003).

Reference cited

Consensus Revenue Estimating Group, 1996 (October), Wyoming State Government revenue forecast FY1997-FY2003: Cheyenne, 22 p.

OIL AND GAS UPDATE

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

While prices paid to Wyoming oil producers in the first nine months of 1996 averaged an estimated $18.61 per barrel (**Table 6**), the average price per barrel in the third quarter was an estimated $19.65. If this price holds for the next three months, the average price for 1996 will be the highest since 1990 when the average price was $21.08 per barrel (**Figure 1** and **Table 2**). But oil production for the first six months of this year, as reported by Petroleum Information, Inc., was 35.7 million barrels (**Table 7**), or 5.6% less than the same period last year. The higher oil prices, however, have helped the rig count, which is currently higher than it has been since late in 1994 (**Figure 11**).

In purchases, Basin Exploration, Inc. has increased its 1.6% interest in the Jepson/Holler Draw Unit to 26.6%. The company will pay one million dollars in cash plus interest in 18 producing wells in Kaye Field. The Jepson/Holler Draw Unit was formed for secondary oil recovery through water injection into the Shannon. The company estimated its share of development costs at $6 million.

Interline Resources signed a letter of intent to sell its Well Draw gas plant and crude oil pipeline system as well as its interest in seven oil wells. The buyer and terms of the transaction were not disclosed. The gas plant has a capacity of 150,000 gallons of natural gas liquids per day. The pipeline system includes gathering stations, storage tanks, and180 miles of pipeline.

The Express Pipeline cleared enough hurdles in the third quarter that its construction began. All major construction should be completed by the end of the year. The pipeline will initially transport up to 172,000 barrels of Canadian crude oil per day (62.78 million barrels per year) to Casper, with a projected increase to 270,000 barrels per day (98.55 million barrels per year). The Wyoming Board of Land Commissioners, the Montana State Land Board, and the U.S. Bureau of Land Management (BLM) all approved rights-of-way across their lands. An appeal against the BLM's approval of the pipeline's right-of-way, filed by the Independent Petroleum Association of Mountain States and the Wyoming Independent Petroleum Association, was rejected by the Department of the Interior's Appeals Board. In addition, the Natrona County Commissioners granted a right-of-way for the pipeline to cross the Natrona County International Airport. Washakie County Commissioners had earlier granted the pipeline permission to cross two of their county roads. Express is also reportedly near an agreement with several Washakie County landowners for access across their land.

Table 6. Monthly average price of a barrel of oil produced in Wyoming (1993 to present).

	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative
JAN	$ 15.08	$ 15.08	$ 11.15	$ 11.15	$14.77	$ 14.77	$16.38	$16.38
FEB	$ 16.00	$ 15.54	$ 11.01	$ 11.08	$15.55	$ 15.16	$16.28	$16.33
MAR	$ 16.47	$ 15.85	$ 11.04	$ 11.07	$15.26	$ 15.19	$18.63	$17.09
APR	$ 16.41	$ 15.99	$ 12.59	$ 11.45	$16.73	$ 15.58	$20.29	$17.90
MAY	$ 16.11	$ 16.01	$ 14.53	$ 12.07	$16.65	$ 15.79	$18.85	$18.08
JUN	$ 15.11	$ 15.86	$ 15.73	$ 12.68	$15.52	$ 15.75	$18.15	$18.10
JUL	$ 13.91	$ 15.58	$ 16.31	$ 13.20	$14.50	$ 15.57	**$18.70**	**$18.18**
AUG	$ 14.08	$ 15.39	$ 14.89	$ 13.41	$15.09	$ 15.51	**$19.25**	**$18.32**
SEP	$ 13.57	$ 15.19	$ 14.10	$ 13.49	$15.41	$ 15.50	**$21.00**	**$18.61**
OCT	$ 14.23	$ 15.09	$ 14.53	$ 13.59	$14.67	$ 15.42		
NOV	$ 12.92	$ 14.89	$ 14.68	$ 13.67	$15.32	$ 15.41		
DEC	$ 10.66	$ 14.54	$ 13.71	$ 13.67	$16.43	$ 15.50		
Average yearly price		**$ 14.54**		**$ 13.67**		**$ 15.50**		

Source: All averages derived from unpublished monthly reports by the Energy Information Administration, except that averages in bold print in 1996 are estimated from various unpublished bulletins listing posted prices.

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

Table 7. Monthly oil production from Wyoming in barrels (1993 to present).

	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative
JAN	7,616,208	7,616,208	7,115,472	7,115,472	6,700,000	6,700,000	6,142,360	6,142,360
FEB	6,583,954	14,200,162	6,387,147	13,502,619	6,100,000	12,800,000	5,672,615	11,814,975
MAR	7,690,771	21,890,933	6,984,248	20,486,867	6,300,000	19,100,000	6,156,106	17,971,081
APR	7,355,334	29,246,267	6,672,207	27,159,074	6,200,000	25,300,000	5,948,804	23,919,885
MAY	7,533,207	36,779,474	6,847,709	34,006,783	6,300,000	31,600,000	5,996,987	29,916,872
JUN	7,307,445	44,086,919	6,594,914	40,601,697	6,200,000	37,800,000	5,864,761	35,781,633
JUL	7,572,346	51,659,265	6,773,956	47,375,653	6,300,000	44,100,000		
AUG	7,370,091	59,029,356	6,685,423	54,061,076	6,100,000	50,200,000		
SEP	7,162,224	66,191,580	6,446,719	60,507,795	6,300,000	56,300,000		
OCT	7,374,889	73,566,469	6,525,817	67,033,612	6,300,000	62,600,000		
NOV	6,897,568	80,464,037	6,257,924	73,291,536	6,100,000	68,700.000		
DEC	7,203,163	87,667,200	6,236,204	79,527,740	6,300,000	75,000,000		
Total Barrels Reported[1]		87,667,200		79,527,740		75,000,000		
Total Barrels Not Reported[2]		1,233,006		651,400		554,113		
Total Barrels Produced[3]		88,960,236		80,179,140		75,554,113		

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

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

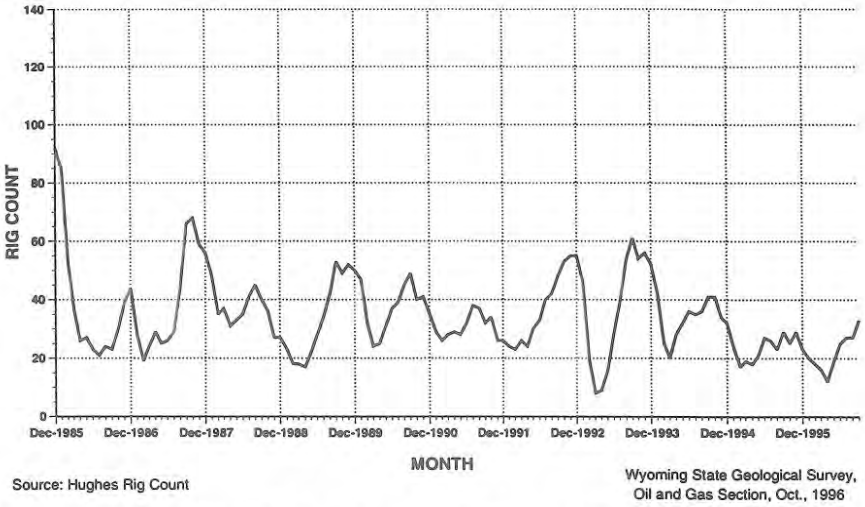


Figure 11. Wyoming daily rig count averaged by month (1986 to present).

KN Energy has begun work on its Pony Express natural gas pipeline. They are converting an existing, crude oil pipeline, formerly owned by Amoco, into a natural gas pipeline that will transport gas from as far west as the gas fields in the Wind River Basin to as far east as Freeman, Missouri. As part of the project, KN is laying 114 miles of 12-inch crude oil pipeline from Casper to Fort Laramie, Wyoming. This new line will enable Amoco to continue shipping oil between these two points. KN is also purging the former Amoco line of any residual crude oil and conducting tests of the line prior to using it for delivery of natural gas. KN expects to place the line in service by early 1997. Initially, the company expects to transport about 60 million cubic feet of gas per day (21.9 billion cubic feet per year). The pipeline should have a capacity of 255 million cubic feet of gas per day (93.1 billion cubic feet per year) by August of 1997.

Preliminary production figures from Petroleum Information, Inc. show natural gas production in Wyoming during the first six months of 1996 at 581.6 billion cubic feet. This production is the highest total ever in the first half of a year (**Table 8**). **Figure 4** shows natural gas production for Wyoming has increased every year since 1986. Spot sale prices for natural gas at Opal, Wyoming, were also higher during the third quarter of 1996 than in the third quarter of 1995 (**Table 9** and **Figure 6**). The average spot sale price through September of this year was $1.16 per thousand cubic feet compared to $1.09 at the same time last year (**Table 9**). The higher price this year is attributed to increased demand for filling storage, which was depleted by last winter's harsh weather.

The BLM approved, with stipulations, the Fontenelle Natural Gas Infill Project. This is a very large project in southwestern Wyoming, which could lead to the drilling of 1,300 new gas wells in Lincoln and Sweetwater Counties over the next 10 years. The Petroleum Association of Wyoming and six of its member companies,

Table 8. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1993 to present).

	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative
JAN	88,172,339	88,172,339	93,146,775	93,146,775	100,224,249	100,224,249	101,437,625	101,437,625
FEB	80,726,687	168,899,026	85,623,666	178,770,441	86,691,577	186,915,826	96,153,851	197,591,476
MAR	88,920,212	257,819,238	94,388,052	273,158,493	94,344,991	281,260,817	103,433,611	301,025,087
APR	86,208,224	344,027,462	92,362,726	365,521,219	93,929,323	375,190,140	99,300,635	400,325,722
MAY	87,857,947	431,885,409	93,886,923	459,408,142	95,791,327	470,981,467	97,652,309	497,978,031
JUN	74,555,764	506,441,173	81,764,661	541,172,803	92,140,614	563,122,081	83,748,520	581,726,551
JUL	91,832,536	598,273,709	94,998,414	636,171,217	92,796,301	655,918,382	95,259,055	676,985,606
AUG	91,562,051	689,835,760	93,743,790	729,915,007	90,393,416	746,311,798		
SEP	90,580,094	780,415,854	88,476,703	818,391,710	92,589,092	838,900,890		
OCT	93,388,208	873,804,062	95,232,646	913,624,356	98,386,458	937,287,348		
NOV	88,046,821	961,850,883	95,312,491	1,008,936,847	94,939,660	1,032,227,008		
DEC	90,133,281	1,051,984,164	87,115,084	1,096,051,931	99,314,617	1,131,541,625		
Total MCF Reported[1]		**1,051,984,164**		**1,096,051,931**		**1,131,541,625**		
Total MCF Not Reported[2]		**2,715,623**		**6,879,705**		**6,448,396**		
Total MCF Produced[3]		**1,054,699,787**		**1,102,931,636**		**1,137,990,021**		

[1] Monthly production reports from Petroleum Information.
[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, 1996.

Table 9. Monthly average spot sale price of a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1993 to present).

	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative	1995 Monthly	1995 Cumulative	1996 Monthly	1996 Cumulative
JAN	$ 2.25	$ 2.25	$ 1.90	$ 1.90	$ 1.40	$ 1.40	$1.25	$1.25
FEB	$ 1.60	$ 1.93	$ 1.80	$ 1.85	$ 1.10	$ 1.25	$1.20	$1.23
MAR	$ 1.80	$ 1.89	$ 1.95	$ 1.88	$ 1.05	$ 1.18	$1.20	$1.22
APR	$ 1.80	$ 1.87	$ 1.60	$ 1.81	$ 1.05	$ 1.15	$1.05	$1.18
MAY	$ 2.30	$ 1.96	$ 1.60	$ 1.77	$ 1.10	$ 1.14	$0.95	$1.13
JUN	$ 1.70	$ 1.91	$ 1.35	$ 1.70	$ 1.15	$ 1.14	$1.10	$1.13
JUL	$ 1.60	$ 1.87	$ 1.45	$ 1.66	$ 1.00	$ 1.12	$1.20	$1.14
AUG	$ 1.70	$ 1.85	$ 1.45	$ 1.64	$ 0.90	$ 1.09	$1.25	$1.15
SEP	$ 1.90	$ 1.85	$ 1.35	$ 1.61	$ 1.05	$ 1.09	$1.20	$1.16
OCT	$ 1.80	$ 1.84	$ 1.20	$ 1.57	$ 1.05	$ 1.09		
NOV	$ 1.80	$ 1.84	$ 1.50	$ 1.56	$ 1.25	$ 1.10		
DEC	$ 2.40	$ 1.89	$ 1.60	$ 1.57	$ 1.30	$ 1.12		
Average yearly price		**$ 1.89**		**$ 1.57**		**$ 1.12**		

Source: American Gas Association's monthly reports.

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

however, have filed an appeal against the BLM's stipulations regarding the emissions of nitrous oxide. The companies are concerned that the cap imposed on these emissions could restrict development of natural gas resources in the Greater Green River Basin. The State of Wyoming has also appealed the decision.

Cross Timbers Oil Co. plans to increase production from its newly acquired properties in Fontenelle, Nitchie Gulch, and Pine Canyon Fields by drilling 30 wells over the next three years and another 50 wells over the life of the field. Cross Timbers purchased the properties from Ensearch Exploration for $40 million. The current production is 12.6 million cubic feet per day.

In the third quarter of 1996, there was only one oil and gas lease sale: the BLM's August sale. The majority of the parcels offered at this sale were located in the Powder River Basin (**Figure 12**). The BLM sale was a fairly good one in that total revenue was the highest since the October, 1995, sale, even though there were fewer parcels offered for lease than normal (**Table 10**). The average price per acre was the highest since the December, 1994, sale. The sale's high per-acre bid of $145 was made by Celsius Energy Co. for a 280-acre parcel that covers portions of sections 9 and 10, T23N, R112W (location A, **Figure 12**). The lease is on the Moxa arch and is less than a mile northwest of gas and condensate production at

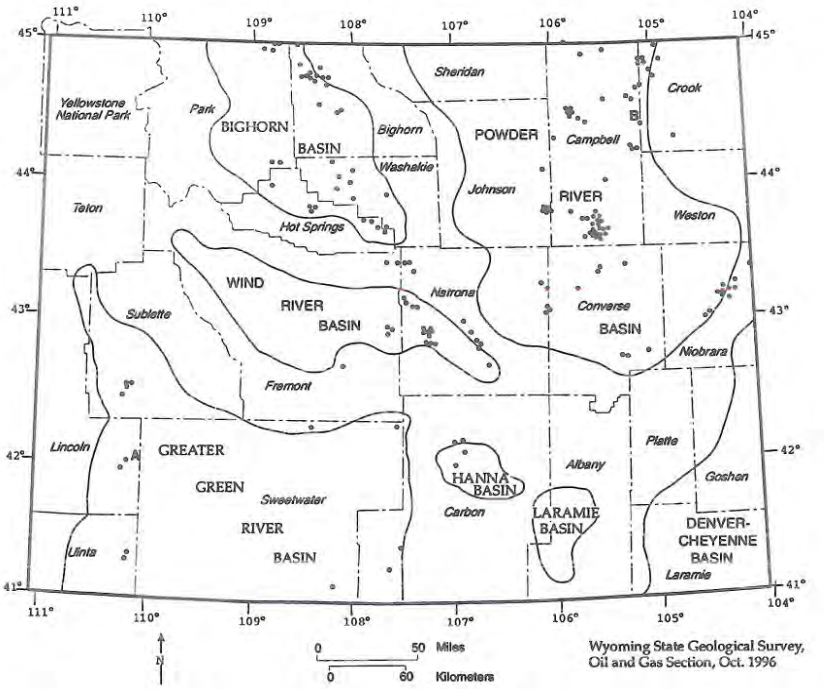


Figure 12. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the August, 1996, sale.

Table 10. 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				
February	$3,909,085	442	290	374,969	237,761	$16.44	$160.00
April	$4,248,182	498	278	369,657	201,690	$21.06	$275.00
June	$3,759,282	480	270	417,447	233,664	$16.09	$325.00
August	$5,100,550	439	294	323,410	217,157	$23.49	$255.00
October	$4,703,706	492	341	411,117	269,003	$17.49	$11,200.00
December	$5,386,789	617	367	479,930	290,384	$18.55	$390.00
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.00
			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

STATE SALES (STATE LAND AND FARM LOAN OFFICE)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1993				
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
			1994				
March	$917,380	200	169	84,571	73,061	$12.56	$170.00
May	$802,688	200	141	75,523	54,199	$14.81	$205.00
September	$586,083	200	149	83,143	61,675	$ 9.50	$190.00
November	$998,001	200	148	88,542	66,217	$15.07	$142.00
TOTAL	$3,304,152	800	607	331,779	255,152	$12.95	$205.00
			1995				
March	$524,165	199	131	89,371	57,702	$9.08	$130.00
May	$452,747	200	125	75,633	49,735	$9.10	$78.00
September	$421,454	200	134	78,032	53,527	$7.87	$65.00
November	$257,852	200	102	80,851	41,744	$6.18	$52.00
TOTAL	$1,656,218	799	492	323,887	202,708	$8.17	$130.00
			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

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

Emigrant Springs Field. Westech Energy made the sale's second highest per-acre bid of $140 for a 39.87-acre lease that covers lot 14 of section 27, T51N, R69W (location B, Figure 12). The lease is about a mile from Minnelusa oil production in Garner Lake Field and from Minnelusa and Muddy oil production in Windmill Field. There were 31 tracts at this sale that received per-acre bids of $50 or more.

Applications for Permit to Drill (APDs) picked up in July from the low levels in the first two quarters of this year. APDs through August 5, 1996, are now at 470 (Table 11). APDs in 1996 should exceed the number issued in 1995 and may even exceed the number issued in 1993 and in 1994.

Until this year, the number of seismic projects permitted by the Wyoming Oil and Gas Conservation Commission had been dropping steadily since 1992 (Table 12). Permits issued in the first three quarters of 1996 have already surpassed the

Table 11. 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[1] APDs
Albany	0	0	1	1
Big Horn	13	3	16	27
Campbell	129	102	151	107
Carbon	35	134	50	38
Converse	37	75	29	9
Crook	29	9	15	19
Fremont	16	46	30	9
Goshen	0	0	0	0
Hot Springs	12	4	13	2
Johnson	18	16	6	12
Laramie	37	15	10	0
Lincoln	136	103	64	16
Natrona	36	63	80	48
Niobrara	5	4	4	3
Park	22	18	20	20
Platte	0	2	0	0
Sheridan	7	3	0	0
Sublette	80	111	61	55
Sweetwater	158	205	153	76
Teton	0	0	0	0
Uinta	49	11	11	5
Washakie	17	12	31	17
Weston	23	6	10	6
TOTALS	**859**	**942**	**755**	**470**

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
[1]Numbers for 1996 are through August 5th.

Table 12. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1993 to present).

County	1993			1994			1995			1996[1]		
	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	0	0	0	1	18	0
Big Horn	0	0	0	5	24	4	1	16	0	1	3	0
Campbell	24	134	29	13	17	50	12	24	43	29	44	217
Carbon	8	115	0	11	117	86	1	0	16	2	5	18
Converse	4	26	0	0	0	0	4	39	20	1	4	0
Crook	5	21	0	3	3	2	1	0	5	5	3	20
Fremont	6	38	62	6	12	104	6	32	56	1	5	0
Goshen	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	1	0	2	1	9	0	2	70	9	4	17	29
Johnson	1	20	0	0	0	0	1	4	0	0	0	0
Laramie	1	67	0	3	57	0	0	0	0	0	0	0
Lincoln	3	27	50	0	0	0	2	18	110	0	0	0
Natrona	3	20	0	1	0	17	3	27	3	0	0	0
Niobrara	0	0	0	1	0	11	0	0	0	1	0	5
Park	5	54	55	1	0	7	0	0	0	5	20	76
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	0	0	0	0	0	0	1	5	0
Sublette	0	0	0	5	4	145	2	0	162	2	17	52
Sweetwater	9	117	187	4	59	0	9	17	497	8	10	670
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	0	0	0	2	0	89	0	0	0	0	0	0
Washakie	4	17	6	0	0	0	0	0	0	0	0	0
Weston	0	0	0	0	0	0	1	13	0	0	0	0
TOTALS	**74**	**656**	**391**	**56**	**302**	**515**	**45**	**260**	**921**	**61**	**162**	**1087**

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

[1]Numbers for 1996 are for the first three quarters of the year.

number of permits issued in 1995 and in 1994. Once again the seismic projects and miles permitted so far in 1996 are concentrated in counties in the Powder River and Greater Green River Basins.

Late in the third quarter, the Wyoming State Geological Survey published the Oil and Gas Section's newly prepared *Oil and Gas Map of Wyoming* (Map Series 48). This 1:500,000-scale map shows the locations and areal extents of over 1,400 active and abandoned oil and gas fields. While all of the productive reservoirs are listed for each field, the fields are color-coded by the predominant age of their reservoir rocks. The map also shows the locations of pipelines and the type of fluids they transport, as well as the location and capacities of natural gas plants and refineries. This is the most detailed published map available for Wyoming, which shows both field and pipeline information.

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 1996. The numbers preceding the discussions below refer to locations on **Figure 13**.

1. Union Pacific Resources reported additional details on its recently completed Phosphoria gas producer in Yellow Creek Field. The 11-3 Yellow Creek Deep well in NW NW section 11, T14N, R121W initially flowed 11.0 million cubic feet of sour gas, 5 barrels of condensate, and 14 barrels of water per day through perforations from three zones between 12,068 and 12,480 feet. During June, the well produced an average of 8.4 million cubic feet of gas, 141 barrels of condensate, and 267 barrels of water per day. In a little over three months, this well has produced 12,305 barrels of condensate and 837.8 million cubic feet of gas. The gas is processed at Amoco's Whitney Canyon gas plant and is transported through the recently-completed Wahsatch [sic] gathering system.

2. Meridian Oil has plans to drill 40-50 development wells in the area of Baggs South Field according to a U.S. Bureau of Land Management (BLM) scoping statement. Targeted reservoirs include the Fort Union, Lance, Lewis, and Mesaverde.

3. An experimental well, operated by FMC Corporation and drilled to test the effects of trona mining on the casing in an oil or gas well, has been completed as a producing gas well in the Green River Formation. The well was drilled to a total depth of 1,672 feet in section 1, T18N, R110W and initially flowed gas at the rate of 150,000 cubic feet per day during testing. The gas was produced from an open hole interval between 1,560 and 1,670 feet. The well is currently shut-in awaiting a pipeline connection. There is presently no production in the Green River Formation in Wyoming, so this well may initiate other shallow tests in this area. Analyses of the gas show that it is over 93% methane, that it was generated by different source rocks

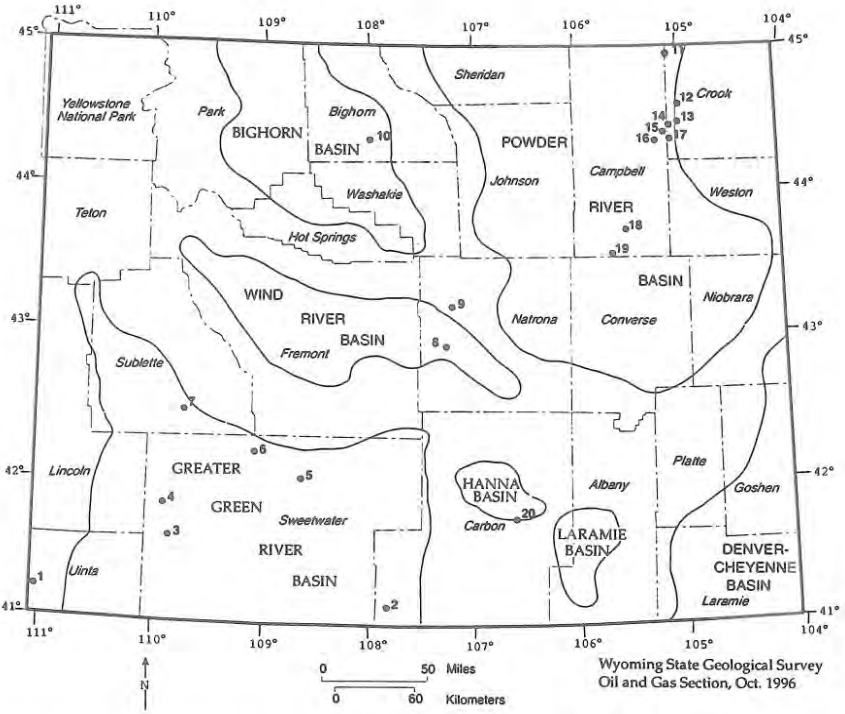


Figure 13. Oil and gas exploration and development activities in Wyoming during the third quarter of 1996 (exclusive of coalbed methane activities).

than the deeper gas that is produced in this basin, and that it is biogenic. Oil shale is one speculated source for this shallow gas.

4. Celsius Energy completed its 1 Seedskadee Federal Unit well in NE NW section 26, T21N, R110W as a Frontier gas discovery. The well initially flowed 622,000 cubic feet of gas per day from perforations between 13,328 and 13,348 and 13,357 and 13,371 feet.

5. BTA Oil Producers completed their 6 Bravo Unit 9219JV-P well in SW NE section 10, T23N, R99W as a Lewis producer. The well flowed 2.1 million cubic feet of gas and 60 barrels of condensate per day from between 6,748 and 6,804 feet.

6. HS Resources completed its 11-7 HSR-Big Bear well in NE SW section 7, T25N, R102W as a Rock Springs Formation discovery. The well pumped 23 barrels of oil, 116,000 cubic feet of gas, and one barrel of water per day from perforations between 7,938 and 7,958 feet.

7. Snyder Oil sold 50 percent of its interest in Jonah Field to Amoco. McMurray, Snyder, and Amoco plan to drill 150-450 natural gas wells to the Lance Formation over a 10-year period. The wells will be up to 12,000 feet in depth.

8. Barrett Resources completed a stepout from Wallace Creek Field. The 9 Wallace Creek Unit well in NW NW section 26, T34N, R87W flowed 3.5 million cubic feet of gas per day from the Muddy between 10,838 and 10,896 feet. The well is half a mile from the nearest producer in Wallace Creek Field.

9. Activity continues in the Waltman Field area. Barrett Resources completed another producer in its Cave Gulch Unit. The 11 Cave Gulch Unit well in NW SE section 30, T37N, R86W flowed 7.2 million cubic feet of gas and 80 barrels of condensate per day from the Lance between 6,904 and 8,202 feet. Barrett also recompleted its 13 Cave Gulch Federal Unit well in SW NW section 32, T37N, R86W. The well flowed 13.5 million cubic feet of gas, 125 barrels of condensate, and 45 barrels of water from the Lance between 5,770 and 8,806 feet. Barrett also completed its 15 Cave Gulch well in NE NE section 31, T37N, R86W. The well produced an average of 960,000 cubic feet of gas, 11 barrels of condensate, and 6 barrels of water per day during its first eight days on line. The well established the Mesaverde as a new pool in Waltman Field. The producing interval was not reported. W.A. Moncrief Jr. also completed a Lance producer in Waltman Field. The 30-1 Cave Gulch Federal Unit well in SW NE section 30, T37N, R87W had an initial flowing potential of 5.6 million cubic feet of gas, 72 barrels of condensate, and 175 barrels of water per day from between 5,965 and 9,099 feet.

10. KCS Energy completed several Phosphoria wells in Manderson Field. The 12-18P Manderson well in SW NW section 18, T50N, R92W flowed 1,940 barrels of oil and 3.8 million cubic feet of gas from an unreported interval. According to KCS, the well has other potential pays in the Muddy, the "Octh Louie" sand in the Mowry, the Dakota, and the Frontier. The 34-18P Manderson Unit well in SW SE section 18, T50N, R92W was completed for an initial pumping potential of 208 barrels of oil, 30,000 cubic feet of gas, and 42 barrels of water per day from an open hole interval between 7,339 and 7,431 feet. The 11-33 Manderson Unit well in NW NW section 33, T50N, R92W was completed for an initial pumping potential of 195 barrels of oil, 58,000 cubic feet of gas, and 3 barrels of water per day from an open hole interval between 6,962 and 7,052 feet. Production from these four new Phosphoria wells is constrained until equipment is installed to process the sour gas. Before the end of the year, KCS plans to complete as many as 25 Phosphoria producers as well as several other wells to test other prospective reservoirs.

11. Cam West Limited Partnership intends to drill its second horizontal Minnelusa well in Rocky Point Field. The 2H Federal-McMillan well in NW SW section 35, T57N, R69W will be drilled to a true vertical depth of 5,436 feet. The company has reached total depth at its 1H Federal-McMillan horizontally-

drilled well in SW SW section 35, T57N, R69W. No other details are available.

12. Plains Petroleum completed a Minnelusa producer in Cambridge Field. The 33-28 Cambridge Unit well in NW SE section 28, T53N, R68W produced 146 barrels of oil during its first day on line.

13. Flying J Oil and Gas is still evaluating an apparent Minnelusa discovery at its 1-5 Glenn-Federal well in NE NE section 5, T51N, R68W. The well has produced about 4,000 barrels of oil on tests, but has not been completed at a stabilized rate of production. No other details are available.

14. Swift Energy discovered oil at its 1 Jones-Federal 42-13 well in SE NE section 13, T51N, R69W for an initial pumping potential of 78 barrels of oil and 5 barrels of water per day from between 7,630 and 7,634 feet in the Minnelusa.

15. Conley P. Smith discovered oil at its 32-3 Charlotte well in NE NE section 32, T51N, R69W. The well flowed 160-170 barrels of oil per day during tests of an undisclosed Minnelusa interval. The new discovery is about a half mile north of Minnelusa and Muddy production at Windmill Field.

16. Plains Petroleum Operating completed a new Minnelusa producer in Rozet Field. The 21-14 Plains-Federal well in NE NW section 14, T50N, R70W pumped 214 barrels of oil and 19 barrels of water per day from an unreported interval.

17. Anderson Oil has an apparent Minnelusa discovery at its 44-13 Anderson well in SE SE section 13, T50N, R69W. During swab tests, 447 barrels of oil and 135 barrels of water were recovered. The producing zone is between 7,912 and 7,930 feet.

18. Yates Petroleum completed a new well in Tuit Draw Field. The 1 Cosner well in C NE section 19, T43N, R72W produced an average of 609 barrels of oil and 17 barrels of water during its first two days on line. The well is producing from the Turner between 10,172 and 10,176 feet.

19. Kerr-McGee completed a horizontally-drilled producer in North Buck Draw Field. The 32-19 North Buck Draw Unit well in SW NE section 19, T41N, R73W flowed 168 barrels of oil and 444,000 cubic feet of gas per day from a horizontal leg at 12,882-13,914 measured depth.

20. Union Pacific Resources began drilling a 12,500-foot Nugget test on the southern flank of the Hanna Basin. The 1-10 Hanna-Federal well is in C SW section 10, T20N, R82W. The nearest Nugget production is at Hatfield, about 35 miles to the southwest. Overland Dome Field, about 10 miles to the southwest, produces from the Niobrara and the Frontier.

A new report on the Hanna Basin has been published by the Wyoming State Geological Survey. Public Information Circular 36 was written by J.A. Lillegraven and A.W. Snoke, and is titled, *A new look at the Laramide orogeny in the Seminoe and Shirley mountains, Freezeout Hills, and Hanna Basin, south-central Wyoming.* This report reflects some new structural and tectonic interpretations that could be of use in exploring for oil and gas in these areas of Wyoming. See p. 56-57 for ordering instructions.

COAL UPDATE

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

Tables 1, 2, 3, and 5 and **Figures 7 and 10** in the **Overview** portion of this issue of *Wyoming Geo-notes* reflect the most current coal production and price forecasts for Wyoming.

As mentioned last quarter, a number of eastern and midwestern states have enacted or are proposing legislation to protect their coal mining industry from western producers such as Wyoming (*Wyoming Geo-notes No. 51*, p. 30-31). In the third quarter, the Illinois General Assembly enacted legislation to remove the 6.25% state sales tax from purchases of coal mining equipment and spare parts valued at less than $250. Mining equipment over $250 had already been exempted from their sales tax. The Alliance for Clean Coal, a coalition of western coal producers and railroads, continues to monitor these new laws and is challenging similar legislation in Ohio.

In Kentucky, the governor is proposing a special session of the legislature to consider giving the coal industry a $40 million tax break on workers compensation. Monies would be diverted from coal severance taxes to cover the tax break.

The Union Pacific-Southern Pacific (UP-SP) Railroad now has access to the Superior Midwest Energy Terminal on Lake Superior. This connection not only allows the UP-SP to compete with the Burlington Northern/Santa Fe for transport of coal from Powder River Basin mines, but it also makes it possible for coal from the Hanna Basin to reach this important terminal.

In a related matter, export coal from the Powder River Basin of Wyoming recently moved through the Superior Midwest Energy Terminal. The coal was bound for the Spanish utility, Endesa. Coal for this market usually goes through terminals on the lower Mississippi River.

At the Federal level, the Surface Transportation Board (STB), which recently authorized construction of the new Tongue River Railroad in Montana, has approved the addition of another 41 miles of trackage to the proposed rail route. Construction of this $225 million project is expected to take two years beyond completion of the final engineering phase, which is in progress. The new 130-mile-line will run from Miles City through Ashland to Decker, opening new Montana coal reserves on the Northern Cheyenne Indian Reservation, on Wesco's Montco prop-

erty, and on the Otter Creek project. The STB, however, has only given Tongue River three years in which to complete the line.

Developments in the Powder River Basin

Early in the quarter, Western Fuels Association (WFA) announced they might buy some third-party coal to displace some of the production from their Dry Fork mine. In late October, that became a reality, causing Dry Fork Coal Co. to lay off 38 of its 45 workers. A WFA official indicated this decision was not only a move to preserve the Dry Fork reserves until the market strengths, but also a chance to capitalize on the current low prices available on the spot market. Dry Fork had been one of several mines providing coal to Basin Electric's 1,710-megawatt (1,710-MW) Laramie River Station at Wheatland, Wyoming. For at least the time being, the Dry Fork mine will remain idled.

Last quarter, Peabody Holding Co. announced that it had begun posting some of its coal prices on the internet. The prices were for short-term subbituminous coal from its four Wyoming mines in the Powder River Basin (PRB). Utility sources have indicated that Peabody's posted prices varied from a low of $3.10 per ton for their lower Btu coal to $4.15 per ton for their higher heat value coal. All prices were quoted FOB the mine.

Wyodak Resources Development, the mining subsidiary of Black Hills Corporation, recently agreed to buy a significant part of Kerr-McGee Coal's reserves and mining facilities at the Clovis Point mine. This property is immediately adjacent to Wyodak's mine in Campbell County. Kerr-McGee will retain some of the reserves located adjacent to the Dry Fork and Fort Union mines. The Clovis Point mine only produced 800,000 tons of coal from 1994 to mid-1996. This was enough production to satisfy due diligence requirements on this Federal lease. Wyodak also agreed to reclaim an existing open pit and to pay overriding royalties to Kerr-McGee when coal is produced from the purchased property. The purchase will increase Wyodak's reserves to 300 million tons by adding 127 million tons of reserves to Wyodak's current 173 million-ton-reserve. This purchase will apparently require Federal approval of a new logical mining unit.

The U.S. Bureau of Land Management (BLM) recently rejected Kennecott Energy's bid of $6.64 million (11 cents/ton) for 60 million tons of coal reserves located next to their Antelope mine. BLM officials determined the offer did not meet fair market value. Kennecott will have another opportunity to submit an acceptable bid for the reserves, probably in November. After that, their lease application may be placed behind five other pending applications (*Wyoming Geo-notes No. 51*, p. 30).

In a related item, the BLM has decided to prepare a single Environmental Impact Statement (EIS) for two pending Federal coal lease sales, which include a combined total of almost one billion tons of coal. Powder River Coal Co. and Kerr-McGee Coal had hoped for separate EISs so that problems with one or the other of the tracts would not hold up a decision on the other (*Wyoming Geo-notes No. 51*, p.

30). BLM officials feel this concern can be addressed by issuing separate decision orders for each of the tracts.

The BLM recently announced that coal unsuitability criteria have been amended to allow Cyprus-Amax Coal and Wyodak Resources to expand portions of their mines. These expansions are located within a buffer zone around the city of Gillette. City officials supported the BLM's decision.

Zeigler Coal Holding announced intentions to delay development of Triton Coal Co.'s North Rochelle mine by about six months. This decision was apparently a result of the low prices currently quoted for PRB coal. The mine is now scheduled to open in late 1998 or early 1999. Western Farmers Electric Cooperative of Oklahoma is still slated as a major customer of the new mine, and will use this source of low-sulfur coal to bring their 400-MW Hugo plant into compliance with Phase 2 of the 1990 Clean Air Act. Zeigler's 1.5-million-ton per year contract with Western Farmers has been extended to 2011. Since the contract specifies that the coal must come from the North Rochelle mine, the extension apparently begins with the opening of that mine. Currently, Zeigler's Buckskin and Cyprus-Amax's Belle Ayr mines are supplying coal to the Hugo plant, but the Buckskin contract ends this year.

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

Goldman Sachs was recently retained by Drummond Coal Co. to evaluate their Caballo Rojo and Fort Union mine holdings in the PRB. The properties may be sold, retained, or become part of a joint venture, depending on Sachs' evaluation. While the Caballo Rojo mine produced 16.8 million tons in 1995 and has a permitted capacity of 30 million tons per year, production from the Fort Union mine was only 450 tons. This small tonnage was designed to meet its minimum lease obligations. The Fort Union mine has a permitted capacity of 9.5 million tons per year (*Wyoming Geo-notes No. 50*, p. 32). Industry sources believe Drummond may already have received some bids on its Caballo Rojo mine.

Officials of KFx, Inc. indicate their K-fuel plant should be operational by the fourth quarter of 1996. The plant, which is located at Drummond Coal Co.'s Fort Union mine, is designed to produce a low-moisture, high-Btu fuel from subbituminous coal. KFx's plant will turn 700,000 tons of coal per year into 500,000 tons of K-fuel. American Electric Power's Ohio Valley Electric Co. has a contract to take approximately one-third of the plant's output over the next three years. KFx believes this premium product can compete with eastern coal at a cost up to $25 per ton. While the construction phase of the plant will employ as many as 150 people, the plant will operate with about 20 workers after it is completed.

Officials from the Land Quality Division of the Wyoming Department of Environmental Quality are urging developers of coal-upgrading plants to move more quickly on their projects if they want to take advantage of an 18-month extension of eligibility for the Section 29 tax credit. Plants can take a year or more to build and an additional 5-6 months may be needed for the approval of necessary permits. In addition to the KFx plant mentioned above, both CarbonTec Energy and Encoal Corporation had been considering plants at Drummond's Caballo Rojo mine and Zeigler Coal Holding's North Rochelle mine, respectively. It is unclear what effect the possible sale of Drummond's holdings in Wyoming might have on the KFx or Carbontec plants.

The Air Quality Division of the Wyoming Department of Environmental Quality has approved capacity expansions for Kennecott Energy's Antelope mine and for Zeigler Coal Holding's North Rochelle mine. The Antelope mine's permitted capacity increased from its current 12 million tons to 30 million tons per year. Permitted capacity at the North Rochelle mine has increased from its present 8 million tons to 20 million tons per year. ARCO's application to increase the capacity of its Black Thunder mine to 55 million tons per year is still pending. This mine is currently permitted at 44 million tons (*Wyoming Geo-notes No. 50*, p. 32).

Developments in southern and western Wyoming

Arch Minerals Corporation has filed an application to lease 3,984 acres of Federal coal lands, which are adjacent to the Carbon Basin properties it purchased from Commonwealth Edison (Edison Development) in June of this year. Arch has indicated it may strip mine coal from these purchased fee lands while the Federal leasing process continues. The extent and timing of this new mining operation will be governed by the speed at which the coal reserves at the Seminoe II and Medicine Bow mines are depleted. According to a company spokesman, Medicine Bow could be mined out next year, while Seminoe II has at least a few years of production left.

Arch's Carbon Basin property is south and east of the Hanna Basin. The property contains an estimated 100 million tons of reserves, a large percentage of which are too deep for surface mining. The major coals are the Finch and Johnson beds, which are up to 12 and 32 feet thick, respectively.

Black Butte Coal recently indicated it will have to cut back production at its Black Butte mine. This followed Sierra Pacific Power and Idaho Power's decision to buy out their 1996 and 1997 contracts with Black Butte. This coal was going to the 521-MW North Valmy plant in Nevada. Fifty-three of the 167 workers that Black Butte now employs will be laid off as a result of the contract buy-out. Since the original contract with Black Butte ran through mid-2007, it is unclear what will happen in regard to contract tonnage beyond 1997.

Over the last two years, it appears that the use of low-cost natural gas, coupled with abundant hydropower, has reduced North Valmy's coal needs. North Valmy used about 0.7 million tons of Wyoming coal in 1995. Competition following de-

regulation of the electric utility industry was also a factor in Sierra Pacific's decision to buy out the contract.

Pittsburg and Midway Coal Mining (P&M) is moving to expand markets and production of coal from their Kemmerer mine. The company has already applied to increase its permitted capacity to 5.5 million tons of coal per year, up from its current 4.2 million tons per year. The Kemmerer mine markets its coal to PacifiCorp's Naughton power plant and to other customers in Wyoming and Idaho.

FMC Corporation is reportedly negotiating the sale of its Skull Point mine to P&M. This open pit mine is located south of P&M's Kemmerer mine. Although most of the coal from Skull Point now goes to FMC's own coking or other industrial facilities, the mine has sold some stoker coal to outside users.

Power plants

PacifiCorp has decided not to buy any coal under its May solicitation for one million tons of Powder River Basin (PRB) coal. They had anticipated the need for coal at the Dave Johnson plant beginning in October and continuing through next year. The company said down-time related to major repairs on the plant and less than anticipated demand reduced their coal needs for the year.

Southern Company Services has announced that Alabama Power's 2,640-MW Miller plant will convert its 1st and 2nd units to accept PRB coal. With these conversions, all four units will be capable of using PRB coal. The conversions, however, will not alter the ability of all four units to burn either eastern bituminous or western subbituminous coals. Southern's timing coincides with the 1999 expiration of a long-term, 4-million-ton per year contract with Jim Walter Resources. While Alabama Power already has offers to supply the coal needs of the Miller plant after 1999, they have not made any firm decisions on their course of action. Cyprus-Amax's Belle Ayr mine is currently providing an unspecified tonnage of PRB coal to the 4th unit under a 3-year contract (*Wyoming Geo-notes No. 51*, p. 35). Other PRB producers are providing additional coal needs on the spot market. An official of Alabama Power said transportation considerations were preventing the company from switching other plants to PRB coal.

Wisconsin Electric Power Co. (WEPCO) has gone to a lower sulfur blend of eastern and PRB coals at its 1,192-MW Oak Creek plant in southeastern Wisconsin. The blend contains 30-50% PRB coal from Kennecott Energy's Antelope mine. The blend may be altered again in 1998 to further reduce sulfur emissions. Although this plant is already in compliance with Phase 2 of the 1990 Clean Air Act, WEPCO's overall system will not be compliant due to expected load growth.

Central Illinois Light announced its intentions to resume testing of western bituminous and PRB subbituminous coals at Unit No. 2 of its Edwards plant at Bartonville, Illinois. This plant is rated at 780-MWs.

Test burns of PRB coal at Centerior Energy's Bay Shore (Cleveland Electric Illuminating Co.) and Lakeshore 18 (Toledo Edison Co.) plants have been com-

pleted. The Bay Shore plant tested a 25% PRB and 75% Appalachian coal blend and is now ready to try a 40%/60% blend. The PRB coal was supplied by Venture Fuels, a joint venture of Kennecott Energy and Midwest Energy Services.

Northern Indiana Public Service Co. (NIPSCO) plans to double the amount of low-sulfur PRB coal it blends with Illinois Basin coal at its 480-MW Bailly plant. The new blend will be 20% PRB coal. NIPSCO has made the change in an effort to reduce sulfur emissions from the power plant. Thunder Basin Coal Co.'s Black Thunder mine provided 32,300 tons of coal used in the blend between March and May.

There is a possibility that Public Service Company of Colorado (PSCCO) will switch three of their Denver area power plants (the 230-MW Arapahoe, 710-MW Cherokee, and 166-MW Valmont plants) to PRB coal. A second test burn at the Arapahoe plant went well, with a third test planned for next year. The Cherokee plant will also test burn a PRB coal late this year or next year. So far, coal from Kennecott Energy's Antelope mine, Peabody's North Antelope mine, and ARCO Coal's Black Thunder mine have been tested. PSCCO's current Colorado contracts limit how much switching can occur. While a 1.7-million-ton per year contract for Colorado coal from Cyprus-Amax expires next year, PSCCO's Colorado coal contract with ARCO runs through 2001. In 1997, shifting of these two contracts to other plants may allow PSCCO to convert the Arapahoe plant to PRB coal if they so choose.

Western Fuels Association's (WFA's) recent test burn of another PRB coal in Cajun Electric Power Cooperative's (CEPC's) 1,678-MW Big Cajun 2 plant went well. The tested coal came from Zeigler Coal Holding's North Rochelle mine. The Big Cajun 2 plant normally uses a lower Btu coal from Zeigler's Buckskin mine. However, a more competitive transportation rate for coal from North Rochelle may prompt a switch to that source once the North Rochelle mine is operational. The next contract reopener for Zeigler is apparently in 1998. Of note, Zeigler is one of the bidders for CEPC's assets, which are now in bankruptcy court.

Coal contracts and solicitations

Table 13 is a tabulation of some of the marketing opportunities for Wyoming coal producers in the third quarter of 1996.

Coalbed Methane

In August, the Wyoming Oil and Gas Conservation Commission (WOGCC) held a second public hearing on its concerns regarding the permitting, drilling, completion, and plugging of coalbed methane wells in Wyoming, especially in the Powder River Basin (PRB). As a result of the two hearings and submitted written comments, the Commission adopted a set of guidelines that addressed its concerns as well as most of the concerns brought out by the industry. Copies of these guidelines are available by contacting the office of the Wyoming Oil and Gas Conservation Commission at (307) 234-7147.

Following passage of the guidelines, coalbed methane operators in the PRB have submitted numerous Applications for Permit to Drill. These submittals followed the Commission's lifting of somewhat different interim guidelines.

Table 13. Marketing opportunities for Wyoming coal producers during the third quarter of 1996[1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	Commonwealth Edison	Unspecified plants	Rochelle	Sp	150,000 t	
2.	Consumers Power	Karn, Weadlock, Cobb, and Campbell	Unspecified PRB mine PRB coals	Sp So	325,000 t 0.5-1.5 million t	Delivery in 4th quarter, 1996. Delivery in 1997.
3.	Defense Fuel Supply Center	Veterans Administration Medical Center-Sheridan, Wyoming	Southern PRB coal	So	6,750 t	For delivery October through September, 1997.
4.	Kansas City Board of Public Utilities	Unspecified plants	PRB coals	So	800,000 t/y	Western Fuels Association is soliciting bids to fill a 4-year contract with escalators or one year of spot coal.
5.	Nevada Power	Reid Gardner	Southwest Wyoming, Utah, and Colorado	So	300,000-600,000 t/y	For delivery over a one- to-five year term, beginning in January, 1997.
6.	Northern Indiana Public Service Co.	Bailly	Powder River Coal Co.'s mines in PRB (?)	T	As needed	Will be blended with eastern coal.
7.	Northern States Power	Sherburne County units 1 & 2	Southern PRB coal	So, T	100,000 t	To date, Sherburne County has used PRB coals from Montana.
8.	Ontario Hydro	Unspecified plants	Low-sulfur coal, including PRB coal	So	Up to 2,000,000 t	For delivery through mid-December; has already tested PRB coals from Kennecott's and Peabody's mines in Wyoming.
9.	PacifiCorp Electrical Generation	Unspecified plants	PRB and other coals	So	0.5-3.5 million t	For one-, three- or five-year offerings.

Table 13. Marketing opportunities for Wyoming coal producers during the third quarter of 1996[1] *(continued)*.

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
10.	Public Service Company of Colorado	Arapahoe	PRB coals	So, T	500,000 t	For 8,600 Btu/lb coal to be delivered between mid-February and October 31, 1997.
11.	Public Service Company of Oklahoma	Northeastern	PRB coals	So	2.8-3.4 million t	Kerr-McGee Coal is making the solicitation, as they have the contract and will fill it with third party sources; minimum of 8,300 Btu/lb.
12.	Southern Co./Georgia Power	Scherer	Antelope	C	Up to 2 million t/y	For 8,800 Btu/lb and 0.2% sulfur coal, delivered over 5-year term (1997-2001).
13.	Southern Company	Miller and others	PRB and other coals	So	Tonnage variable	Six-year terms starting in September 1999; PRB specifications are for 8,400 Btu/lb compliant coal.
14.	Tennessee Valley Authority	Allen Gallatin	Medicine Bow/Seminoe II Black Thunder	T T	Portion of 23,500 t/wk Portion of 54,808 t/wk	In both cases, Wyoming coal will be blended with higher Btu western and Illinois Basin coal; for 1997 delivery.
15.	Texax Municipal Power Agency	Gibbons Creek	Black Thunder	Sp	1 million t	Delivery between October and next spring; option to purchase 15% more; the company is also continuing test burns of coal from at least seven PRB mines in Wyoming.
16.	Texas Utilities Electric	Monticello	PRB coals	So	Up to 2 million t/y	For 2 years beginning Jan.1, 1997; prefers 2-year offerings, but will accept 1-year offers.

Table 13. Marketing opportunities for Wyoming coal producers during the third quarter of 1996[1] *(continued)*.

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
17.	Western Farmers Electric Cooperative	Hugo	Belle Ayr	C	1.2 million t	A one-year contract for 1997.
18.	Wisconsin Power and Light	Unspecified plants	PRB coals	So	500,000 t/y or 800,000 t/y	Requesting a long-term offer on 0.5 million tons or a one-year offer on 0.8 million tons for delivery in 1997.

[1]Data obtained from : Coal Week©, Coal Outlook©, trade journals, periodicals, FERC database, and personal contacts.
C =contract coal; Sp =Spot coal; So =solicitation; T =Test burn; t =short ton; t/y =tons per year; t/wk =tons per week; PRB =Powder River Basin.
Wyoming State Geological Survey, Coal Section, October, 1996.

INDUSTRIAL MINERALS AND URANIUM UPDATE

Ray E. Harris
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Decorative and dimensional stone

At the end of the third quarter, an Italian stone producer initiated negotiations for the acquisition of two properties in Wyoming. One, near Manville, will be used for dimensional limestone. This property has been studied, mapped, and described by the Wyoming State Geological Survey (Harris, 1987). The second property, a light pink granite, is the McGinnis Pass locality described by the Wyoming State Geological Survey in its report on decorative stone localities in Wyoming (Harris, 1991, locality 20, p. 13). The producer may also follow-up on an anorthosite containing zoned iridescent plagioclase. This site has been recommended by a consultant working for the company.

The sandstone quarry south of Douglas, which was operated by Front Range Stone, has closed, and its owner, Sunrise Stone of Wheatland, is reclaiming the site. Stone from this quarry was sent to Disney World in Orlando, Florida.

Two years ago, large granite boulders were quarried from a locality in the Cooney Hills in Platte County for use in the landscaping of a large private property near Aspen, Colorado. Although the stones were quarried and paid for, they were never shipped, because the buyer changed his mind. Since then, these boulders have been stored at Abbott Construction's yard in Wheatland. This summer, another contractor from Aspen purchased most of these boulders on the recommendation of the original architect. The boulders are now in Aspen.

Trona

In Wyoming, trona is mined by underground methods at five locations west of Green River in Sweetwater County, and refined into sodium products at plants near the mines. Production in 1996 is expected to exceed last year's record (**Table 1**, p. 1).

The U.S. Bureau of Land Management (BLM) held its second trona lease sale of the year on September 27th. A total of eight separate tracts, containing more than 500 million tons of minable trona, were offered. The BLM accepted the sealed bids on six of the tracts: three went to Solvay Minerals, one to Church & Dwight, and two to Rock Springs Realty Company, a subsidiary of Union Pacific. The bids on two tracts were rejected as being below fair market value. The bonus bids on the accepted tracts totalled $24,725,000. Half of this money comes to the State of Wyoming, payable in equal five-year installments. At the earlier trona lease sale held in May, two tracts were leased for a total bonus of $2,297,250. That bonus payment was paid in full in July. The bid on a third tract was rejected.

These were the first and second sodium (trona) lease sales since 1986. Although the BLM has not announced a future lease sale, they are likely to offer the unleased tracts again. In regard to the second round of bidders, neither Church & Dwight nor Rock Springs Realty Company have announced any plans to mine trona or construct a sodium products plant.

According to the U.S. Geological Survey, the average year-end price for U.S. soda ash in 1995 was $74.50 per short ton (Kostick, 1996). This price is an average of all bulk dense soda ash (refined trona) sold at either list, off-list, discounted, or export prices. The list (spot sale) price of soda ash is the price offered to short-term buyers. The list price presently is $105 per short ton FOB Wyoming. Off-list prices are contractual prices offered to large volume, longer-term buyers. Four of the six producers in the U.S. announced five-dollar per ton increases effective October 1, 1996, on all off-list contracts for soda ash. Off-list soda ash prices are currently about $78 per ton, but the market is apparently softening. Kostick (1996) feels this softening will likely cause a decline in prices in the last half of the year. Consequently, off-list soda ash price may end the year at about $76 per ton, up only $1.50 from the 1995 price (Kostick, 1996).

Uranium

According to the Uranium Exchange, the unrestricted price of yellowcake on the spot market was $15.25 per pound on October 1st, which is down 25 cents from the September price. This is still 75 cents higher than in the second quarter and continues the uranium price increases that began in early 1995 (**Figure 14**).

Wyoming uranium producers are optimistic that prices will continue to increase. The two existing producers, Comin (Cogema Mining) and Power Resources, have expanded production in the Powder River Basin. There are two other companies considering future production: Rio Algom at the Smith Ranch site in the Powder River Basin and Kennecott Energy at the Jackpot underground mine on Green Mountain south of Jeffrey City.

In addition, the Canadian firm, CAMECO announced its intentions to acquire Power Resources through a purchase of Magnox Electric's North American Holdings. This purchase will add considerable resources to CAMECO's existing holdings.

Uranium production in Wyoming is expected to increase. **Figure 15** shows the historical production of yellowcake in Wyoming and the current production forecast.

Zeolites

U.S. Zeolite, Inc. is planning to construct a small zeolite processing facility at Bitter Creek, southeast of Rock Springs in Sweetwater County. Tom Van Fleet, President of U.S. Zeolite, has applied for a zoning change for a parcel of land in Bitter Creek to use as the plant site.

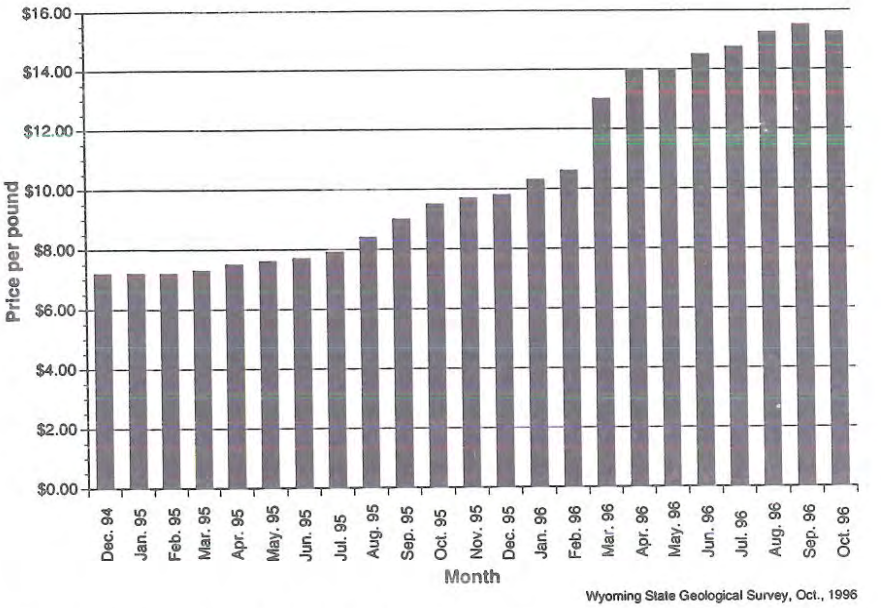

Figure 14. Unrestricted price of yellowcake on the spot market (Source: Uranium Exchange).

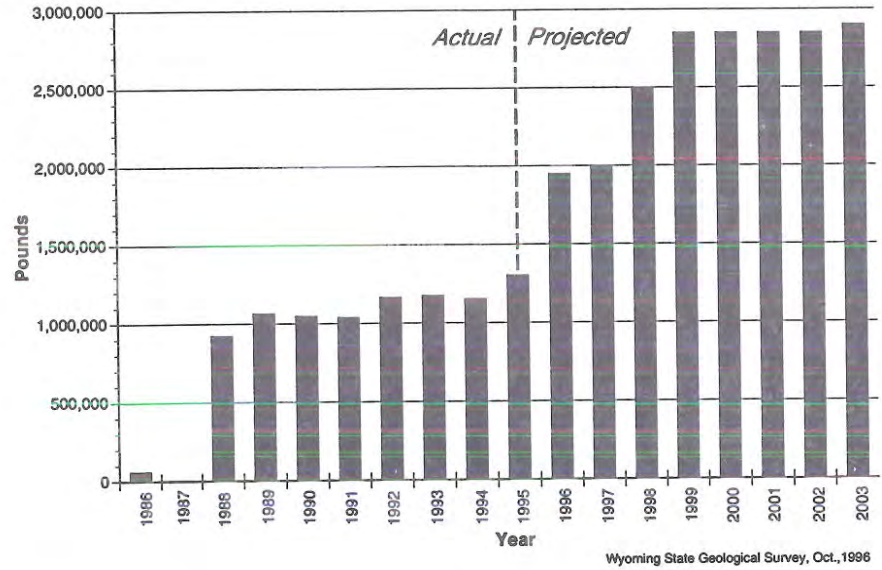

Figure 15. Historical production of yellowcake in Wyoming (1986-1995) with forecasts to 2003.

U.S. Zeolite's zeolite deposit is located southeast of Bitter Creek. As reported in Wyoming State Geological Survey Open File Report 90-4 (Harris and King, 1990), the zeolite mineral, clinoptilolite, occurs in the Washakie Formation of Eocene age. It forms a bright blue layer, called the "Robin's Egg Blue bed", in the sedimentary sequence. Clinoptilolite makes up to 95% of the minerals in the bed. It is thought to have formed as a low-temperature alteration product of a volcanic ash.

Zeolite is the collective name for a group of relatively rare and unique minerals. Because zeolites are natural ion exchangers, they have a wide variety of uses, from water purification and softening to deodorizers, absorbents, and industrial chemicals, most of which are used in the refining of petroleum. Water softeners are synthetic zeolites.

Zeolites are mined in a number of other states, including Oregon, Nevada, and Arizona. The zeolite mining industry may be in the same position as the trona industry was in the 1950s. At that time, most soda ash was produced synthetically, which is the case for most zeolites today. Soda ash processed from mined trona, however, has been replacing synthetic soda ash worldwide, as it is less expensive to produce. With the production of natural zeolite products, synthetic production could be replaced by less expensive mined and processed zeolite (Harris and King, 1990).

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METALS AND PRECIOUS STONES UPDATE

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Diamonds

Exploration by companies and consultants working in the Wyoming craton has led to some interesting new discoveries and information regarding the potential for

diamond occurrences in Wyoming. While the two most significant areas are the Colorado-Wyoming State Line district and the Green River Basin of southwestern Wyoming, new information about anomalies in the Bighorn and Owl Creek mountains and in central Wyoming have raised interest in those areas as well.

Colorado-Wyoming State Line District

At Redaurum's Kelsey Lake diamond mine in the northern portion of the district, plans were initiated to expand operations north into Wyoming. The mine and mill, which were commissioned last April, have produced several remarkable gemstones. The latest was a 28.3-carat yellow stone, the size of a thumbnail. This is apparently the fifth largest verified diamond found in the U.S. (Hausel, 1995).

The Kelsey Lake mine is expected to produce 25,000 carats of diamonds this year and increase production to 150,000 carats/year in the future (Ringold, 2/14/96). The mine has an expected operating life of about 12 years, and should reach a maximum depth of 575 feet. Since production only began last April, the discovery of additional large stones is probable. The value of the mine's reserves reportedly totals more than $150 million (Northern Miner, 6/24/96).

In addition to the Kelsey Lake kimberlites, approximately 30 other kimberlites have been identified in the State Line district. Diamonds have been found in every kimberlite in the district that has been tested. And there are several pipes on the Wyoming side of the district that still have not been tested (Hausel, 1996).

Elsewhere in the district, Royal Gold announced (9/19/96) that it had recovered kimberlitic indicator minerals during recent exploration of lands belonging to the Union Pacific-Santa Fe railroad. The company reported encouraging results, which according to their release, suggested the presence of kimberlite in an area where kimberlites had not been previously identified. *USA Today* (9/23/96) reported that 17 of 73 stream-sediment samples collected by Royal Gold yielded kimberlitic indicator minerals.

Canadian Corporate Newsnet (9/15/96) reported that U.S. Diamond Corp. had reached an agreement to acquire majority interest in some claims in the State Line district.

Green River Basin

In response to diamond exploration in the Green River Basin, the U.S. Bureau of Land Management (BLM) announced that it was going to open more than 86,000 acres to non-metalliferous location i.e. open to claim staking. This was officially set to occur at 9 a.m. on November 14th. These lands had been withdrawn from mineral entry to protect oil shale and(or) coal lands. The opened lands include various sections in Ts13-15N, R112W and Ts13-17N, R113W. Further information on this action should be directed to Jim Paugh at the BLM's Wyoming State Office [(307) 775-6306].

The Green River Basin of southwestern Wyoming is a highly anomalous Tertiary basin overlying an Archean craton. In addition to the ten "kimberlitic" breccia pipes that have been found in the basin, kimberlitic indicator minerals occur over a 1,000-square-mile area, providing some evidence for dozens, if not hundreds, of yet undiscovered breccia pipes. The current exploration in this basin by Guardian Enterprises, in particular, is providing some very exciting results!

Guardian Enterprises continued exploration of a 240-square-mile area in the Green River Basin. According to press releases from Guardian (7/31/96 and 9/24/96), they have recovered additional diamonds from an alluvial source they believe is separate from the ten breccia pipes that they discovered last year. Guardian has reportedly found more than forty diamonds in this alluvial source. Prior to these new discoveries, Guardian had reportedly found three diamonds associated with the breccia pipes.

Geochemical studies of a sample collected from one of the ten pipes discovered by Guardian has provided some interesting results. The 1.5-ton bulk sample was processed for diamonds and kimberlitic indicator minerals at the Wyoming State Geological Survey's laboratory. Although no diamonds were found in the sample, numerous kimberlitic indicator minerals were recovered. These recovered minerals included hundreds of garnets, pyroxenes, and oxides, along with some mini-xenoliths.

Microprobe analyses of the garnets and other indicator minerals were performed by Dr. Tom McCandless at the University of Arizona. Both peridotitic and eclogitic garnets were recovered from the sample. The peridotitic garnets were dominantly calcic G9 pyropes, and the eclogitic pyrope-almandine garnets were low in sodium ($\leq$ 0.06 wt.% Na_2O). All but one pyroxene analysis yielded K_2O < 0.07%. The exception was a calcic chromian diopside of peridotitic paragenesis which yielded 0.10% K_2O, suggesting that it originated within the diamond cogenetic field for eclogitic diopside.

Oxides from the sample included ilmenites and chromites. The ilmenites yielded 4.8-7.0 wt.% MgO and 0-4.5 wt. % Cr_2O_3, which are typical of kimberlitic ilmenites. The ilmenite compositions are favorable for the preservation of diamond if diamond was originally present. The chrome spinels yielded 14.5-57.0 wt.% Cr_2O_3 and 0-19.7 wt.% MgO.

Seventeen garnet-pyroxene mini-xenoliths were analyzed. Thirteen of the samples contained garnets with high almandine content, suggesting a granulite (lower crustal) source. Four of the samples yielded magnesian pyrope-almandine garnets of probable eclogitic origin. None of the garnets contained elevated Na_2O, suggesting they originated above the diamond stability field (Tom McCandless, written communication, 8/27/96).

A name for the host rock in the breccia pipes remains enigmatic. Back-scatter microprobe analysis of rock samples from the breccia pipe and a dike showed the groundmass to be highly silicified (Dr. Tony Irving, personal communication, 1996).

Silicification is also indicated by whole-rock analyses, which yielded very high silica contents. The samples yielded from 67.66-44.08% SiO_2, 0.47-0.27% TiO_2, 9.86-5.25% Al_2O_3, 5.13-2.82% Fe_2O_3, 0.22-0.04% MnO, 14.95-4.29% MgO, 17.99-5.10% CaO, 1.75-0.57% Na_2O, 2.49-1.41% K_2O, 0.56-0.22% P_2O_5, 17.77-6.6% LOI, 0.14-0.07% Cr_2O_3, and 755-256 ppm Ni (Hausel and others, 1996). One sample yielded 5.44% CO_2.

The high nickel and chrome suggest that there was a contribution from a mafic to ultramafic source rock. The MgO content is low and the SiO_2 content is high compared to an average kimberlite. The possibility that the host rock is a lamproite or lamprophyre is still under investigation. At this point, however, the best name to use is "breccia pipe".

Typically, diamond districts around the world produce both productive and less productive pipes within the same region. Consequently, the State Survey hopes to acquire and study samples from all of the discovered pipes.

The State Geological Survey's geophysical surveys over the pipe showed the breccia was relatively conductive. Magnetic surveys yielded only a weak, positive anomaly (**Figure 16**).

Lonetree geophysical anomalies

The State Survey has also investigated a group of circular anomalies identified on aerial photographs by Gordon Marlatt, a consulting geologist from Laramie. The anomalies lie west of Guardian's property in an area covered by Quaternary alluvium and glacial outwash.

Geophysical surveys were conducted over two of the structures, designated LT1 and LT2. These structures exhibit subtle, circular, topographic expressions with depressions at their centers. Two profile lines (W-E and N-S) were run through each of the anomalies using an electromagnetic unit and a proton precession magnetometer. EM and magnetic anomalies were detected in the topographic depression, LT1. The EM produced a weak conductor (40 to 50 mmho/m) over the depression as well as a weak magnetic anomaly (125 gamma maximum) similar to those reported for some kimberlites in the Colorado-Wyoming Kimberlite Province to the east. Similar results were obtained over the LT2 anomaly.

Bighorn Mountains

The Wyoming State Geological Survey recently acquired an unpublished company report, which describes the discovery and analyses of some kimberlitic indicator minerals from the Bighorn and Owl Creek Mountains. While the report is undated, it was apparently prepared in the 1980s. According to the report, some of the peridotitic pyropes had G10 compositions. These chemistries suggest the pyropes were derived from the diamond stability field.

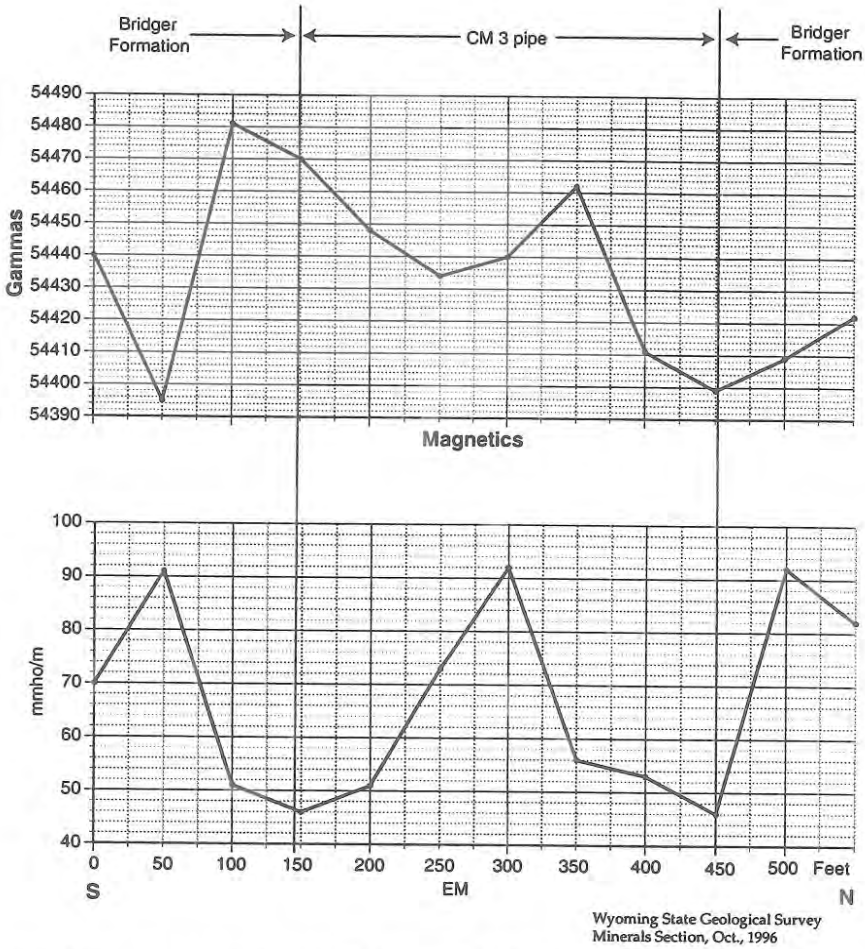

Figure 16. Electromagnetic (EM) and magnetic S-N profiles produced over Guardian's CM3 pipe, Green River Basin, Wyoming.

Central Wyoming

Several years ago, the Wyoming State Geological Survey identified kimberlitic indicator minerals in central Wyoming. More recently, Woody Motten, a consulting geologist from Casper, discovered a circular depression at an undisclosed locality in the same region of the State. As a follow-up to this discovery, the State Geological Survey conducted some geophysical surveys over the depression. These surveys showed a distinct EM anomaly, associated with a weak magnetic anomaly. Geophysical modeling indicates a pipe-like structure beneath the depression, which is surrounded by granitic rocks. Further evaluation of the structure will require drilling.

Gold

Residents in the South Pass area report that a major company has been exploring for gold in that area of the State. The South Pass area was Wyoming's principal gold mining district in the late 1800s and early 1900s, and may have produced more than 348,000 ounces of gold. Much of the gold is localized in steeply plunging ore shoots in fold closures associated with isoclinal folds within shear zones.

The Carissa mine is one property at South Pass that continues to attract exploration and development interest. Available reports indicate 180,000 ounces of gold were recovered from the mine in the past (Hausel, 1991). Recent drilling on the property shows the mineralized shear continues to a depth of at least 900 feet. The drill holes penetrated mineralized zones containing from 0.033-2.5 ounce-per-ton (opt) gold. Some zones with widths up to 80 feet were intersected.

Copper

The Wyoming Department of Environmental Quality (DEQ) recently contracted Harrison-Western to reopen the drainage adit of the historic Ferris-Haggarty copper mine in the Encampment district of the Sierra Madre. The DEQ hopes to identify and stop the source of some cupriferous waters that drain from the mine into Haggarty Creek.

The Ferris-Haggarty mine was an important copper producer in the early 1900s. Records indicate the mine may have produced as much as 21 million pounds of copper with minor gold and silver from a quartzite breccia along a contact with a hanging wall felsic schist. Exxon Minerals conducted a sampling program in a portion the underground workings in 1988. They reported samples containing from 0.10-21.3% Cu, 1.1 ppm to 2.34 opt Ag, and 75 ppb to 0.33 opt Au. Reserves reportedly included 928,500 tons of ore averaging 6.5% Cu and containing 116,800 ounces of gold. The Wyoming State Geological Survey is planning to conduct detailed studies of the deposit while it is accessible.

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Technically recoverable Resources (January 1, 1996)	
Discovered (Includes oil, gas liquids, and condensate)	3.62 billion barrels[1]
Undiscovered	6.18 billion barrels[1]
Total	9.78 billion barrels
Remaining Reserve Base (January 1, 1996)	
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	0.98 billion barrels[2]
Indicated and inferred reserves (Reserve growth in conventional fields)	2.64 billion barrels[1]
Total	3.62 billion barrels

NATURAL GAS

Remaining Technically recoverable Resources (January 1, 1996)	
Discovered (Includes 36.2 trillion cubic feet (TCF) of methane[1] and 121.8 TCF of CO_2[3])	157.0 trillion cubic feet
Undiscovered (Includes 15.72 TCF of conventional methane[1]; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO_2[3])	171.6 trillion cubic feet
Total	328.6 trillion cubic feet
Remaining Reserve Base (January 1, 1996)	
Measured reserves (Proved reserves) (Includes 9.2 TCF of methane[2] and 60.1 TCF of CO_2[3])	69.3 trillion cubic feet
Indicated and infered reserves (Reserve growth in conventional fields)	26.0trillion cubic feed
Total	95.3 trillion cubic feet

COAL

Remaining Resources (January 1, 1996)	
Identified and Hypothetical (Discovered)	1,427.2 billion tons[4]
Speculative (Undiscovered)	31.5 billion tons[4]
Total	1,458.7 billion tons
Remaining Reserve Base (January 1, 1996)	
Demonstrated strippable (Measured and indicated reserve base)	25.6 billion tons[5]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5 billion tons[5]
Total	68.1 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)	1.99billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1989)	
Uranium oxide recoverable at $30.00 per pound	66 million pounds[7]

OIL SHALE

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

[1] Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 1118, 20 p.
[2] Modified from Energy Information Administration, 1995, U.S. crude oil, natural gas, and natural gas liquids reserves: 1994 Annual Report, 153 p.
[3] De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.
[4] Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000-scale (color) and 44 p. pamphlet.
[5] Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 p.
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[7] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.
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OVERVIEW OF HISTORICAL SEISMICITY IN YELLOWSTONE NATIONAL PARK

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While Yellowstone National Park is one of the more seismically active areas in the conterminous U.S., it is the most seismically active area in Wyoming. There have been a number of damaging earthquakes that have occurred either in or near the park, with one earthquake resulting in the loss of life. Based upon the seismic history of the park, earthquakes in the magnitude 6.5-7.5 range are possible, and should be expected in the future.

The earthquake record in western and northwestern Wyoming only covers 125 years, which dates back to early reports from what is now Yellowstone National Park. Because this is a short earthquake record, patterns of seismicity are still under investigation.

Interpretations are difficult because many earthquakes in Yellowstone National Park have been poorly located, especially those that occurred prior to 1970. In fact, most earthquakes that occurred prior to 1960, were located solely on the bases of what people felt and where they were located. **Figure 17** is a plot of historic earthquakes in and around the park, and includes all significant earthquakes from 1871 through March, 1995. A different pattern of seismicity is apparent when only the more recent, accurate data are plotted. For example, a plot of earthquakes in the park between 1973-1990, indicates that most of these earthquakes were located in the southern two thirds of the park (Smith and Braile, 1993).

Many thousands of earthquakes have occurred in Yellowstone National Park over the last 125 years. The earthquakes described below represent only a small percentage of these quakes. Most, but not all of the earthquakes that caused damage, are described in the following discussions.

OVERVIEW OF EARTHQUAKES IN THE LATE 1800S

One of the first recorded earthquakes in Wyoming was from the Yellowstone National Park area. F.V. Hayden (1872) reported that "on the night of the 20th of July (1871), we experienced several severe shocks of an earthquake, and these were felt by two other parties, fifteen or twenty-five miles distant, on different sides of the lake". Hayden received reports from Steamboat Point and the southeast arm of Lake Yellowstone. This event was assigned an intensity V by Fischer (1960).

In 1893, there were a series of reports printed in *The Laramie Boomerang* that provided additional insight into seismicity in Yellowstone National Park. The February 23, 1893, issue of the paper reported that a series of earthquakes had been felt in the park during the previous few weeks. The report stated that the main road south of the Norris Geyser Basin caved in for a long distance and to an unknown

EXPLANATION

⊕ Location of determined epicenter to nearest 0.1 latitude and longitude.

2 ● Number of events at location.

* ● Multiple events in vicinity.

I-XII Intensities(degree of shaking)derived from Modified Mercalli Intensity Scale of 1931.

2.0-7.5 Magnitudes(instrumental readings of relative earthquake size).

(ML) Local magnitude(Richter).

(Mα) Body wave magnitude.

All magnitudes and intensities shown are highest recorded at location.

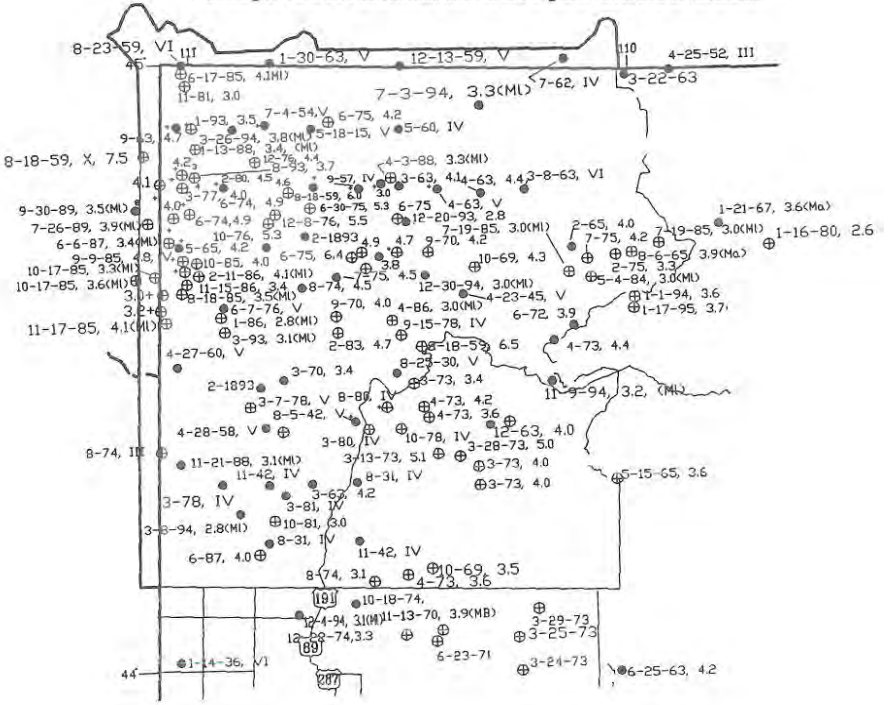

Figure 17. Plot of historic earthquake epicenters in Yellowstone National Park and vicinity.

depth. In fact, in one place there was a huge gap in the earth, about 75 feet wide and several hundred feet in length.

The March 9, 1893, issue of *The Laramie Boomerang* reported that an army officer in Yellowstone National Park, writing to a friend at Cheyenne, said that the earthquake disturbances continued. The officer reported that ever since the shock of ten days ago, there had been unprecedented and violent activity at the Giant, Giantess, and Great Castle Geysers. The earth opened up in their vicinity, with some excavations acres in extent. The newspaper reported that the eruptions shook the country for miles around, and the few people in the park were greatly alarmed. The officer also described an Indian legend in which a village in the park had been swallowed up by an earthquake many years ago.

OVERVIEW OF EARTHQUAKES IN THE EARLY- TO MID-1900S

Considering the current level of seismic activity in the park, it is obvious there are significant gaps in the seismic history of the area. For example, Fischer (1960) reports no seismic activity between 1871 and 1914, 1916 and 1925, and 1927 and 1930. Recent studies, however, indicate that there may be hundreds to thousands of earthquakes in the park every year.

On July 21, 1926, there was an intensity IV earthquake reported at the Lake Ranger Station (Fischer, 1960). Hanging pictures, dishes, and groceries were moved.

From August 24, 1930, through December 22, 1930, there were a series of earthquakes felt in the park. One of the larger events in this period occurred on August 25, 1930. This intensity V earthquake threw dishes from shelves and obviously disturbed the water in Lewis Lake (Fischer, 1960). From August 24, 1931, through August 27, 1931, there were a series of earthquakes near the south entrance and the southern part of Lewis Lake. The August 24, 1931, earthquake had eighteen aftershocks, and shook buildings and moved dishes.

On January 14, 1936, there was an intensity VI earthquake that occurred southwest of the park. That earthquake cracked plaster and chimneys at the Lake Hotel and rocked beds at Moran, Wyoming (Fischer, 1960).

From the late 1930s through the 1940s, there were a number of earthquakes reported in the park, although few caused significant damage. On August 5, 1942, an intensity V earthquake was felt at West Thumb. Dishes and windows were rattled (Fischer, 1960).

During April, 1945, there were a series of earthquakes in the Yellowstone Lake area. On April 21 and April 23, 1945, intensity V earthquakes shook bushes and trees and overturned vases and small objects (Fischer, 1960).

On January 8, 1947, an intensity IV-V earthquake just south of the park shook the building at the Snake River Ranger Station, rattled windows, and caused pictures to swing (Fischer, 1960). Then on November 23, 1947, an earthquake in southwestern Montana was felt as an intensity IV event throughout Yellowstone National Park (Stover and Coffman, 1993). Fischer (1960) reported that windows and dishes rattled, hanging objects swung, and some pendulum clocks stopped.

OVERVIEW OF EARTHQUAKES IN THE 1950S

The 1950s were host to a number of earthquakes in or near Yellowstone National Park. In fact, one of the largest recorded earthquakes in the region occurred in 1959.

Other earthquakes in the 1950s, however, should not be overlooked. On June 27, 1950, an intensity VI earthquake occurred in the north-central portion of the park. At West Yellowstone, Montana, tourists ran from buildings and knicknacks and groceries fell from shelves (Fischer, 1960). On July 4, 1954, an intensity V earthquake was reported near Mammoth. Windows, doors, and dishes rattled, and small objects moved (Fischer, 1960). On December 21, 1956, an intensity V earthquake was felt at the Lake Hotel. Small objects were shifted, and trees and bushes were shaken (Fischer, 1960). On April 28, 1958, a series of intensity V earthquakes were felt at Old Faithful. Windows rattled, walls creaked, and small objects moved (Fischer, 1960).

The Hebgen Lake earthquake is the most significant historic earthquake in and around Yellowstone National Park. It occurred on August 17, 1959. This earthquake, which had a magnitude of 7.5 and a maximum intensity of X, had an epicentral location a few miles to the northwest of West Yellowstone, Montana. The earthquake initiated a major landslide, which dammed the Madison River. So much material was displaced so quickly that the landslide generated a great blast of air that blew people about like leaves (Witkind, 1964). Twenty-eight people were killed by that earthquake and its effects. New fault scarps were noted near Hebgen Lake, and many geysers were adversely affected. There were 156 aftershocks recorded during the first 21 hours following the main shock, including some magnitude 6.0-6.5 events within the park. The magnitude 7.5, intensity X earthquake serves as a model for the maximum credible earthquake that can be expected to occur in western and northwestern Wyoming.

OVERVIEW OF EARTHQUAKES IN THE 1960S

During the 1960s, there were a number of earthquakes felt in the park, although only a few caused any damage. Many of these earthquakes occurred in the Hebgen Lake area. The only earthquakes from the Hebgen Lake area addressed in the remainder of this report, however, are those that were felt in Yellowstone National Park.

On April 21, 1960, an intensity V earthquake in the Hebgen Lake area caused dishes to fall at West Yellowstone, and water to slosh over the sides of a fish bowl (Coffman and von Hake, 1973). On August 26, 1962, an intensity V earthquake in the north-central portion of the park stopped pendulum clocks at Canyon and frightened many people (Coffman and von Hake, 1973). On March 8, 1963, a magnitude 3.8, intensity VI earthquake in northeastern Yellowstone caused plaster to crack and fall at Canyon Village. Large cracks separated walls and ceilings in several houses (Coffman and von Hake, 1973). On December 17, 1963, a series of intensity III-V earthquakes near Mammoth caused pictures and mirrors to shift. These events were followed by a magnitude 4.3 earthquake on December 20, 1963, in the Hebgen Lake area. As with the earlier events, pictures on walls in the Mammoth area were moved. A small landslide also occurred at Hebgen Dam (Coffman and von Hake, 1973).

Coffman and von Hake (1973) reported a magnitude 5.8 earthquake on October 21, 1964, and a magnitude 4.9 earthquake on October 8, 1965, in the Hebgen Lake area. They did not report any damage within the park. The rest of the significant seismic activity in the 1960s centered around Hebgen Lake, and caused little or no damage in Yellowstone National Park.

OVERVIEW OF EARTHQUAKES IN THE 1970S

There were a number of earthquakes in the park during the 1970s, with a few causing significant damage. On July 16, 1974, a magnitude 4.4 earthquake at Hebgen Lake was felt as an intensity V event at the Norris Geyser Basin. This was followed on August 30, 1974, by a magnitude 4.5, intensity V earthquake in the central portion of the park. During this event, items fell off store shelves in West Yellowstone, and power lines behind the Old Faithful Inn bounced up and down (Coffman, von Hake, and Stover, 1982).

A magnitude 6.4, intensity VII earthquake occurred in the central portion of Yellowstone on June 30, 1975. Landslides closed twelve miles of road between Norris Junction and Madison Junction for almost a day. Three- to four-foot deep cracks, fifteen to twenty feet long, were found in the Virginia Cascades area. Other roads in the park were closed for brief periods of time due to earthquake-induced landslides (*Jackson Hole News*, July 3, 1975).

During the last quarter of 1976, there were a number of earthquakes recorded in the park, although few caused damage. On December 9, 1976, a magnitude 5.1, intensity V earthquake in northwestern Yellowstone caused small objects to fall at Canyon Village, and caused turbidity in the Gibbon River (Minsch and others, 1978). On December 19, 1976, a magnitude 4.9, intensity VI earthquake in the same area cracked windows at Mammoth. Christmas decorations and household items were also knocked to the floor (Minsch and others, 1978).

There were few additional damaging earthquakes in the park from 1977 through 1979, although Coffman, von Hake, and Stover (1982) did report that a March 6, 1977, swarm of 129 tremors occurred at Old Faithful, causing minor changes in thermal activity at the Upper Geyser Basin.

OVERVIEW OF EARTHQUAKES IN THE 1980S

There were a few damaging earthquakes and a number of earthquake swarms in Yellowstone National Park in the 1980s. On March 12, 1981, a magnitude 3.8 earthquake was the first of a swarm of more than 200 events recorded on the seismograph at Old Faithful (Stover, 1984).

On February 6, 1983, a magnitude 4.7 earthquake in the central portion of the park was felt as an intensity V event at Old Faithful, overturning small objects. Four hot springs became turbid within two hours of the earthquake, and the water level in Gention Pool, located about six miles north of Old Faithful, dropped approximately 30 inches (Stover, 1987).

In 1985, there was unusual seismic activity in the park, with thousands of events recorded by the University of Utah Seismograph Stations. An intense swarm began on September 19, 1985, near Old Faithful. About 25 earthquakes were felt, with the largest having a magnitude of 4.2, and five having magnitudes greater than 3.5 (Smith and others, 1986). Another swarm, located between West Yellowstone and Madison Junction, began on October 7, 1985, and continued through December 27, 1985. More than 2,900 events were located during this time period (Nagy and others, 1989), with 28 having magnitudes greater than 3.5. During this swarm, four large events, with magnitudes from 3.7-4.0, occurred on October 19, 1985. Another three events, with magnitudes from 4.1-4.9, occurred on November 9, 1985. Abnormal geyser activity was reported at Old Faithful during October, 1985 (Smith and others, 1986).

The park had relatively few earthquakes that were felt in 1986, 1987, and 1988. Activity increased in 1989, with three swarms defined by Peyton and others (1990). No significant damage was reported.

OVERVIEW OF EARTHQUAKES IN THE 1990S

Earthquake activity increased in the park in 1990, with 712 earthquakes recorded and five swarms defined (Hardman and others, 1991). No significant damage was reported.

On July 20, 1992, a magnitude 3.9, intensity V earthquake was felt at the Lake Hotel. Many guests were awakened and some packed up and left the area (Nava and others, 1996). No significant damage was reported.

On March 26, 1994, a magnitude 4.9 earthquake, located about 10 miles north-northwest of Madison Junction, was reported by the University of Utah Seismograph Stations. Park personnel described major hydrothermal changes in the Norris

Geyser Basin, with an estimated five-fold increase in the total hydrothermal discharge rate for an undetermined length of time (Nava and others, 1996).

On August 27, 1995, three earthquakes occurred 35 miles southeast of Yellowstone Lake's West Thumb, at an area outside the park. These were felt at Grant Village and Fishing Bridge. The largest of the earthquakes had a magnitude of 4.5, and it caused items to fall off the shelves at the Hamilton Store in Grant Village.

SUMMARY

Yellowstone National Park is a seismically active area, and damaging earthquakes will continue to occur. The largest earthquake expected to occur in the near vicinity of the park would have a magnitude of 7.5. There is a potential for the loss of life and(or) significant property damage in or near the park whenever an earthquake of this size occurs.

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ROCK HOUND'S CORNER

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

Lately, we have received numerous inquiries concerning methods for identifying diamond. Diamonds are not extremely difficult to identify, particularly if one has access to some mineralogical or gemological equipment.

Diamonds come in a variety of shapes and colors. Most diamonds are isometric. In other words, the basic crystal form is equal-dimensional. In its simplest form, diamond occurs as six-sided cubes known as hexahedrons. However, the most common habit of diamond is the octahedron. Octahedrons form eight-sided bipyramids, although some may develop ridges on the octahedral crystal faces producing crystals of trisoctahedral and hexoctahedral habit.

Partial resorption of octahedral diamonds often result in rounded dodecahedrons (12-sided) with rhombic faces (similar to the habit of some garnets). In some cases, dodecahedral diamonds develop ridges on the rhombic faces resulting in a 24-sided crystal known as a trishexahedron. Four-sided tetrahedral diamonds are sometimes encountered in nature. These are probably distorted octahedrons.

Most diamonds are grease attractive and water repellant. This means diamonds will frequently adhere to grease, which is why diamonds are often extracted by using tables covered with grease. Since they are also water repellant, diamonds can float on water even though they have a specific gravity of 3.5 (3.5 times heavier than water).

One of the simplest methods for diamond identification is to use the Gemological Institute of America's GEM tester, which measures the surface conductivity of diamond. The GEM tester will either read "diamond" or "synthetic". Nearly every diamond that I've tested on these instruments has registered as diamond. However, there have been some exceptions.

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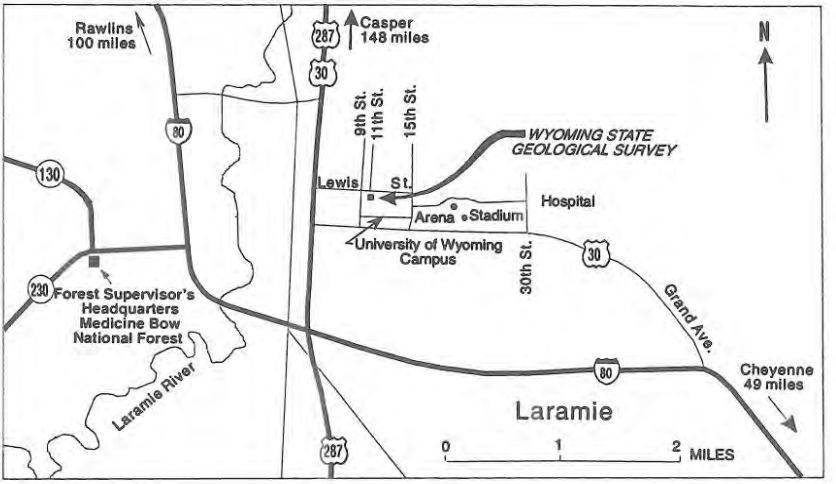

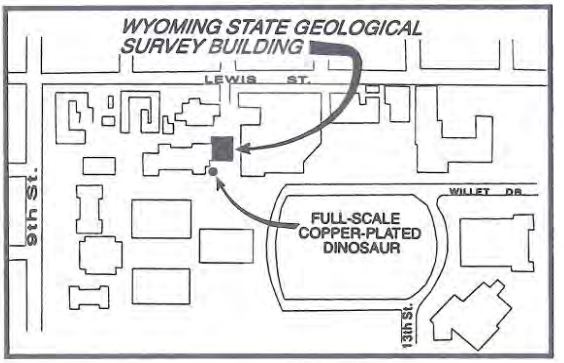

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