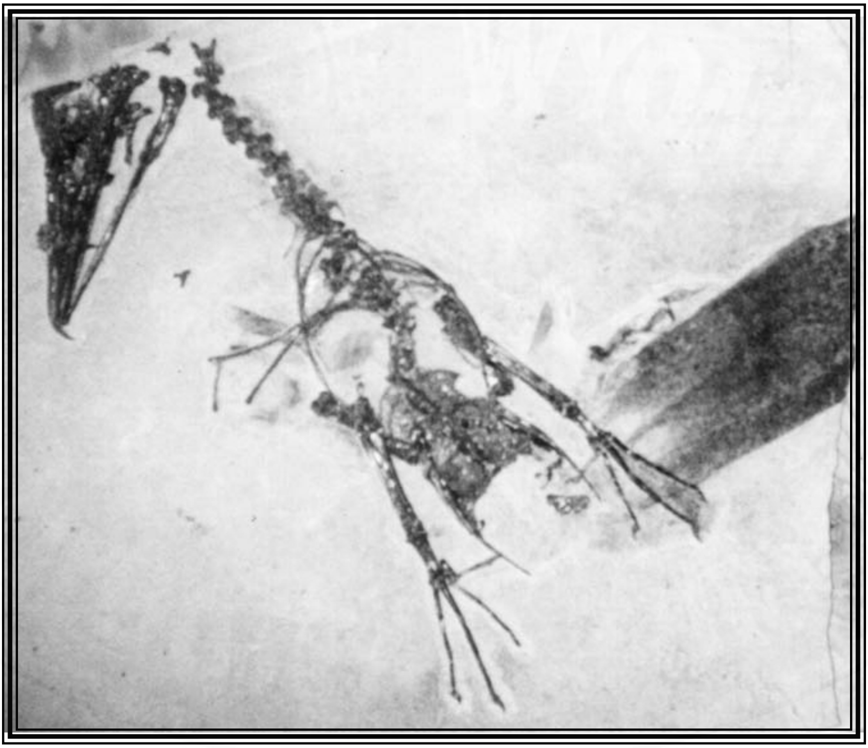
Wyoming Geo-notes

Number 66



Wyoming State Geological Survey
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June, 2000

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Front cover: A new bird fossil from the Green River Formation in the Fossil Basin, southwestern Wyoming. The State of Wyoming recently received this spectacular fossil from Ulrich's Fossil Gallery, operators of a fossil quarry on state land. Dr. Jason Lillegraven of the Department of Geology and Geophysics at the University of Wyoming has tentatively identified the bird as a type of crane. Comparison with a previously known specimen of a frigate bird (*Limnofregata azygosternon*) illustrated in Wyoming State Geological Survey Bulletin 63, p. 208, suggests some strong similarities. Experts more familiar with this group of fauna will make the final identification. This fossil may even represent a new species. Specimen preparation by Carl Ulrich, photograph by Robert M. Lyman.

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MINERALS UPDATE

OVERVIEW AND GENERAL COMMENTS

Lance Cook
State Geologist, Wyoming State Geological Survey

Coalbed methane well spacing

The Wyoming Oil and Gas Conservation Commission (WOGCC) has proposed special rule making for coalbed methane wells in the Powder River Basin. On Tuesday, May 16, 2000, Governor Jim Geringer signed a letter of approval for the Commission to amend Chapter 3, Section 2 of its rules to define the location of wells drilled to the Wasatch and Fort Union Formations. The exact language of the proposed rule is as follows:

Chapter 3, Section 2. Location of Wells (All Lands Except Indian).

(d) Any well drilled in the Powder River Basin projected to test the Ft. Union and/or Wasatch Formations shall be located in the center of the northeast quarter (NE1/4) and the center of the southwest quarter (SW1/4) of a one-hundred sixty (160) acre quarter section or lot or tract or combination of lots or tracts substantially equivalent thereto with a two-hundred foot (200') tolerance in any direction from such center locations. All areas subject to existing orders for drilling and spacing units in the above-described area shall be exempt from the aforesaid well location requirements, as will all wells previously drilled or permitted. Further, this rule is vacated for all federal exploratory units in the Powder River Basin for the Ft. Union and/or Wasatch Formations provided that no well be drilled closer than four-hundred sixty feet (460') from the exterior boundaries of a federal exploratory unit or any uncommitted tract within a federal exploratory unit. Upon unit contraction, lands deleted from the unit shall thereafter be subject to this rule.

The effect of this proposed rule would be to create a well density of one well per 80 acres, rather than the present standard of one well per 40 acres. The Commission is charged by Wyoming statute to protect and conserve the natural resource and protect correlative rights by affording each owner the opportunity to drill and produce as a prudent operator without waste and the drilling of unnecessary wells. The Commission believes that the proposed rule is necessary to meet its statutory obligation.

There have been 27 dockets presented to the Commission for coalbed methane spacing issues, and the Commission has seen technical testimony that suggests adequate data exists to support this proposed rule. In accordance with Commission rules and practice, this rule will be observed in the permitting process from the date of its proposal, and no additional 40-acre locations will be permitted before the hearing date. If the Commission decides against the proposed rule, then the 40-acre spacing permits will be issued. Permits that expire undrilled will not be renewed unless they are in accordance with the proposed rule.

A public hearing on this proposed rule is scheduled before the Commission at 9:00 a.m. on July 11, 2000, at the Basko Building in Casper, Wyoming. The public is welcome to attend and observe or comment during the hearing.

Coalbed methane pamphlet

The Wyoming State Geological Survey has recently produced Information Pamphlet 7, Coalbed methane in Wyoming, by R.H. De Bruin, R.M. Lyman, R.W. Jones, and L.W. Cook. We have attempted to answer the most frequently asked questions about coalbed methane in this color brochure without making it too technical for the lay person or an investor. The pamphlet is free upon request.

Other notes

Final production figures for 1999 were received in the first quarter of 2000 for nearly all Wyoming minerals, so **Table 1** now includes actual production for 1999. Market analyses and statistical data for Wyoming minerals are provided in the separate updates that follow. In 1999, production of methane and coal were somewhat less than predicted in our last Wyoming Geo-notes (No. 65, March, 2000); oil production was unchanged; and carbon dioxide and in situ uranium production was more than predicted (**Table 1**). Our forecast production (2000 through 2006) for

Table 1. Wyoming mineral production (1985-1999) with forecasts to 2006[1].

Calendar Year	Oil[2,3]	Methane[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[7]	In-situ Uranium[7,8]	Sulfur[3,9]
1985	131.0	597.9	—	—	140.4	10.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	11.9	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3	1.20
1996	73.9	1,023.4	149.0	1.10	278.4	18.6	1.9	1.22
1997	70.2	1,040.7	151.0	1.10	281.5	19.4	2.2	1.23
1998	65.7	1,072.6	151.0	1.10	314.9	18.6	2.3	1.20
1999	61.4	1,130.9	161.0	1.10	336.5	19.0[10]	2.8	1.20
2000	57.4	1,137.1	161.0	1.10	348.3	19.5	1.8	1.20
2001	54.3	1,163.1	161.0	1.10	360.1	20.0	1.6	1.20
2002	51.3	1,189.6	161.0	1.10	363.7	20.0	1.6	1.20
2003	48.5	1,216.6	161.0	1.10	367.3	21.1	1.6	1.20
2004	45.8	1,244.2	161.0	1.10	371.0	22.0	1.6	1.20
2005	43.3	1,272.3	161.0	1.10	374.7	22.0	1.6	1.20
2006	40.9	1,301.0	161.0	1.10	378.5	22.0	1.6	1.20

[1]Modified from CREG's Wyoming State Government Revenue Forecast, February, 2000; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1985-1999; [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, 1985-1998); [7]Wyoming Department of Revenue, 1985-1998; [8]Millions of pounds of yellowcake (not available [N/A] for 1985 and previous years because it was only reported as taxable value); [9]Millions of short tons; [10] Final production for 1999 not available pending release of in-situ production figures.

carbon dioxide has been revised upward while forecast production for methane and coal have been revised downward. Coal production from many Wyoming mines may have reached a plateau, with low prices and slackened demand both contributing. Some coal mines in the state are predicting cutbacks in production for 2000.

With the exception of oil, actual and forecast prices for the four major minerals produced in Wyoming (**Table 2**) have not changed significantly from our last Wyoming Geo-notes (No. 65, March, 2000). Increased oil prices at the end of 1999 contributed to a healthy increase in end-of-year and average oil prices. Natural gas prices increased only slightly in 1999 but we expect that the price increases we are seeing in early 2000 will continue through the year. Final prices for coal and trona in 1999 were not available in the first quarter.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1999) with forecasts to 2006[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	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.78	42.29
1998	10.67	1.81	5.41	41.29
1999	16.44	2.06	5.23	37.58
2000	15.00	1.85	5.13	37.81
2001	15.00	1.85	4.99	38.32
2002	15.00	1.85	4.99	38.86
2003	15.00	1.85	5.03	39.36
2004	15.00	1.85	5.05	39.64
2005	15.00	1.85	5.07	39.64
2006	15.00	1.85	5.08	39.64

[1]Modified from CREG, Wyoming State Government Revenue Forecast, February, 2000; [2]First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1999; [3]Wellhead price in dollars per thousand cubic feet (MCF). Source: Wyoming Office of State Lands and Investments, 1989-1997 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments); [4]Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-1998; [5]Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1998.

OIL AND GAS UPDATE

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

Oil prices continued to increase in 2000. Prices paid to Wyoming oil producers during the first quarter of 2000 averaged $25.78 per barrel. The average price for that quarter is $15.73 higher than for the first quarter of 1999. The average price in March of $27.00 per barrel (**Table 3**) is the highest average monthly price in the last four years. **Figure 1** shows the posted sweet and sour crude prices and first purchase price for Wyoming oil averaged by month. Crude oil prices may drop somewhat in the second quarter of 2000 since the Organization of Petroleum Exporting Countries (OPEC) announced that it would increase production by 1.7 million barrels per day. Mexico and other oil-producing countries outside OPEC also are expected to raise production.

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1997 through March, 2000).

	1997		1998		1999		2000	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	$22.56	$22.56	$12.79	$12.79	$9.30	$9.30	$23.94	23.94
FEB	$19.45	$21.01	$12.16	$12.48	$9.09	$9.20	**$26.40**	**$25.17**
MAR	$17.99	$20.00	$10.97	$11.97	$11.77	$10.05	**$27.00**	**$25.78**
APR	$16.81	$19.20	$11.54	$11.87	$14.34	$11.13		
MAY	$17.74	$18.91	$11.19	$11.73	$15.16	$11.93		
JUN	$15.90	$18.41	$9.63	$11.38	$15.36	$12.50		
JUL	$16.29	$18.11	$10.20	$11.21	$17.39	$13.20		
AUG	$16.61	$17.92	$9.58	$11.01	$18.43	$13.86		
SEP	$16.42	$17.75	$11.19	$11.03	$20.97	$14.65		
OCT	$17.89	$17.77	$11.04	$11.03	$20.01	$15.18		
NOV	$16.51	$17.65	$9.64	$10.90	$22.20	$15.82		
DEC	$14.72	$17.41	$8.05	$10.67	$23.22	$16.44		
Avg. yearly price		**$17.41**		**$10.67**		**$16.44**		

Source: All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 2000 are estimated from various unpublished bulletins listing posted prices.
Wyoming State Geological Survey, Oil and Gas Section, April, 2000.

Oil production in Wyoming for 1999 was about 61.4 million barrels (**Table 4**), according to figures from the Wyoming Oil and Gas Conservation Commission (WOGCC). Although this production is a drop of about 6.7% from 1998, the decline in production has moderated over the past several months because of higher prices for Wyoming oil. Our forecast production for the next seven years has not changed (**Table 1** and **Figure 2**) since the last issue of Wyoming Geo-notes (No. 65, March, 2000).

Natural gas production in Wyoming (which includes CO_2, helium, and methane) for 1999 was about 1.29 trillion cubic feet according to production figures from the WOGCC. This production is up 5.7% from 1998 (**Table 5** and **Figure 3**). Coalbed methane production from the Powder River Basin accounted for 58.2 billion cubic

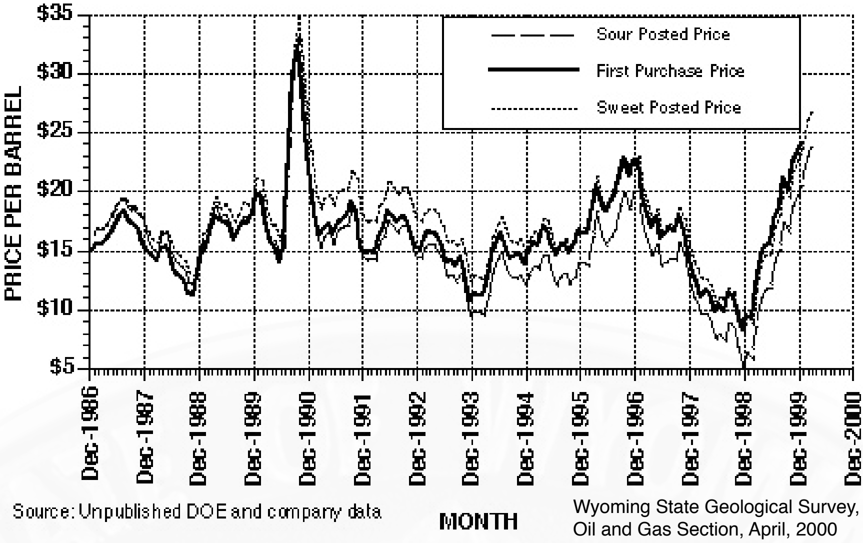


Figure 1. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through March, 2000).

feet (BCF) of that total and was about 4.5% of Wyoming's natural gas production. The total 1999 production for the state was about 19.3 BCF more than that forecast, with 10 BCF more CO_2 produced and 9.3 BCF more methane produced. Accordingly, our forecasts for both CO_2 and methane have been revised slightly from Wyoming Geo-notes No. 65 (March, 2000).

The average price for oil produced in Wyoming in 1999 was $16.44 per barrel, which is somewhat higher than our predicted $15.00 per barrel. At this point we have not increased our forecast for years beyond 1999 (see **Table 2** and **Figure 4**).

Natural gas prices for 1999 were about what we forecast in the last Wyoming Geo-notes (No. 65, March, 2000). Final numbers indicated that Wyoming natural gas was $2.06 per thousand cubic feet (MCF) in 1999 rather that our forecast $2.05 per MCF (**Table 2** and **Figure 5**). Estimates for prices from 2000 through 2006 have not changed.

Spot prices for natural gas at Opal, Wyoming averaged $2.32 during the first quarter of 2000. This is $0.67 higher than for the first quarter of 1999 (**Table 6** and **Figure 6**), and the highest first quarter price since 1997.

A recent financial transaction has created one of the largest independent oil companies in the world. Anadarko Petroleum agreed to buy Union Pacific Resources in an all-stock deal worth an estimated $4.4 billion. Overall, the combined company will hold crude oil and natural gas reserves equaling 1.94 billion barrels. Union Pacific Resources was one of the largest landowners in Wyoming. The new company will be called Anadarko Petroleum as before and has plans to step up the pace of drilling, particularly in North America.

In order to protect the health and safety of underground trona miners, the Bureau of Land Management (BLM) is conducting a public review concerning the closing of

Table 4. Monthly oil production from Wyoming in barrels (1996 through December, 1999).

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	6,153,037	6,153,037	5,964,848	5,964,848	5,846,364	5,846,364	5,329,489	5,329,489
FEB	5,693,084	11,846,121	5,459,518	11,424,366	5,233,502	11,079,866	4,739,393	10,068,882
MAR	6,176,805	18,022,926	6,014,780	17,439,146	5,759,176	16,839,042	5,296,370	15,365,252
APR	5,977,362	24,000,288	5,729,869	23,169,015	5,534,568	22,373,610	5,064,115	20,429,367
MAY	6,035,505	30,035,793	6,050,971	29,219,986	5,626,125	27,999,735	5,197,604	25,626,971
JUN	5,916,019	35,951,812	5,761,549	34,981,535	5,335,463	33,335,198	4,995,657	30,622,628
JUL	6,076,992	42,028,804	5,964,005	40,945,540	5,464,514	38,799,712	5,157,726	35,780,354
AUG	6,414,850	48,443,654	5,868,789	46,814,329	5,287,415	44,087,127	5,251,239	41,031,593
SEP	6,180,180	54,623,834	5,710,557	52,524,886	5,109,053	49,196,180	5,076,375	46,107,968
OCT	6,186,019	60,809,853	5,949,974	58,474,860	5,274,269	54,470,449	5,155,963	51,263,931
NOV	6,221,912	67,031,765	5,800,811	64,275,671	5,232,287	59,702,736	5,005,860	56,269,791
DEC	6,330,701	73,362,466	5,900,791	70,176,462	5,078,909	64,781,645	5,083,604	61,353,395
Total Barrels Reported		**[1]73,362,466**		**70,176,462**		**64,781,645**		**61,353,395**
Total Barrels Not Reported		**[2]525,957**		**52,364**		**897,131**		
Total Barrels Produced		**[3]73,888,423**		**70,228,826**		**65,678,776**		

[1] Monthly production reports from Petroleum Information/Dwights LLC, except for 1999 which is from Wyoming Oil and Gas Conservation Commission.

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

[3] Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, April, 2000.

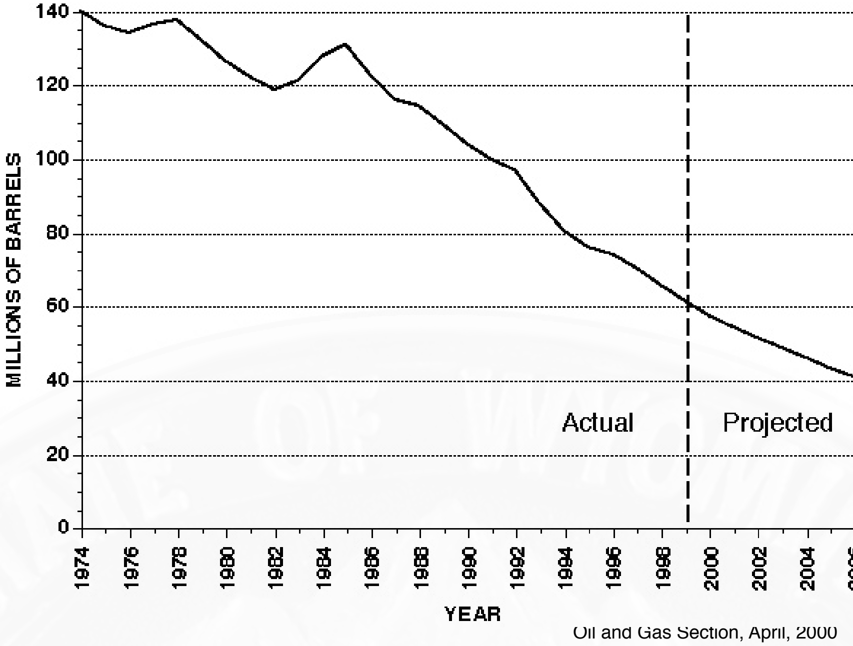


Figure 2. Annual crude oil production from Wyoming (1974 through 1999) with forecasts to 2006.

portions of trona mining areas in southwestern Wyoming to oil and gas leasing and development. The area consists of 218,613 acres of federal minerals managed by the BLM, 30,959 acres of state minerals, and 223,873 acres of private minerals. This area would be closed to oil and gas leasing and development for deep natural gas resources until the completion of trona mining and abandonment of the mines. Shallow gas wells within the area could be allowed, subject to special rules currently under development. Several options for compensating current lessees within the withdrawal area are being considered.

A Texas Representative has introduced the Marginal Wells Preservation Act into the nation's House of Representatives. The legal definition of a marginal well is one that produces an average of 15 barrels or less of crude oil per day or 90 MCF or less of gas per day. The bill would allow a $3 per barrel tax credit for the first three barrels produced from existing marginal oil wells, and up to a $.50 per MCF tax credit for the first 18 MCF produced from an existing marginal gas well. The tax credit would be phased in if prices for oil drop below $14 per barrel and if prices for gas drop below $1.56 per MCF. The bill also includes provisions to allow expensing of geological and geophysical costs, and to delay rental payments.

The Mineral Management Service (MMS) distributed $541.4 million to 36 states during 1999 as the state's share of federal mineral royalties. Wyoming received $239.8 million as its share, more than 44% of the national total. Most of Wyoming's total came from oil, gas, and coal production. New Mexico received the second highest total, $148.6 million.

Leasing activity at the February BLM sale was concentrated in the Powder River Basin (**Figure 7**). The lease sale netted about $5.5 million with 180 parcels leased

Table 5. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1996 through December, 1999).

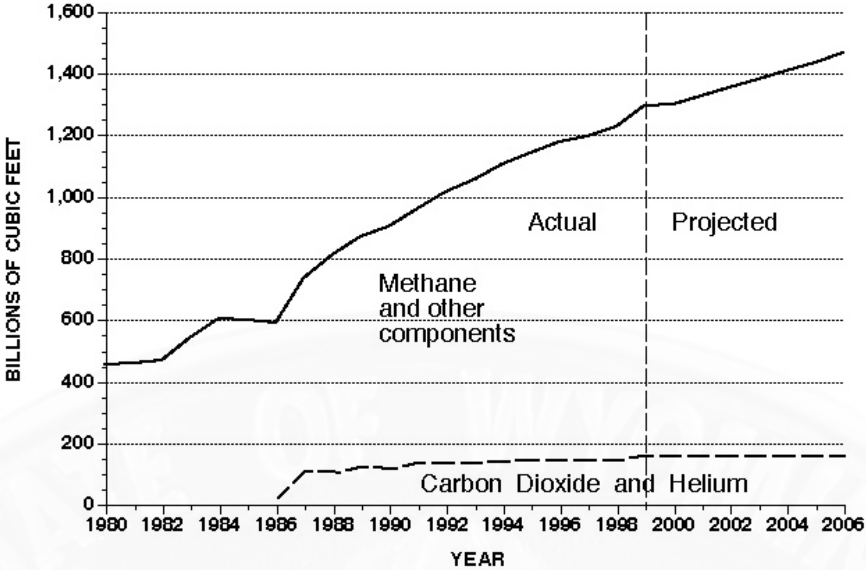
	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	101,359,648	101,359,648	99,579,818	99,579,818	103,640,214	103,640,214	108,336,694	108,336,694
FEB	96,303,300	197,662,948	91,766,159	191,345,977	94,501,819	198,142,033	93,913,971	202,250,665
MAR	103,541,127	301,204,075	104,157,578	295,503,555	103,906,999	302,049,032	110,925,501	313,176,166
APR	99,479,609	400,683,684	99,459,039	394,962,594	98,201,007	400,250,039	102,116,215	415,292,381
MAY	97,900,863	498,584,547	101,070,371	496,032,965	96,741,237	496,991,276	104,611,350	519,903,731
JUN	87,069,612	585,654,159	91,905,308	587,938,273	98,413,520	595,404,796	102,538,111	622,441,842
JUL	100,219,275	685,873,434	100,129,497	688,067,770	102,055,968	697,460,764	106,499,212	728,941,054
AUG	99,874,019	785,747,453	97,673,622	785,741,392	105,378,334	802,839,098	107,275,817	836,216,871
SEP	93,510,551	879,258,004	100,028,888	885,770,280	98,474,782	901,313,880	108,069,440	944,286,311
OCT	95,441,022	974,699,026	102,206,875	987,977,155	96,470,624	990,880,952	118,341,925	1,062,628,236
NOV	94,015,007	1,068,714,033	100,752,128	1,088,729,283	103,445,859	1,101,230,363	110,959,332	1,173,587,568
DEC	99,141,298	1,167,855,331	103,415,430	1,192,144,713	99,339,043	1,200,569,406	119,455,447	1,293,043,015
Total MCF Reported [1]			**1,167,855,331**		**1,192,144,713**		**1,200,569,406**	
1,293,043,015								
Total MCF Not Reported [2]			**5,663,874**		**683,432**		**22,955,142**	
Total MCF Produced [3]			**1,173,519,205**		**1,192,828,145**		**1,223,524,548**	

[1] Monthly production reports from Petroleum Information/Dwights LLC.

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

[3] Wyoming Oil and Gas Conservation Commission.

Wyoming State Geological Survey, Oil and Gas Section, April, 2000.



Oil and Gas Section, April, 2000

Figure 3. Annual natural gas production from Wyoming (1980 through1999) with forecasts to 2006.

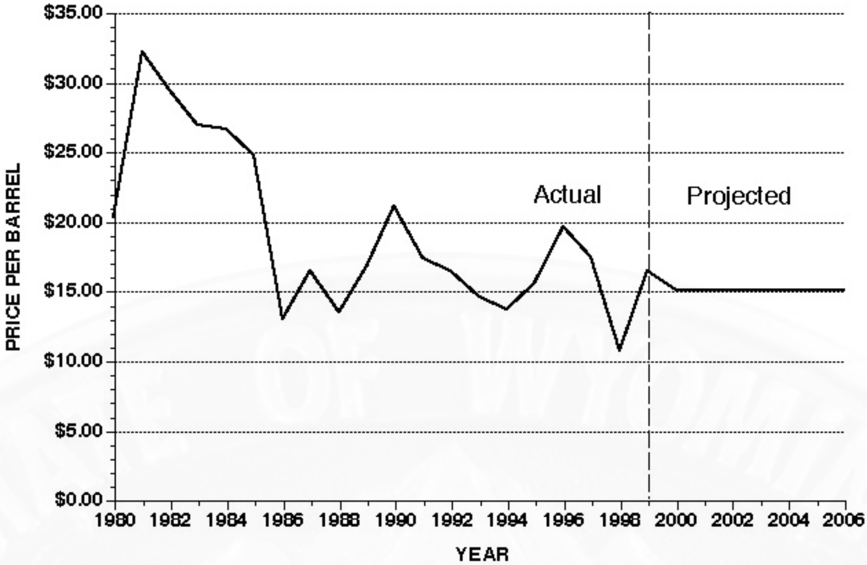
on a total of 130,289 acres (**Table 7**). There were a total of 55 parcels at this sale that received bids of $50 or more per acre.

Lyle Lovgren made the February sale's highest per-acre bid of $525 for an 928.22-acre lease that covers parts of sections 6, 8, 17, and 19, T47N, R74W (**location A, Figure 7**). The lease is in the Hoe Creek Field area, where oil production from the Parkman Sandstone is currently shut in. There is coalbed methane drilling in Fort Union Formation coals in the vicinity of the lease. Powder River Resources made the sale's second highest per-acre bid of $430 for an 80-acre lease that covers N/2 NW section 27, T49N, R75W (**location B, Figure 7**). The lease is about a mile and one half east of Parkman oil production in Dead Horse Creek Field, and is an area that has experienced coalbed methane activity in the Fort Union.

There were 2973 Applications for Permit to Drill (APDs) approved by the WOGCC in the first quarter of 2000 (**Table 8**). The quarterly total is more than the number of APDs approved in 1995, 1996, 1997, or 1998 (**Table 8**). Campbell County again led the state with 75.1% of the total APDs that were approved; Sheridan and Johnson counties combined for another 16.9%. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

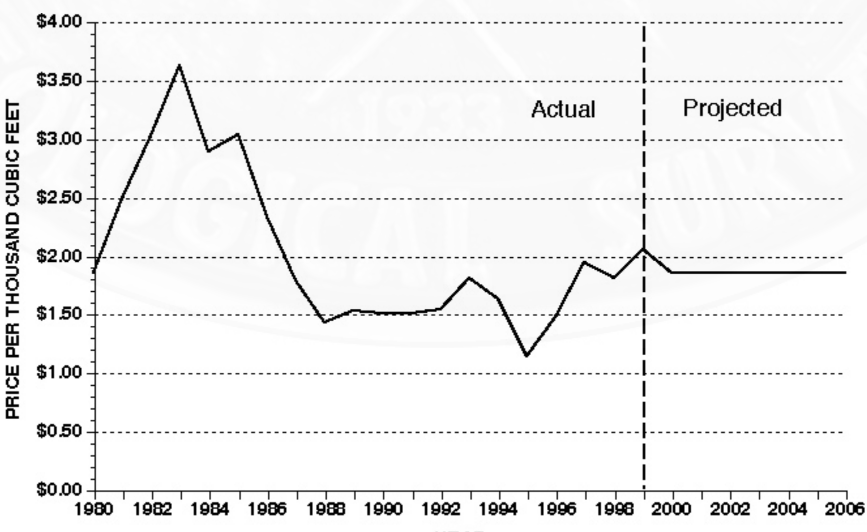
The WOGCC permitted eight seismic projects in the first quarter of 2000 (**Table 9**). The number of permits and miles permitted was up substantially from the first quarter of last year. Geophysical activity in Wyoming is traditionally low during the first quarter of the year.

The average daily rig count for the first quarter of 2000 was 34. This average is nine more than for the first quarter of 1999. The rig count does not include rigs



Oil and Gas Section, April, 2000

Figure 4. Average prices paid for Wyoming crude oil (1980 through 1999) with forecasts to 2006.



Oil and Gas Section, April, 2000

Figure 5. Average prices paid for Wyoming methane (1980 through 1999) with forecasts to 2006.

Table 6. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1997 through March, 2000).

	1997 monthly	1997 cumulative	1998 monthly	1998 cumulative	1999 monthly	1999 cumulative	2000 monthly	2000 cumulative
JAN	$3.90	$3.90	$2.05	$2.05	$1.80	$1.80	$2.20	$2.20
FEB	$2.50	$3.20	$1.70	$1.88	$1.65	$1.73	$2.40	$2.30
MAR	$1.40	$2.60	$1.90	$1.88	$1.50	$1.65	$2.35	$2.32
APR	$1.45	$2.31	$1.90	$1.89	$1.60	$1.64		
MAY	$1.60	$2.17	$1.95	$1.90	$2.00	$1.71		
JUN	$1.35	$2.03	$1.65	$1.86	$2.00	$1.76		
JUL	$1.45	$1.95	$1.60	$1.82	$2.00	$1.79		
AUG	$1.40	$1.88	$1.75	$1.81	$2.20	$1.84		
SEP	$1.50	$1.84	$1.60	$1.79	$2.60	$1.93		
OCT	$2.05	$1.86	$1.65	$1.78	$2.40	$1.98		
NOV	$3.00	$1.96	$2.00	$1.80	$2.85	$2.05		
DEC	$1.95	$1.96	$2.00	$1.81	$2.10	$2.06		
Avg. yearly price		**$1.96**		**$1.81**		**$2.06**		

Source: American Gas Association's monthly reports.
Wyoming State Geological Survey, Oil and Gas Section, April, 2000.

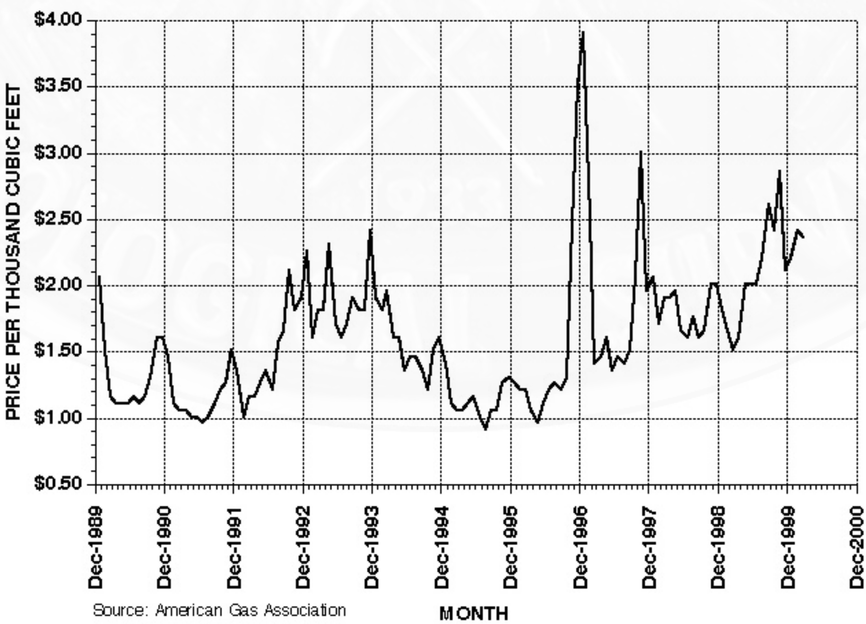


Figure 6. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through March, 2000).

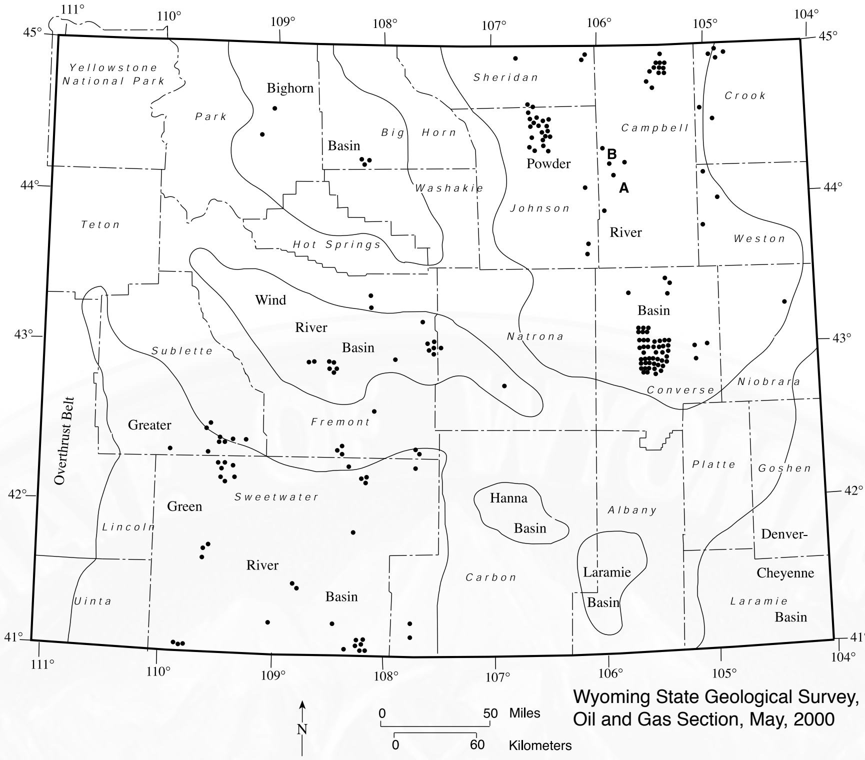


Figure 7. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its February, 2000 sale.

drilling for coalbed methane. **Figure 8** shows the Wyoming daily rig count averaged by month.

Exploration and development

Company data, news releases, and information compiled and published by Petroleum Information/Dwights LLC are used to track oil and gas exploration and development activity in Wyoming. This section reports the most significant activities exclusive of coalbed methane (see the **COAL UPDATE** for development activities in this industry) during the first quarter of 2000. The paragraph numbers correspond to locations on **Figure 9**.

1. Chevron USA completed a horizontal redrill in southwestern Painter Reservoir Field. The 23-21 BH Painter Reservoir Unit well in NE SW section 31, T16N, R119W, flowed 2.6 million cubic feet of gas (MMCF), 425 barrels of oil, and 304 barrels of water per day from the Nugget Sandstone at a true vertical depth of about 10,011 feet.
2. Chevron USA also completed a new well in Whitney Canyon-Carter Creek Field. The 2-5 F Chevron-Federal well flowed 14.2 MMCF of gas, 134 barrels of condensate, and 9 barrels of water per day from perforations in the Mission Canyon Member of the Madison Limestone between 14,502 and 14,984 feet.

Table 7. Federal and State competitive oil and gas lease sales in Wyoming (1996 through February, 2000).

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
1996							
TOTAL	$11,487,567	1828	1125	1,403,444	739,505	$15.53	$1,450.00
1997							
TOTAL	$31,976,603	1787	1485	1,578,938	1,206,642	$26.50	$600.00
1998							
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00
December	$15,229,257	407	278	388,783	277,538	$54.87	$800.00
TOTAL	$63,800,496	2247	1710	2,217,975	1,621,637	$39.34	$800.00
1999							
February	$2,734,442	170	138	157,779	124,880	$21.90	$325.00
April	$2,121,220	124	116	129,358	121,421	$17.47	$280.00
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00
Octoer	$4,395,288	214	175	195,827	142,525	$30.84	$580.00
December	$5,598,020	176	164	128,480	124,093	$28.99	$410.00
TOTAL	$24,197,991	1,069	945	1,060,674	929,674	$26.03	$32,000.00
2000							
February	$5,497,834	192	180	130,289	120,219	$45.73	$525.00

STATE SALES (OFFICE OF STATE LANDS AND INVESTMENTS)

price Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	H i g h per acre
1996							
TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	
$206.00							
1997							
TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	
$340.00							
1998							
April	$1,203,792	300	161	115,646	63,848		
$18.85	$320.00	June$1,660,438		300	148108,654		52,501
$31.63	$600.00						
October	$1,313,792	298	178	98,856	65,212	$20.14	
$590.00							
December	$1,045,447	300	187	121,551	77,852	$13.43	
$215.00							
TOTAL	$5,223,469	1198	674	444,707	259,413	$20.14	
$600.00							

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

Wyoming State Geological Surey, Oil and Gas Section, April, 2000.

Table 8. Number of Applications for Permit to Drill (APD) approved by the Wyoming Oil and Gas Conservation Commission (1995 through March, 2000).

County	1995 APDs	1996 APDs	1997 APDs	1998 APDs	1999 APDs	2000 APDs
Albany	1	1	0	0	0	0
Big Horn	16	53	59	13	6	0
Campbell	151	554	941	1586	4461	2234
Carbon	50	77	84	96	127	38
Converse	29	20	16	6	19	6
Crook	15	37	26	29	30	21
Fremont	30	26	58	76	67	42
Goshen	0	0	0	0	0	0
Hot Springs	13	24	42	1	8	1
Johnson	6	16	6	49	304	153
Laramie	10	2	3	2	0	0
Lincoln	64	55	122	105	51	14
Natrona	80	74	59	36	51	19
Niobrara	4	7	8	8	5	3
Park	20	30	25	11	12	1
Platte	0	0	0	0	0	0
Sheridan	0	0	2	35	416	348
Sublette	61	118	179	230	189	38
Sweetwater	153	136	210	181	124	46
Teton	0	0	0	0	0	0
Uinta	11	10	27	26	26	7
Washakie	31	30	36	9	0	0
Weston	10	10	5	6	4	2
Totals	**755**	**1280**	**1908**	**2505**	**5900**	**2973**

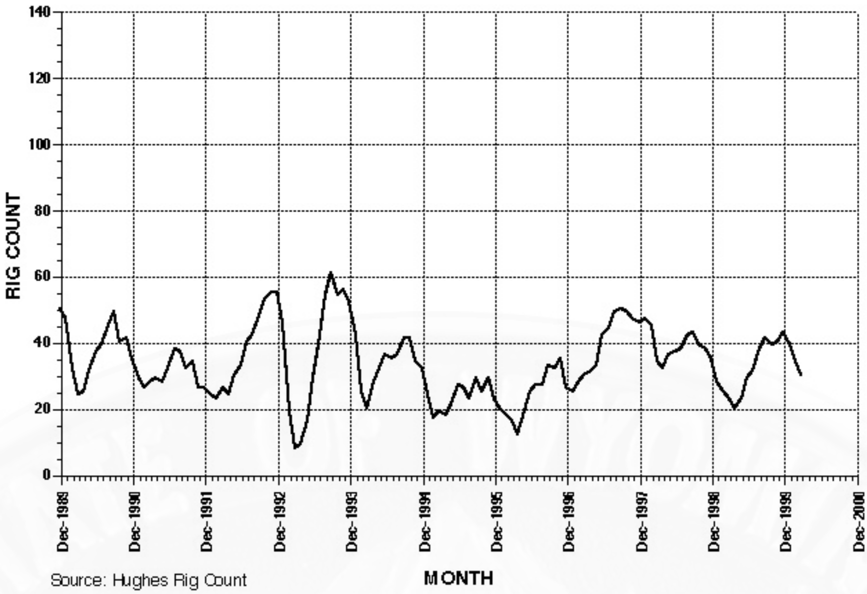
Source: All data are from the Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, April, 2000.

3. Cabot Oil & Gas completed two new dual-zone producers in the Cow Hollow Field area. The 40-13 Hams Fork well in SE SE section 13, T22N, R113W, flowed 1.3 MMCF of gas and 37 barrels of condensate per day from a fracture-stimulated Frontier Formation interval between 10,792 and 10,814 feet and from a fracture-stimulated Dakota Sandstone interval between 11,720 and 11,730 feet. The 10-13 Blackjack well in SW NW section 13, T22N, R113W, flowed 1.0 MMCF of gas and 20 barrels of condensate per day from a fracture-stimulated Frontier interval between 10,870 and 10,898 feet and from a fracture-stimulated Dakota interval between 11,771 and 11,781 feet.
4. EOG Resources completed a new well in the Tip Top Field. The 168-18H Burley well in SW SE section 18, T28N, R113W, pumped 186 barrels of oil, 87 thousand cubic feet of gas (MCF), and 65 barrels of water per day from two fracture-stimulated intervals in the Mesaverde Formation between 1720 and 1723 feet and between 2145 and 2149 feet.
5. Two new wells were completed on the Pinedale anticline. Wexpro Company's 3 Mesa Unit well in SW NW section 16, T32N, R109W, flowed 11.4 MMCF of gas and 113 barrels of condensate per day from 11 fracture-stimulated Lance Formation intervals. Anschutz Exploration's 13-16 Gannett well in SW SW section 16, T33N, R109W, flowed 2.4 MMCF of gas, 12 barrels of condensate, and 73 barrels of water per day from five fracture-stimulated zones in the Lance.
6. Five new wells were completed in Jonah Field. McMurry Oil completed its 5-6 Jonah-Federal well in SW SW section 6, T28N, R108W. The well flowed

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1997 through March, 2000).

	1997			1998			1999			2000		
County	Permits	Conventional Miles	3-D Sq Miles	Permits	Conventional Miles	3-D Sq Miles	Permits	Conventional Miles	3-D Sq Miles	Permits	Conventional Miles	3-D Sq Miles
Albany	0	0	0	0	0	0	0	0	0	0	0	0
Big Horn	2	0	45	1	0	16	0	0	0	0	0	0
Campbell	20	52	79	14	18	182	4	4	10	2	12	2
Carbon	3	7	190	4	0	318	5	77	57	0	0	0
Converse	1	5	0	4	12	239	1	0	50	0	0	0
Crook	7	8	18	2	2	4	1	0	10	1	0	4
Fremont	6	43	126	2	100	0	1	0	88	1	0	101
Goshen	2	227	0	0	0	0	0	0	0	0	0	0
Hot Springs	1	8	0	4	19	0	0	0	0	0	0	0
Johnson	2	7	17	1	4	0	0	0	0	0	0	0
Laramie	0	0	0	0	0	0	0	0	0	0	0	0
Lincoln	3	7	116	1	10	0	1	0	32	0	0	0
Natrona	5	14	101	6	12	214	2	0	230	0	0	0
Niobrara	0	0	0	0	0	0	5	16	31	0	0	0
Park	4	56	58	3	16	132	3	25	32	0	0	0
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	1	14	0	0	0	0	0	0	0
Sublette	1	0	61	2	1	115	3	0	308	0	0	0
Sweetwater	4	66	296	6	214	66	9	0	530	4	12	278
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	0	0	0	2	0	147	1	0	26	0	0	0
Washakie	3	36	0	4	41	35	1	0	8	0	0	0
Weston	1	0	17	1	0	35	1	40	0	0	0	0
Totals	**65**	**536**	**1124**	**58**	**463**	**1503**	**38**	**162**	**1412**	**8**	**24**	**385**

Source: All data are from the Wyoming Oil and Gas Conservation Commission.
Wyoming State Geological Survey, Oil and Gas Section, April, 2000.



Oil and Gas Section, April, 2000

Figure 8. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month (December, 1989 through March, 2000).

5.9 MMCF of gas, 70 barrels of condensate, and 30 barrels of water per day from five fracture-stimulated intervals in the Lance between 8213 and 10,729 feet. McMurry's 13-13 Yellow Point well in SW SW section 13, T28N, R109W, flowed 5.3 MMCF of gas and 133 barrels of condensate per day from four fracture-stimulated intervals in the Lance between 8092 and 9722 feet. Santa Fe Snyder's 3-1-28-109 Yellow Point well in NE NW section 1, T28N, R109W, flowed 1.5 MMCF of gas, 25 barrels of condensate, and 27 barrels of water per day from eight fracture-stimulated intervals in the Lance between 7802 and 10,147 feet. Forest Oil's 23-13 Elm-Federal well in NW NE section 23, T28N, R109W, flowed 6.0 MMCF of gas from two fracture-stimulated intervals in the Lance above 9700 feet. Amoco Production's 9-25 Cabrito Unit well in NE SE section 25, T29N, R108W, flowed 3.5 MMCF of gas per day from 12 fracture-stimulated zones in the Lance between 8982 and 12,180 feet.

7. Camwest Exploration discovered gas at its 1-28 Poblano-Federal well in NE SE section 28, T28N, R107W. The well flowed at rates of 1.2 to 2.4 MMCF of gas per day with five to 30 barrels of condensate per MMCF of gas from over 160 feet of multiple-stacked channel sands in an undisclosed interval in the Mesaverde Formation. The new discovery is about seven miles southeast of Jonah Field.
8. Texaco Exploration & Production extended Stagecoach Draw Field with its 13A Stagecoach Draw Unit well in SE SE section 29, T23N, R107W. Gas flowed at a rate of 7.6 MMCF of gas and 110 barrels of water per day from fracture-stimulated zones in the Almond Formation between 7929 and 7932 feet and in the Ericson Sandstone between 8397 and 8400 feet.
9. Kestrel Energy received a flow line permit from the BLM, which will allow it to complete two new wells. The 27-3 UPRC well encountered excellent gas

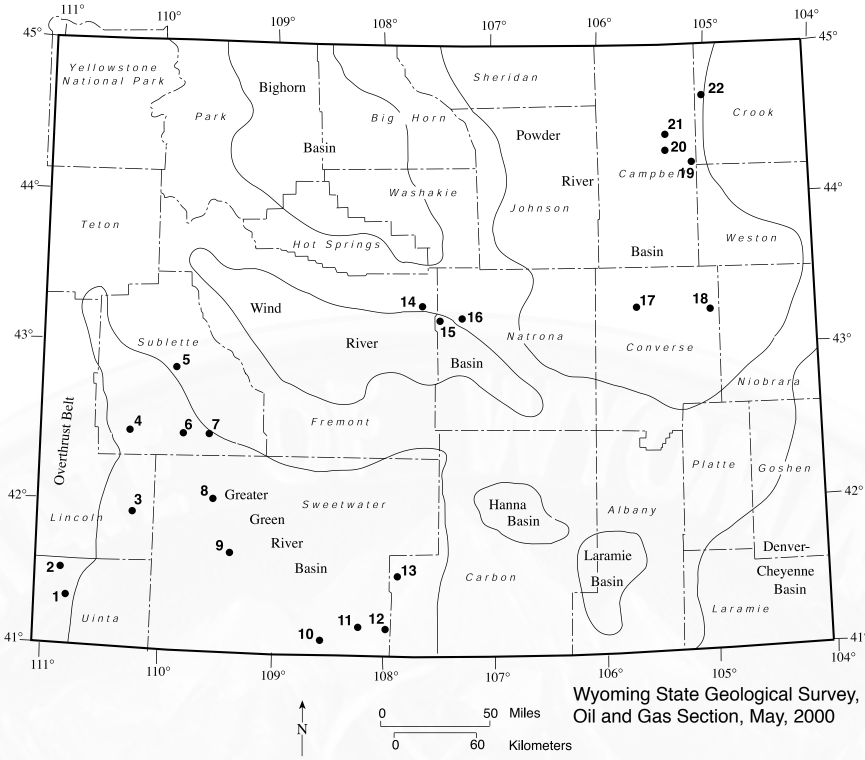


Figure 9. Oil and gas exploration and development activities in Wyoming during the first quarter of 2000, exclusive of coalbed methane activities.

shows in the Second Frontier and wireline logs indicated that there were 26 feet of net pay in the well. The 28-4 Greens Canyon well also had excellent sand development in the Second Frontier with additional pay zones in both the Muddy and the Dakota sandstones. The company estimated that the 1300 acres in the project area has possible reserves of 47 BCF of gas.

10. Questar Exploration & Production completed a new shallow gas producer in Kinney Field. The 8-3 Big Drop well in NW SW section 8, T13N, R99W, flowed 2.0 MMCF of gas per day from the Wasatch Formation between 1292 and 1298 feet.
11. EOG Resources completed an offset to its 1999 gas discovery in the Lewis Shale. The 1-13E Powder Mountain Unit well in SE NE section 13, T14N, R96W, flowed 4.6 MMCF of gas and 28 barrels of water per day from an undisclosed sand interval in the Lewis.
12. Marathon Oil completed a new gas producer about one mile southwest of Dripping Rock Field. The 1-29 Willow Creek in NW NW section 29, T14N, R94W, flowed 2.7 MMCF of gas and 13 barrels of water per day from the Almond Formation between 12,699 and 12,710 feet.
13. Santa Fe Snyder completed two new gas wells on the west side of Standard Draw Field. The 6-20-18-93 Standard Draw well in S/2 NW section 20, T18N, R93W, flowed 4.0 MMCF of gas, 65 barrels of condensate, and 19 barrels of water per day from four fracture-stimulated zones in the Almond between 8956

and 9152 feet. The 4-8-18-93 Standard Draw well in SE NW section 8, T18N, R93W, flowed 1.9 MMCF of gas, 22 barrels of condensate, and 13 barrels of water per day from six fracture-stimulated zones in the Almond between 9024 and 9255 feet.

14. Louisiana Land & Exploration completed a new well in Madden Field. The 38 Madden Deep Unit well in NW SE section 4, T38N, R90W, flowed 4.7 MMCF of gas and 86 barrels of water per day from three intervals in the Fort Union Formation between 5492 and 9960 feet.
15. Tom Brown completed a new well in Frenchie Draw Field. The 41 Graham Unit well in NE SE section 18, T37N, R89W, flowed 4.0 MMCF of gas and 21 barrels of condensate per day from the Fort Union between 10,282 and 11,446 feet.
16. Barrett Resources reentered a well in Waltman Field and recompleted it as a Fort Union producer. The 1-36 West Cave Gulch well in NW NE section 36, T37N, R87W, flowed 5.1 MMCF of gas per day from two fracture-stimulated intervals between 4994 and 5473 feet. The well was completed in 1998 and had produced 1.16 BCF of gas, 7000 barrels of condensate, and 6688 barrels of water from the Lance Formation. Barrett recovered gas at rates up to 16.0 MMCF per day with some water in a test of its 5-12 Bullfrog well in SW SE section 12, T36N, R87W. The well was tested in an undisclosed interval in the subthrust Lakota. Several zones in the Frontier Formation as well as in the Muddy Sandstone will also be tested in the well.
17. Vastar Resources completed a wildcat in the Muddy Sandstone. The 1-35 European Swallow well in NW SW section 35, T39N, R75W, produced an average of 377 barrels of oil during its first 10 days on line. The well is two miles southeast of Vastar's 1-22 African Swallow discovery. The African Swallow well has produced 6.2 BCF of gas, 555,997 barrels of condensate, and 14,245 barrels of water during its first 15 months on line.
18. Abraxas Petroleum has scheduled a horizontal test in the Turner Sandy Member of the Carlile Shale. The 3H-10-38-67 Turner well will be drilled from a surface location in SW SW section 10, T38N, R67W, to a true vertical depth of 8173 feet.
19. Barrett Resources discovered oil in the Minnelusa Formation at its 31-6 Duvall well in NW NE section 6, T49N, R69W. The well pumped 253 barrels of oil per day from perforations between 8555 and 8575 feet. The well is half a mile north of a Minnelusa producer in Halverson Field.
20. Duncan Oil completed a new Minnelusa well in FD Field. The 34-13 Record well in SW SE section 13, T50N, R71W, pumped 253 barrels of oil per day from perforations between 9143 and 9162 feet.
21. Fancher Oil discovered oil in the Minnelusa at its 31-11 Reb-Fee well in NE SW section 31, T51N, R71W. The well pumped 145 barrels of oil and 152 barrels of water per day from perforations between 9508 and 9510 feet. The well is a half-mile northwest of an inactive Springen Ranch Field well that produced from the Muddy Sandstone.
22. Westech Energy completed a wildcat well in the Minnelusa. The 3-30 NW Morel-Federal well in NE NW section 30, T54N, R68W, pumped 120 barrels of oil and 28 barrels of water per day from perforations between 7090 and 7095 feet. The well is about two miles east of Minnelusa production in Trout Pond Field.

COAL UPDATE

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The final 1999 coal production for Wyoming, as reported by the State Inspector of Mines (Stauffenberg, 1999), was about 336.5 million short tons (tons) (**Table 10**). This establishes a new state production record and exceeds 1998's production by 21.5 million tons or 6.8%. All the production except 1.7 million tons was from surface coal mines.

Table 10. Coal production and employment in Wyoming, by mine and coal field, for 1999. Data from Stauffenberg (1999).

Operator	Mine name	Number of Employees	Production (short tons)
	Powder River Coal Field		
Antelope Coal Company	Antelope	188	22,685,000
Big Horn Coal Co.		12	76,401
Caballo Coal Company	Caballo Mine	305	26,468,718
Caballo Coal Company	Rawhide Mine	19	807,892
Cordero Mining Company	Cordero Rojo Complex	404	45,674,755
Dry Fork Coal Co.	Dry Fork	9 average	1,219,590
Fuller Construction Co. & Morrison Knudsen Corporation	Coal Creek Mine	297	11,229,923
Glenrock Coal Co.	Dave Johnson Mine	169	2,956,038
Jacobs Ranch Coal Co.	Jacobs Ranch Mine	355	29,081,030
KFx Fuel Partners L.D.	KFx Raw Coal Facility	3 average	33,028
Powder River Coal Co.	North Antelope/ RochelleComplex	650	68,865,691
RAG Coal West, Inc.	Belle Ayr Mine	253	17,885,338
RAG Coal West, Inc.	Eagle Butte Mine	186	17,416,240
Thunder Basin Coal Co. LLC	Black Thunder Mine	508	48,670,418
Thunder Basin Coal Co. LLC	Coal Creek Mine	4	Listed under Fuller Const.
Triton Coal Co.	Buckskin Mine	145	15,587,569
Triton Coal Co.	North Rochelle Mine	172	8,171,479
Wyodak Resources Development Corp.	Wyodak Mine	43	3,179,585
	Hanna Coal Field		
Arch of Wyoming, LLC.	Medicine Bow	49	614,254
Arch of Wyoming, LLC.	Seminoe II	47	422,263
RAG Shosone Coal Co.	Shoshone #1	79	1,706,939
	Green River Coal Field		
Black Butte Coal Co.	Black Butte	144	3,086,646
Bridger Coal Co.	Jim Bridger	375	6,300,944
	Hams Fork Coal Field		
Pittsburg & Midway Coal Co.	Kemmerer Mine	279	4,320,197
TOTALS		4,606	336,459,938

Wyoming State Geological Survey, Coal Section, April, 2000

During the first quarter of 2000, the spot market for Wyoming coal was slack with erosion in spot prices. In January, 2000, this downward trend in spot coal prices was believed due to the lack of market activity tied to the extra coal stockpiled at electric utilities in preparation for the Y2K "non-event." A mild February negated the need for extra coal over much of the Upper Midwest, which is a major part of the market area for Wyoming coal. In March, lower water levels in the Great Lakes area was retarding the amount of Wyoming coal being moved along that water system, furthering the slow down.

In response to the slack spot market, many producers in the Powder River Basin are becoming less willing to allow continued rollovers of deliveries. Some companies are thinking about either reducing production or delaying production increases until spot market prices strengthen. Our earlier estimates looked for a 6% production increase for the year 2000 but the increase will probably be closer to 3.5% instead. The total coal production in 1999 was slightly less than that predicted (but within 0.6%), and with the slight downturn in production now occurring at some mines, we have revised our production forecast for the years 2000 through 2006 (**Tables 1** and **11**). Compare these figures to the historic and projected coal production by county, Table 12 in Wyoming Geo-notes No. 65 (March, 2000).

The new production estimates have not changed our estimate of the percentage of coal from the Powder River Basin, which sells for more than $5.00/ton (termed higher-priced coal). The tonnage sold at these higher prices is that remaining from older, long-term contracts that had escalation clauses built into them. Our estimated coal prices (**Table 2**) have not changed from Wyoming Geo-notes No. 65 (March, 2000); 1999 data are not yet available.

Domestic steam coal deliveries for 1999 (**Table 12**) showed how that market sector led the way to the state's new record growth in coal production. Wyoming's coal producers had shipped 321.3 million tons of steam coal by year's end, an increase of about 5.4% over the tonnage delivered in 1998. Monthly coal deliveries from Wyoming mines showed a slowdown in the last three months of 1999 (**Figure 10**). The amount of coal sold under contract in the last three months of 1999 was actually less than that sold under contract in 1998 (**Figure 11**) but was offset by more coal sold on the spot market than in 1998.

Export sales of Wyoming coal showed a good increase in 1999. Estimated exports increased by nearly 4 million tons: in 1998, the state exported approximately 2.2 million tons to Spain and Canada; in 1999, exports were approximately 6.2 million tons with all of the growth in sales to our northern neighbor.

The remaining 1999 production was sold to the commercial, industrial, and residential markets. This amounted to about 9 million tons.

Developments in the Powder River Basin (PRB)

The Peabody Group announced that its North Antelope/Rochelle mine complex passed a milestone in December as it shipped its 500-millionth ton of coal (**location 5, Figure 12**). The North Antelope mine began production in late 1983 and the Rochelle mine began production in 1985. The two mines were combined last January into the largest producing operation in the world. The company said

Table 11. Wyoming coal production by county[1, 2] (in millions of short tons) from 1995 to 1999 with forecasts to 2006.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Powder River Basin												
Campbell County	232.4	245.3	246.3	274.1	296.3	306.3	317.1	320.7	322.3	331.0	333.7	337.5
Converse County	14.1	15.8	17.8	23.4	24.0	27.0	30.0	30.0	30.0	25.0	25.0	25.0
Sheridan County	M	M	M	M	M	M	M	M	M	M	M	M
Southern Wyoming												
Carbon County	3.8	4.7	5.0	3.5	3.5	2.0	M	M	2.0	2.0	3.0	3.0
Sweetwater County	9.1	8.2	7.8	9.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.5	4.4	4.6	4.7	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Wyoming[3]	**263.9**	**278.4**	**281.5**	**314.9**	**336.5**	**348.3**	**360.1**	**363.7**	**367.3**	**371.0**	**374.7**	**378.5**
Annual Change11.4%	5.5%	1.1%	11.9%	6.9%	3.5%	3.4%	1.0%	1.0%	1.0%	1.0%	1.0%	
Higher-priced coal[4]	**26%**	**24%**	**22%**	**17%**	**13%**	**9%**	**6%**	**4%**	**4%**	**4%**	**4%**	**4%**

[1]Tonnage from the Wyoming State Inspector of Mines, 1995-1999.
[2]County estimates by the Wyoming State Geological Survey, April, 2000, for 2000-2006.
[3]Estimate modified from CREG's Wyoming State Government Revenue Forecast, October, 1999.
[4]Estimated percentage of Powder River Basin coal production that is sold at prices above $5.00/ton (older long-term contracts that have not yet expired).
[M means minor tonnage (less than 50,000 tons)].
Wyoming State Geological Survey, Coal Section, April, 2000.

Table 12. Monthly coal deliveries from Wyoming's mines in short tons (1996 through December, 1999)

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	21,793,387	21,793,387	25,165,405	25,165,405	26,536,217	26,536,217	26,970,936	26,970,936
FEB	20,374,055	42,167,442	20,743,224	45,908,629	23,196,152	49,732,369	25,675,015	52,645,951
MAR	22,507,800	64,675,242	22,566,012	68,474,641	23,861,472	73,593,841	28,082,331	80,728,282
APR	22,579,959	87,255,201	20,961,008	89,435,649	24,768,989	98,362,830	25,836,684	106,564,966
MAY	22,216,016	109,471,217	23,102,867	112,538,516	25,278,960	123,641,790	28,414,354	134,979,320
JUN	20,698,814	130,170,031	20,862,610	133,401,126	24,450,835	148,092,625	24,508,742	159,488,062
JUL	24,842,971	155,013,002	24,074,929	157,476,055	25,663,577	173,756,202	27,986,592	187,474,654
AUG	24,421,537	179,434,539	23,002,254	180,478,309	26,591,950	200,348,152	28,066,096	215,540,750
SEP	23,339,792	202,774,331	22,452,566	202,930,875	26,041,099	226,389,251	26,836,683	242,377,433
OCT	22,615,721	225,390,052	21,623,057	224,553,932	26,659,121	253,048,372	26,311,074	268,688,507
NOV	21,421,085	246,811,137	21,695,072	246,249,004	25,620,216	278,668,588	26,316,687	295,005,194
DEC	22,105,530	268,916,667	24,695,740	270,944,744	26,102,620	304,771,208	26,308,752	321,313,946
Total Tonnage Reported[1]		**268,916,667**		**270,944,744**		**304,771,208**		**321,313,946**
Total Tonnage Not Reported[2]		**9,508,289**		**10,536,772**		**10,190,883**		**15,145,992**
Total Tonnage Produced[3]		**278,424,956**		**281,481,516**		**314,962,091**		**336,459,938**

[1]From Federal Energy Regulatory Commission (FERC) Form 423, 1996-1999.
[2]Includes estimates of residential, industrial, and exported coal, plus tonnage not reported on FERC's Form 423.
[3]Wyoming State Mine Inspector's Annual Reports.
Wyoming State Geological Survey, Coal Section, April, 2000.

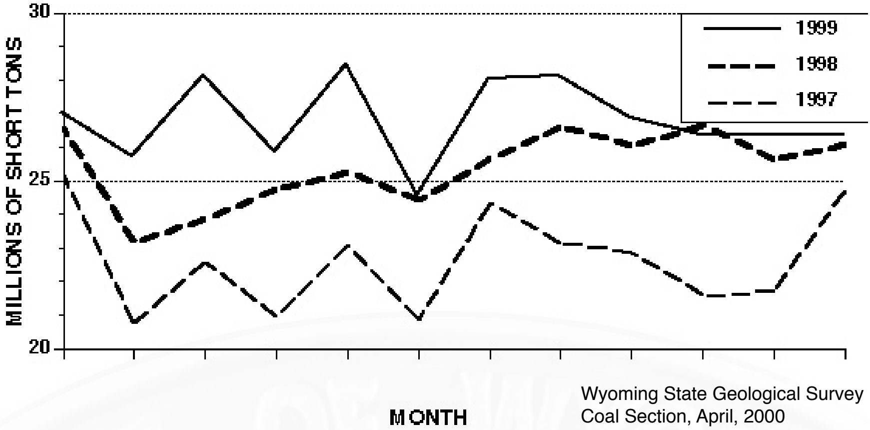

Figure 10. Reported monthly deliveries from Wyoming coal mines (1997 through December, 1999). Derived from data on the Federal Energy Regulatory Commission's (FERC's) Internet bulletin board.

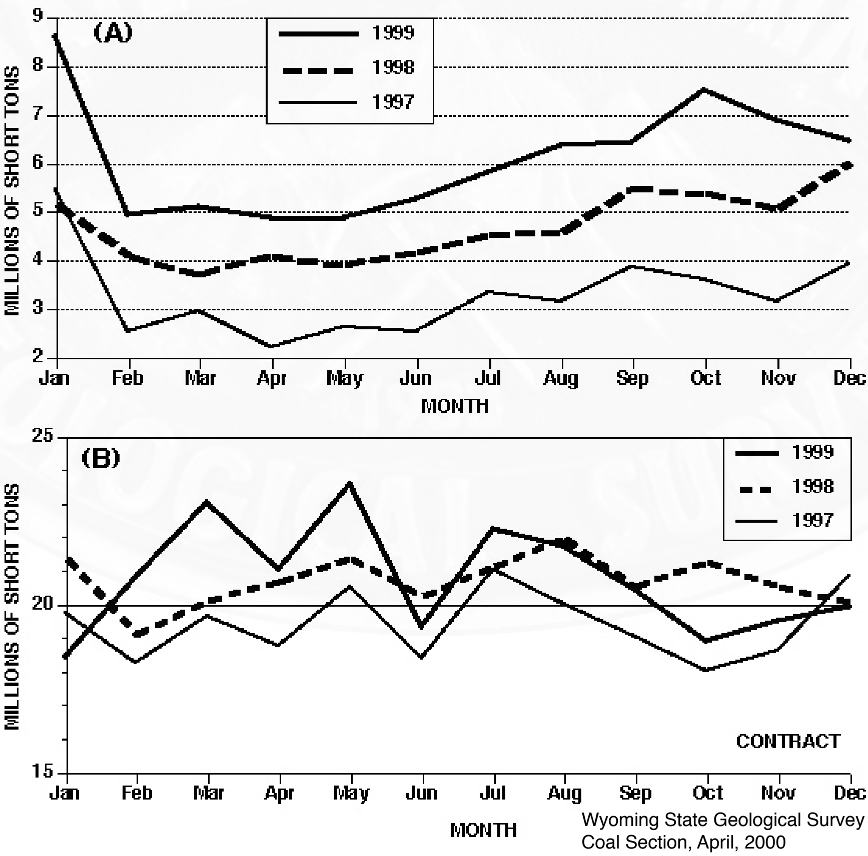

Figure 11. Monthly coal deliveries from Wyoming coal mines (1997 through December, 1999). (A) Coal sold on the spot market and (B) coal sold on contract. Derived from data on FERC's Internet bulletin board and Form 423.

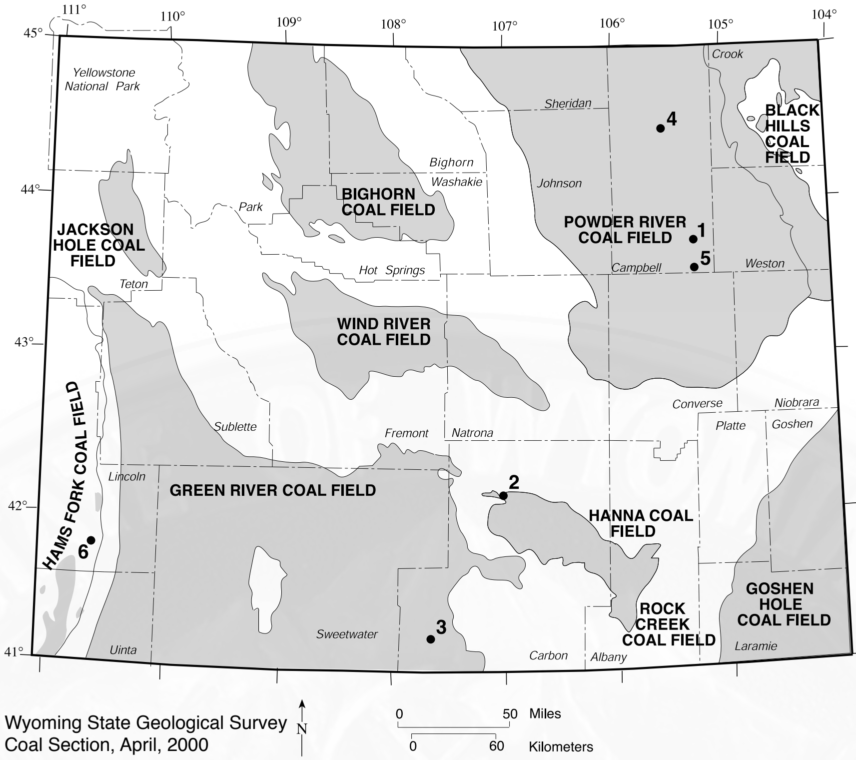

Figure 12. Coal developments and coalbed methane activities in Wyoming during the first quarter of 2000.

the complex also set a new combined surface mine production record by shipping 68.9 million tons of coal in 1999. This involved loading 5122 unit trains in 1999 (Coal Daily 1/19/00).

State Representative Rick Badgett (R-Sheridan) introduced a bill in the Wyoming Legislature that contains language for the opportunity to construct a coal slurry pipeline from the PRB to deep into the heart of Texas. House Bill (HB 0165) addresses the appropriation of water produced from coalbed methane wells to transport coal via pipeline. Progress on this bill and others of interest to the coal industry can be monitored at the Wyoming Legislature's web site, http://legisweb.state.wy.us/.

Triton Coal Co. announced in February it is applying for a drilling exploration permit on 858 acres of unleased federal coal lands adjacent to the company's Buckskin surface mine (**location 4, Figure 12**). Triton is inviting potential partners to participate in the exploration project. Under the standard procedures of the Mineral Leasing Act, partners can participate on a pro-rata basis (Coal Week, 2/21/00).

Developments in southern Wyoming

After a reported deal with Renco Coal Inc. (RCI) fell through, Chevron Corporation may withdraw their Pittsburg & Midway Coal Mining Company (P&M) from the divestiture market. After RCI, a sister company of Lodestar Energy, balked at the purchase of P&M, another company, Vulcan Coal Holdings, LLC., reportedly was interested in the company. Chevron reported that a deal with Vulcan was not very likely. The sale of P&M would probably be tabled for the immediate future so P&M employees could get back to their normal business (Coal Daily, 1/5/00). P&M owns and operates the Kemmerer surface mine in the Hams Fork Coal Field (**location 6, Figure 12**).

Transportation developments

Wisconsin Power and Light (WPL) filed an complaint with the federal Surface Transportation Board (STB) claiming that the Union Pacific Railroad (UP) is overcharging for coal shipments received at the utility's Edgewater (Wisconsin) plant from the southern PRB. After WPL failed to negotiate a haulage contract to replace a now expired contract, UP countered with a common carrier rate of $14.66/ton. WPL's complaint stated that it believed the rate was above the STB's jurisdictional threshold of 180% of UP's variable cost. Therefore, WPL asked the STB to find that the UP rate is unreasonable and asked the STB to establish the maximum reasonable rate that the UP may charge (Coal Daily, 1/11/00).

The Canadian Pacific, Union Pacific, CSX, and Norfolk Southern railroads posted an open letter to shippers on January 11, 2000 warning of "serious concerns with the potential impact of the proposed BNSF-CN merger on the future structure of the rail industry." The four Class I railroads are concerned about the proposed merger of the Burlington Northern & Santa Fe Railway (BNSF) with the Canadian National Railroad (CN). The proposed merger could trigger another round of major railroad consolidations "resulting in two large rail systems serving North America." In their letter, the four railroads pointed out that "no remaining Class I railroad could afford to sit by and just let one line get disproportionately larger" (Coal Daily, 1/12/00).

The proposed BNSF-CN merger could impact the expansion of the Dakota Minnesota & Eastern Railroad (DM&E) into the PRB. It is feared that after the proposed merger the CN may not be willing to interchange with the DM&E for business out of the PRB (Coal Daily, 1/12/00).

The DM&E celebrated the loading its one-billionth bushel of grain since it began service in 1986. Kevin Schieffer, the Chief Executive Officer for DM&E, used the occasion to point out that his railroad's build-in project to the PRB would help agricultural interests along the new proposed routes by opening new transportation and market opportunities beyond just the coal industry (Coal Daily, 1/20/99).

UP has broken its one-month train loading record for the southern PRB. In January, 2000, the line originated 904 trains out of the coal field, eclipsing the railroad's old record of 884 trains loaded in March of 1999 (Coal Daily, 2/15/00).

The UP also reported completion of its double-track project between Gibbon, Nebraska and Marysville, Kansas. The four-year, $157-million project in this transportation corridor connects with the railroad's new triple-track main line which runs from Gibbon to North Platte, a major haulage route for PRB coal (Coal Daily, 3/29/00).

Coalbed Methane Developments

Kennecott Energy Co. has filed suit in federal court claiming that M&K Oil Co. has refused to work with them to resolve overlapping lease holdings. M&K operates three oil and gas wells that are in conflict with an ongoing expansion project at Kennecott's Jacobs Ranch coal mine **(location 1, Figure 12)**. The mine's production pit will reach one well this year; the other two wells will be in the mine's path during the year 2001. Kennecott offered several solutions, which included an offer to buy out the wells at market value or pay to reestablish the wells after mining. In a counter suit, M&K claimed it has no obligation to accommodate the mine expansion because its oil and gas leases (including coalbed methane) predate the coal leases Kennecott received from the federal government (Coal Daily, 1/19/00).

Dudley & Associates is adding to its Hanna Basin coalbed methane exploration program (Wyoming Geo-notes No. 65, March, 2000, p. 32). The company has scheduled a 1300-foot coalbed methane test approximately 18 miles north-northwest of Sinclair, Wyoming (**location 2, Figure 12**). The well will test the coalbed methane potential of the Upper Cretaceous Medicine Bow and Fox Hills formations (PI/Dwights Plus Drilling Wire, 3/3/00, p. 8).

Stone & Wolf is planning a coalbed methane program in the southeastern Green River Coal Field (**location 3, Figure 12**). The Bureau of Land Management has called for public comment on the proposed coalbed methane project, which calls for exploration and development in three areas or pods. The areas extend from approximately 6 miles north of Baggs to 24 miles north of Baggs, and all east of State Highway 789 (PI/Dwights Plus Drilling Wire, 3/3/00, p. 12). Each pod will consist of 32 wells. An environmental document will be prepared as an environmental assessment (EA). If the project is successful, any additional drilling will require additional environmental assessments. Most likely, a full environmental impact study (EIS) will be required before a higher density of development would be permitted.

In January, Pennaco Energy announced that its gross production of coalbed methane in the Powder River Basin was over 46 million cubic feet (46 MMCF) of gas per day. In the south Gillette area, daily production was 43.9 MMCF per day from 249 wells, each averaging 176,000 cubic feet (176 MCF) of gas per day. The rest of the company's production comes from wells in the Pennaco/CMS area of mutual interest. The company reported that there were 14 Pennaco-operated rigs in the PRB.

Regulatory developments

The Wyoming Legislature passed a pair of bills in March that create new taxes on coal transportation in the state. HB 207 imposes a new excise tax on commercial intrastate transportation of coal mined in Wyoming. It requires a tax be levied at the rate of one-tenth of a mill ($.0001) for each ton of coal, or portion of a ton of coal, per mile commercially transported within the boundary of the state. Conservative estimates indicate that the new tax will generate over $180,000 per month.

The second bill (HB 80) imposes a charge of 7-cents-per-mile for each train-mile that railroads travel in Wyoming. The bill also carries an additional $100 charge for each public rail crossing on a railroad's line. It is estimated that this tax would generate income of nearly $1.5 million a year (Coal Daily, 3/15/00).

Coal-related fatalities in the U.S. rose to 34 in 1999, the worst year since 1996 when 39 coal-related deaths were reported. For the second straight year, Wyoming had one fatality. Since 1995, the state's mines have reported four coal-related fatalities. Despite the fact that Wyoming coal mines are amongst the safest in the world, these statistics are a sober reminder that safety should remain at the forefront of a mine employee's daily tasks.

Market developments and opportunities

In January, Arizona Electric Power began testing southern PRB coal from the Jacobs Ranch mine. The test was a series of blends with its current coal supplied by Pittsburg & Midway Coal Mining Company. Blends of 30, 40, and 50%, as well as 100% PRB are being tested (Coal Week, 1/24/00).

Ameren Corp. is looking at ways it can enter the business of transporting and marketing PRB coal. The St. Louis utility plans to build an 8000-foot-long rail loop and a coal transfer terminal integrated into its current barge-handling facility. The planned transfer facility is designed to handle 8 to 10 million tons of coal per year (Coal Week, 3/27/00).

Ameren's Meramec power station burns almost 2 million tons of PRB coal annually, and the utility hopes it can facilitate moving PRB coal to other Midwest plants. While principally offering coal distribution services, Ameren also hopes to gain fuel savings by leveraging its PRB coal needs with additional coal purchases to be resold to other utility customers.

Construction for Ameren's rail loop (which will connect with UP) is scheduled to begin in June and to be operational by August, 2001 (Coal Daily, 3/23/00). Ameren hopes that the barge terminal will be in service by early 2002.

Reliant Energy gained approval from the Texas Natural Resource Conservation Commission to test burn PRB coal at their Limestone power plant. The plant is looking at petcoke and PRB coal to boost the Btus of the plant's lignite fuel. The company said it would most likely test burn some coal from the Cordero-Rojo complex currently being used at its Parish plant (Coal Week, 3/12/00).

Table 13 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal, announced during the first quarter of 2000.

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Table 13. Marketing activities for Wyoming coal producers during the first quarter of 2000.[1]

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	PacifiCorp	Dave Johnston	Cordero Rojo/PRB	C	1.8 million t	For delivery April 1, 2000 to March of 2004
2.	Central and South West Corp.	System	PRB & Colorado	So	4 million t	For delivery in 2001 bidding will be via the company's electronic bidding system
3.	City Public Service Board of San Antonio	Deely & Spruce	PRB	So	unspecified	2001 coal needs
4.	Consumers Energy	J.H. Campbell	PRB	So	700,000 t.	Delivery between May & December 2000, with minimum of 8650 Btu/lb.
5.	Detroit Edison Co.	System	North Rochelle/PRB	Sp	750,000 t.	Delivery this year to vessel-served plants on the Great Lakes
6.	Texas Minicipal Power Agency	Gibbons Creek	PRB	So	unspecified	2001 coal needs
7.	Wisconsin Electric Power Co	Pleasant Prarie	PRB	So	up to 2 million t/y	Delivery beginning 1/01/2001 for 3 to 6 years
8.	Lower Colorado River Authority	Fayette Power Project	Cordero Rojo/PRB	Sp	500,000 t	Delivery in the rest of 2000
9.	MidAmerican Energy	System	PRB	So	up to 1 million t	Delivery over balance of 2000
	MidAmerican Energy	System	PRB	So	1 to 3 million t	Delivery over 2001 to 2002
	MidAmerican Energy	System	PRB	So	1 to 3 million t/y	3 to 5 year period beginning in 2001
10.	Kentucky Utilities	Ghent	Western Coal	So	unspecified	short and long term coal dilivery beginning in May or June, 2000
11.	Arizona Electric Power Coop.	Apache	Western Coal	So	1.4-1.5 million t	Delivery in 2001 Btu range 8,800-12,500
12.	Pennsylvania Power & Light-Montana	Corette	Eagle Butte/PRB	C	500,000 t	1 year contract beginning January 1, 2000
13.	American Electric Power	System	PRB	So	unspecified	contracts up to 2 years and 9 months minimum 8,300 Btu/lb & compliance surfur

[1]Data obtained from: Coal Week, Coal Daily, Coal Age, FERC database, and personal contacts.
Note: C = contract coal; Sp = spot coal; So = solicitation; t =short ton; t/y = short tons per year; PRB = Powder River Basin; and BNSF = Burlington Northern/Santa Fe railroad.
Wyoming State Geological Survey, Coal Section, April, 2000.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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The U.S. Geological Survey (USGS) released its Preliminary Statistical Summary of nonfuel mineral production for the calendar year 1998 (U.S. Geological Survey, 2000). Wyoming continued its 13th ranking among the 50 states in the value of nonfuel mineral production for 1998 with $1.06 billion and ranked 1st in per capita value. According to the USGS, the principal nonfuel minerals produced in Wyoming in order of value were soda ash, bentonite, helium, cement, and crushed stone. For most states, construction materials (crushed stone, sand and gravel, cement, lime, and others) are the leading nonfuel minerals (**Table 14**). Wyoming (along with several other states) is unique in that specialty industrial minerals produce the most value. Several of the top 20 states also produce high value metals, while Wyoming does not.

Table 14. Statistical summary of the top 20 nonfuel mineral producing states in the U.S. Source: U.S. Geological Survey, 2000.

Rank	State	Valuation (billions of dollars)	Principal minerals produced in order of value
1	Nevada	3.10	Gold, silver, copper, sand and gravel
2	California	2.97	Sand and gravel, cement, boron, crushed stone, gold
3	Arizona	2.82	Copper, sand and gravel, cement, molybdenum
4	Florida	1.96	Phosphate, crushed stone, cement, sand and gravel
5	Texas	1.92	Cement, crushed stone, sand and gravel, magnesium
6	Georgia	1.79	Kaolin, crushed stone, cement, fuller's earth, sand and gravel
7	Michigan	1.75	Iron, cement, sand and gravel, magnesium, crushed stone
8	Minnesota	1.73	Iron, sand and gravel, crushed stone, dimension stone
9	Missouri	1.36	Crushed stone, cement, lead, lime, zinc
10	Utah	1.30	Copper, sand and gravel, magnesium, gold, cement
11	Pennsylvania	1.28	Crushed stone, cement, sand and gravel, lime
12	Ohio	1.15	Crushed stone, sand and gravel, salt, lime, cement
13	**Wyoming**	1.06	Soda ash, bentonite, helium, cement, crushed stone
14	New York	0.98	Crushed stone, cement, sand and gravel, salt, zinc
15	Alabama	0.95	Cement, crushed stone, lime, sand and gravel
16	Alaska	0.91	Zinc, gold, lead, silver
17	Illinois	0.86	Crushed stone, cement, sand and gravel, lime
18	New Mexico	0.86	Copper, potash, sand and gravel, cement, crushed stone
19	North Carolina	0.79	Crushed stone, phosphate, sand and gravel, industrial sand, feldspar
20	Tennessee	0.71	Crushed stone, zinc, cement, sand and gravel, ball clay

Wyoming State Geological Survey, April, 2000

Wyoming was the featured state in the February, 2000, issue of North American Minerals News, a publication of Industrial Minerals Magazine, London, England (Harris, 2000). Wyoming was the second U.S. state to be featured in the monthly series called "State Surveys."

The Industrial Minerals and Uranium Section of the Wyoming State Geological Survey (WSGS) received a $23,896 grant from Union Pacific Land Resources Corporation (UP) to study decorative stone in the southern quarter of Wyoming. Sites to be studied will include, but are not limited to, surface and minerals owned by UP. The grant will fund field studies of quarry sites and publication of the results.

Ray Harris, head of the Industrial Minerals and Uranium Section and Principal Investigator on the grant, estimates that about 60 sites will be studied in detail. A final report will be published and released to the public at the completion of the project on October 31, 2002.

This grant is a milestone for the WSGS in government-industry partnerships. Although the WSGS has previously received funding from private industry for geologic studies, this is the largest award to date.

Chemical grade limestone

Pete Lien & Sons (Lien) of Rapid City, South Dakota operates the Hartville limestone quarry near Hartville in Platte County (**Figure 13**). Lien sells limestone crushed to 1/2” minus to the Laramie River coal-fired power plant north of Wheatland for emissions control, and limestone (sugar rock) crushed to 3” minus to sugar beet plants in several nearby states and Wyoming for use in the sugar extraction process.

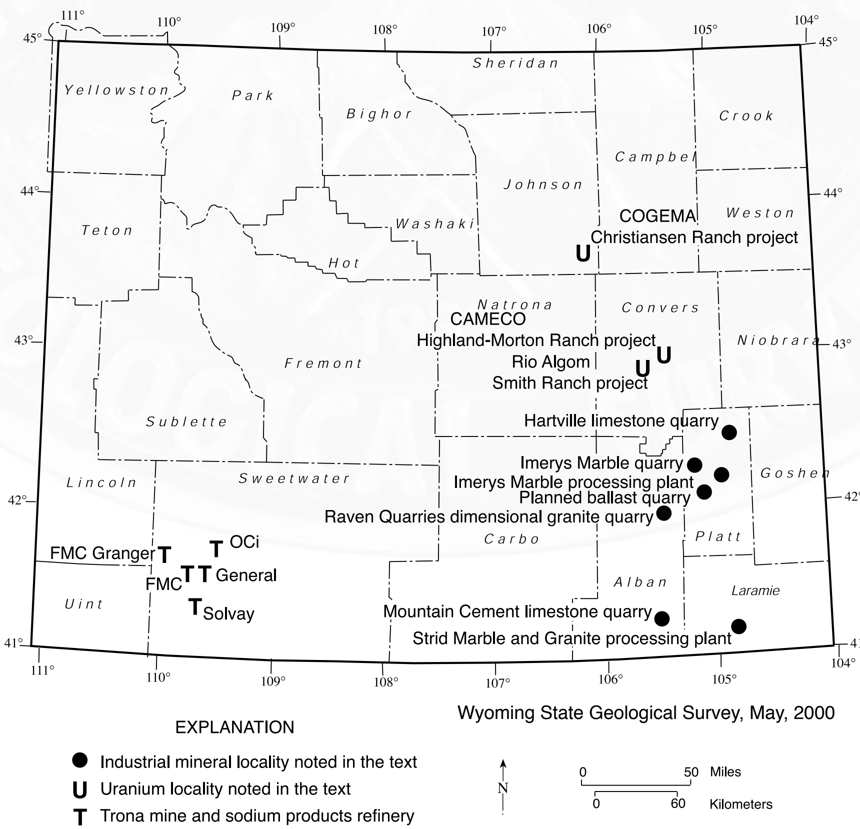

Figure 13. Map of selected industrial mineral and uranium sites in Wyoming.

Lien is planning to expand production of limestone in Wyoming as it acquires additional contracts for sugar rock.

Mountain Cement quarries over 750,000 short tons per year of limestone near Laramie (**Figure 13**) where it is used as the principal raw material in cement manufacture. Mountain Cement is shifting its limestone source to another quarry site about half a mile south and is reclaiming the former quarry site.

Construction aggregate

The production of construction aggregate in Wyoming should increase greatly in 2000. This increase is due in part to railroad construction and upgrading projects, particularly on the Burlington Northern/Santa Fe and Union Pacific rail lines that serve the Powder River Coal Field. Railroad base material and ballast is quarried in Wyoming by: Meridian Aggregates west of Cheyenne in Laramie County; Neosho Construction at Bald Butte in Niobrara County; and Guernsey Stone at Guernsey in Platte County. Western Stone is studying a site in the Cooney Hills 8 miles west of Wheatland for a future ballast quarry (**Figure 13**).

The Wyoming Department of Transportation is planning more highway construction this year due to an increase in federal highway funding. These projects will also require larger amounts of aggregate (both sized gravel and crushed rock, principally limestone) than in past years.

Decorative and dimensional stone

A custom stone fabricating plant has opened and is operational in Wyoming. Strid Marble and Granite in Cheyenne is capable of cutting 30 tons of stone per day into slab (10' x 5' x 3/4") and polishing 60 tons of slab. Strid has been fabricating stone from Raven Quarries in Albany County (**Figures 13** and **14**) and selling this product in the Colorado-Wyoming area. Stone quarried and finished in Wyoming is now available on the market. For information about their products, contact Raven Quarries in Wheatland at (307) 322-5058 or Strid Marble and Granite in Cheyenne at (307) 638-3662, Email stridmarble@mine-engineers.com.

In addition to small amounts of stone processed at Strid Marble and Granite, Raven Quarries continues to ship blocks of variegated pink granite called "Mirage Granite" (**Figure 15**) to Western Granite in Mexico for processing and sale to markets primarily located in southern California. Raven currently has no contracts for its black granite, "Wyoming Raven."

Figure 14. A 10' x 5' slab of Mirage Granite quarried by Raven Quarries in northern Albany County and cut and polished by Strid Marble and Granite. Photograph courtesy Strid Marble and Granite.

The white marble aggregate operation at Wheatland has changed its name from Georgia Marble to Imerys Marble (**Figure 13**). Georgia Marble was purchased several years ago by Imerys, a giant French chemical and industrial minerals company, and the holding company recently changed the names of all of its operations in the U.S., including all of the Georgia Marble operations, to Imerys. Imerys plans to upgrade and expand its white marble quarry. Imerys is surveying the site to remove overburden and waste rock, and is redesigning the quarry with a goal of increased production in the future. Imerys produces mineral pigments, mineral additives, kaolin, refractory materials, and ceramics as well as decorative and dimensional stone.

Figure 15. Quarrying Mirage Granite at the Raven Quarry, 1999

Trona

The U. S. Bureau of Land Management (BLM) released the findings of a joint industry/government investigation of the compatibility of oil and gas drilling and underground trona mining in the Known Sodium Leasing Area (KSLA) of Wyoming. The study concluded that oil and gas exploration and production is incompatible with underground trona mining. This is due to the catastrophic danger to underground workers in the event of a leak of produced fluids or gases from a well into a mine or into a producing trona horizon. There is a high potential for leaks to develop from the rupture of the casing in producing wells due to horizontal bedding plane slip in strata penetrated by the wells. The slip is due to adjustments in overlying rock strata caused by the removal of trona during mining. The BLM is currently formulating a policy designed to resolve trona/oil and gas conflicts in the KSLA.

The study was conducted by committees of technical and managerial experts from the trona mining companies, the oil and gas industry, the BLM, the Wyoming State Geological Survey (for the State of Wyoming), the Union Pacific Railroad, which owns mineral rights in the KSLA, and other groups. The technical committee, headed by William G. Fischer of Trona Associates, Inc., prepared a mathematical model of rock and well deformation due to mining. Numerous specialists in gas fingerprinting, rock mechanics, and well drilling and casing techniques were consulted during the study. Two test wells were drilled in areas of active trona mining to demonstrate the accuracy of the mathematical model. The wells were monitored by downhole sensors including video cameras; deformation of the wells during and after mining was measured and recorded. The managerial committee decided policy issues based on the findings of the technical committee. These panels met approximately once a month for six years.

Uranium

The spot market price of yellowcake continued to fall during the first quarter of 2000. At the end of the quarter, the price according to the Uranium Exchange web site (http://www.uxc.com/top_review.html) was $9.10 per pound, its lowest since October, 1995. The price dropped in mid-April to $9.00 per pound (**Figure 16**). Luckily, yellowcake production from the three current Wyoming producers is under long-term contract and is not subject to short-term fluctuations in the spot market price. The spot market price does, however, reflect the health of the uranium mining industry and the price of future contracts.

The observed price decline is related to the continued influx of inexpensive uranium from stockpiles in countries of the former Soviet Union, less expensively produced yellowcake from Canada and other countries, and slow growth of nuclear power worldwide. Only some far eastern countries are constructing nuclear power plants. Although Europe currently leads in the percentage of nuclear-generated electricity (e.g., Lithuania 97%, France 89%), Japan and other eastern nations are increasing their percentage, while the rest of the world is remaining static.

As a result of the decreased demand for uranium and the resulting decline in the price of yellowcake, COGEMA expects to cease production at Christiansen Ranch in Wyoming in mid-2000, and Rio Algom plans to reduce production at Smith Ranch (**Figure 13**). The amount of uranium produced in Wyoming in the next few years will be about half that of 1999 (**Table 1**).

Figure 16. Spot market yellowcake prices, as of April, 2000. Source: Uranium Exchange weekly reports.

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METALS AND PRECIOUS STONES UPDATE

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Diamonds

In a press release dated April 19, 2000, McKenzie Bay International reported their purchase of all outstanding shares of Diamond Company NL from Redaurum Ltd. McKenzie Bay assigned Diamond Company to its wholly owned subsidiary, Great Western Diamond Company.

Diamond Company NL owns the fully permitted open-pit Kelsey Lake diamond mine located along the Colorado-Wyoming border south of Laramie, and immediately south of an area where the Wyoming State Geological Survey (WSGS) and Colorado State University made discoveries of diamondiferous kimberlite in the 1970s. The WSGS mapped a group of 20 diamondiferous kimberlites in this area, which is north of the state line (see Hausel, 1998).

Diamond Company assets include the trademarks Colorado Diamonds® and Kelsey Lake Diamonds® under which only diamonds recovered from Kelsey Lake may be marketed. Other assets of the Kelsey Lake mine include Colorado and Wyoming mining permits, mining leases, equipment, and a diamond recovery plant. The mining leases encompass nine known kimberlites, three of which have been tested for diamond content. Mining is currently permitted for the KL-1 and KL-2 kimberlite pipes; each pipe encompasses 10.5 acres and they are situated 1/2 mile apart. The diamond recovery equipment includes a 225-ton-per-hour diamond recovery rotary pan plant with two 14-foot-diameter “coarse” pans and two 14-foot-diameter “fine” pans.

Drilling at Kelsey Lake has shown continuity of highly weathered kimberlite ore to a 350-foot depth with a minimum resource of 16.9 million metric tons. However, the kimberlite is open at depth, and potential resources are considerably greater. Ore grades of 3.4 to 4.6 carats per hundred tons excluding diamonds smaller than 2.0 mm, diamonds greater than 25 mm, and coated diamonds, were obtained from a Sortex® diamond x-ray sorting machine.

According to the 1999 Canadian Mines Handbook, the mine began production in 1996. Reported 1997 production included 4520 carats; limited production in 1998 included diamonds up to 6 carats in weight. Some diamonds recovered from the mine included some fabulous gems weighing as much as 28 carats. With the addition of the Sortex® in the recovery circuit, it is anticipated that even larger diamonds will be recovered.

Based on records in the WSGS files, some bulk samples from the Schaffer and Aultman kimberlites in Wyoming, which are north of Kelsey Lake, yielded similar ore grades. The average grades determined for these kimberlites ranged from 0.5 to 1 carat per hundred tons, but individual bulk samples ran as high as 9.74 carats per hundred tons.

Considerable diamond exploration and development continues north of Wyoming in Canada. Serious diamond exploration began in Canada in 1980 by Charles Fipke. A few years later, the Canadian government funded research projects designed to search for diamonds. Currently, more than 60 diamond exploration companies are registered in Canada as a result of the government-sponsored research projects and incentives.

Canada is now expected to produce approximately 10% of the world's diamonds. Prior to 1998, Canada had not produced diamonds. In October 1998, Canada's first commercial diamond mine, Ekati, went into production. This mine is located nearly 200 miles north of Yellowknife in the Northwest Territories. Because of the mine's location near the Arctic Circle, more than $700 million was spent to develop an infrastructure, making the mine one of the most expensive mining operations in history. Even with this expense, the Ekati mine is anticipated to produce more than $4 billion in diamonds. A second mine, Diavik, is scheduled for production in the same region in the near future, and a third mine is proposed to the south in Alberta.

Wyoming and Montana are underlain by similar favorable basement rocks as Alberta and Saskatchewan. Such basement rocks are thought to be necessary for the generation of kimberlitic and lamproitic magmas from the diamond stability field at depth within Earth's upper mantle.

The WSGS has identified a few hundred diamond targets in the past two decades (see the following web site: http://www.wsgsweb.uwyo.edu/metals/metals.htm). Much of the current WSGS effort is devoted to identifying kimberlites in the Iron Mountain and Indian Guide districts of the Laramie Mountains. However, due to funding cutbacks, this project will be scaled down considerably at the end of the current fiscal year. As a result three contract geologists will be laid off on July 1, 2000.

The WSGS is conducting ground electromagnetic (EM) surveys over a group of structurally controlled depressions in the Indian Guide district (**Figure 17**). These depressions yield EM signatures similar to other kimberlites in the region (**Figure 18**). These depressions are shown on the web site mentioned above. (Many kimberlites produce topographic depressions upon weathering because kimberlite is considerably softer than most country rocks. In fact, some kimberlites discovered in the Northwest Territories were located under shallow lakes in similar depressions).

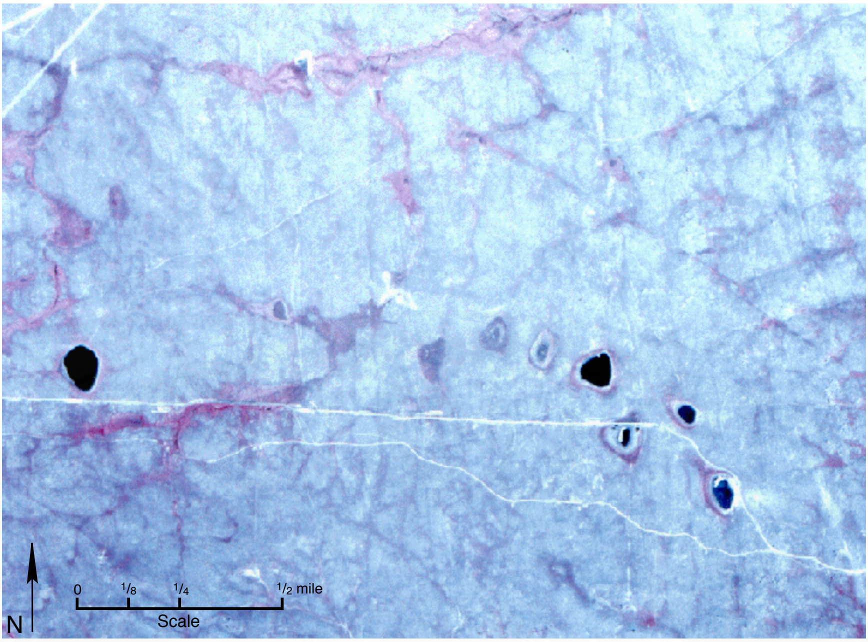


Figure 17. A group of structurally controlled depressions discovered by the WSGS 4 miles due west of the Iron Mountain district in the Indian Guide area line up with the Iron Mountain kimberlite trend. This is a black and white rendition of a color infrared air photograph. The WSGS is currently investigating many of these depressions in an attempt to find their origin.

The WSGS continues to map kimberlites in the Iron Mountain district. In 1998 and 1999, the WSGS discovered several kimberlites, and the Iron Mountain district is now recognized as the second largest kimberlite district in the U.S.

Geochemical analyses of samples from the Iron Mountain district collected by the WSGS in 1998 and 1999 have provided interesting results. A comparison of data from the Kelsey Lake kimberlites (Coopersmith, 1991, **Figures 19** and **20**), with data from the Iron Mountain kimberlites (Waldman and McCallum, 1991, **Figure 21** and the WSGS, **Figure 22**), shows that the geochemistry for Kelsey Lake (a commercial diamond mine) is essentially indistinguishable from the Iron Mountain kimberlites. In other words, the diamond-stability (G10) garnets show a similar distribution for both groups of kimberlites.

Many researchers have suggested that the magnesium and chromium contents of picroilmenites from kimberlites provided an indication of the redox conditions of the kimberlite magma during its emplacement. It was suggested that chromium depletion in the picroilmenites provided a measurement of oxidation of the kimberlite magma. This is important since diamonds will burn, or be resorbed, under oxidizing conditions. Picroilmenites from Kelsey Lake kimberlites show distinct chromium depletion, suggesting either these kimberlites should not contain diamonds or that any preserved diamonds should exhibit evidence of resorption. However, this is not the case at Kelsey Lake, as the diamonds from the mine have been of excellent qual-

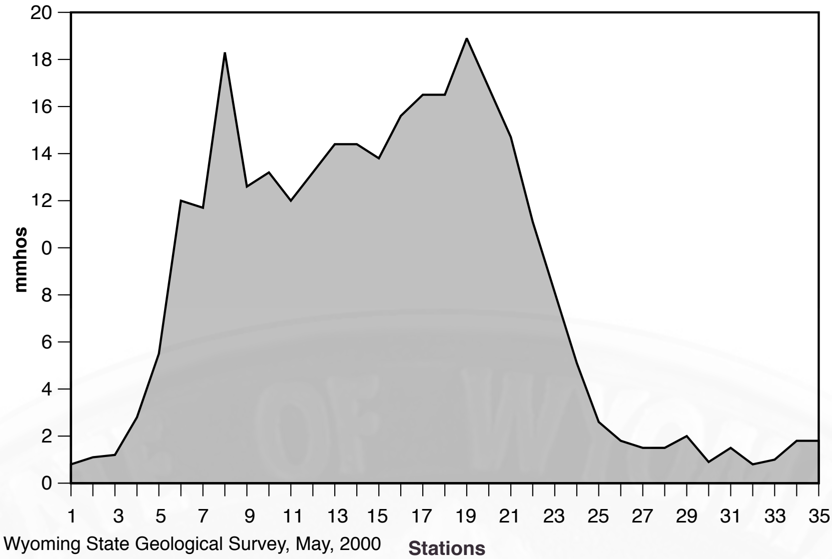


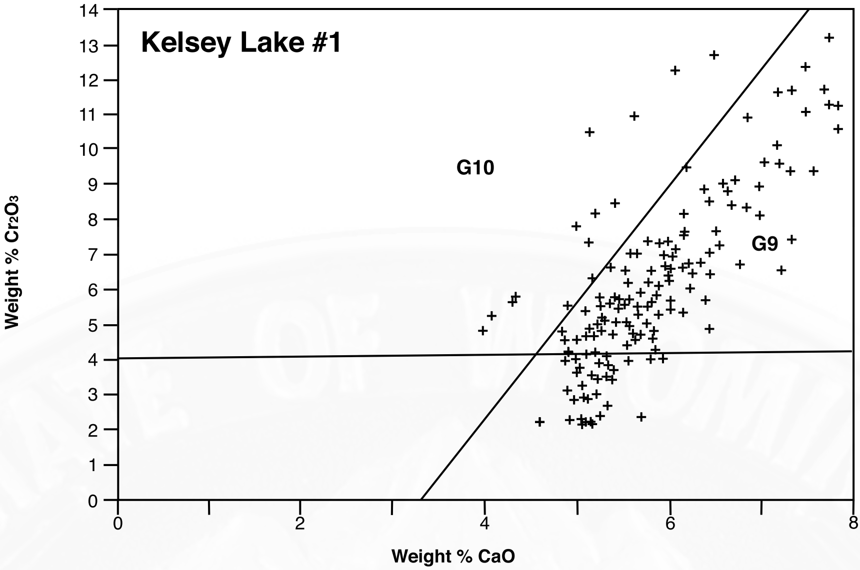
Figure 18. The Plumbago Canyon 5 EM survey is one of several conductivity anomalies measured over topographic depressions in the Indian Guide district of the central Laramie Mountains by Woody Motten, WSGS contract geologist. The distinct conductivity high that occurs over the depression is typical of kimberlites discovered by the WSGS in both the Iron Mountain district (Hausel and others, 2000) and the State Line district (Hausel and others, 1981). Length of profile is about 600 feet.

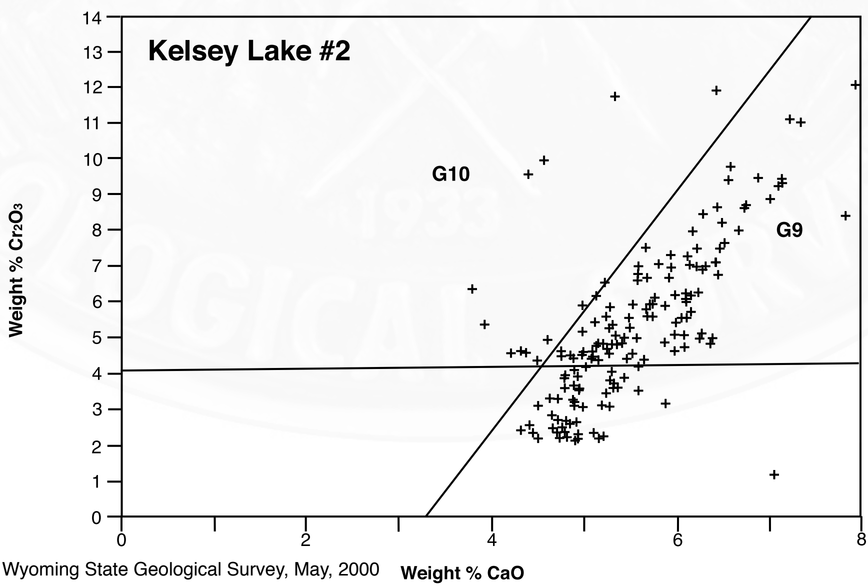
ity, with many well-preserved octahedrons. Thus, it appears that chromium depletion in the picroilmenites does not provide a gage of the oxidizing conditions.

Some researchers have suggested that the Iron Mountain kimberlites should not contain diamonds since the picroilmenites show depletion in chromium. As seen in **Figure 21**, the picroilmenites from Iron Mountain show similar chromium depletion as the picroilmenites from Kelsey Lake (**Figure 20**). As at Kelsey Lake, chromium depletion at Iron Mountain may not be a good indicator of oxidation, and we anticipate that a low-grade resource of diamonds should be found in the Iron Mountain district.

The data collected by the WSGS show at least 14 of the Iron Mountain kimberlites contain sub-calcic, high-chrome, harzburgitic G10 (diamond-stability) pyrope garnets. The chemistry of these garnets is similar to diamond-inclusion garnets, and we interpret that they originated from the diamond-stability field.

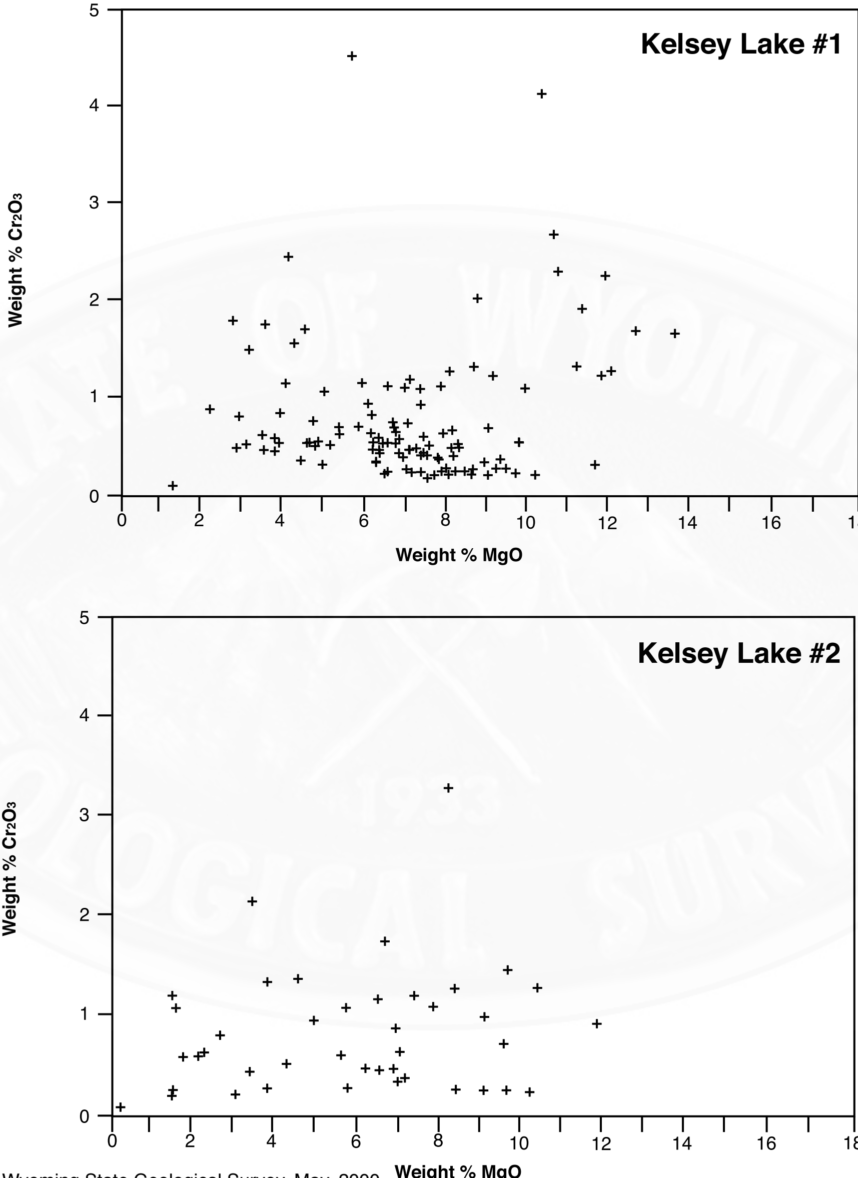
In addition to diamond-stability garnets collected from Iron Mountain, these types of garnets have been identified from stream sediment samples collected by the WSGS in the Mule Creek, Middle Sybille Creek, and Elmers Rock areas of the Laramie Mountains, as well as from the Seminoe Mountains region (see web site mentioned above). The data generated by the WSGS support the fact that Wyoming may be part of an important diamond province and could become an important source of diamonds in the future. This could help generate new tax revenues for Wyoming since diamonds produce the most valuable gemstones on Earth.





Wyoming State Geological Survey, May, 2000

Figure 19. Geochemistry of pyrope garnets from the Kelsey Lake #1 and #2 diamondiferous kimberlites (from Coopersmith, 1991). Those garnets that plot in the G10 field on the left-hand side of the inclined line have chemistry similar to garnet inclusions in diamond.



Wyoming State Geological Survey, May, 2000

Figure 20. Geochemistry of picroilmenites from Kelsey Lake #1 and #2 kimberlites (from Coopersmith, 1991).

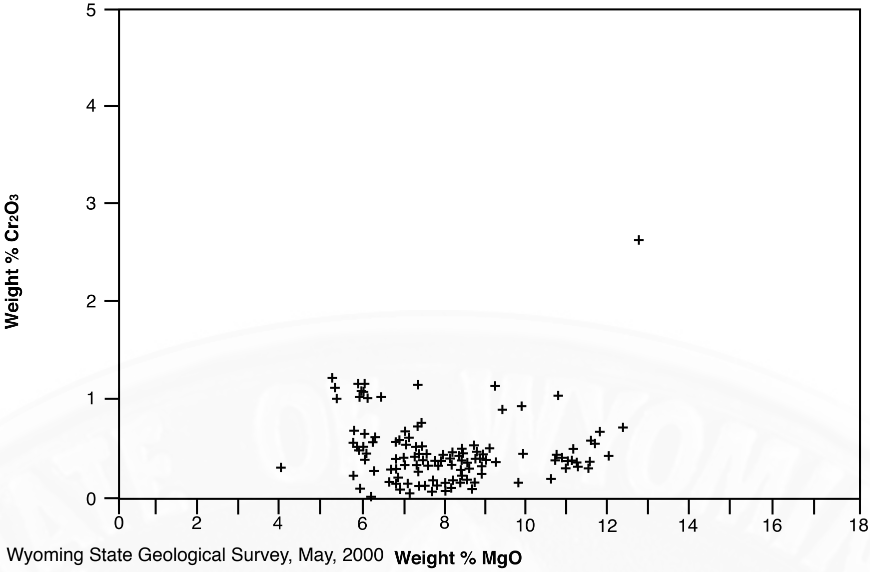


Figure 21. Geochemistry of picroilmenites from the Iron Mountain kimberlites (modified and adapted from McCallum and Waldman, 1991). Compare with data from Kelsey Lake in Figure 20.

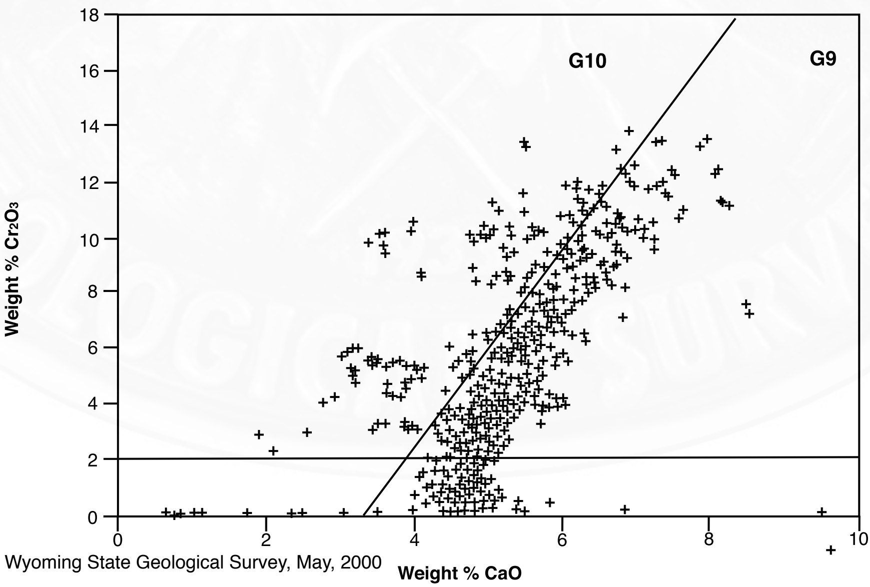


Figure 22. Geochemistry of pyrope garnets from the Iron Mountain kimberlites (Analyses by Robert W. Gregory of the WSGS). Compare with data on diamond stability garnets at Kelsey Lake in Figure 19.

Platinum-palladium rush continues

Southeastern Wyoming is underlain by a platinum-palladium-nickel province. The author has written a paper for an upcoming Wyoming Geological Association

(WGA) guidebook outlining this previously unrecognized province. Publication of the guidebook is expected by WGA's annual field conference this September.

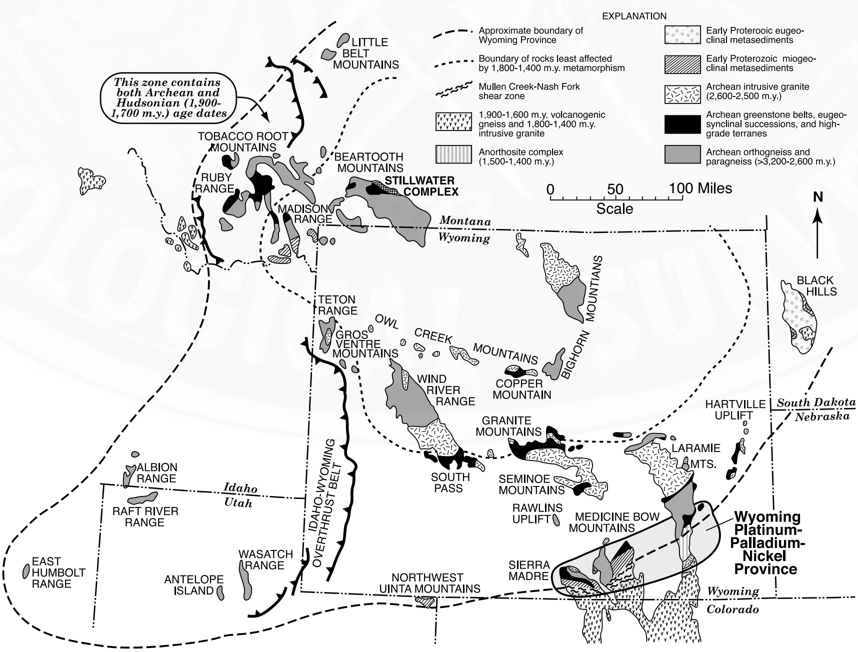
According to the above paper, the geology of the Laramie Mountains, Medicine Bow Mountains, and Sierra Madre is favorable for the discovery of significant platinum-group metal and nickel deposits in a region that parallels the Cheyenne belt or Mullen Creek-Nash Fork shear zone (**Figures 23** and **24**). Several platinum-group metal and nickel anomalies have already been recognized in this region (see Wyoming Geo-notes No. 64, December, 1999), and have been described on the WSGS web site at

http://www.wsgsweb.uwyo.edu/metals/Mineral_survey_medbow/survey_med_bow.htm

This region is currently receiving considerable interest, and a group of companies including Cowboy Exploration, Donnybrook, General Minerals, Trend Minerals, and Ursa Major Resources, have staked large regions for these important strategic metals.

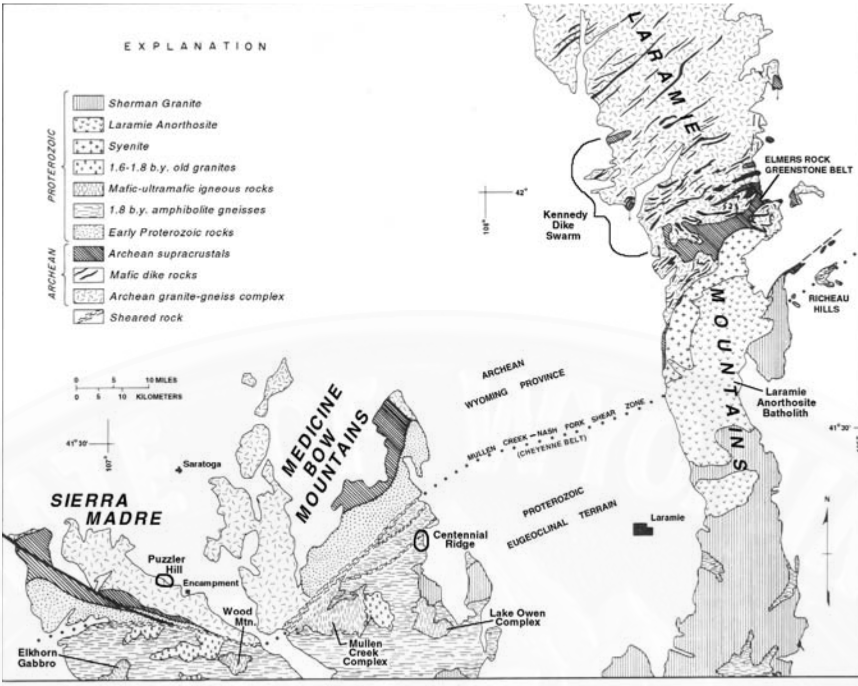
Section news

At the end of June, funding for the diamond project research will end. Three contract geologists–Rachael Toner, Wayne Sutherland, and Woody Motten will



Wyoming State Geological Survey, May, 2000

Figure 23. Location map of the Wyoming platinum-palladium-nickel province, as defined by the WSGS (Hausel, 2000).



Wyoming State Geological Survey, May, 2000

Figure 24. Map of Precambrian rocks in southeastern Wyoming showing location of the Cheyenne belt (Mullen Creek-Nash Fork shear zone) and areas with potential platinum-palladium-nickel deposits. See Wyoming Geo-notes 64 (December, 1999) for descriptions of these areas.

terminate their employment with the WSGS. These people have done an excellent job, and will be greatly missed. One of these people, Wayne Sutherland, has worked on a series of WSGS projects over the past few years and deserves special recognition.

Profile–Wayne M. Sutherland

Wayne Sutherland has worked for the Metals and Precious Stones Section as a contract geologist on the diamond research project. Some of his previous work for the section included an inventory of mines and mineral occurrences on the Medicine Bow National Forest, mapping the Precambrian and Phanerozoic geology of the 1:24,000-scale Barlow Gap Quadrangle, and co-authoring WSGS Bulletin 71, Gemstones and other unique minerals and rocks of Wyoming–A field guide for collectors (in press). Wayne has worked on special projects and grants for the WSGS in both the Coal Section and the Metals and Precious Stones Section at various times in the 1980s and 1990s. He has also been employed as a geologist for the U.S. Bureau of Land Management, Pathfinder Mines Corp., Newmont Exploration, and as an independent consultant.

W. Dan Hausel receives recognition

W. Dan Hausel, head of the Metals and Precious Stones Section was recently selected for inclusion in Marquis' Millennium edition (2000-2001) of Who's Who in Science and Engineering. Hausel was selected for authoring nearly 400 scientific publications on geology and mineral deposits, mapping more than 500 square miles in Wyoming and Alaska, and making several gold, diamond, and other mineral discoveries. Hausel is also a popular public speaker and has lectured to thousands of people across the country on geology and mineral resources.

Prospecting short course

Members of the Rocky Mountain Prospectors and Treasure Hunters Club attended a short course on diamond exploration methods at the WSGS on Friday, April 28, 2000. The short course, taught by W. Dan Hausel, was filled.

Upcoming lectures and field trips

- Field trip to the Sloan diamond pipe, May 19, 2000, 9 a.m., Sloan Ranch, Colorado.
- Lecture on Medicine Bow (Grand Encampment) Mining District, Rocky Mountain Prospectors and Treasure Hunters Club, June 7, 2000, 7 p.m., Fort Collins, Colorado.
- Field trip to the Medicine Bow Mining districts, Rocky Mountain Prospectors and Treasure Hunters Club, June 16, 2000, Centennial, Wyoming.
- Natrona County Gem Show information booth, July 7 and 8, 2000, Casper, Wyoming.
- Lecture on Gold at South Pass, Rocky Mountain Prospectors and Treasure Hunters Club, August 2, 2000, 7 p.m., Fort Collins, Colorado.
- Field trip to the South Pass mining district, Rocky Mountain Prospectors and Treasure Hunters Club, August 11, 2000, Atlantic City mine, Wyoming.

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GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE

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

COOPERATIVE MAPPING PROGRAM

The Wyoming State Geological Survey (WSGS) has been involved with cooperatively funded geologic mapping since 1984. The U. S. Geological Survey (USGS) started the program with funding from the Federal-State Cooperative Mapping Program (COGEOMAP) established in 1984. The program operated on the basis of federal funding to the states with each federal dollar matched with a state dollar. In the 1980s, the WSGS participated in the COGEOMAP Program completing a number of 1:24,000-scale geologic maps in two project areas, the southern Bighorn Mountains and South Pass (**Figure 25**). The WSGS Geologic Mapping Section completed a total of seven quadrangle maps in the southern Bighorn Mountains area and the Metals and Precious Stones Section completed eight quadrangle maps in the South Pass area. These maps are listed along with project funding amounts in **Table 15**. Between 1989 and 1998, the WSGS Geologic Mapping Section completed an additional five quadrangles in the southern Bighorn Mountains area (**Figure 25**) with WSGS funding only.

The National Geologic Mapping Act of 1992 created a new national cooperative mapping program referred to as the STATEMAP Program. The WSGS began this program in 1995 with 1:24,000-scale mapping in the Laramie area (**Figure 25**). Subsequent projects included 1:24,000-scale mapping of Guernsey, Guernsey Reservoir, and Barlow Gap quadrangles. In 1997, the WSGS expanded its STATEMAP efforts to digitize existing surficial and bedrock 1:100,000-scale geologic maps. Maps

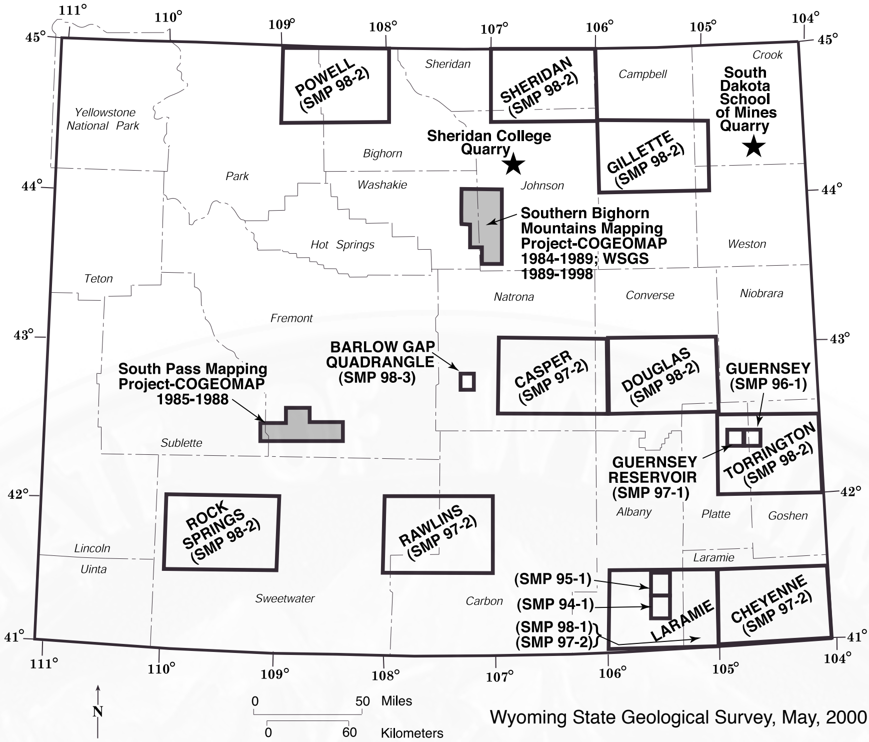

Figure 25. Index map to selected paleontological activities and geologic mapping projects in Wyoming. Map areas designated SMP are State Mapping Projects, by year. See Table 15 for project descriptions.

completed under STATEMAP97 and STATEMAP98 are listed along with funding amounts in **Table 15**. The WSGS has completed a total of twenty 1:24,000-scale geologic maps under COGEOMAP and STATEMAP. One 1:100,000-scale bedrock geologic map (Laramie Quadrangle) has been mapped and compiled under STATEMAP. In addition, the WSGS Geologic Hazards Section digitized two existing 1:100,000-scale bedrock geologic maps (Cheyenne and Gillette quadrangles) and nine 1:100,000-scale surficial geologic maps (**Figure 25**).

With STATEMAP99 funds, the WSGS is compiling a 1:100,000-scale bedrock geologic map of the Sheridan Quadrangle; digitizing the bedrock geologic map of the Laramie 1:100,000-scale Quadrangle; and digitizing surficial geologic maps of the Buffalo, Cody, Newcastle, Thermopolis, and Worland 1:100,000-scale quadrangles. STATEMAP2000 has provided the WSGS with $45,000 for compiling and digitizing six existing 1:100,000-scale bedrock or surficial geologic maps (see Wyoming Geo-notes No. 65, March, 2000, p. 45-47). The mapping efforts of the WSGS have been aided by a total of $238,513 from the Cooperative Mapping Program providing a combined total of $477,026 for mapping efforts from 1984 through July of 2000 (**Table 15**). The Federal/State cooperative geologic mapping programs have indeed been instrumental in the geologic mapping accomplishments in Wyoming.

Table 15. Summary or federal/state cooperative geologic mapping programs in Wyoming.

Fiscal year	Project description and map scale	State Dollars	Federal Dollars	Total Dollars
1986	1-Initiated mapping of the Mayoworth, and Red Fork Powder River Quadrangles, 1:24,000-scale **COGEOMAP**	$14,070	$14,070	$28,140
	2-Initiated mapping of the Radium Springs and Anderson Ridge Quadrangles, 1:24,000-scale **COGEOMAP**	$8,245	$8,245	$16,490
1987	1-Geologic maps of the Radium Springs and Anderson Ridge Quadrangles, 1:24,000-scale **COGEOMAP**	$7,845	$7,845	$15,690
	2-Geologic maps of the Mayoworth, and Red Fork Powder River Quadrangles, 1:24,000-scale **COGEOMAP**	$14,070	$14,070	$28,140
1988	1-Geologic maps of the Fraker Mountain, Barnum, and Tabbletop Quadrangles, 1:24,000-scale **COGEOMAP**	$12,000	$12,000	$24,000
	2-Geologic maps of the Miners Delight, South Pass, Lewiston Lakes, Halls Meadow Spring, Atlantic City, and Louis Lake Quadrangles, 1:24,000-scale **COGEOMAP**	$12,434	$12,434	$24,868
1989	Geologic maps of the Tallon Spring and Turk Springs Quadrangles, 1:24,000-scale **COGEOMAP**	$11,700	$11,700	$23,400
1995	Geologic map of the Laramie Quadrangle, 1:24,000-scale **STATEMAP94**	$12,000	$12,000	$24,000
1996	Geologic map of the Howell Quadrangle, 1:24,000-scale **STATEMAP95**	$10,000	$10,000	$20,000
1997	Geologic map of the Guernsey Quadrangle, 1:24,000-scale **STATEMAP96**	$8,499	$8,499	$16,998
1998	1-Geologic map of the Guernsey Reservoir Quadrangle, 1:24,000-scale **STATEMAP97**	$14,000	$14,000	$28,000
	2-Digital geologic map of the Cheyenne Quadrangle and digital surficial geologic maps of the Casper, Cheyenne, Laramie, and Rawlins Quadrangles, 1:100,000-scale **STATEMAP97**	$17,000	$17,000	$34,000
1999	1-Geologic map of the Laramie Quadrangle, 1:100,000-scale **STATEMAP98**	$18,500	$18,500	$37,000
	2-Digital surficial geologic maps of the Douglas, Gillette, Powell, Rock Springs, Sheridan, and Torrington Quadrangles, 1:100,000-scale **STATEMAP98**	$20,000	$20,000	$40,000
	3-Geologic map of the Barlow Gap Quadrangle, 1:24,000-scale **STATEMAP98**	$18,650	$18,650	$37,300
2000	1-Geologic map of the Sheridan Quadrangle, 1:100,000-scale **STATEMAP99-in progress**	$19,500	$19,500	$39,000
	2-Digital geologic map of the Laramie Quandrangle and digital surficial geologic maps of the Buffalo, Cody, Newcastle, Kaycee, and Worland Quadrangles, 1:100,000-scale **STATEMAP99-in progress**	$20,000	$20,000	$40,000
	TOTALS	$238,513	$238,513	$477,026

Wyoming State Geological Survey, May, 2000

ACTIVITIES ON STATE DINOSAUR QUARRIES

The operators of two dinosaur quarries holding scientific permits for State of Wyoming lands recently submitted their annual reports on quarry activities for the 1999 field season. The two quarries are located southwest of Buffalo and in a roadcut along Interstate 90 west of Sundance, respectively (**Figure 25**). Mike Flynn of Northern Wyoming Community (Sheridan) College operates the former quarry and Dr. James Martin of South Dakota School of Mines and Technology operates the latter quarry. Both quarries are located in paleostream channels in the dinosaur-fossil-rich Jurassic Morrison Formation and are used for student instruction in paleontology and fossil removal methods as well as fossil specimen collection, preparation, and research.

Dr. Martin indicated that work was completed on removing an adult Allosaurus from the quarry west of Sundance. Microfaunal levels associated with the Allosaurus were also catalogued and removed. Quarry workers assigned approximately 64 field numbers to specimens of snails, fish, turtles, amphibians, crocodilians, and dinosaurs. Martin indicated that specimen collection was down from the previous field season due to other commitments and financial constraints. He does, however, anticipate more activity during the upcoming field season.

Mike Flynn indicated that the quarry southwest of Buffalo was used in May of 1999 for instructing a college class in recognition of paleoenvironments, geology, and training in fossil collecting procedures. A camarasaur vertebral column was removed from the quarry in August and transported to the college geology laboratory for preparation. A small vertebra, possibly crocodilian, was found associated with the camarasaur material. Flynn indicated that this could represent one of the first non-dinosaur vertebrates found at the quarry. Work also continued at the Allosaurus site north of the main quarry with the removal of a sacrum and nearly complete brain case with associated skull bones. A total of 21 specimens including Camarasaurus, Allosaurus, and various sauropod bones were catalogued and removed from the quarry during the 1999 field season. Flynn indicates that the quarry will continue to be excavated and will again serve as a field methods classroom in the 2000 field season.

GRANTS FOR FIELD GEOLOGY FELLOWSHIP AWARDED

The Wyoming Geological Association (WGA) recently awarded grants for field expenses to seven students planning field mapping projects in the Rocky Mountain area. The grants were made from the WGA's J. David Love Field Geology Fellowship in support of field geology projects and in honor of J. David Love, renowned for his distinguished career as a field geologist in Wyoming with U.S. Geological Survey.

Recipients of the fellowship included:

- Dianne Burns of the University of Wyoming for her stratigraphic work on the Casper Formation in southeastern Wyoming,
- Thomas Douglas of Dartmouth College for his efforts in relating mineralization fluid sources in the New World mine to the Heart Mountain detachment fault in northwestern Wyoming,

- Benjamin Fruchey of the University of Wyoming for his mapping and geochronological study of the evolution of the Rattlesnake Hills greenstone belt in central Wyoming,
- Malka Machlus of Columbia University for her stratigraphic project involving the Green River Formation of southwestern Wyoming,
- Aaron Cavosie of the University of New Mexico for his mapping and work on the Buckhorn Creek shear zone in the northern Front Range of Colorado,
- Margaret McMillan of the University of Wyoming for her study involving the late Cenozoic tilt of the Cheyenne Tablelands of southeastern Wyoming, and
- Meredith Rhodes of the University of Wisconsin for her stratigraphic project involving the Laney Member of the Green River Formation in southwestern Wyoming.

There were 25 worthy applicants this year, making the decision on the awards a tough one. The J. David Love Field Geology Fellowship does an excellent job of stimulating field geology and specifically field mapping, an important discipline which has been overlooked by many university geology programs in recent years.

NEW PUBLICATIONS ON WYOMING GEOLOGY

Three new articles relating to the use of 3-D seismic data in oil and gas exploration and development were released in the January issue of The Mountain Geologist. These papers represent the culmination of five years of the Rocky Mountain Association of Geologists/Denver Geophysical Society annual symposiums. The articles relating to Wyoming geology are summarized below:

Natali and others (2000) detailed the use of 3-D seismic in interpreting the Cave Gulch Field structure and the subsequent design of a development program for the field. Use of the seismic data allowed for accurate drilling of increasingly deeper targets in the field. Cave Gulch Field, located in the Wind River Basin, represents one of the most significant discoveries of the 1990s with estimated reserves in excess of 600 billion cubic feet (BCF) of gas.

Warner (2000) reported on the use of 3-D seismic in interpreting the structural geology and pressure compartmentalization of Jonah Field in the northwestern Greater Green River Basin. The field contains 150 producing wells and the estimated ultimate gas recovery is in excess of 3.5 trillion cubic feet (TCF) of gas. Use of the 3-D seismic data was instrumental in defining the field's wrench-fault-dominated structure and designing a drilling program to produce the overpressured gas from the upper Lance Formation.

Estes-Jackson and others (2000) chronicled the use of 3-D seismic in the re-evaluation and re-vitalization of older fields. This particular study focused on the use of 3-D seismic data to re-evaluate Riverton Dome Field in the Wind River Basin, leading to the drilling of three successful wells in the Muddy Sandstone and identifying additional opportunities in Upper Cretaceous reservoirs and the Tensleep Sandstone within the field.

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Warner, E.M., 2000, Structural geology and pressure compartmentalization of Jonah Field based on 3-D seismic data and subsurface geology, Sublette County, Wyoming: The Mountain Geologist, v. 37, no. 1, p. 15-30.

EARTHQUAKES IN WYOMING

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

The Geologic Hazards Section has completed a color brochure, Earthquakes in Wyoming (Information Pamphlet 6) and a pamphlet How to make your Wyoming home more earthquake resistant (Information Pamphlet 5). Both publications were generated through Wyoming's Earthquake Program, which is managed by the Section (Wyoming Geo-notes No. 63, September, 1999, p. 48-50). The publications were printed with funds made available by the Wyoming Emergency Management Agency. Both pamphlets are available for free public distribution at the Wyoming State Geological Survey.

The preliminary version of Information Pamphlet 5 was printed in two issues of Wyoming Geo-notes: Wyoming Geo-notes No. 48 (November, 1995) contains an article on how to make a house more earthquake resistant, and Wyoming Geo-notes No. 64 (December, 1999) contains an article on how to make a manufactured, mobile, or modular home more earthquake resistant.

The majority of Information Pamphlet 6 is printed below. Those desiring a pamphlet-sized color version can contact the Wyoming State Geological Survey.

INTRODUCTION

Earthquakes are common in Wyoming. Historically, earthquakes have occurred in every county in Wyoming over the past 120 years, with some causing significant damage. **Figure 26** shows the generalized distribution of historical earthquakes in Wyoming.

The first recorded earthquake in the state occurred in the area now known as Yellowstone National Park (**Figure 27**) on July 20, 1871. During the early geologic

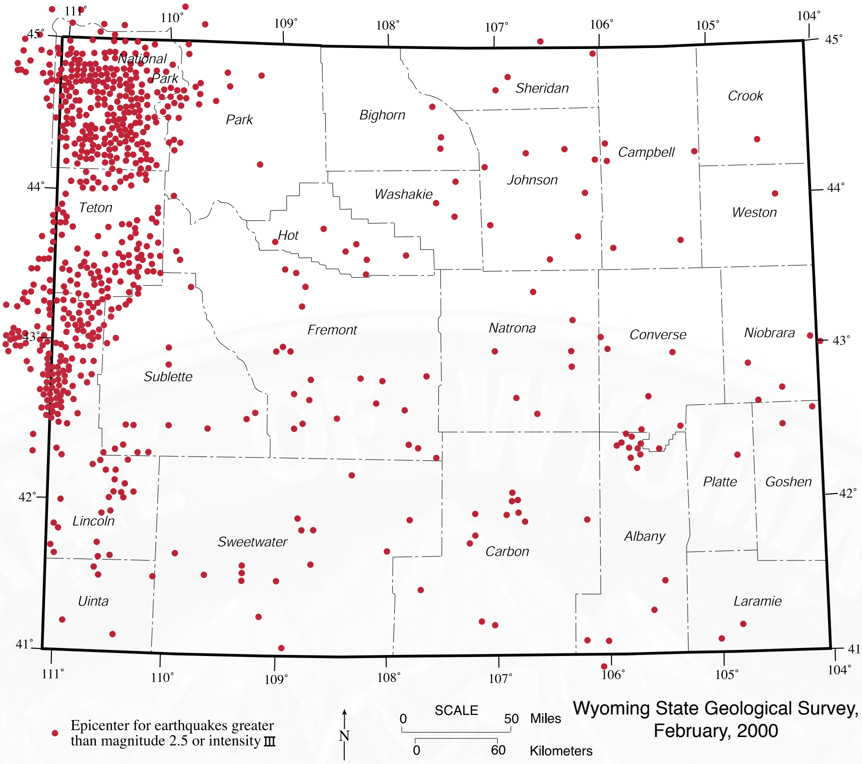

Figure 26. Generalized historical earthquake epicenter map for Wyoming.

investigations of Yellowstone, Ferdinand V. Hayden of the U.S. Geological Survey reported that “on the night of the 20th of July, 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.” Yellowstone National Park is now known as one of the more seismically active areas in the United States.

CAUSES OF EARTHQUAKES

Earthquakes in Wyoming occur because of movements on existing or newly created faults, movements of (or in) the magma chamber beneath Yellowstone National Park, and from man-made events such as blasting at mines, mine collapses, or explosions. Most historical earthquakes have occurred as a result of movements on faults not exposed at the surface. These deeply buried faults, which are not expected to generate earthquakes with magnitudes greater than 6.5, have not been studied in detail. A series of faults exposed at the surface in Wyoming, however, have activated and generated earthquakes from hundreds to thousands of years ago. Future earthquakes with magnitudes from 6.75 to 7.5 are expected to occur along those exposed faults. Known active faults, which are present in western and central Wyoming, are shown in black on **Figure 28**. The suspected active faults shown in gray on **Figure 28** are those for which activity has not been confirmed during the Quaternary (within the last 1.65 million years).

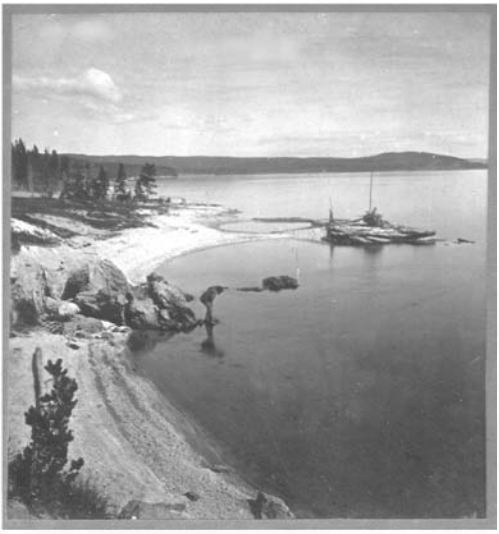

Figure 27. "Cresent Beach on Yellowstone Lake," from a stereographic negative by Joshua Crissman of Bozeman, Montana, originally published by W.I. Marshall of Fitchburg, Massachusetts as stereopair #55. Stereo photographs taken by Crissman are the first publically available images of Yellowstone. Crissman photographs were taken during the Hayden survey of the Yellowstone area. This photograph was taken between July 15 and August 8, 1871, probably within days of the first reported earthquake in Wyoming (Territory). Photograph from the personal collection of Lance Cook.

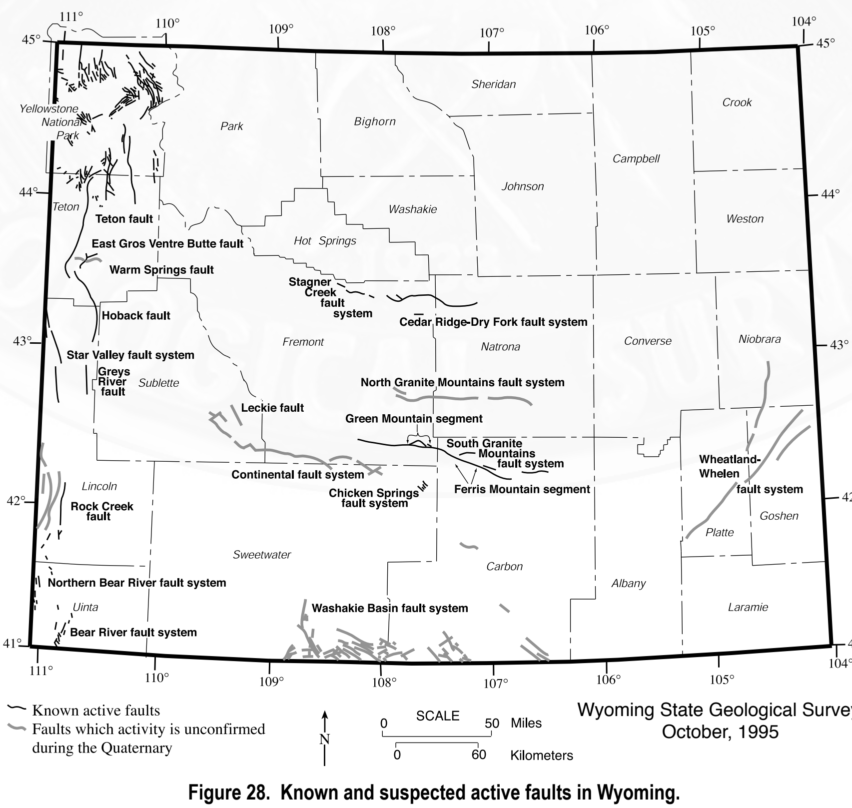

Figure 28. Known and suspected active faults in Wyoming.

Earthquakes can originate at various depths, usually depending on the depth and orientation of faults. The initial zone of rupture on a fault that results in the generation of seismic waves is called the earthquake hypocenter or focus. The point on the ground surface directly above the hypocenter is the epicenter. Earthquakes can be associated with faults that rupture near the surface as well as those that are many miles deep.

EARTHQUAKE MEASUREMENTS

There are many ways to describe the size and strength of an earthquake and its associated ground shaking. The most familiar classifications are the Richter Magnitude Scale, developed in 1935, and the Modified Mercalli Intensity Scale, developed in 1931.

Magnitude is an instrumentally determined measure of the size of an earthquake and the total energy released. Each one step increase in magnitude equates to a 32 times increase in associated seismic energy. In other words, a magnitude 7.5 earthquake releases approximately one thousand times more energy than a magnitude 5.5 earthquake. A magnitude 7.5 earthquake releases about as much energy as a one Megaton hydrogen bomb, and a magnitude 6.5 earthquake releases about as much energy as a Hiroshima-type atomic bomb.

Intensity is a qualitative measure of the degree of shaking an earthquake imparts on people, structures, and the ground. For a single earthquake, intensities can vary depending upon the distance from the hypocenter and epicenter. A much simplified twelve level intensity scale is shown below.

Modified Mercalli Intensity Scale

I. Not felt except by very few.
II. Felt only by a few persons at rest.
III. Felt noticeably indoors. Vibration like passing of truck.
IV. Felt indoors by many. Sensation like heavy truck striking building.
V. Felt by nearly everyone. Some dishes and windows broken. Cracked plaster in a few places. Pendulum clocks stop.
VI. Felt by all, many frightened and run outdoors. A few instances of fallen plaster and damaged chimneys.
VII. Everybody runs outdoors. Damage negligible in well-designed and well-built structures, slight to moderate damage in well-built ordinary structures, considerable damage in poorly built structures.
VIII. Damage slight in specially designed structures, considerable in ordinary buildings with partial collapse, great in poorly built structures.
IX. Damage considerable in specially designed structures, and great in substantial buildings, with partial collapse. Buildings shifted off foundations. Underground pipes broken.
X. Some well-built wooden structures and most masonry and frame structures destroyed. Ground badly cracked. Rails bent. Landslides.
XI. Few structures remain standing. Bridges destroyed. Broad fissures in ground.
XII. Damage total.

TOP TEN EARTHQUAKES IN WYOMING

There have been a number of earthquakes that have caused damage or concern among Wyoming residents. The top ten earthquakes that have occurred in or near Wyoming are described below in chronological order. The list is rather subjective, and does not include some earthquakes that have caused damage. Detailed information an all Wyoming earthquakes can be obtained from the Wyoming State Geological Survey.

November 7, 1882. A magnitude 6.2 to 6.5, intensity VII event occurred between Laramie and Estes Park, Colorado. It was felt throughout the southern half of Wyoming, in northeastern Utah, and over most of Colorado. Plaster was cracked in Laramie.

November 14, 1897. An intensity VI to VII event occurred near Casper and was one of the largest events recorded in central and eastern Wyoming. The Grand Central Hotel in Casper was considerably damaged by the earthquake.

June 12, 1930. An estimated magnitude 5.8, intensity VI event occurred near Grover in the Star Valley of western Wyoming. A brick building, swimming pool, and numerous plaster walls in homes were cracked. Numerous aftershocks occurred.

March 26, 1932. An intensity VI event in the Jackson area broke the plaster on walls and cracked the foundations in several local homes and businesses. There were a number of aftershocks.

August 17, 1959. A magnitude 7.5, intensity X event occurred just outside of Yellowstone National Park, near Hebgen Lake in Montana. The event triggered a landslide that dammed the Madison River, eventually creating Earthquake Lake. Twenty-eight people lost their lives; most of them were buried in the campground located directly beneath the landslide. Numerous aftershocks, with some as large as magnitude 6.5, occurred within or near Yellowstone National Park.

June 30, 1975. A magnitude 6.4, intensity VII event occurred in the central part of Yellowstone National Park. Landslides closed 12 miles of road between Norris Junction and Madison Junction. Cracks in the ground 3 to 4 feet deep, and 15 to 20 feet long were found in the Virginia Cascades area.

October 18, 1984. A magnitude 5.5, intensity VI event occurred approximately 4 miles west-northwest of Toltec in northern Albany County. The earthquake was felt in Wyoming, South Dakota, Nebraska, Colorado, Utah, Montana, and Kansas. It cracked buildings in Douglas and Medicine Bow and cracked chimneys in Casper, Douglas, Guernsey, Lusk, and Rock River.

November 3, 1984. A magnitude 5.1, intensity VI event occurred 10 miles northwest of Atlantic City. The earthquake cracked foundations, walls, and windows in Lander and Atlantic City. It was also felt in Casper and Dubois.

February 3, 1994. A magnitude 5.9, intensity VII event occurred at Draney Peak, Idaho, near Wyoming's Auburn Fish Hatchery in the Star Valley. The earthquake damaged the fish hatchery, and a home near Auburn had cracks in the foundation and ceiling. It was felt in Rock Springs, Salt Lake City, Utah, and Grand Junction, Colorado. There were hundreds of aftershocks, with the largest being a magnitude 5.3, intensity VI event on February 11, 1994.

February 3, 1995. A magnitude 5.3, intensity V event occurred near Little America. The earthquake was associated with the collapse of a 3000-foot-wide by 7000-foot-long portion of a trona mine. One miner lost his life as a result of the collapse. Although the earthquake was felt as far away as Rock Springs and Salt Lake City, only minor damage was reported to buildings in Green River and Little America.

It is important to remember that earthquakes occurring outside the boundaries of Wyoming can also cause damage within the state. Examples include the Hebgen Lake, Montana event in 1959 and the Draney Peak, Idaho event in 1994.

WYOMING'S EARTHQUAKE POTENTIAL

In general, earthquakes do not result in ground surface rupture unless the magnitude of the event is greater than magnitude 6.5. Because of this, areas of the state that do not have active faults exposed at the surface are thought to be capable of having earthquakes with magnitudes up to 6.5. The historical record in and around Wyoming supports the fact that earthquakes that large can occur. Most of Wyoming, therefore, can have a magnitude 6.5 earthquake, which can cause significant damage. Even though such events occur infrequently, residents should be prepared for such an event.

The earthquake potential is quite different in areas where active faults are exposed at the surface. A series of faults in western Wyoming (**Figure 28**) are capable of magnitude 7.2 to 7.5, intensity X earthquakes. These include the Teton fault, at the base of the Teton Range; the Star Valley fault, bounding the east side of the Star Valley; the Greys River fault in northeastern Lincoln County; the Rock Creek fault in southwestern Lincoln County; and the Bear River fault system, southeast of Evanston. Based upon recent studies, many of these fault systems are thought to be overdue for activation. It is not known, however, when any of these systems may activate.

There are a number of active faults exposed in Yellowstone National Park (**Figure 28**). Many of those faults are related to volcanic eruptions, volcanic explosions, and caldera-forming collapses that helped to form the present day Park. Much of the present and future earthquake activity in the Park is still related to the underlying magma chamber, although large earthquakes related to other regional factors are possible. Based upon recent studies and the seismic history of the Park, earthquakes in the magnitude 6.5 to 7.5 range are possible, and should be expected in the future.

There are a series of active faults along the northern and southern margins of the Wind River Basin. The Stagner Creek fault system, near Boysen Reservoir in northern Fremont County is capable of generating a magnitude 6.75 earthquake. The South Granite Mountains fault system, in southeastern Fremont County and northwestern Carbon County, is composed of a number of segments that are each capable of generating a magnitude 6.75 earthquake. In addition, the exposed Chicken Springs fault system in northeastern Sweetwater County is thought to be capable of generating a magnitude 6.5 earthquake.

WHAT TO DO DURING AN EARTHQUAKE

If you are outside, do the following:

- Stay outside.
- Stay away from buildings, chimneys, fences, trees, and power lines.
- If you are in a car, stay in it. Pull over and stop, away from high structures, power lines, overpasses, and trees.

If you are inside, do the following:

- Stay inside, unless conditions warrant otherwise.
- Duck, cover, and hold. Duck under a sturdy table or desk, sit with your back against a strong inside wall, or stand under a doorway.
- Stay away from windows and glass doors.
- Stay away from heavy standing objects such as bookcases.

SOURCES OF ADDITIONAL INFORMATION

Listed below are a number of agencies or organizations that can provide additional information on earthquake, earthquake preparedness, and earthquake response.

Wyoming State Geological Survey
P.O. Box 3008
Laramie, WY 82071-3008
Phone: (307) 766-2286
Fax: (307) 766-2605
E-mail: wsgs@wsgs.uwyo.edu
jcase@wsgs.uwyo.edu
Agency Web: http://wsgsweb.uwyo.edu
Earthquake Web: http://www.wrds.uwy.edu

Wyoming Emergency Management Agency
5500 Bishop Blvd.
Cheyenne, WY 82009-3320
Phone: (307) 777-4900
Fax: (307) 635-6017
E-mail: wema@wy-arng.ngb.army.mil
Agency Web: http://132.133.10.9
FEMA Web: http://www.fema.gov

PUBLICATIONS OF INTEREST

Draft directory of earthquake-related human resources for Wyoming–Preliminary Hazards Report PHR 95-1.

Earthquake epicenters and suspected active faults with surficial expression in Wyoming–Preliminary Hazards Report PHR 97-1.

Earthquakes and active faults in Wyoming–Preliminary Hazards Report PHR 97-2.

How to make your Wyoming home more earthquake resistant–Information Pamphlet 5.

Wyoming Geo-notes–quarterly publication contains general and specific information about Wyoming earthquakes.

ROCK HOUND'S CORNER

W. Dan Hausel
Senior Economic Geologist-Metals and Precious Stones, Wyoming State Geological Survey

JADE

The Wyoming State Mineral and Gem Show scheduled for the weekend of June 24 and 25, 2000 in Torrington, Wyoming will feature jade as a gemstone. Because of the interest in jade, I thought it would be appropriate to discuss jade in the Rock Hound's Corner. The following discussion is extracted from the section on jade in the new Wyoming State Geological Survey bulletin on gemstones of Wyoming (Hausel and Sutherland, 2000).

Jade is the gemologist's designation applied to two distinct and unrelated mineral species: nephrite and jadeite. Of the two gemstones, only nephrite has been found in Wyoming. Such an abundance of nephrite jade has been found in the state that nephrite jade is often considered synonymous with Wyoming Jade, even though it is found elsewhere in the world.

Nephrite is an amphibole that is formed of extremely dense and compact fibrous tremolite-actinolite whereas jadeite is a pyroxene of the augite series. These two minerals closely resemble one another, and are essentially indistinguishable in hand specimen without the aid of physical tests, such as petrographic and/or X-ray diffraction (XRD) analyses.

Many similar appearing rocks are mistaken for nephrite jade. These include rounded, stream-worn or wind-polished cobbles of amphibolite, metadiabase, epidotite, quartzite, leucocratic (white) granite, and serpentinite. These rocks can be distinguished from jade by any number of tests including some simple field observations. For example, amphibolite, metadiabase, and leucocratic granite typically have a granular texture that is lacking in jade. The freshly broken surface of quartzite tends to sparkle in sunlight due to the reflection of light off individual quartz grains. Epidotite has a distinct pistachio green color and perfect cleavage. Serpentinite is relatively soft and often can be easily scratched with a pocket knife. In addition, serpentinite exhibits pockets or zones of weak to moderate magnetism, unlike jade.

Nephrite jade [$Ca_2(Fe, Mg)_5(Si_4O_{11})_2(OH)_2$] never shows any external structure, except where the mineral rarely pseudomorphs the habit of another mineral. For instance, in the Granite Mountains of central Wyoming, nephrite pseudomorphs after quartz have been found that have pseudohexagonal habit but these are uncommon. Typically, nephrite occurs in irregular masses and lacks cleavage.

Microscopic examination of nephrite typically shows a mass of matted, intricately interwoven fibers. This unusual form makes nephrite jade extremely tough and resistant to fracturing [toughness can be represented by fracture strength, which is about 30,000 pounds per square inch for nephrite (Bradt and others, 1973)]. As a result, unless the rock has a schistose fabric, rounded boulders of nephrite are nearly impossible to break with a hammer. Because of toughness and attractive appearance, nephrite, which has been termed the axe stone, has been prized since prehistoric times.

Only carbonado, a black granular to compact industrial form of diamond, is tougher than jade. However, gem-quality diamond, the hardest known mineral found in nature, lacks the toughness of jade and is easily smashed with a hammer. It is the toughness of jade, combined with its hardness, that makes the gemstone carvable and durable.

Nephrite has a specific gravity of 2.9 to 3.02. Its hardness, as reported by Bauer (1968) and Hurlbut and Switzer (1979), ranges from 6 to 6.5. The mineral ranges from opaque to translucent masses and has a vitreous to almost waxy luster. Nephrite is also reported to occur in black, white, and a variety of green shades.

The green color in nephrite jade is the result of iron within the crystal lattice. When iron is absent, the mineral is practically colorless to cloudy white, resulting in a variety known as muttonfat jade. Other varieties of Wyoming jade include translucent, emerald-green imperial jade; apple-green jade, olive-green jade, leaf-green jade, black jade, and snowflake (mottled) jade (Bauer, 1968). The greater commercial values are attached to the lighter green, translucent varieties.

Sherer (1969) investigated the origin of Wyoming jade and suggested that nephrite jade developed by metasomatic alteration of amphibole during metamorphism. According to Sherer, blocks of amphibolite were disrupted more than 2.5 billion years ago and trapped in quartzofeldspathic gneiss. Portions of the amphibolite xenoliths were then altered to nephrite by metamorphic fluids derived from regional, amphibolite-grade, metamorphism. In other words, amphibole (which is represented by the mineral hornblende, a major constituent of amphibolite) reacted with hot metamorphic fluids (water) producing actinolite (nephrite jade), clinozoisite, and chlorite. The simplified chemical (unbalanced) reaction can be written as:

$$25Ca_2(Mg, Fe)_3Al_4Si_6O_{22}(OH)_2 + 4H_2O = Ca_2(Mg, Fe)_5Al_4Si_8O_{22}(OH)_2 + 24Ca_2Al_{34}Si_3O_{12}(OH) + 14Mg_5Al_2Si_3O_{10}(OH)_8$$

or

amphibole + water = actinolite (nephrite jade) + clinozoisite + chlorite

Along with nephrite, a distinct wallrock alteration assemblage was produced. Typically, the bleached leucocratic granite-gneiss adjacent to jade is often mottled pink and white due to the presence of secondary clinozoisite, pink zoisite, pistachio green epidote, green chlorite, as well as white plagioclase which is pervasively altered to white mica. This wallrock alteration assemblage can be used as a guide to find blind (hidden) jade deposits. For instance, rocks displaying this alteration assemblage are often found scattered in the gneiss between known jade deposits in the Tin Cup district, and may suggest the presence of shallow, undiscovered, jade occurrences (W. Dan Hausel, personal field notes, 1996).

Individual pieces of detrital jade can vary in appearance. Some pieces may be covered with a cream to reddish-brown weathered rind that hides the characteristic color of the jade. But where naturally polished with a high-gloss waxy surface, known as slicks, the detrital jade is recognizable.

Large volumes of jade were recovered from central Wyoming a few decades ago; however, small quantities of the gemstone can still be found (**Figure 29**). Jade has been reported as far west as the Wind River Range (McFall, 1976), and as far east as Guernsey and the Laramie Mountains. To the north, it has been reported in the Wind River Basin, and has been found as far south as the Rawlins golf course near Interstate 80 (Hagner, 1945) and even farther south in the Sage Creek Basin near the Sierra Madre.

Several large boulders have been found in Wyoming. The largest was a 14,000 pound boulder of low-quality black jade reportedly found in the Prospect Mountains (Root, 1980) at the southern end of the Wind River Range (Hemrich, 1975). Some spectacular specimens of green jade have been found in the central part of the state in the Granite Mountains and Crooks Gap regions near Jeffrey City.

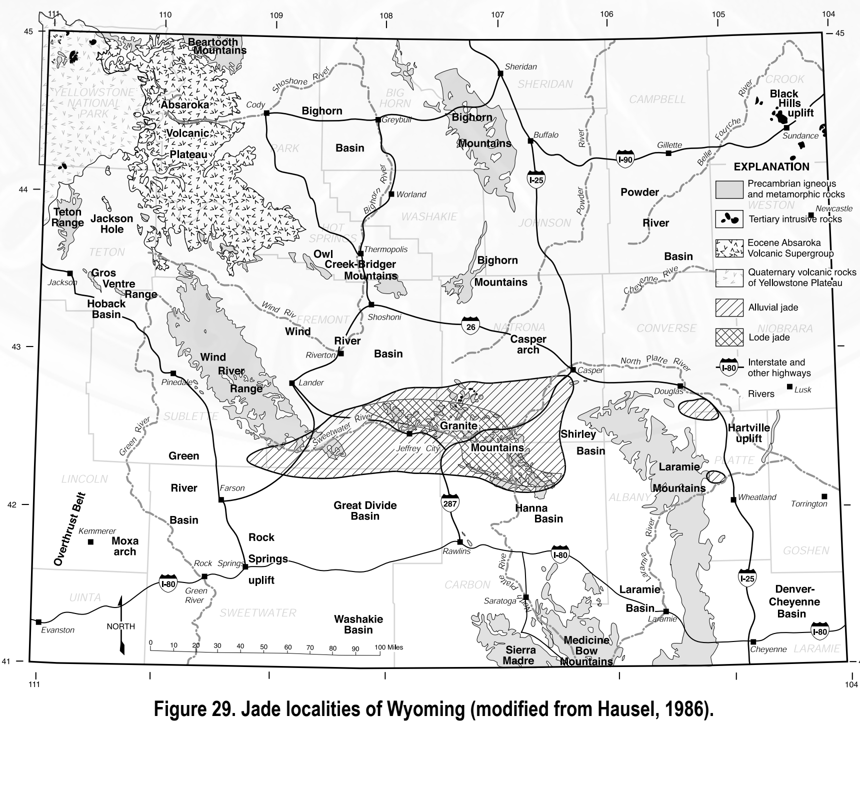

Figure 29. Jade localities of Wyoming (modified from Hausel, 1986).

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Hagner, A.F., 1945, Diehl-Branham jade: Wyoming State Geological Survey Mineral Report MR 45-7, 2 p.

Hausel, W.D., 1986, Minerals and rocks of Wyoming: Wyoming State Geological Survey Bulletin 66, 117 p.

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Hemrich, G.I., 1975, The Game Warden's jade: Gems and Minerals, no. 457, p. 8-15.

Hurlbut, C.S., Jr., and Switzer, G.S., 1979, Gemology: John Wiley and Sons, New York, New York, 243 p.

McFall, R.P., 1976, Wyoming jade: Lapidary Journal, v. 30, no. 1, p. 182-194.

Root, F., 1980, Wyoming jade: Wyoming State Geological Survey Information Circular, 8 p.

Sherer, R.L., 1969, Nephrite deposits of the Granite, Seminoe, and Laramie Mountains, Wyoming: Ph.D. dissertation, University of Wyoming, Laramie, 194 p.

STAFF PROFILE — ALAN J. VER PLOEG

Richard W. Jones
Editor/Geologist, Wyoming State Geological Survey

Alan J. Ver Ploeg is head of the Geologic Mapping Section at the Wyoming State Geological Survey (WSGS). Alan is responsible for geologic mapping and stratigraphic projects for the WSGS and for coordinating the agency's activities (such as the STATEMAP program) in these areas. He prepares geologic reports and does both field mapping and map compilations for detailed and regional geologic maps in Wyoming as well as coordinates a volunteer mapping program. He performs annual compliance examinations of permitted fossil quarries on State of Wyoming lands in support of the Wyoming Department of State Lands and Investments and answers most of the Survey's inquiries concerning paleontology. Alan also works with other Survey sections, giving them help on stratigraphy, subsurface correlations, and structural/stratigraphic problems in Wyoming basins. He furnishes his expertise in Wyoming geology on Survey projects where needed, to other state agencies as requested, and answers public inquiries on Wyoming geology.

Figure 30. Alan J. Ver Ploeg is head of the Survey's Geologic Mapping Section.

Alan was born in Sully, Iowa and grew up on the family farm near Pella, Iowa. After graduating from Pella High School in 1965, he continued his education at Iowa State University in Ames, Iowa. Alan is one of three Iowa State graduates on the WSGS staff, which reflects the Wyoming connection to Iowa State through that university's geology field camp located near Shell. Evidently the spectacular Wyoming geology they are exposed to imprints heavily on Iowa State field camp students, and many cannot wait to get back to Wyoming after graduation. Such was the case with Alan. After earning B.S. and M.S. degrees at Iowa State in 1970 and 1973, respectively, Alan accepted a job with Chevron Oil Company in New Orleans, Louisiana. After ten months working as a petroleum geologist in the "Big Easy," Alan decided that it was "too easy" and answered Wyoming's call by moving to Rawlins where he began his career in Wyoming geology.

In Rawlins, Alan was employed as a geologist with the U.S. Bureau of Land Management (BLM), first as a geologist doing oil and gas work with their operations division, second as a geologist in the Medicine Bow Resource Area, and finally as geologist for the entire Rawlins District. With his training in petroleum geology and his experience in Wyoming geology with BLM, Alan was a logical choice when the oil and gas geologist position at the WSGS opened, and in October, 1976, he joined the WSGS staff, where he has been ever since.

The most senior staff geologist with the WSGS, Alan spent his first 10 years with the Survey as head of the Oil and Gas Section. He considers his work on Trapper Canyon and the rest of the tar sand deposits and occurrences in Wyoming as one of his most significant contributions during that period, along with several important maps and publications on the newly developing Overthrust Belt play in western Wyoming. All total during this period, Alan produced some 60 maps, reports, and articles on Wyoming's oil and gas and related topics.

In a 1986 position switch, Alan became the new Head of the Geologic Mapping Section at the WSGS, a position he has held ever since. Alan considers his mapping project in the southern Bighorn Mountains, where he mapped some 12 7.5-minute quadrangles and one 1:100,000-scale quadrangle, one of his most significant contributions. Much of this area had never been mapped since Darton's mapping in the late 1800s and early 1900s. His recent mapping of quadrangles in the Laramie Basin, as well as his emphasis on producing geologic maps of the more populated areas of the state (e.g., Gillette, Sheridan, and Cheyenne) is also significant. He has been instrumental in procuring a large amount of federal mapping funds for the Survey under various programs (see his article on page 44 of this issue of Wyoming Geo-notes). Since 1986, he has published as either author or co-author about 120 maps, reports, articles, and papers on different aspects of Wyoming geology.

According to Alan, "the favorite part of my job is being able to get outdoors to do field work and geologic mapping. There are not very many careers in geology that allow one to do that anymore." He likes living in Laramie and enjoys what Wyoming has to offer.

Alan is a Registered Professional Geologist in Wyoming (PG-1587) and has been a long-time member of the American Association of Petroleum Geologists, the Wyoming Geological Association (WGA), and the Geological Society of America. Alan represents the WSGS on the Governor's Wyoming Geographic Information Advisory Committee (WGIAC), organized and coordinates with the Geologic Mapping Advisory Board for the State of Wyoming, and is a member of WGA's J. David Love Fellowship Committee.

Alan is a Civil War and western history buff and is a member of the Wyoming State Historical Society. He collects old western photographs and maps, and has a sizable collection of original reports and documents of early geology explorations as well as some classic early geologic publications and maps of Wyoming and the West. Alan enjoys playing softball in the summer and is an avid college and University of Wyoming sports fan (except when Iowa State is playing).

NEW PUBLICATIONS AVAILABLE

NEW PUBLICATIONS BY THE WYOMING STATE GEOLOGICAL SURVEY

Oil and gas fields map of central and southeastern Wyoming basins, by R.H. De Bruin, 1999: Map Series 54, scale 1:350,000-$25.00, plotted color map, rolled only; $60.00, viewable image of map and viewing software (Mr. Sid) on CD-ROM.

Coalbed methane activity in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, and L.L. Hallberg, 2000: Coalbed Methane Map CMM 00-01-$30.00, rolled only; $100.00, digital version (ArcInfo/ArcView format) on CD-ROM.

*Coalbed methane activity in the western Powder River Basin, Campbell, Converse, Johnson, Natrona, and Sheridan Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, L.L. Hallberg, and M.M. Harrison, 1999: Coalbed Methane Map CMM 00-02-$30.00, plotted color map, rolled only; $100.00, digital version (ArcInfo/ArcView format) on CD-ROM.

*Stream classification and drainage systems map of the northeast Wyoming coalbed methane development area, by Wyoming Department of Environmental Quality, 2000: Coalbed Methane Map CMM 00-03-$15.00, plotted color map, rolled only; a digital version (ArcInfo/ArcView format) of this map is now included with the CD-ROM versions of Coalbed Methane Maps 00-01 and 00-02.

How to make your Wyoming home more earthquake resistant, by J.C. Case and J.A. Green, 2000: Information Pamphlet 5-Free upon request.

Earthquakes in Wyoming, by J.C. Case and J.A. Green, 2000: Information Pamphlet 6 -Free upon request.

*Coalbed methane in Wyoming, by R.H. De Bruin, R.M. Lyman, R.W. Jones, and L.W. Cook, 2000: Information Pamphlet 7-Free upon request.

Each geologic section of the Survey now prepares and releases some of its own numbered reports and maps. Please contact the following Staff Geologists for coverage, availability, prices, or further information on specific commodities or topics [Phone: (307) 766-2286; FAX: (307) 766-2605; or use the Email addresses included below]:

James C. Case - Geologic hazards and environmental geology
(Email: jcase@wsgs.uwyo.edu)
Rodney H. De Bruin - Oil and gas
(Email: rdebru@wsgs.uwyo.edu)
Ray E. Harris - Industrial minerals and uranium
(Email: rharri@wsgs.uwyo.edu)
W. Dan Hausel - Metals and precious stones
(Email: dhause@wsgs.uwyo.edu)
Robert M. Lyman- Coal
(Email: blyman@wsgs.uwyo.edu)
Alan J. Ver Ploeg - Geologic mapping and stratigraphy
(Email: averpl@wsgs.uwyo.edu)

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

OTHER PUBLICATIONS NOW AVAILABLE FROM THE WYOMING STATE GEOLOGICAL SURVEY

Interpreting the landscapes of Grand Teton and Yellowstone National Parks–Recent and ongoing geology, by J.M. Good and K.L. Pierce, 1996: Published by Grand Teton Natural History Association – ISBN 0-931895-45-6, $13.00.

Geologic and historic guide to the Beartooth Highway, Montana and Wyoming, by H.L. James, 1995: Montana Bureau of Mines and Geology Special Publication 110 - $20.00.

Roadside geology of Wyoming: by D.R. Lageson and D.R. Spearing, 1988: published by Mountain Press Publishing Company - ISBN 0-87842-216-1, $18.00.

A correlated history of Earth, by Pan Terra, Inc., 1998: Full color wall chart, 38” high x 28” wide, laminated - $20.00.

Order these and other publications from: Wyoming State Geological Survey, P.O. Box 3008, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286; Fax (307) 766-2605; and Email: sales@wsgs.uwyo.edu. An order form is also included at the back of this issue of Wyoming Geo-notes. Many of these publications are also available over-the-counter at the WOGCC (Basko Building) in Casper, Wyoming. A free list of publications is available on request.

As of September 1, 1999, we are including postage charges on all mailed and shipped orders, including prepaid orders. Please use the shipping and handling chart on our order forms to calculate charges for your order.

NEW RELEASE OF WYOMING TOPOGRAPHIC MAPS ON CD-ROM

The Wyoming State Geological Survey (WSGS) is a dealer for All Topo Maps: Wyoming, published by iGage. The Wyoming set has been upgraded and improved in Release 2. All previous purchasers of All Topo Maps: Wyoming are entitled to upgrade their existing version for a reasonable price. The WSGS has the upgrade kits available for Release 2 as well as the full map sets. In addition to the features originally described in earlier issues of Wyoming Geo-notes, Release 2 contains these new features:

- Higher resolution images and printouts.
- All 1:100,000-scale metric maps of Wyoming are now included. Includes the 56 quadrangles entirely in Wyoming and 21 quadrangles containing a part of Wyoming.
- Ability to search by Township and Range as well as by Zip Code.
- Maps can be combined seamlessly (Big Topo tool), direct interfaces with GPS receivers are available (GPS Interface tool), and a viewer and annotation tool (All Topo Viewer) enables export in a variety of formats.
- Faster map decompression and Big Topo compression.
- New packaging for the 7-disk set is stronger, in a dust resistant box, and disks are packaged individually in polypropylene sleeves.

The WSGS can upgrade your old sets for $38.00. Return the old sets to us along with your original serial number and retain your existing installation and serial number. Purchasers of Release 1 after January 1, 2000 can upgrade for $15.00. The set of seven CD-ROMs sells for $140.00; Wyoming addresses must include 6% sales tax. Available over-the-counter or prepaid only. For more information and a description of other features, please contact the Survey's sales office in Laramie.