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Wyoming State Geological Survey
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Front cover: Left half of stereopair #21 - "Crater of the Castle and Hot Spring Basin" by W.H. Jackson photographer, Hayden Survey, 1871. Albumen print in the "Yellowstone Series" published by E. & H.T. Anthony & Co., New York. From the personal collection of Lance Cook.

Table of Contents

MINERALS UPDATE

OVERVIEW AND GENERAL COMMENTS

Lance Cook
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Coalbed methane

The hot topic in Wyoming resources continues to be coalbed methane (CBM) in the Powder River Basin. With over 80 rigs currently active and thousands of wells yet to be drilled, this area will continue to be one of the hottest gas plays in the U.S. As of March 1, 2000, the Wyoming Oil and Gas Conservation Commission (OGCC) had issued 10,000 CBM well permits. Because of the nature of land and mineral ownership in the Powder River Basin, conflicts have arisen between the surface owners (who are often not the mineral owners) and the mineral owners and lessees.

Agencies of the State of Wyoming that have jurisdiction over the CBM activities are doing their best to address concerns and issues. The Wyoming Department of Environmental Quality (DEQ), State Engineer's Office, and OGCC are trying very hard to make sure that the impacts from CBM are minimized and occur within the existing legal framework. But state agencies are bound by existing laws and cannot make new laws; only the Wyoming State Legislature can make new laws. Outside of new legislation, a citizen's best defense of his property rights is to be informed and educated, so that he can look out for his own interests.

The Wyoming State Geological Survey (WSGS) is not a regulatory agency so we have no control over the CBM activity. However, we are charged with helping to promote the beneficial use of the state's resources for its citizens, and in this context, we are working on some of the technical issues that have been raised. We are working with the U.S. Bureau of Land Management (BLM), the relevant state agencies, and the individual landowners to fulfill our statutory mission and to make sure that decisions are based on sound science and are consistent with geologic facts and observations.

The OGCC has maintained very close communication with the CBM operators. The Commission staff has been most diligent at attempting to mitigate the operator/surface owner conflicts that have occurred. When notice of conflict has been received, the Commission has attempted to mediate, and where appropriate, has strongly encouraged operators to compensate surface owners/water rights owners for damages. This has been very successful. The operators are aware, and for the most part understand, that they are responsible for damages.

Pilot programs are in place to address the feasibility of water re-injection on a wide scale. This will have to be an economic decision; the CBM operators are determining the actual costs of gathering and injecting the produced water into shallow aquifers so that the water can be utilized at a later time. We also understand

that there is proposed legislation in Wyoming to allow a severance tax credit for production from an operator's wells where the operator is re-injecting his produced water. This may be a positive incentive.

Additionally, in cooperation with DEQ and the State Engineer's Office, the Commission is working with operators to approve and permit seepage return pits, which allow return of the produced water to shallow aquifers. Initially, this is being implemented in the western part of the basin, where soil erosion is a serious problem. We hope that this will work to the benefit of all parties. The surface owners are supportive of this effort where it has been tried thus far.

DEQ is in the process of updating some of their standards for dissolved solids in water discharged from CBM wells. This will bring State DEQ standards into line with Federal Environmental Protection Agency (EPA) standards, and eliminate difficulties operators have encountered in complying with two different sets of standards.

The Wyoming Business Council is aggressively pursuing a number of possible alternatives for beneficial use of the produced water beyond surface disposal. Among the possibilities being explored are:

- enhancement of the Gillette public water supply through re-injection;
- development of a bottled water industry;
- storage in surface facilities, providing recreational opportunities as well as augmentation of the public water supply; and
- power plant cooling for new power generating facilities.

Additionally, the Campbell County Conservation District is implementing a Coordinated Resource Management (CRM) process. This process is used to bring all interested parties of an issue to the table where they can discuss concerns and possible solutions. It is not a democratic process, but a consensus of the group. The District has brought landowners, operators, state and county officials, and federal agencies together to arrive at agreeable solutions to the CBM issues. This process has been used in the Caballo Creek and Wildhorse Creek drainages. We hope that by fostering open communication, this process will help defuse many of the conflicts between operators and surface owners.

Finally, on the federal side, the BLM has finalized their plans for National Environmental Policy Act (NEPA) documentation to deal with CBM. The BLM will prepare a drainage case environmental assessment (EA) to deal with immediate problems of drainage created by private wells offsetting government minerals. Concurrently, and for the longer term, the BLM will prepare a new environmental impact statement (EIS) for oil and gas operations in the Powder River Basin. This will manage oil and gas activity for the longer term, and this EIS will be used to update and amend the Resource Management Plan (RMP) for the Buffalo Resource Area. The State of Wyoming will be a cooperating agency in the preparation of both the EA and the EIS.

Other notes

Minor revisions have been made to the mineral production forecasts and prices. Market analyses and statistical data for Wyoming minerals are provided in the separate updates that follow these introductory comments. Oil volume forecasts have been increased (**Table 1**). The decline in oil production (following last year's depressed prices) has not been as great as feared earlier, so we have increased the volume forecasts. The forecast price for natural gas (methane) has been raised slightly for 1999, as has the price for crude oil (**Table 2**). We are still forecasting flat prices for oil and gas on a long-term basis (**Table 2**), as the Organization of Petroleum Exporting Countries (OPEC) controls the incremental volumes of oil, and so directly or indirectly controls the prices of hydrocarbons. We have reduced the forecast for uranium production (**Table 1**), based on information from the producers. However, some good news may be on the horizon for uranium. The world's stocks of uranium are declining while demand increases in all industrialized countries except Germany and the United States.

Table 1. Wyoming mineral production (1985-1998) 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	61.1	1,121.6	151.0	1.10	338.5	19.0	2.5	1.20
2000	57.4	1,147.1	151.0	1.10	357.0	19.5	1.8	1.20
2001	54.3	1,173.1	151.0	1.10	369.5	20.0	1.6	1.20
2002	51.3	1,199.6	151.0	1.10	373.2	20.0	1.6	1.20
2003	48.5	1,226.6	151.0	1.10	376.9	21.1	1.6	1.20
2004	45.8	1,254.2	151.0	1.10	380.7	22.0	1.6	1.20
2005	43.3	1,282.3	151.0	1.10	384.5	22.0	1.6	1.20
2006	40.9	1,311.0	151.0	1.10	388.4	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, 1985-1998; [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.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985-1998) 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	15.00	2.05	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, 1985-1998; [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

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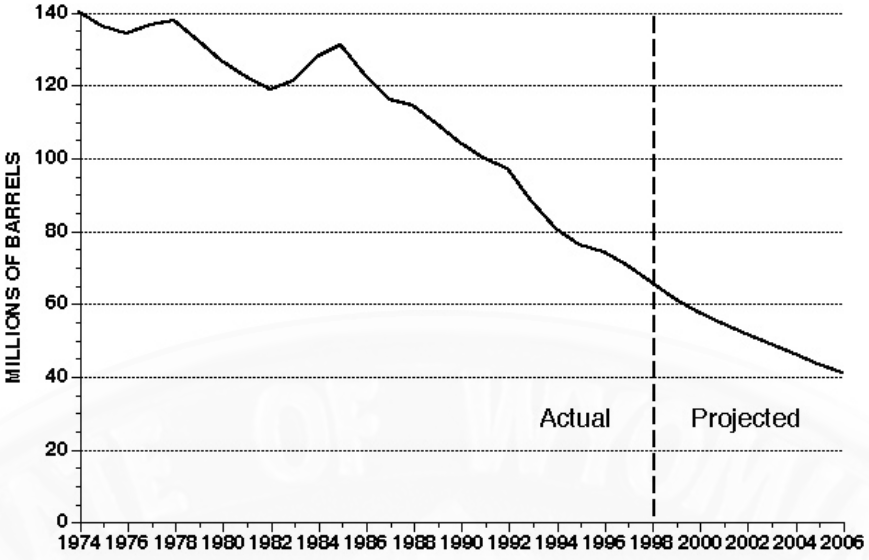
Staff Geologist-Oil and Gas, Wyoming State Geological Survey

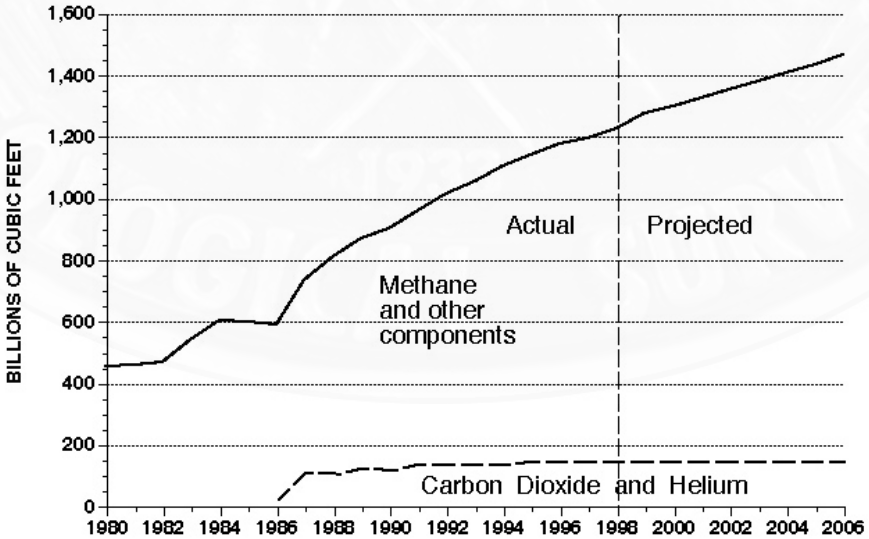
This issue of Wyoming Geo-notes contains several revised estimates for Wyoming oil and gas since the previous issue (Geo-notes No. 64, December, 1999). The State of Wyoming's Consensus Revenue Estimating Group (CREG) has increased their estimates for oil production, oil prices, and methane prices. Wyoming oil production forecasts for 1999 to 2006 (**Table 1** and **Figure 1**) increased in response to tighter supplies and higher prices for crude oil worldwide.

The forecast methane production for 1999 to 2006 (**Table 1** and **Figure 2**) was not changed from the previous estimates (see Geo-notes No. 64), but the average prices for both crude oil and methane forecast for 1999 did increase slightly. Crude oil prices worldwide have firmed due to production restraint by most major producers within the Organization of Petroleum Exporting Countries (OPEC) and also by some non-OPEC members. In response to curtailed production and rising prices, CREG raised the projected price of crude oil to $15.00 a barrel for 1999 (**Table 2** and **Figure 3**). In response to increased spot prices for Wyoming natural gas, CREG raised its natural gas price estimate for 1999 to $2.05 per thousand cubic feet (MCF) (**Table 2** and **Figure 4**).



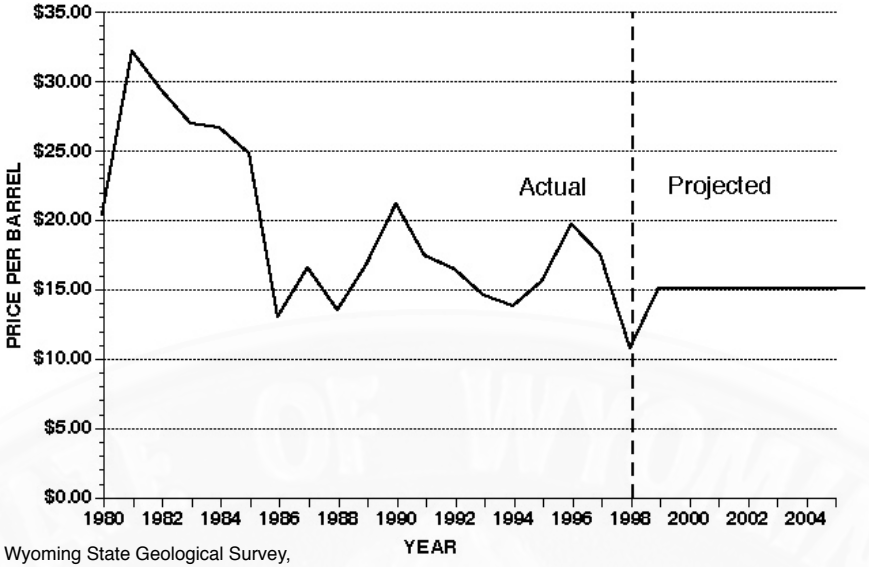
Wyoming State Geological Survey,
Oil and Gas Section, February, 2000

Figure 1. Annual crude oil production from Wyoming (1974 through 1998) with forecasts to 2006.



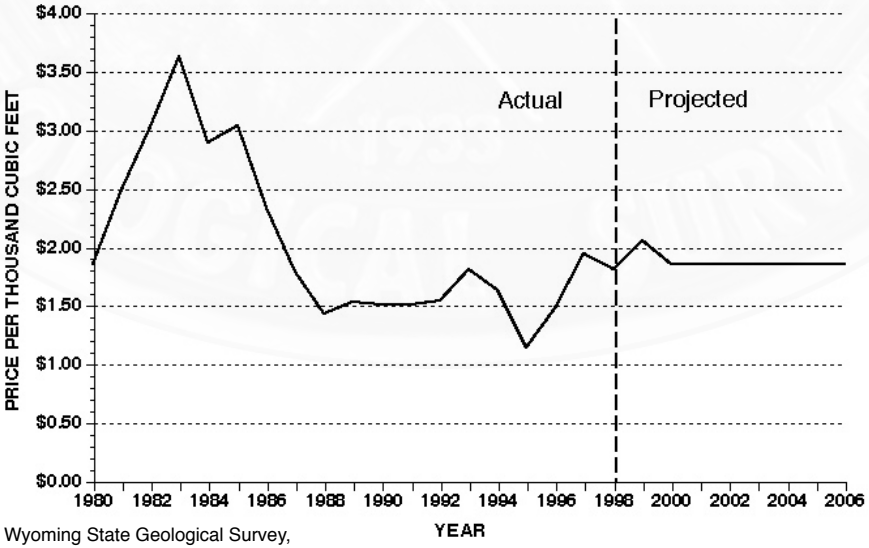
Wyoming State Geological Survey,
Oil and Gas Section, February, 2000

Figure 2. Annual natural gas production from Wyoming (1980 though 1998) with forecasts to 2006.



Wyoming State Geological Survey,
Oil and Gas Section, February, 2000

Figure 3. Average prices paid for Wyoming crude oil (1980 through 1998) with forecasts to 2006.



Wyoming State Geological Survey,
Oil and Gas Section, February, 2000

Figure 4. Average prices paid for Wyoming methane (1980 through 1998) with forecasts to 2006.

Prices paid to Wyoming oil producers during the fourth quarter of 1999 averaged $21.68 per barrel. The average price for that quarter is $11.81 higher than for the fourth quarter of 1998, and the average price for 1999 is $5.74 higher than the average price for 1998. The average price in December of $23.00 (**Table 3**) is the highest average monthly price in the last four years and is the highest since the peak in late 1990 (**Figure 5**).

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

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	$16.38	$16.38	$22.56	$22.56	$12.79	$12.79	$9.30	$9.30
FEB	$16.28	$16.33	$19.45	$21.01	$12.16	$12.48	$9.09	$9.20
MAR	$18.63	$17.09	$17.99	$20.00	$10.97	$11.97	$11.77	$10.05
APR	$20.29	$17.90	$16.81	$19.20	$11.54	$11.87	$14.34	$11.13
MAY	$18.85	$18.08	$17.74	$18.91	$11.19	$11.73	$15.16	$11.93
JUN	$18.15	$18.10	$15.90	$18.41	$9.63	$11.38	$15.36	$12.50
JUL	$18.98	$18.22	$16.29	$18.11	$10.20	$11.21	$17.39	$13.20
AUG	$19.59	$18.39	$16.61	$17.92	$9.58	$11.01	$18.43	$13.86
SEP	$21.48	$18.74	$16.42	$17.75	$11.19	$11.03	$20.97	$14.65
OCT	$22.63	$19.13	$17.89	$17.77	$11.04	$11.03	$20.01	$15.18
NOV	$21.19	$19.31	$16.51	$17.65	$9.64	$10.90	$22.04	$15.81
DEC	$22.42	$19.56	$14.72	$17.41	$8.05	$10.67	**$23.00**	**$16.41**
Avg. yearly price		**$19.56**		**$17.41**		**$10.67**		**$16.41**

Source: All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 1999 are estimated from various unpublished bulletins listing posted prices.
Wyoming State Geological Survey, Oil and Gas Section, February, 2000.

Oil production in Wyoming for the first 10 months of 1999 was about 51 million barrels (**Table 4**), according to figures from the Wyoming Oil and Gas Conservation Commission (OGCC). Although this production is a drop of about 6.4% from the first 10 months of production in 1998, the decline in production has moderated over the past several months because of higher prices for Wyoming oil. As discussed above, the CREG production estimates for 1999 to 2006 have been raised accordingly.

Spot prices for natural gas at Opal, Wyoming averaged $2.45 per MCF during the fourth quarter of 1999. This is $0.57 higher than for the fourth quarter of 1998 (**Table 5** and **Figure 6**). The average spot price for 1999 is the highest since 1986.

Natural gas production in Wyoming for the first 10 months of 1999 was about 1.05 trillion cubic feet according to production figures from the OGCC. This production is up 5.8% from the first 10 months of 1998 (**Table 6**).

The U.S. Department of Energy (DOE) (1999) released its new reserve estimates for crude oil, natural gas liquids, and natural gas in the United States. **Table 7** shows Wyoming's relative ranking among the top ten states in proved reserves of crude oil, dry natural gas, and natural gas liquids. Wyoming's proved reserves of dry natural gas should increase significantly with the development of coalbed meth-

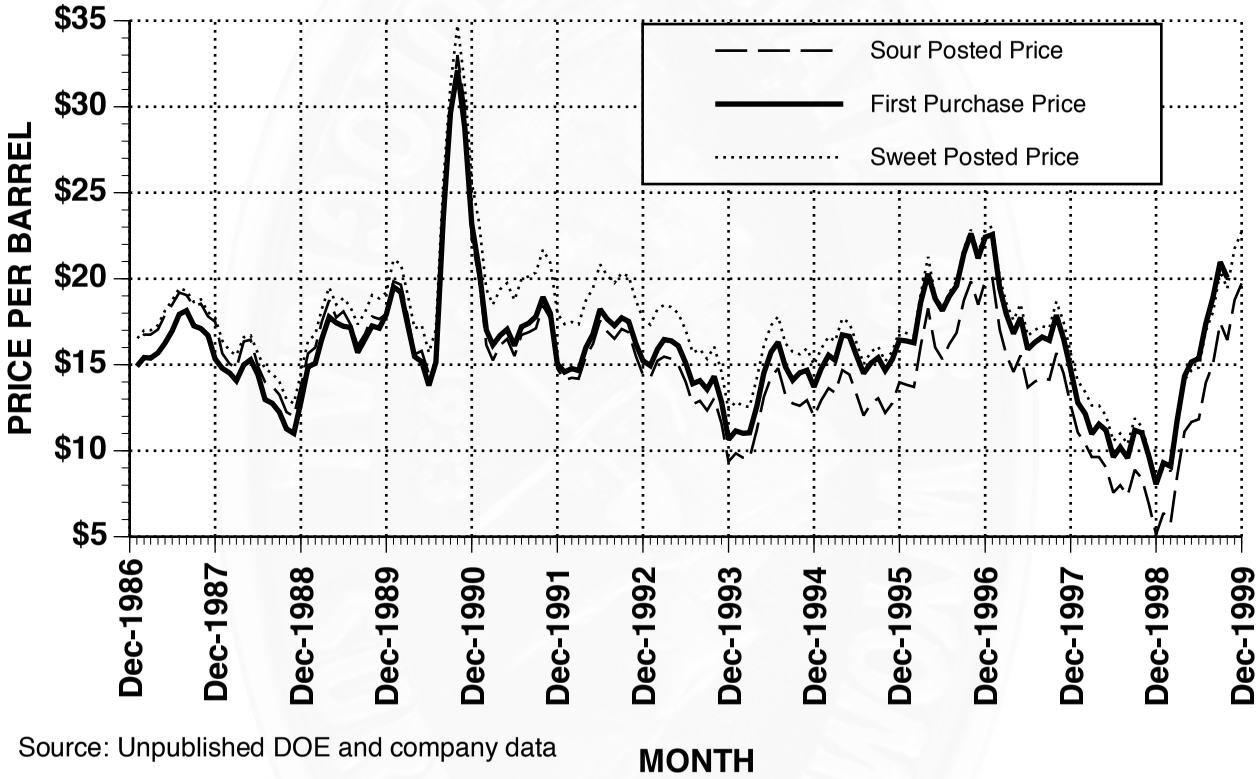


Figure 5. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through December, 1999).

Table 4. Monthly oil production from Wyoming in barrels (1996 through October, 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	5,323,577	5,323,577
FEB	5,693,084	11,846,121	5,459,518	11,424,366	5,233,502	11,079,866	4,735,025	10,058,602
MAR	6,176,805	18,022,926	6,014,780	17,439,146	5,759,176	16,839,042	5,293,189	15,351,791
APR	5,977,362	24,000,288	5,729,869	23,169,015	5,534,568	22,373,610	5,057,051	20,408,842
MAY	6,035,505	30,035,793	6,050,971	29,219,986	5,626,125	27,999,735	5,135,581	25,544,423
JUN	5,916,019	35,951,812	5,761,549	34,981,535	5,335,463	33,335,198	4,987,135	30,531,558
JUL	6,076,992	42,028,804	5,964,005	40,945,540	5,464,514	38,799,712	5,124,415	35,655,973
AUG	6,414,850	48,443,654	5,868,789	46,814,329	5,287,415	44,087,127	5,163,276	40,819,249
SEP	6,180,180	54,623,834	5,710,557	52,524,886	5,109,053	49,196,180	5,063,892	45,883,141
OCT	6,186,019	60,809,853	5,949,974	58,474,860	5,274,269	54,470,449	5,115,704	50,998,845
NOV	6,221,912	67,031,765	5,800,811	64,275,671	5,232,287	59,702,736		
DEC	6,330,701	73,362,466	5,900,791	70,176,462	5,078,909	64,781,645		
Total Barrels Reported [1]		**73,362,466**		**70,176,462**		**64,781,645**		
Total Barrels Not Reported [2]		**525,957**		**52,364**		**897,131**		
Total Barrels Produced [3]		**73,888,423**		**70,228,826**		**65,678,776**		

[1] Monthly production reports from Petroleum Information/Dwights LLC, 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, February, 2000.

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

	1996		1997		1998		1999	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
JAN	$1.25	$1.25	$3.90	$3.90	$2.05	$2.05	$1.80	$1.80
FEB	$1.20	$1.23	$2.50	$3.20	$1.70	$1.88	$1.65	$1.73
MAR	$1.20	$1.22	$1.40	$2.60	$1.90	$1.88	$1.50	$1.65
APR	$1.05	$1.18	$1.45	$2.31	$1.90	$1.89	$1.60	$1.64
MAY	$0.95	$1.13	$1.60	$2.17	$1.95	$1.90	$2.00	$1.71
JUN	$1.10	$1.13	$1.35	$2.03	$1.65	$1.86	$2.00	$1.76
JUL	$1.20	$1.14	$1.45	$1.95	$1.60	$1.82	$2.00	$1.79
AUG	$1.25	$1.15	$1.40	$1.88	$1.75	$1.81	$2.20	$1.84
SEP	$1.20	$1.16	$1.50	$1.84	$1.60	$1.79	$2.60	$1.93
OCT	$1.30	$1.17	$2.05	$1.86	$1.65	$1.78	$2.40	$1.98
NOV	$2.45	$1.29	$3.00	$1.96	$2.00	$1.80	$2.85	$2.05
DEC	$3.50	$1.47	$1.95	$1.96	$2.00	$1.81	$2.10	$2.06
Avg. yearly price		**$1.47**		**$1.96**		**$1.81**		**$2.06**

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

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

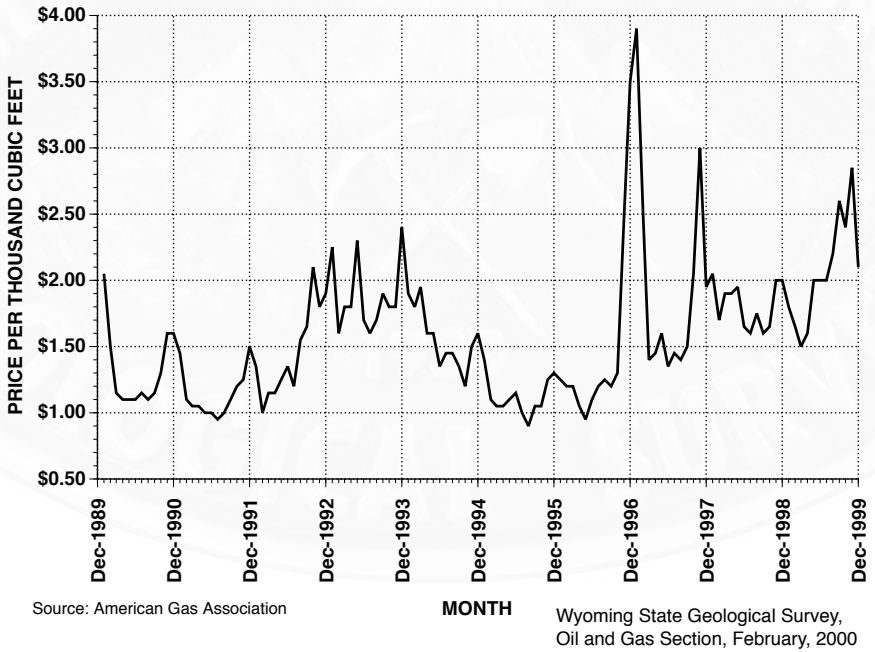


Figure 6. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through December, 1999).

ane resources. At the end of 1998, Wyoming ranked third in natural gas reserves, fourth in natural gas liquids reserves, and seventh in crude oil reserves. **Table 8** shows that Wyoming's natural gas reserves in 1998 increased to their highest level ever, despite record production. Reserves of crude oil and natural gas liquids both decreased in 1998. The crude oil decline was caused by very low crude oil prices

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1996 through October, 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	108,151,202	108,151,202
FEB	96,303,300	197,662,948	91,766,159	191,345,977	94,501,819	198,142,033	93,793,117	201,944,319
MAR	103,541,127	301,204,075	104,157,578	295,503,555	103,906,999	302,049,032	110,758,145	312,702,464
APR	99,479,609	400,683,684	99,459,039	394,962,594	98,201,007	400,250,039	101,985,902	414,688,366
MAY	97,900,863	498,584,547	101,070,371	496,032,965	96,741,237	496,991,276	104,209,038	518,897,404
JUN	87,069,612	585,654,159	91,905,308	587,938,273	98,413,520	595,404,796	101,907,150	620,804,554
JUL	100,219,275	685,873,434	100,129,497	688,067,770	102,055,968	697,460,764	105,161,660	725,966,214
AUG	99,874,019	785,747,453	97,673,622	785,741,392	105,378,334	802,839,098	98,825,688	824,791,902
SEP	93,510,551	879,258,004	100,028,888	885,770,280	98,474,782	901,313,880	107,523,204	932,315,106
OCT	95,441,022	974,699,026	102,206,875	987,977,155	96,470,624	990,880,952	116,299,870	1,048,614,976
NOV	94,015,007	1,068,714,033	100,752,128	1,088,729,283	103,445,859	1,101,230,363		
DEC	99,141,298	1,167,855,331	103,415,430	1,192,144,713	99,339,043	1,200,569,406		
Total MCF Reported [1]		**1,167,855,331**		**1,192,144,713**		**1,200,569,406**		
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, February, 2000.

Table 7. Wyoming's ranking in proved reserves of crude oil (billions of barrels), dry natural gas (trillions of cubic feet), and natural gas liquids (billions of barrels) at the beginning of 1999.

State	Crude Oil	State	Dry Natural Gas	State	Natural Gas Liquids
Alaska	5.052	Texas	37.584	Texas	2.544
Texas	4.927	New Mexico	14.987	New Mexico	0.929
California	3.843	Wyoming (3)	13.650	Oklahoma	0.698
New Mexico	0.620	Oklahoma	13.645	Wyoming (4)	0.535
Oklahoma	0.599	Alaska	9.927	Louisiana	0.411
Louisiana	0.551	Louisiana	9.147	Kansas	0.334
Wyoming (7)	0.547	Colorado	7.881	Alaska	0.320
Kansas	0.246	Kansas	6.402	Colorado	0.260
North Dakota	0.245	Alabama	4.604	Utah	0.140
Colorado	0.212	West Virginia	2.868	Alabama	0.081

Source: U.S. Department of Energy, 1999.

Table 8. Comparison of Wyoming's proved reserves of crude oil (billions of barrels), dry natural gas (trillions of cubic feet), and natural gas liquids (billions of barrels) for the years 1980 through 1998.

Date	Crude Oil	Dry Natural Gas	Natural Gas Liquids[1]
1980	0.928	9.100	0.239
1981	0.840	9.307	0.269
1982	0.856	9.758	0.477
1983	0.957	10.227	0.552
1984	0.954	10.482	0.602
1985	0.951	10.617	0.664
1986	0.849	9.756	0.665
1987	0.854	10.023	0.647
1988	0.825	10.308	0.808
1989	0.815	10.744	0.627
1990	0.794	9.944	0.568
1991	0.757	9.941	0.524
1992	0.689	10.826	0.462
1993	0.624	10.933	0.420
1994	0.565	10.789	0.395
1995	0.605	12.166	0.415
1996	0.603	12.320	0.505
1997	0.627	13.562	0.600
1998	0.547	13.650	0.535

Source: U.S. Department of Energy, 1999.
[1]Estimated from U.S. Department of Energy figures.

that made part of Wyoming's reserves economically unrecoverable. Higher prices in 1999 may add some reserves to these two commodities when DOE's proved reserves figures become available for 1999.

The final environmental impact statement for the Continental Divide/Wamsutter II area is now available for review. The area covers more than a million acres and is located about 25 miles west of Rawlins and about 40 miles east of Rock Springs along Interstate 80. The oil and gas operators propose to drill a maximum of 3000 wells at 3000 locations over the next 20 years, with 150 to 300 wells drilled per

year. The U.S. Bureau of Land Management's (BLM's) preferred alternative for the project is the proposed action.

During the fourth quarter of 1999, Veritas Land Surveys completed field acquisition of a 200-square-mile 3-D seismic program over the Pinedale anticline in Sublette County. The Pinedale anticline 3-D program overlaps and extends into the nearby Jonah Field, where Veritas also acquired 120 square miles of 3-D seismic data. The 3-D program was done for Ultra Petroleum.

A new report by the Gas Research Institute (GRI) predicts that electricity generation will be the fastest-growing market for natural gas over the next 15 years. The study predicts that independent power generating companies will increase their share of the electricity generating market from 3% in 1997 to 27% in 2015. GRI believes that natural gas will be the major beneficiary of the changing electric utility industry and that nearly half the total increase in U.S. gas demand (projected by GRI) between 1997 and 2015 will come from gas used to generate electricity.

Golder Associates, Marathon Oil, and Roger Straub, in cooperation with the Eastern Shoshone and Northern Arapaho tribes of the Wind River Reservation, will undertake a project to provide increased understanding of Circle Ridge Field reservoirs for the tribes and Marathon Oil. The DOE-sponsored study should also help other operators understand the same formations in other fields on the reservation and in fields throughout the U.S. where fractures are an important factor in reservoir permeability.

The team will develop models of fracture location, size, and orientation in the Phosphoria Formation/Tensleep Sandstone reservoir in Circle Ridge Field. Only 15% of the original oil in place in this reservoir has been recovered in over 50 years of operation and current production is 97% water. The reservoir rock has good porosity, but fluid flow in the reservoir is controlled by fractures. The 24-month project will be funded with $365,000 from DOE and $205,000 in cost sharing from Marathon Oil.

Leasing activity at the Wyoming Office of State Lands and Investments' October sale was centered in the Greater Green River Basin around Jonah and Stagecoach Draw fields, as well as in the Powder River Basin (**Figure 7**). The sale's highest per-acre bid of $475 was made by Powder River Resources for a 103.39-acre lease that covers parts of sections 30 and 31, T50N, R74W (**location A, Figure 7**). The lease is about a mile northeast of a current Fort Union coalbed methane program. Powder River Resources also acquired a 40-acre parcel (SE NE section 20, T50N, R74W) for $425 per acre, also near Fort Union coalbed methane development (**location A, Figure 7**). The sale's second highest per-acre bid of $440 was made by Hanson & Strahn for a 640-acre lease that covers all of section 36, T28N, R107W (**location B, Figure 7**). The lease is about nine miles south of Lance production in Jonah Field. In all, 39 parcels received bids of $50 or more per acre at this sale, and the 216 parcels leased generated revenues of about $2.4 million (**Table 9**).

Leasing activity at the October U.S. Bureau of Land Management (BLM) sale was concentrated in the Powder River Basin and on the southeastern flank of the Greater Green River Basin (**Figure 8**). Barrett Resources Corp. made the sale's

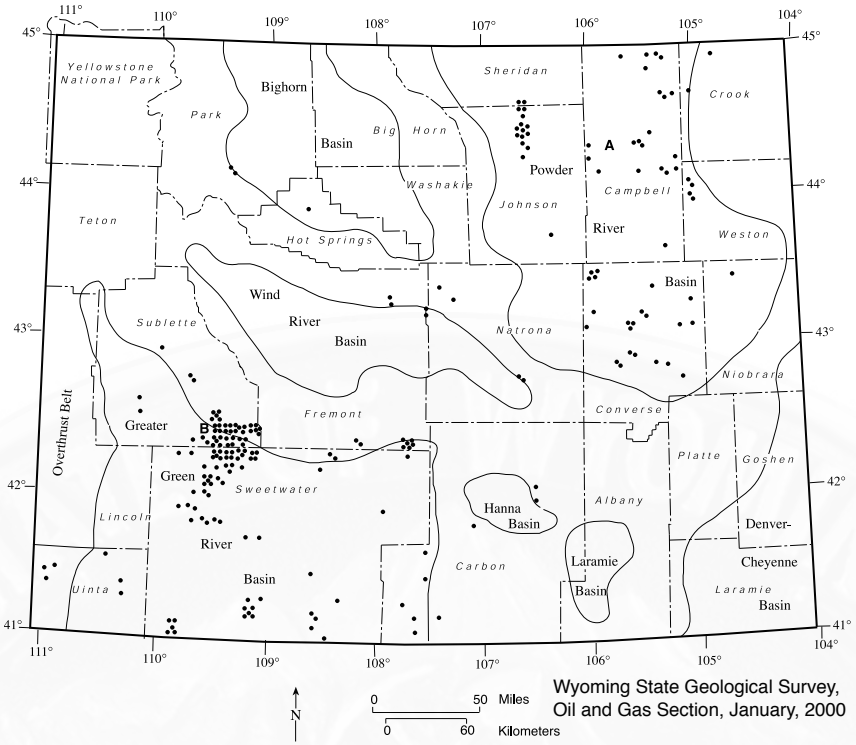


Figure 7. Locations of state oil and gas tracts leased by the Office of State Lands and Investments at its October, 1999 sale.

highest per-acre bid of $580 for an 81.81-acre lease that covers parts of section 32, T50N, R75W (**location A, Figure 8**). The lease is about two miles north of a Fort Union coalbed methane program scheduled by Devon Energy Corp., just south of Dead Horse Creek Field. Barrett Resources also made the sale's second highest per-acre bid of $450 for a 2040.08-acre lease that covers parts of sections 14, 15, 22, 23, 24, and 25, T46N, R76W, and the sale's third highest per-acre bid of $400 for a 2104.77-acre lease that covers parts of sections 3, 4, 10, 11, 12, and 13, T46N, R76W (**location B, Figure 8**). The leases are three to five miles north of a Fort Union coalbed methane program by Yates Petroleum Corp. There were a total of 14 parcels at this sale that received bids of $50 or more per acre, and the 175 parcels that were leased generated revenues of about $4.4 million (**Table 9**).

Leasing activity at the Wyoming Office of State Lands and Investments' December sale was centered in the Powder River and Greater Green River basins (**Figure 9**). The sale's highest per-acre bid of $500 was made by Barrett Resources for a 120-acre parcel that covers N/2 SE and SE SE section 15, T51N, R76W (**location A, Figure 9**). The lease offsets production from the Muddy Sandstone at Elk Draw Field. The sale's second highest per-acre bid of $375 was made by Vastar Resources for a 640-acre tract that covers all of section 16, T38N, R75W (**location B, Figure 9**). The tract is about a mile east of the company's African Swallow discovery well in the Muddy Sandstone. That well produced 533,000 barrels of

Table 9. Federal and state competitive oil and gas lease sales in Wyoming (1996 through 1999).

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)								STATE SALES (OFFICE OF STATE LANDS AND INVESTMENTS)							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1996								**1996**			
TOTAL	$11,487,567	1828	1125	1,403,444	739,505	$15.53	$1,450.00	TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
				1997								**1997**			
TOTAL	$31,976,603	1787	1485	1,578,938	1,206,642	$26.50	$600.00	TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	$340.00
				1998								**1998**			
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00								
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00	April	$1,203,792	300	161	115,646	63,848	$18.85	$320.00
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00	June	$1,660,438	300	148	108,654	52,501	$31.63	$600.00
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00	October	$1,313,792	298	178	98,856	65,212	$20.14	$590.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00	December	$1,045,447	300	187	121,551	77,852	$13.43	$215.00
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	TOTAL	$5,223,469	1198	674	444,707	259,413	$20.14	$600.00
				1999								**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	April	$1,815,526	299	196	123,119	89,194	$20.35	$890.00
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00	June	$1,002,039	300	190	108,310	69,858	$14.34	$400.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00	October	$2,369,527	300	216	109,140	77,261	$30.67	$475.00
October	$4,395,288	214	175	195,827	142,525	$30.84	$580.00	December	$956,113	291	129	115,502	51,674	$18.50	$500.00
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	TOTAL	$6,143,205	1,190	731	456,071	287,987	$21.33	$890.00

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, February, 2000.

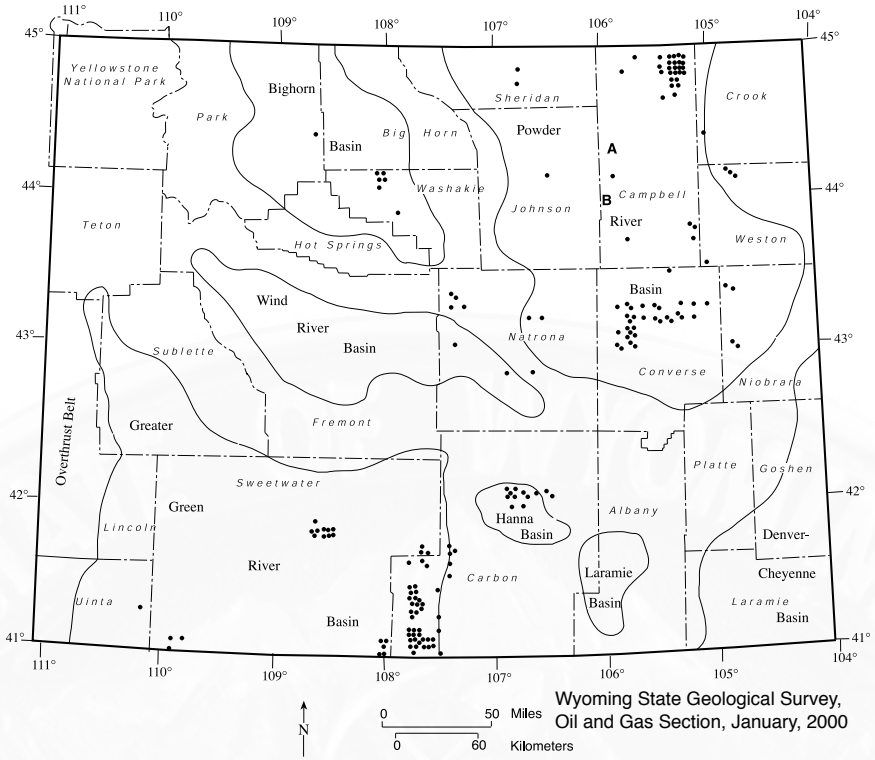


Figure 8. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its October, 1999 sale.

condensate and 5.6 billion cubic feet (BCF) of gas in its first year on line. The well currently produces 433 barrels of condensate and 10.3 million cubic feet (MMCF) of gas per day. This sale had 11 parcels that received bids of $50 or more per acre, and netted revenues of about $0.96 million from 129 leased parcels (**Table 9**). Total revenue from state lease sales in 1999 was $6.1 million. The State of Wyoming receives all the proceeds from these sales.

Leasing activity at BLM's December lease sale was predominantly in the Greater Green River and Powder River basins (**Figure 10**). Barrett Resources made the sale's highest per-acre bid of $410 for a 586.2-acre lease that covers parts of sections 1, 2, and 12, T36N, R87W (**location A, Figure 10**). The parcel is less than a mile west of gas and condensate production from the Fort Union and Lance formations at Waltman Field. Powder River Resources made the sale's second highest per-acre bid of $332 for a 481.7-acre lease that covers parts of section 1, T35N, R76W (**location B, Figure 10**). The lease is about a mile southeast of Muddy Sandstone production at Derrick Draw Field. This sale had 24 parcels that received bids of $50 or more per acre, and generated about $5.6 million in revenues from 164 leased parcels (**Table 9**). In 1999, the total revenue from federal lease sales in Wyoming was about $24.2 million. About half of this money also goes to the State of Wyoming.

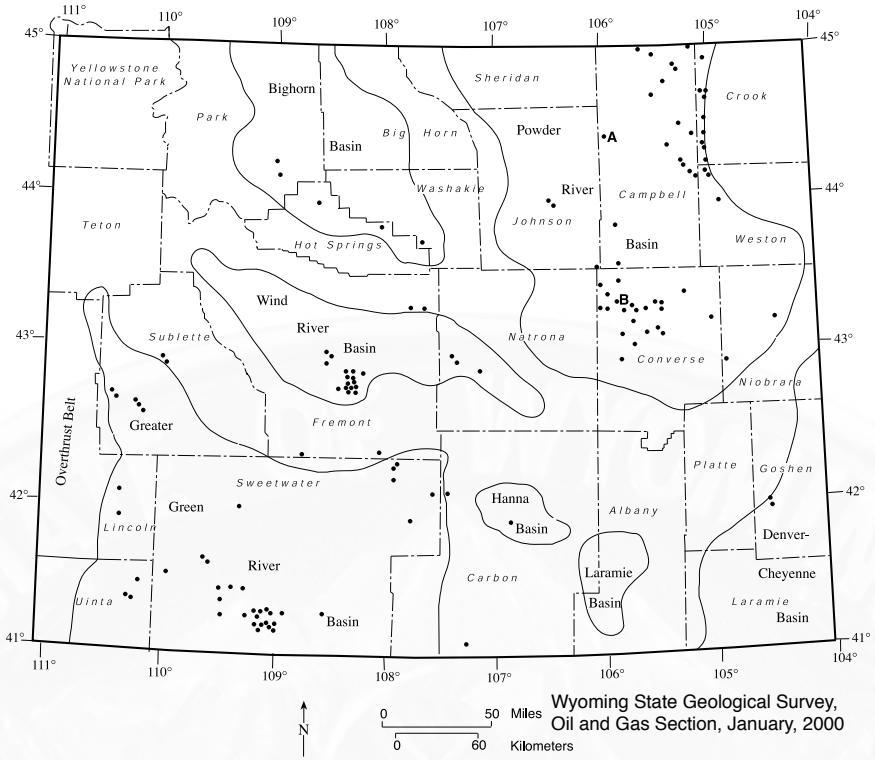


Figure 9. Locations of state oil and gas tracts leased by the Office of State Lands and Investments at its December, 1999 sale.

There were 5900 Applications for Permit to Drill (APDs) approved by the OGCC in 1999 (**Table 10**). The yearly total is more than the number of APDs approved in 1996, 1997, and 1998 combined (**Table 10** and **Figure 11**). Campbell County again led with 75.6% of the total APDs that were approved. Sheridan and Johnson counties combined for another 12.2% of the total APDs that were approved. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

The OGCC permitted a total of 38 seismic projects in 1999 (**Table 11**). The number of permits was the lowest in the last four years, but the area covered by 3-D projects was down only 6% from last year.

The average daily rig count for the fourth quarter of 1999 was 41, three more than in the fourth quarter of 1998 (**Figure 12**). The rig count does not include rigs drilling for coalbed methane. The average rig count for the year, however, was down seven from the average count in 1998 (**Figure 13**).

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

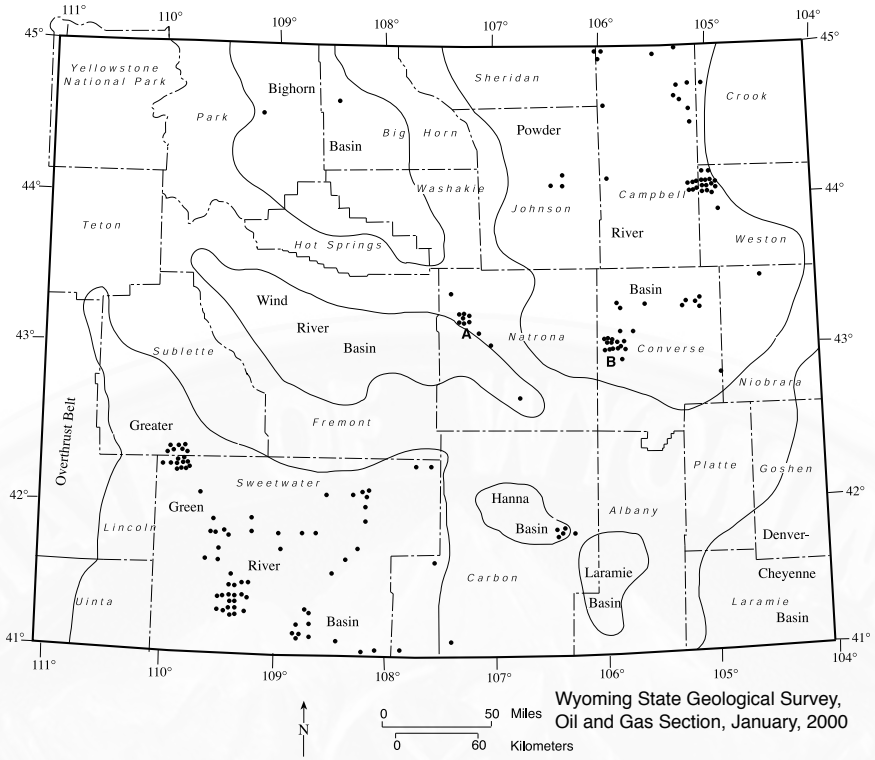


Figure 10. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its December, 1999 sale.

development activity in Wyoming. This section reports the most significant activities during the fourth quarter of 1999. The paragraph numbers correspond to locations on **Figure 14**.

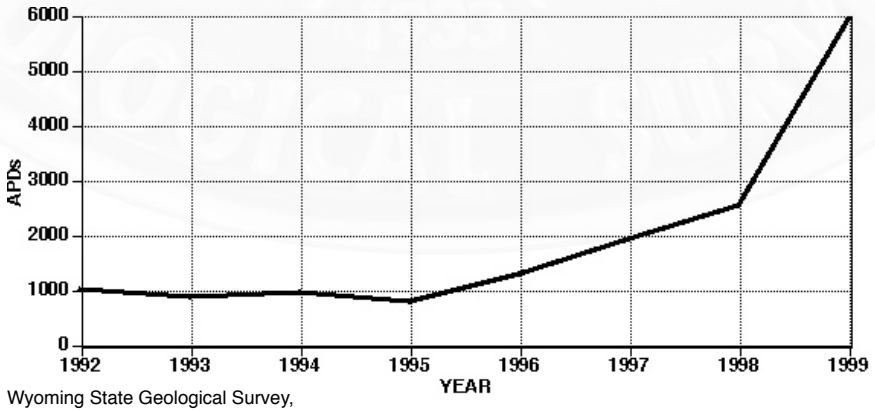
1. Chevron USA completed a new producer on the north end of Whitney Canyon – Carter Creek Field. The 2-29M Chevron-Federal well in SE NW section 29, T19N, R119W, flowed 8.9 million cubic feet of gas (MMCF), 83 barrels of condensate, and one barrel of water per day from the Mission Canyon Limestone (of the Madison Group) between 14,141 and 14,804 feet, and from the Lodgepole Limestone (of the Madison Group) between 15,343 and 15,360 feet.

2. Mobil Oil completed a multiple-zone development well in Tip Top Field. The T16X-13G1 Tip Top Unit well in NW SW section 13, T28N, R114W, flowed 3.2 MMCF of gas per day from the first Frontier sandstone between 5450 and 5470 feet and from four intervals in the second Frontier sandstone between 5963 and 6151 feet. The well also flowed 2.1 MMCF of gas from four zones in the Muddy Sandstone between 6830 and 7070 feet.

Table 10. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1995 through December, 1999).

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

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



Wyoming State Geological Survey,
Oil and Gas Section, February, 2000

Figure 11. Annual Applications for Permits to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1992 through 1999).

Table 11. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1996 through December, 1999).

	1996			1997			1998			1999		
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	1	18	0	0	0	0	0	0	0			
Big Horn	2	3	66	2	0	45	1	0	16			
Campbell	32	56	220	20	52	79	14	18	182	4	4	10
Carbon	2	5	18	3	7	190	4	0	318	5	77	57
Converse	1	4	0	1	5	0	4	12	239	1		50
Crook	5	3	20	7	8	18	2	2	4	1		10
Fremont	2	5	15	6	43	126	2	100	0	1		88
Goshen	0	0	0	2	227	0	0	0	0			
Hot Springs	4	17	29	1	8	0	4	19	0			
Johnson	0	0	0	2	7	17	1	4	0			
Laramie	0	0	0	0	0	0	0	0	0			
Lincoln	0	0	0	3	7	116	1	10	0	1		32
Natrona	0	0	0	5	14	101	6	12	214	2		230
Niobrara	2	0	23	0	0	0	0	0	0	5	16	31
Park	6	20	82	4	56	58	3	16	132	3	25	32
Platte	0	0	0	0	0	0	0	0	0			
Sheridan	1	5	0	0	0	0	1	14	0			
Sublette	2	21	52	1	0	61	2	1	115	3		308
Sweetwater	8	17	670	4	66	296	6	214	66	9		530
Teton	0	0	0	0	0	0	0	0	0			
Uinta	1	0	40	0	0	0	2	0	147	1		26
Washakie	0	0	0	3	36	0	4	41	35	1		8
Weston	1	0	16	1	0	17	1	0	35	1	40	
Totals	**70**	**174**	**1251**	**65**	**536**	**1124**	**58**	**463**	**1503**	**38**	**162**	**1412**

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

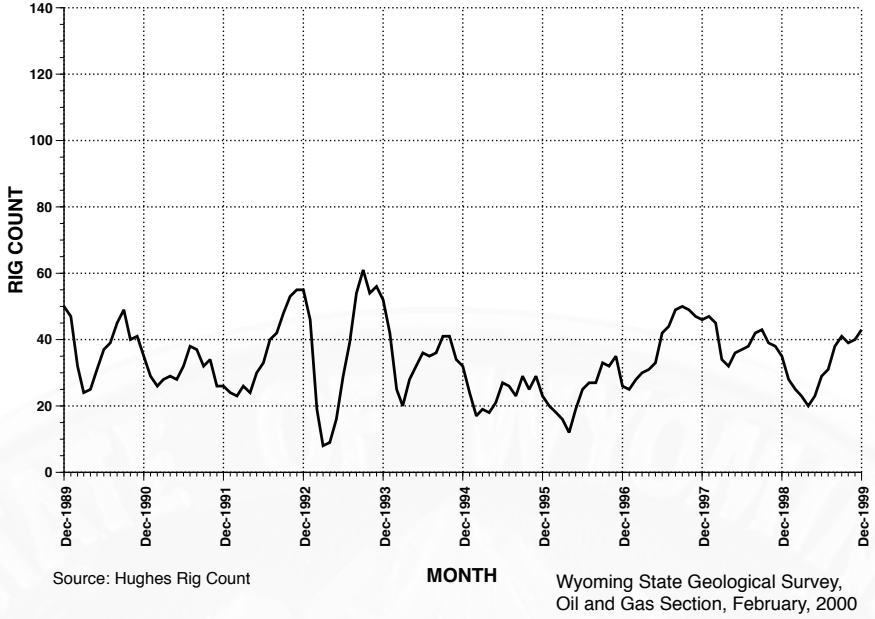


Figure 12. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month (December, 1989 through December, 1999).

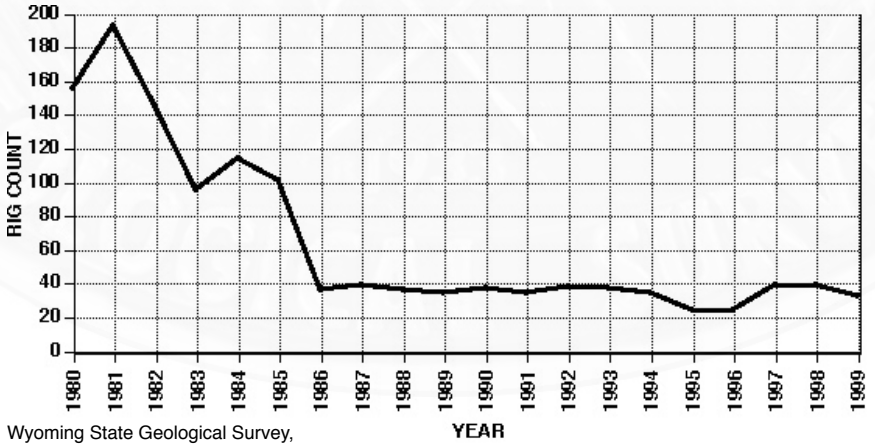


Figure 13. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by year (1980 through 1999).

3. Wexpro completed a new well in the Lance Formation at its 3 Mesa Unit well in SW NW section 16, T32N, R109W. The well flowed 2.6 MMCF of gas per day from the first of 11 proposed fracture stimulation jobs in the Lance.

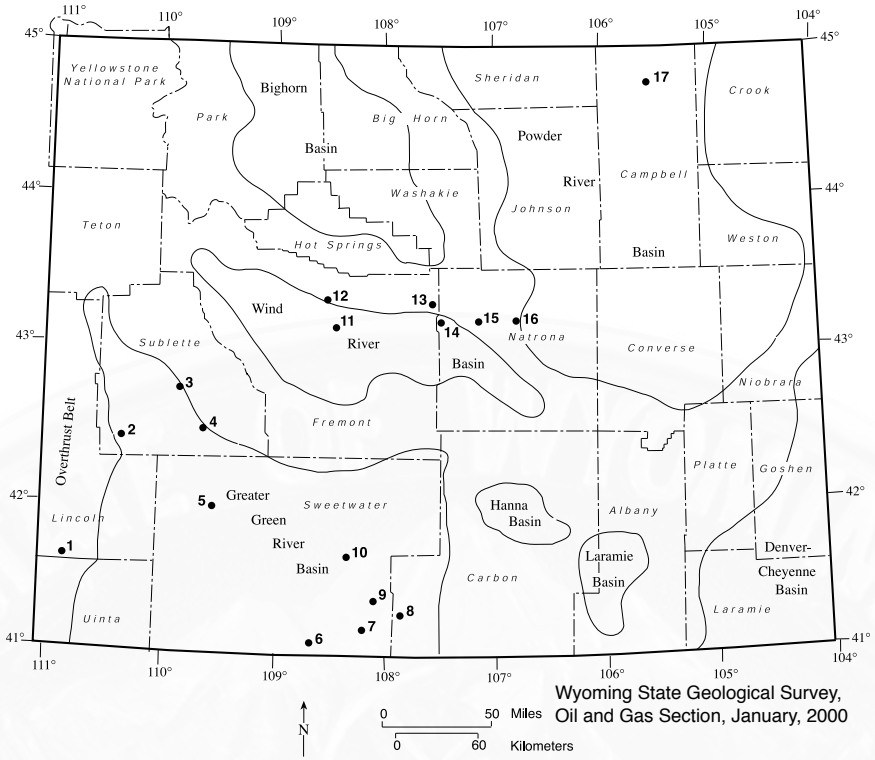


Figure 14. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 1999, exclusive of coalbed methane activities.

4. McMurry Oil completed two new Lance producers and Amoco Production completed one producer on the southwestern flank of Jonah Field. The 15-30 Corona-SHB well in SW SE section 30, T29N, R108W, flowed 4.4 MMCF of gas and 26 barrels of condensate per day from the Lance between 8298 and 9338 feet. The 11-13 Yellow Point well in NE SW section 13, T28N, R108W, flowed 5.8 MMCF of gas, 152 barrels of condensate, and 12 barrels of water per day from the Lance between 7852 and 10,054 feet. Amoco completed its 3-31 Cabrito well in NE NW section 31, T29N, R107W. The well produced a total of 225.8 MMCF of gas, 4749 barrels of condensate, and 960 barrels of water from an undisclosed interval in the Lance during its first two months on line.

5. Texaco Exploration & Production completed the 24A Stagecoach Draw Unit well in SE SW section 19, T23N, R107W. The well flowed 3.2 MMCF of gas, 11 barrels of condensate, and 34 barrels of water per day from the Almond Formation between 8000 and 8003 feet.

6. Wexpro, Questar Exploration & Production, Marathon Oil, Enervest, and Basin Exploration submitted a proposal to the BLM to develop their leases in the Vermillion Creek Basin. The companies propose to drill up to 56 wells in an

area that covers 92,490 acres. The companies anticipate that three to eight wells will be exploratory and the remainder will be production wells. The BLM will prepare an environmental document for the proposed project. Exploratory wells in the area have already discovered gas in the Mesaverde, Nugget, Morrison, Curtis, Entrada, and Carmel formations.

7. Tom Brown, Inc. discovered gas in the Fox Hills Sandstone at its 34-26X Powder Mountain-Federal well in SW SE section 26, T14N, R96W. The well flowed an average of 6.8 MMCF of gas per day from about 13,100 feet during its first month on line. The well was originally set up to evaluate the Lance and potential production was discovered in that formation as well as in the Fox Hills.

8. Cabot Oil & Gas discovered gas at its 10-32 Lookout Wash Unit well in SW NW section 32, T15N, R93W. The well flowed 699 thousand cubic feet (MCF) of gas and 15 barrels of condensate per day from the Almond between 10,946 and 10,954 feet.

9. Marathon Oil confirmed its Willow Reservoir Field discovery with the 1-16 North Wedge well in SE NW section 16, T16N, R95W. The well flowed 1.3 MMCF of gas, five barrels of condensate, and 25 barrels of water per day from the Almond between 12,634 and 12,646 feet.

10. Union Pacific Resources recovered the deepest horizontal core to date at its 1-H Sidewinder well in NW NW section 2, T19N, R97W. The core was cut in the Frontier Formation at a true vertical depth between 15,493 and 15,499 feet and recovered 58.6 feet of a possible 60 feet. The 1-H Sidewinder was drilled on the upthrown side of a fault, as was the 4H Rock Island discovery well that began producing 14 MMCF of gas per day in May, 1999. Union Pacific is drilling or has staked locations for three other horizontal wells in this area.

11. Tom Brown, Inc. discovered gas at its 29-33 Tribal-Grayling well in NW SE section 29, T2N, R4E. The well flowed 777 MCF of gas, 21 barrels of condensate, and 82 barrels of water per day from the Meeteetse Formation between 11,170 and 11,255 feet and from the Mesaverde between 12,070 and 12,638 feet.

12. Tom Brown, Inc. also completed a new gas well in Muddy Ridge Field. The 3-11-M Tribal-MR well in NW NW section 30, T4N, R3E, flowed 3.7 MMCF of gas, 12 barrels of condensate, and 77 barrels of water per day from three zones: a zone in the Lance between 9008 and 9538 feet; a zone in the Meeteetse between 9610 and 10,840 feet; and a zone in the Mesaverde between 11,408 and 12,213 feet.

13. Three new gas wells were completed in the Madden Field area. Louisiana Land & Exploration completed the 52 Madden Deep Unit well in NW SE section 1, T38N, R90W, which flowed 3.8 MMCF of gas and 20 barrels of water per day from the Fort Union Formation at depths between 9328 and 9344 feet, and between 9464 and 9484 feet. Double Eagle Petroleum & Mining completed its 1 Allen Deep well in SE NW section 26, T39N, R90W. The well flowed 3.5 MMCF of gas per day from the Fort Union in an undisclosed interval. Burlington Resources completed drilling at its 5-6 Bighorn well in SW NW section 6, T38N,

R89W. The well penetrated 196 net feet of pay in the Madison Limestone, based on well-log analysis. The well reached a total depth of 25,190 feet in only 300 days and encountered no water in the Madison. Three other Madison wells are already producing gas at Madden Field, and another well to test the Madison began drilling in January, 2000.

14. Tom Brown, Inc. discovered gas in the Meeteetse Formation in Frenchie Draw Field at its 34 Graham Unit well in NE NW section 22, T37N, R89W. The well flowed 4.9 MMCF of gas and 1720 barrels of water per day from the Fort Union between 10,382 and 10,470 feet, from the Lance between 10,616 and 12,558 feet, and from the Meeteetse between 12,964 and 13,068 feet.

15. W. A. Moncrief, Jr. completed a new well in Waltman Field. The 28-1 Federal well in NE NW section 28, T37N, R86W, flowed 8.0 MMCF of gas per day from an undisclosed Muddy Sandstone interval.

16. BreitBurn Energy completed a second offset to the company's Lost Dome discovery in the Tensleep Sandstone. The 4 Lost Dome-Federal well in NE NW section 13, T37N, R83W, produced 885 barrels of oil and 900 barrels of water per day during its first month on line. The well is producing from an undisclosed interval in the Tensleep Sandstone.

17. Trend Exploration completed a new well in Jazbo Field. The 7-7 Trend-Federal well in NE NW section 7, T55N, R72W, pumped 675 barrels of oil and 20 barrels of water per day from the Minnelusa Formation between 8687 and 8692 feet.

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COAL UPDATE

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Although final coal production figures for 1999 will not be available for several months, all indications are that the forecast 338.5 million short tons (see Geo-notes No. 64) will be reached (**Table 1**) and that forecast coal prices will remain as predicted (**Table 2**).

Some historical data and projected coal production by county is shown in **Table 12**. It also provides an estimate of the percentage of coal from the Powder River Basin which sells for more than $5.00 per ton (termed higher-priced coal). The

Table 12. Wyoming coal production by county[1, 2] (in millions of short tons), from 1995 to 1998 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	296.8	312.0	326.5	330.2	331.9	340.7	343.5	347.4
Converse County	14.1	15.8	17.8	23.4	25.0	30.0	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	3.7	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	5.0	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**	**338.5**	**357.0**	**369.5**	**373.2**	**376.9**	**380.7**	**384.5**	**388.4**
Annual Change11.4%	5.5%	1.1%	11.9%	7.5%	6.0%	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, 1995-1998.
[2]County estimates by the Wyoming State Geological Survey, October, 1999, for 1999-2006.
[3]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, October, 1999.

Table 13. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1985-1997) with forecasts to 2006.

Year	Northeastern	Southern	Statewide
1988	$7.35	$21.45	$9.16
1989	$6.94	$19.76	$8.63
1990	$6.86	$19.36	$8.43
1991	$6.58	$18.81	$8.06
1992	$6.61	$18.84	$8.13
1993	$6.02	$17.72	$7.12
1994	$5.62	$17.42	$6.62
1995	$5.60	$17.35	$6.38
1996	$5.40	$17.30	$6.15
1997	$5.03	$17.19	$5.78
1998	$4.73	$17.15	$5.41
1999	$4.61	$17.11	$5.23
2000	$4.63	$16.63	$5.13
2001	$4.56	$16.89	$4.99
2002	$4.56	$16.79	$4.99
2003	$4.54	$16.91	$5.03
2004	$4.56	$17.00	$5.05
2005	$4.55	$17.00	$5.07
2006	$4.57	$17.00	$5.08

Statewide data for 1988-1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991-1998 are derived from Wyoming Department of Revenue information; statewide estimates for 1999-2006 are from CREG's Wyoming State Government Revenue Forecast, October, 1999; and for all regional breakdowns are by the Wyoming State Geological Survey (January, 2000).

tonnage sold at these higher prices is that remaining from older, long-term contracts that had escalation clauses built into them. **Table 13** shows a breakdown of the average prices for coal produced in northeastern Wyoming and southern Wyoming over the past eleven years and projected average prices through 2006.

Coal deliveries for the third quarter, 1999, as derived from the Federal Energy Regulatory Commission's (FERC's) Form 423 (**Table 14**), showed continued strong growth in Wyoming's coal production. By the end of the third quarter the state's coal producers had shipped nearly 242.4 million short tons of steam coal; this represented an increase of about 7% over the 226.4 million short tons delivered in the first three quarters of 1998. **Figure 15** shows monthly coal deliveries from January, 1997 through September, 1999. **Figure 16** breaks these monthly deliveries into spot sales and contract sales.

Developments in the Powder River Basin (PRB)

A seven-year-old dispute between Peabody Coal and the Federal Government over royalties on coal produced at the North Antelope mine (**location A, Figure 17**) was settled in November with Peabody agreeing to pay $11 million to the government in two installments. The dispute arose over North Antelope's coal contract with Arkansas Power and Light Company (now Entergy Arkansas, Inc.) which was signed over ten years ago. That contract called for delivery of all North Antelope's production to the utility. As the mine production expanded, a method to get around the contract was implemented whereby Peabody's Rochelle Coal Company repur-

Table 14. Monthly coal deliveries from Wyoming's mines in short tons (1996 through October, 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		
NOV	21,421,085	246,811,137	21,695,072	246,249,004	25,620,216	278,668,588		
DEC	22,105,530	268,916,667	24,695,740	270,944,744	26,102,620	304,771,208		
Total Tonnage Reported[1]		**268,916,667**		**270,944,744**		**304,771,208**		
Total Tonnage Not Reported[2]		**9,508,289**		**10,536,772**		**10,190,883**		
Total Tonnage Produced[3]		**278,424,956**		**281,481,516**		**314,962,091**		

[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, January, 2000.

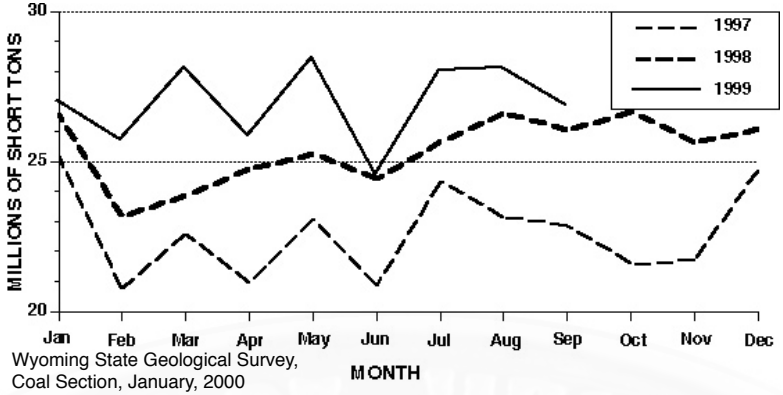

Figure 15. Reported monthly deliveries from Wyoming coal mines (1997 through September, 1999). Derived from data on the Federal Energy Regulatory Commission's (FERC's) Internet bulletin board.

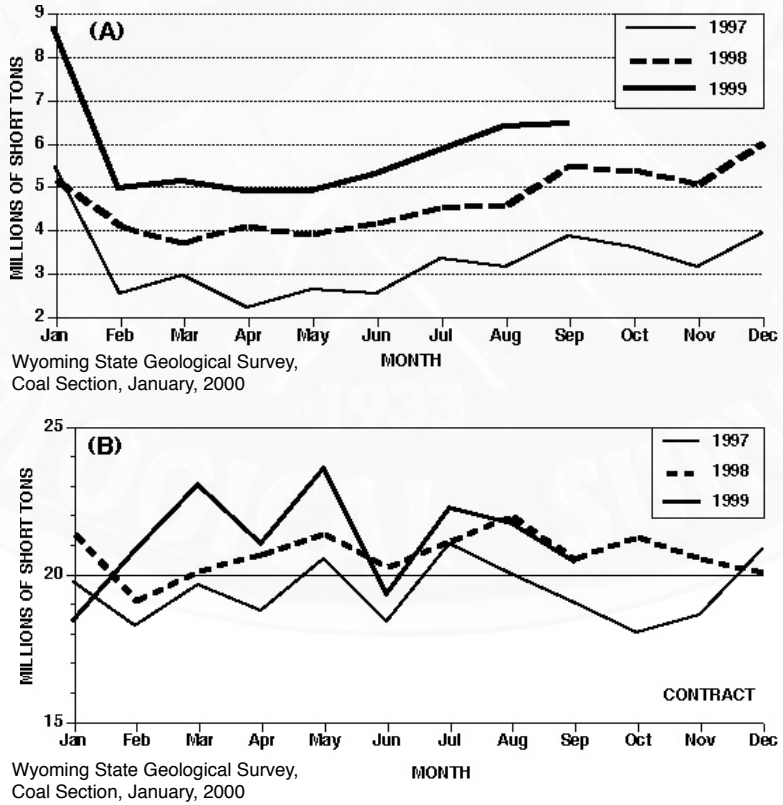

Figure 16. Monthly coal deliveries from Wyoming coal mines (1997 through September, 1999). (A) Coal sold on the spot market and (B) coal sold on contract. Derived from data on the Federal Energy Regulatory Commission's (FERC's) Internet bulletin board and Form 423.

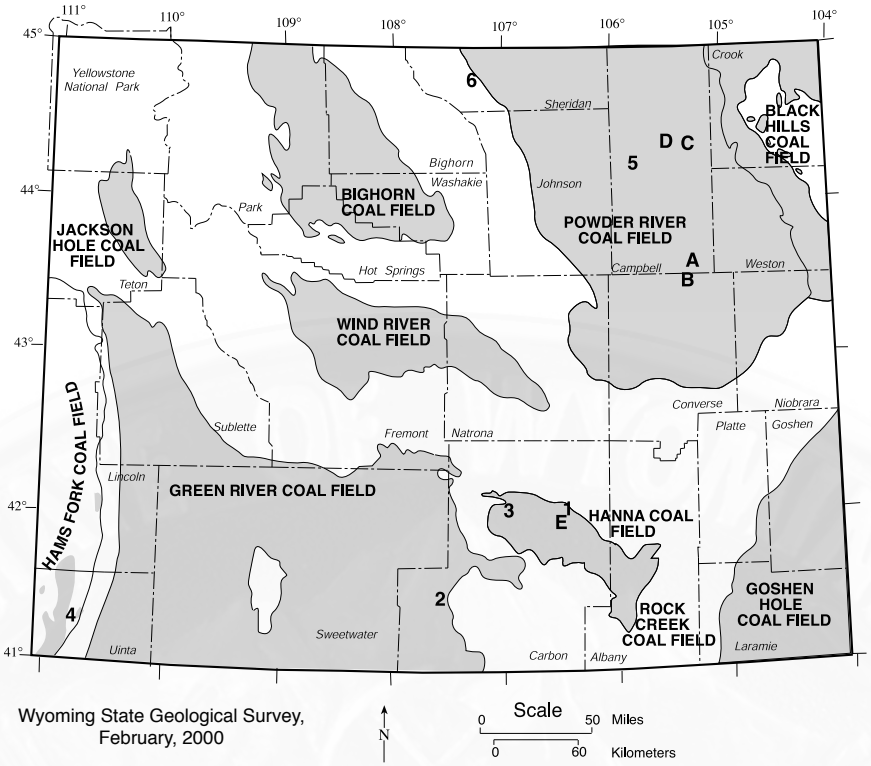

Figure 17. Coal developments (lettered) and coalbed methane activities (numbered) in Wyoming during the fourth quarter of 1999.

chased some of the coal from North Antelope prior to shipment to the Arkansas utility. Peabody then resold the coal and shipped it to other customers. The Federal Government, in a 1992 audit, ruled that Peabody owed additional royalties each time it sold the coal, contending that the royalties were underpaid between July 1, 1989 and September 21, 1994 (Coal Daily, 11/9/99).

The U.S. Bureau of Land Management (BLM) released the Draft Environmental Impact Statement (DEIS) on the Horse Creek tract (**location B, Figure 17**), which was nominated for lease by Kennecott Energy Co.'s Antelope Coal Company. The Lease by Application (LBA) tract is located adjacent to the Antelope mine; as nominated, the tract covered approximately 2837 acres containing roughly 246 million short tons of recoverable coal. In the DEIS, the area was expanded to 3215 acres containing 279 million short tons of recoverable coal. If Kennecott wins the tract through the competitive bid process, it would extend the life of the mine by approximately nine years (Coal Daily, 11/11/99).

Production has been suspended since June at the K-Fuel plant near Gillette (**location C, Figure 17**) while K-Fuel Inc.'s operating partner, Thermo Eckotek Corporation, began exploring its intention to sell the plant and divest its interest in the K-Fuel partnership. While the company said that progress is being made in

regard to the future of the facility, it did not indicate when the plant would resume production. K-fuel is a patented, enhanced coal-based fuel which uses coal from the Fort Union mine as its feedstock (Coal Daily, 11/18/99).

In November, Phillips Coal Company denied rumors that it was for sale. The company is part owner of the Dry Fork mine in the PRB (**location D, Figure 17**), as well as owner of lignite operations in Louisiana, Texas, and Mississippi (Coal Daily, 11/19/99).

Developments in southern Wyoming

MidAmerican Energy Co. contracted with Arch of Wyoming to supply coal in the year 2000 for its George Neal plant in Iowa. The contract is believed to be for 100,000 short tons of coal from the Seminoe II mine (**location E, Figure 17**) in Carbon County, Wyoming. The utility said that the contract is flexible and will fill out the plant's supply of Hanna Basin coal for the year (Coal Daily, 11/15/99).

Transportation developments

The Canadian National Railroad and Burlington Northern/Santa Fe Railway (BNSF) announced their proposed merger, which would create the largest railroad in North America. The new railroad will be named North American Railways Inc. If approved by stockholders and by governmental regulatory consent, the rail system would consist of 50,000 miles of track, employ roughly 67,000 people, and generate revenues of nearly $1.5 billion per year (Coal Daily, 12/27/99).

On December 14,1999, the National Mining Association (NMA) and the American Association of Railroads (AAR) signed an agreement to enhance rail service in the coal industry. The agreement consists of two major elements: first, the creation of two executive committees, one given the responsibility to identify industry-wide policy issues, and the other charged with addressing specific coal transportation issues; second, the creation of a formal process to resolve service disputes between NMA and AAR members.

The first committee, known as the Joint Policy Committee, is designed to meet once annually, but can be called to meet in special session when necessary. The second committee, to be known as the Joint Coal Logistics Committee, will meet twice a year to make non-binding recommendations on issues related to rail transportation service, efficiency, and deployment of assets.

The other key element, called the Rail/Coal Communication/Dispute Resolution Process, was developed to address " issues which may arise with regard to the adequacy and reliability of railroad and coal company services required for coal shipments from mines to power plants, and other coal-consuming facilities, and to inland and coastal ports, in order to supply U.S. coal to domestic and foreign markets" (Coal Daily, 12/15/99).

The Wyoming State Legislature's Joint Revenue Interim Committee announced its support of the proposed Rail Mile Tax bill. If passed, the new tax would charge

the railroads 7 cents per each train-mile that the railroads travel in the state and an additional $100 for each public crossing on a company's lines.

The railroad industry points out that under the Federal Railroad Revitalization and Regulatory Act of 1976, states are for the most part prohibited from levying new taxes against railroads. To enable this, the revenue committee is working on draft legislation that would ask Congress to amend the Act to allow states "a more relevant and flexible tax policy with regard to the railroad industry" (Coal Daily, 12/20/99).

TXU Electric & Gas Co. (TXU) has contracted the BNSF for coal deliveries to the Big Brown power plant, Texas in preparation for their switch to Wyoming coal. Scheduled to begin burning PRB coal (replacing the plant's mine mouth lignite source) in early 2000, TXU recently completed a 25-mile spur line connecting the power plant to the BNSF.

The new transportation contract calls for deliveries of approximately 2.5 million short tons of PRB coal a year. TXU is also switching its Martin Lake, Texas power plant to PRB coal, and has a four-year contract with the BNSF and Kansas City Southern Railway for a joint haul to Martin Lake. The Martin Lake plant will receive 0.5 to 1 million short tons of coal annually from the Wyoming portion of the PRB.

In October, Rail Link, Inc., a company that works as a third party loader at Peabody's North Antelope and Rochelle operations and Kennecott's Antelope mine, began train-handling service to West Texas Utilities' Oklaunion, Texas plant. The company also performs train-handling functions at City Public Service Board of San Antonio (Coal Daily 10/6/99). Rail Link, Inc. takes loaded trains from the BNSF main line to the power plants (where the utilities' crews unload them) and then returns the empty trains to the main line. Savings to the utilities result from Rail Link's labor efficiencies.

Coalbed methane developments

Wyoming's U.S. Senators Michael Enzi and Craig Thomas drafted legislation that would create a formal resolution process to settle conflicts between gas leaseholders and coal operators in the PRB. Under the proposed legislation (Powder River Basin Resource Development Act, S. 1950), new language would be added to the federal Mineral Leasing Act to help resolve conflicts in areas where coal mining and coalbed methane (CBM) development are being conducted in the same area.

The bill's new language would require companies with conflicting interest to first sit down at the bargaining table and attempt to come up with a satisfactory development schedule or sequence. Failing that, the conflict cases would be decided by a federal district court charged with the responsibility of determining whether it is in the public's best interest to suspend or terminate the gas or coal lease to accommodate either gas or coal production. That ruling is to be based solely on the amount of tax and royalties generated by each conflicting mineral plan. Once that ruling has been made, a panel of three experts, one each appointed from the

conflicting parties and the third being appointed by the Secretary of the Interior, would get together to determine just compensation owed for the postponement or loss of any coal or methane affected by the decision (Coal Daily, 11/30/99).

Barrett Resources in October announced it would drill a 3600-foot-deep CBM test well in the Hanna Basin (**location 1, Figure 17**). The well is located 7 miles northeast of the town of Hanna and 1 1/2 miles south-southeast of the Metfuel, Inc. CBM project of the early 1990s (Rocky Mountain Region Report, 10/5/99). The target for the well is believed to be Tertiary coals of the Hanna Formation.

Late Cretaceous Mesaverde Formation coals will be tested by a 1500-foot-deep CBM well (**location 2, Figure 17**) to be drilled by North Finn off the eastern flank of the Washakie Basin. Location of the well is approximately 27 miles north of Baggs, in Carbon County (Rocky Mountain Region Report, 10/5/99).

Dudley & Associates, LLC is also targeting Mesaverde coals in an area about 15 miles northeast of the town of Sinclair in northeastern Carbon County (**location 3, Figure 17**). Four holes have been staked with the target depth said to be in the 2500-foot-depth range (Rocky Mountain Region Report, 12/3/99).

Chevron USA Production reportedly has moved a rig into an area 7 miles east of Evanston (**location 4, Figure 17**) in the Hams Fork Coal Field to begin drilling the first of four CBM wells to test Tertiary coals of the Evanston Formation. Depth of the holes is expected to be in the 2700-foot range (Rocky Mountain Region Report, 10/5/99).

The Record of Decision for the Wyodak Coalbed Methane Environmental Impact Statement (EIS) (area around **location 5, Figure 17**) was signed in early December. The signing approved Alternative I, which approved the drilling of 5000 wells. BLM's Buffalo Field Office immediately imposed a moratorium on accepting Applications for Permits to Drill (APDs) for methane wells. BLM apparently has more than 3500 applications pending, and when these are added to the wells being permitted and completed on state and private lands, the total number of wells exceeds the number analyzed in the Wyodak EIS.

The Record of Decision for the Lower Prairie Dog Creek Methane Environmental Assessment (EA) (area around **location 6, Figure 17**) was signed by BLM on November 23. This EA was approved under Alternative I which analyzed impacts for drilling 190 wells in a 54-square-mile area of Sheridan County (Rocky Mountain Region Report, 10/3/99).

Babcock & Brown Energy (BBE) reportedly has contracted to do the initial testing of Infinity Inc.'s 20,595-acre CBM property in the Green River Basin. BBE will obtain all necessary permits, drill the initial test well, and manage and supervise the development drilling. In addition, BBE will be responsible for the evaluation and production of the initial well (Rocky Mountain Region Report, 10/4/99).

U.S. Energy Corp. (USE), a long-time member of the uranium mining industry, has entered into the PRB CBM play by buying a 50% working interest in 185,000 acres of Quantum Energy, LLC leaseholds. USE had nine drill rigs involved in the

effort as of December 13, 1999. The company hopes to generate over $1 million annually via contract drilling and related revenue using construction and exploration equipment from an idle uranium mine (COAL WEEK, 12/20/99).

Regulatory developments

The Environmental Protection Agency (EPA) announced it was filing suit against eight large coal-burning utilities, charging them with violating Clean Air Act (CAA) provisions regarding plant modifications. EPA and the Department of Justice said the purpose of the suit is to force installation of post-combustion pollution controls at older coal-fired power plants that had been "grandfathered" under the CAA as exempt from the tighter emission standards newer plants are held to. The 32 plants involved in the suit represent nearly 12 % of the U. S. coal-fired generating capacity (Coal Daily, 11/4/99).

Coal companies in the Powder River Basin are worried that retrofits mandated by the EPA lawsuit could reduce the overall demand for PRB coal. The market in the PRB was somewhat slack in the fourth quarter so the impact of the litigation is yet to be determined (Coal Daily, 11/8/99).

The Mine Safety and Health Administration (MSHA) has established a toll-free phone number for citizens to report unsafe access to both active and inactive or abandoned mine sites and to publicize potential hazards. The number is 1 (800) 499-1038. The caller will be asked to leave a detailed message, or in the case of an emergency, the call will be forwarded and handled immediately (Mining Week, 12/20/99).

Market developments and opportunities

Colorado Springs Utilities is moving toward plans to use only Powder River Basin coal at its Nixon plant in Colorado. The Nixon plant has traditionally burned Colorado coal blended with PRB coal. The reason is simple economics: by burning cheaper PRB coal, the utility feels it can reduce operating costs and be in a better position to compete with other utilities in the area (Coal Daily, 10/18/99).

Table 15 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal announced during the fourth quarter of 1999.

Reference cited

Federal Energy Regulatory Commission (FERC) Electric Form 423 (http: //www.ferc.fed.us/electric/f423/form423.htm)

Table 15. Marketing activities for Wyoming coal producers during the fourth quarter of 1999.[1]

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1. Kansas City Board of Public Utilities	Nearman	Peabody Mines/PRB	Sp	250,000 to 300,000 t.	8500 Btu, delivery in 2000
2. Lansing Board of Water & Light	Lansing	Black Thunder/PRB	C	600,000 t/y	For two years beginning in 2000 originating on UP delivery by Canadian National
3. Lower Colorado River Authority	Seymour	PRB	So	1,000,000 t.	For 2000 delivery. 8200-,800 Btu/lb and maximum 1.2 lbs SO2/mmBtu.
4. Ontario Power Generation Inc.	Nanticoke Nanticoke	PRB Southern PRB	So So	5,000,000 t. up to 3.5 million t/y	Delivery in 2000 8800 Btu, and 0.57 lbs. SO@/mmBtu, for year 2001 and 2002 bid FOB mine
5. Salt River Project	Coronado	New Mexico & PRB	So	500,000 t.	Delivery during 2000
6. San Antonio City Public Service Board	System wide	PRB	So	6-7 million t/y	Replacement for expired Kennecott contract
7. Southwestern Public Service Co.	Harrington	Cordero Rojo/PRB	Sp	1,700,000 t.	Delivery on BNSF, 8500 Btu., for year 2000
8. Western Fuel Association	Laramie River & others	PRB	So	6,000,000 t/y	Delivery in 2001 3.5 million for Laramie River and the rest for other WFA managed plants

[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 Railway.
Wyoming State Geological Survey, Coal Section, January, 2000.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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Bentonite

Bentonite is an industrial clay with unique properties that make it useful for a wide variety of products including kitty litter, metal casting, groundwater isolation barriers, water treatment, mineral fillers used in a number of products including certain food products, and oil well drilling fluid. Bentonite is produced in Wyoming by six companies at ten different locations (**Figure 18**). Wyoming is the leading producer of bentonite in the U.S.

Information about Wyoming bentonite and its products may be found on the Internet. Five Wyoming bentonite producers have informational web sites; the urls for the company sites are:

American Colloid – http://www.colloid.com/COLLOID.htm
Bentonite Performance Minerals, Inc. – http://www.bentonite.com/
Black Hills Bentonite – http://www.bhbentonite.com/
CETCO – http://www.cetco.com/
Wyo-Ben – http://wyoben.com/.

Construction aggregate

Simons Construction has opened a new granite ballast and construction aggregate quarry on the Khaun Ranch in Niobrara County, south of Lusk (**Figure 18**). This quarry will supply rock for local highway construction projects and may provide material for reconstruction and upgrading of the Union Pacific Railroad line from the Powder River Basin coal fields to Morrill, Nebraska. The bright red granite is also a potential decorative aggregate and dimensional stone.

Neosho Construction, which operates the Bald Butte Quarry about three miles south of the Khaun property (**Figure 18**) is currently supplying granite gneiss ballast to the Union Pacific Railroad. This material has been used on several local projects in the past.

Decorative and dimensional stone

A new dimensional stone company has incorporated in Wyoming. Mediterranean Indian Atlantic Stone of Wyoming (MIAS-W) has begun to examine stone quarry sites and acquire exploration permits. A MIAS-W representative has established an office in Cheyenne and the company is planning to build a trim and tile plant in Laramie (**Figure 18**). The British-based Mediterranean Indian Atlantic Stone Company is initiating construction of a fabricating plant on the Mississippi River in Mississippi which will process blocks from India, Brazil, China, Wyoming,

and elsewhere. Smaller blocks and reject pieces from Wyoming quarries will be processed in the Laramie plant.

Perlite

Perlite production is reported in Wyoming in several industrial mineral production statistics; however, perlite is not mined in Wyoming. Perlite ore is mined at Antonito, Colorado, and shipped to the Harborlite Co. expansion plant west of Green River (**Figure 18**) where it is processed into a product used as a filtrate by the soda ash plants in the area. Information about Harborlite perlite may be found on the Internet at: http://www.worldminerals.com/perlite/index.html.

Perlite is expanded rhyolite. Rhyolite is a high-silica glassy volcanic rock that contains trapped water. When heated, this rock explosively breaks down upon expansion of the trapped water into steam. The resulting product consists of small shards of siliceous volcanic glass. These particles are processed into various-sized

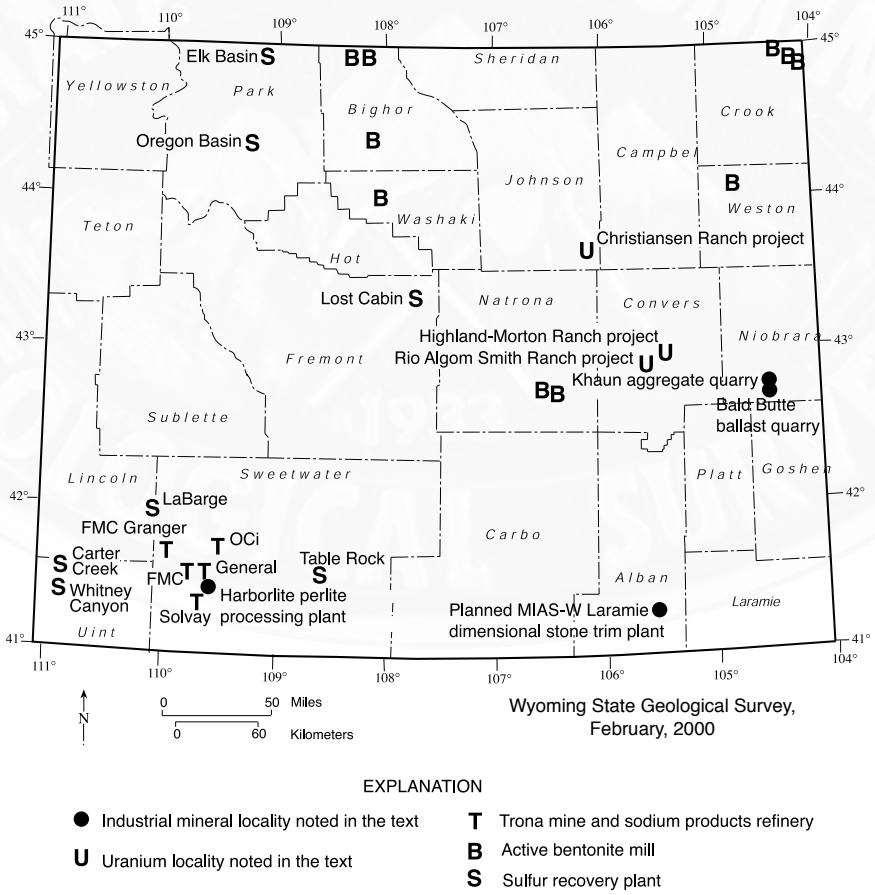

Figure 18. Map of selected industrial mineral and uranium sites in Wyoming.

products used primarily for filtration, as they are in Wyoming. Other uses for perlite include soil conditioners, high temperature insulation, cryogenic insulation, an additive in certain types of wallboard, lightweight refractory products, lightweight roof tiles, lightweight cement, various types of coatings including swimming pools, as a carrying agent in crop dusts and explosives, as a fine abrasive as in silver polish, and as a dehumidifier in de-watering apparatus.

Sulfur (recovered)

Sulfur production in Wyoming has remained nearly constant over the past three years according to data released by the Wyoming Oil and Gas Conservation Commission. All sulfur produced in Wyoming is recovered as a byproduct from the refining of natural gas containing hydrogen sulfide (H_2S). Wyoming's sulfur producers are shown in **Figure 18** and their 1998 production on **Table 16**.

Wyoming ranks second in the nation after Texas in the production of recovered sulfur. Sulfur is used primarily to produce sulfuric acid, an important industrial chemical with many uses.

Table 16. Sulfur production (in short tons) from Wyoming, 1998.

Plant	Production
La Barge	452,606
Whitney Canyon	405,945
Carter Creek	262,880
Lost Cabin	82,811
Elk Basin	16,628
Oregon Basin	2,167
Table Rock	361
TOTAL	1,223,398

Trona

Trona mined in Wyoming is processed into soda ash and other sodium chemicals at five plants operated by four companies west of Green River, in Sweetwater County (**Figure 18**). Soda ash is the ninth most widely used chemical in the United States, according to OCi Chemical Corporation, one of the Wyoming producers.

Domestically, 48% of soda ash is used in making glass; 26% is used in other chemicals, particularly sodium silicate; 12% in cleaning agents like detergents; 3% in the pulp and paper industry; 3% in water treatment; and 8% in various other uses.

According to Doug Gardner, Vice President of the American Natural Soda Ash Corporation (ANSAC), about 4 metric tons (4.41 short tons) of soda ash were exported from Wyoming in 1999. This represents approximately 40% of Wyoming's total soda ash production. According to Mr. Gardner, the world consumption of soda ash grew by 2.7% over the past two years while world production of soda ash grew by about 3%. Almost all of the world's growth in demand is in mainland China. Although China represents the major growth market for soda ash in the immediate future, the country is not purchasing soda ash overseas but instead, it is constructing synthetic soda ash plants. Soda ash produced in these plants is far more expensive to produce than it would be for China to purchase natural soda ash imported from the U.S.

According to Mr. Gardner of ANSAC, the world production capacity of soda ash by country is now (1999) 37.3 million short tons annually (**Table 17**). The U.S. produces almost all of the world's natural soda ash, except for minor amounts produced by Turkey and Kenya. All of the rest of the world's production is by the more expensive synthetic (Solvay) process.

Table 17. World production capacity of soda ash (in millions of short tons) for 1999.

Country	Production capacity
USA	11.9
China	8.5
Western Europe	7.2
Eastern Europe	4.7
India	1.5
Asia except China	1.2
All others	2.3
TOTAL	37.3

Currently, world capacity for soda ash exceeds demand. This has resulted in the stagnation in annual production exports from Wyoming. However, all of the world's excess soda ash capacity is in Wyoming, which is promising for the future. How distant this future is will depend on increasing exports into Europe, China, and India, and substituting natural soda ash for synthetic wherever it is cost effective.

Information about Wyoming trona and sodium products may be found on the Internet. All four Wyoming trona producers have informational pages. The urls for the company web sites are:

FMC: http://www.fmc.com/markets/indchem/alkali.html
General: http://www.genchem.com/soda_ash_top.html
OCi: http://www2.ocichemical.com/ocichemical/corporate.html
Solvay: http://www.solvay.com/na/smi/.

Additional information on Wyoming and other U.S. trona deposits may be found at the ANSAC web site: http://www.ansac.com/.

Uranium

According to information published by Bob O'Dell in the December 6, 1999 edition of the Rocky Mountain Scout, one pound of yellowcake, the product of Wyoming's uranium mills, is equivalent in terms of the amount of electricity generated, to 8.9 short tons of coal or 37.1 barrels of crude oil. Wyoming's 1998 uranium production was 2,327,463 pounds of yellowcake. This uranium produced the same amount of electricity as 207,144,590 short tons of coal or 86,348,877 barrels of crude oil. Wyoming's relatively small uranium industry, therefore, produced the equivalent in electricity of 2/3 of all of the coal shipped from Wyoming the same year, and 1 1/3 times the amount of electricity that could have been generated from Wyoming's entire 1998 crude oil production. Nuclear power also generates electricity without producing carbon dioxide or other chemical emissions.

As reported in Geonotes 63 and 64, Wyoming's in-situ uranium production increased to record levels in 1998, and the 1999 production rate is equal to or a little above last year's rate (**Table 1**). However, in December, 1999, COGEMA announced that they will cease producing yellowcake from the Christiansen Ranch in-situ operation in Wyoming in mid-2000, and Rio Algom announced cutbacks in

production from its operations in North America, including the Smith Ranch in-situ operation in Converse County, Wyoming. As a result, 2000 production figures have been revised downward (**Table 1**). No cutbacks have been announced by CAMECO in regard to the Highland and Morton Ranch operations in Converse County (**Figure 18**). Spot market uranium prices continued to decline at year's end, reflecting a continued uncertainty about the supply of uranium from Russia and other countries of the former Soviet Union (**Figure 19**).

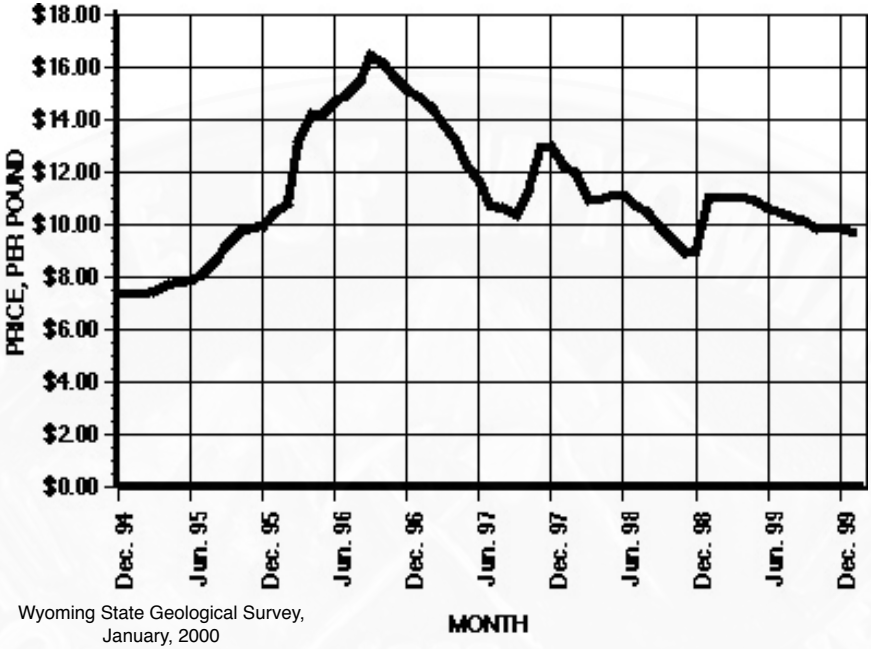

Figure 19. Spot market yellowcake prices, as of January 31, 2000. Source: Uranium Exchange weekly reports and Bob O'Dell, Rocky Mountain Scout.

METALS AND PRECIOUS STONES UPDATE

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

Diamond project

During the past two field seasons, the Wyoming State Geological Survey (WSGS) discovered several kimberlites (one of two primary host rocks for diamonds) in the Iron Mountain district in southeastern Wyoming. A 4-mile-long kimberlite dike-blow-pipe complex in a 10 mi^2 area of the Iron Mountain district was mapped by the WSGS.

Evidence for hidden kimberlites in the district led to follow-up geophysical surveys, which resulted in the discovery of more kimberlite intrusives under a thin veneer of alluvium. The geology of the district also suggests that there should be several more kimberlites north of the complex as currently mapped (see **Figure 20**), as well as several hidden kimberlites within the complex. For instance, kimberlites are projected under a Tertiary boulder conglomerate in sections 8 and 17, T19N, R70W, as well as at several other localities on the map. A more detailed map is available on the WSGS web site at: http://www.wsgsweb.uwyo.edu/metals/diamond_exploration.htm.

Research by the WSGS shows that the Iron Mountain district is one of the two largest kimberlite districts in the U.S. Electron microprobe analyses of garnets show that several of the kimberlites originated within the diamond stability field. Currently, 14 different sample sites have yielded sub-calcic, high-chrome, harzburgitic G10 (diamond-stability) pyrope garnets (see **Figure 20**). This suggests that diamonds should be found within the district. Several other samples will be tested for presence of diamond-stability minerals.

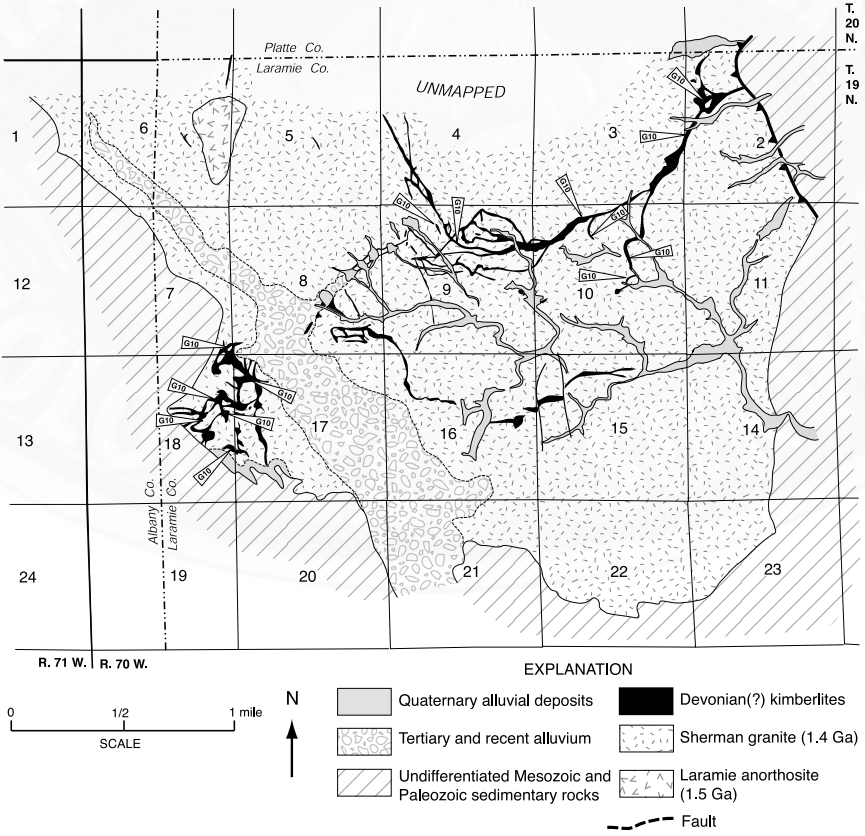

Figure 20. Schematic geologic map of the Iron Mountain kimberlite district, Wyoming. Arrows labeled G10 point to localities where G10 pyrope garnets were found.

A similar project in the 1980s, funded by the now defunct University of Wyoming Mining and Mineral Resource Research Institute, led the WSGS to the discovery of more than 300 kimberlitic indicator mineral anomalies in the Laramie, Seminoe, and Medicine Bow mountains. Re-evaluation of some of those anomalies led to the identification of G10 pyropes within the Elmers Rock greenstone belt of the Wyoming craton as well as to the south in the Sheep Rock-Middle Sybille Creek area. Another sample site along the northern flank of the Seminoe Mountains, also within the craton, has been greatly expanded, and several chrome-rich pyropes, including some diamond stability (G10) garnets, have been recovered over a few square miles.

Based on our research, the Wyoming craton is a major source of kimberlite and lamproite, the only two host rocks commercially mined for diamonds. To date, more than 120,000 diamonds have been mined from the State Line kimberlites in Colorado and Wyoming, including some of the largest diamonds in the U.S. About half of all diamonds found in Wyoming have been of gem quality.

Diamonds have also been found or reported in the Laramie, Medicine Bow, Granite, Gros Ventre, Wind River, and Sierra Madre mountains, and in the Greater Green River and Powder River basins. Kimberlitic indicator minerals have been identified in the Laramie, Medicine Bow, Sierra Madre, and Seminoe mountains, and in the Greater Green River and Bighorn basins. Despite these occurrences of diamonds and kimberlitic indicator minerals, only a very small region of the state has been explored for diamonds.

Value-added commodities identified during the various diamond projects have included other semi-precious gemstones, such as peridot, pyrope garnet, and chromian diopside. As a follow-up to the WSGS diamond projects, more than three dozen companies have explored Wyoming for diamonds.

Platinum-group metals

Southeastern Wyoming is underlain by a platinum-group metal (PGM) province. According to a report currently being compiled by the Metals and Precious Stones Section of the WSGS, the geology of the Laramie and Medicine Bow mountains and the Sierra Madre is favorable for the discovery of significant amounts of PGMs. Several PGM anomalies have already been recognized in this region (see Geo-notes No. 64), and have been described on the WSGS web site at: http://www.wsgsweb.uwyo.edu/metals/Mineralsurveymedbow/surveymedbow.htm. Additional PGM targets in southeastern Wyoming are also described.

Areas of interest in southeastern Wyoming include the New Rambler district and surrounding Mullen Creek complex, Centennial Ridge, Douglas Creek, and the Lake Owen layered mafic complex in the Medicine Bow Mountains. Puzzler Hill and some adjacent areas in the Sierra Madre have also yielded significant PGM anomalies. The Laramie anorthosite complex in the Laramie Mountains is also considered a potential target for PGMs.

Currently, consultants and companies are exploring southeastern Wyoming for PGMs. The discovery of significant PGMs would be very beneficial to Wyoming's economy, as PGMs are extremely rare and highly valued. PGMs are used in neurosurgical and dental apparatus, anticancer drugs, fiber optic cables, eyeglasses, fuel cells, paints, pacemakers, chemical manufacturing, petroleum refining, cellular phones, computer hard drives, etc. PGMs are also known as environmental metals (those used in manufacturing and the operation of anti-pollution devices). Platinum in concert with palladium is used in catalytic converters to convert auto emissions into harmless CO_2 and H_2O.

The new year began with nearly 20% of all manufactured goods either containing some PGMs, or being manufactured with the use of PGMs. Currently, a worldwide shortfall of these metals has resulted in significant price increases. PGMs are more precious than gold or silver: platinum was selling for $456 per ounce; palladium, $481 per ounce; and rhodium, $1450 per ounce on January 25, 2000. For comparison, the asking price for silver was $5.22 per ounce, and for gold was $286 per ounce. Currently, PGMs are mined in only a few places worldwide, with more than 90% of the world's supply mined in South Africa and Russia. In the United States, PGMs are strategic metals, those for which the U.S. is almost entirely dependent on sources outside the country.

Upcoming lectures and field trips

The following schedule lists W. Dan Hausel's upcoming talks by title, interest group, date, time, and location.

- Gemstones of Wyoming, Mile Hi Rock and Mineral Society, March 17, 2000, Denver, Colorado.
- Diamond prospecting short course, Rocky Mountain Prospectors and Treasure Hunters, April 28, 2000, 1 to 5 pm, WSGS building, Laramie, Wyoming.
- Field trip to the Sloan diamond pipe, Rocky Mountain Prospectors and Treasure Hunters, May 19, 2000, 9 am, Sloan Ranch, Colorado.
- Medicine Bow (Grand Encampment) Mining District, Rocky Mountain Prospectors and Treasure Hunters Club, June 7, 2000, 7 pm, Ft. Collins, Colorado.
- Field trip to the Medicine Bow mining districts, Rocky Mountain Prospectors and Treasure Hunters Club, June 16, 2000, Centennial, Wyoming.
- Wyoming diamonds, Wyoming State Gem and Mineral Show, June 24, 2000, Torrington, Wyoming.
- Wyoming diamonds, Wyoming State Gem and Mineral Show, June 25, 2000, Torrington, Wyoming.
- Natrona County gem show–Information booth and gemstone talk, July 7 and 8, 2000, Casper, Wyoming.
- Gold at South Pass, Wyoming, Rocky Mountain Prospectors and Treasure Hunters, August 2, 2000, 7 pm, Ft. Collins, Colorado.
- Field trip to the South Pass Mining District, Rocky Mountain Prospectors and Treasure Hunters, August 11, 2000, Atlantic City mine, Wyoming.

New publications

During the past quarter, the Metals and Precious Stones Section published the following papers:

1) Hausel, W.D., 1999, Wyoming–Exploration opportunities abound: Pay Dirt, November, 1999, p. 9-12.
2) Hausel, W.D., 2000, Diamond fever: International California Mining Journal, v. 69, no. 6, p. 13-15.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Technically Recoverable Resources (January 1, 1998)

Discovered (Includes oil, gas liquids, and condensate)	3.47 billion barrels[1]
Undiscovered	6.18 billion barrels[1]
Total	9.65 billion barrels

Remaining Reserve Base (January 1, 1998)

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

NATURAL GAS

Remaining Technically Recoverable Resources (January 1, 1998)

Discovered (Includes 35.6 trillion cubic feet (TCF) of methane[1] and 121.5 TCF of CO_2[3])	157.1 trillion cubic feet
Undiscovered (Includes 14.72 TCF of conventional methane[1]; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO_2[3])	170.6 trillion cubic feet
Total	327.7 trillion cubic feet

Remaining Reserve Base (January 1, 1998)

Measured reserves (Proved reserves) (Includes 13.6 TCF of methane[2] and 59.8 TCF of CO_2[3])	73.4 trillion cubic feet
Indicated and inferred reserves (Reserve growth in conventional fields)	22.8 trillion cubic feet
Total	96.2 trillion cubic feet

COAL

Remaining Resources (January 1, 1999)

Identified and Hypothetical (Discovered)	1,426.3 billion tons[4]
Speculative (Undiscovered)	31.5 billion tons[4]
Total	1,457.8 billion tons

Remaining Reserve Base (January 1, 1999)

Demonstrated strippable (Measured and indicated reserve base)	24.7 billion tons[5]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5 billion tons[5]
Total	67.2 billion tons

TRONA

Original Resources

Trona	76.0 billion tons[6]
Mixed trona and halite	51.0 billion tons[6]
Total	127.0 billion tons

URANIUM

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

Remaining Reserve Base (December 31, 1989)

Uranium oxide recoverable at $30.00 per pound	66 million pounds[7]

OIL SHALE

Original Resources (January 1, 1981)

Identified (Discovered)	320 billion barrels of shale oil[8]

[1] Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 1118, 20 p.
[2] Modified from Energy Information Administration, 1998, U.S. crude oil, natural gas, and natural gas liquids reserves: Advance Summary, 1997 Annual Report: Washington D.C., 12 p.
[3] De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.
[4] Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000-scale (color) and 44 p. pamphlet.
[5] Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 p.
[6] Wiig, S.V., Grundy, W.D., and Dyni, J.R., 1995, Trona resources in the Green River Basin in southwest Wyoming: U.S. Geological Survey Open File Report 95-476, 88 p.
[7] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.
[8] Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE

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

STATEMAP 2000 PROGRAM

The Wyoming State Geological Survey (WSGS) was recently notified that two mapping projects had been funded under the U.S. Geological Survey's STATEMAP 2000 Program. The review panel for the STATEMAP proposal approved $45,000 to fund compilation of a 1:100,000-scale map and to digitize six existing 1:100,000-scale geologic maps. In this cooperative federal/state program, each federal dollar is matched with a state dollar (usually in the form of the primary researcher's salary), giving a total of $90,000 allocated to these projects. These two projects were selected with the assistance and approval of the Wyoming Geologic Mapping Advisory Committee and will involve two of the WSGS geologic sections.

Consistent with the Survey's mapping program priority of completing geologic maps for the more populated areas in Wyoming, the Geologic Mapping Section will compile and map the geology of the Lander 1:100,000-scale Quadrangle. This quadrangle was originally proposed and approved as part of the STATEMAP 1999 Program, but due to a shift in priorities (developed in consultation with the Wyoming Mapping Advisory Committee), the Sheridan 1:100,000-scale Quadrangle (**Figure 21**) was substituted for the Lander Quadrangle. The Sheridan Quadrangle was substituted due to the demands for up-to-date geologic mapping brought on by the recent boom in exploration and development of coalbed methane resources in this part of the Powder River Basin.

The Lander Quadrangle (**Figure 21**) is located in westcentral Wyoming, on the southwestern side of the Wind River Basin. Section personnel will evaluate and compile existing geologic mapping to the 1:100,000 scale. Limited new geologic mapping using aerial photography and field checking will be used to fill the gaps in existing mapping and to correct outdated mapping. The map will be completed in 2001 with funding from the STATEMAP 2000 Program. Funding ($20,500) will be used to acquire needed aerial photography, negatives, and orthophoto sheets for the component 1:24,000-scale base maps; to pay one geological assistant's salary; and to pay for field vehicle rental and travel expenses.

Few published larger-scale geologic maps exist for much of the area included in the Lander 1:100,000-scale Quadrangle; the majority of the existing maps are dated and lack an accurate topographic base. The Wyoming Business Council has selected Fremont County and specifically the Lander and Riverton areas for promotion of industrial development, and a new, accurate geologic map will complement these efforts. With expanding construction in the Lander area, accurate up-to-date mapping is needed by the construction and concrete industries to locate sand, gravel, and limestone resources. This new geologic map will help identify potential geologic hazards and help locate stable roadbeds for access into new industrial and housing developments. In addition, accurate geologic information, and

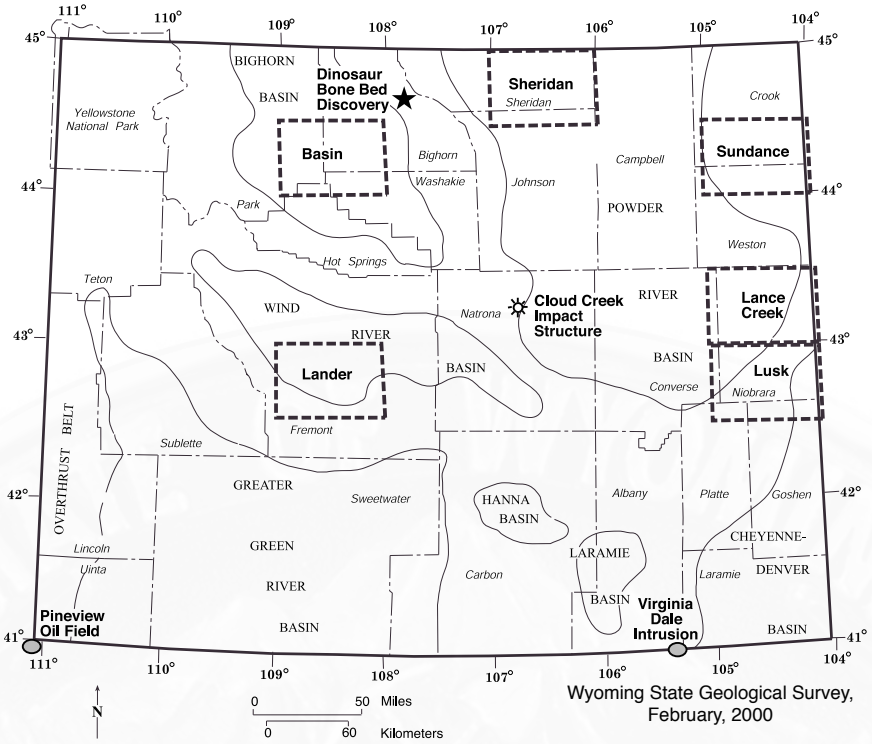

Figure 21. Index to selected geologic mapping activities, recent articles on Wyoming geology, and paleontological activities in Wyoming.

specifically information on structural geology, is required to enhance predictability in selecting water-well drill sites in the area.

The Geologic Hazards Section, using $24,500 from the STATEMAP 2000 Program, will digitize a total of six 1:100,000-scale surficial and bedrock geologic maps (also see **DIGITAL MAPS** and **DIGITAL PRODUCTS**, pages 50 and 52). The surficial maps, which are currently unpublished section reports, cover the Basin, Lance Creek, Lusk, and Sundance 1:100,000-scale quadrangles (**Figure 21**). The bedrock geologic maps cover the Lander and Sheridan 1:100,000-scale quadrangles (**Figure 21**), which are currently being compiled and mapped by the Geologic Mapping Section under STATEMAP 1999 and STATEMAP 2000. The funding will be used to acquire existing 1:100,000-scale digital topographic and public land survey data from EROS Data Center; it will cover one geological assistant's salary; and will pay map scanning costs.

Digital geologic maps are being more widely used than ever before by federal, state, and local governments, geologic and geographic researchers, and by private industry. The emphasis of STATEMAP is to acquire new geologic maps and compile existing data at 1:100,000 scale (consistent with National Digital Mapping Standards) for inclusion in the National Digital Geologic Map Database. This project will provide digital coverages of both published geologic maps and unpublished preliminary maps

of surficial geology. This type of data is in demand by city and county planners. The Geologic Hazards Section's report on digital maps and products in this issue shows completed, current, and planned digital mapping projects by the WSGS.

This year the STATEMAP panel reviewed proposals from 44 state geological surveys and competition was quite stiff for available funds totaling $4,033,821. STATEMAP funds have been awarded yearly since the passage of the National Geologic Mapping Act in 1992. Funds from this cooperative program helped the WSGS accelerate geologic mapping efforts in Wyoming from 1992 through 1999. The WSGS has completed 17 maps using funding from this program since its involvement in 1994; an additional 11 maps were completed independent of the program's funding; and an additional 7 maps are in progress with STATEMAP 1999 funding. Nationally, state geological surveys have produced 1907 geologic maps since the program began in 1992 through the end of 1998. State surveys have completed another 699 maps during this time period, independent of these program funds.

Efforts have been continuing to reauthorize the National Geologic Mapping Act of 1992 in order to continue funding of this national mapping program. On November 19, 1999, the U. S. Senate passed S.607, the National Geologic Mapping Reauthorization Act of 2000, and at that point it had passed both the Senate and House. The President has since signed the act into law. Efforts are currently underway to seek the appropriations needed to fund the act for the next five years.

VIRGINIA MUSEUM FINDS DINOSAUR BONE BED

In November, 1999, Nicholas Fraser, curator of vertebrate paleontology at the Virginia Museum of Natural History, reported the discovery of an enormous bone bed, which contains the remains of at least five species of dinosaurs. The discovery is located north of Shell (**Figure 21**), approximately one mile from the famous Howe Quarry where Barnum Brown of the American Museum of Natural History removed thousands of dinosaur bones in the 1930s. This find and the numerous other finds in the vicinity are contained in rocks of the Jurassic Morrison Formation that are over 138 million years old.

Fraser indicated that the crew identified bones from numerous sauropods including mainly Apatosaurus and Diplodicus, the predator Allosaurus, and the spike-tailed Stegosaurus. The number of bones found and occurrence of numerous other finds in the area since the 1930s fuel the theory that some sort of catastrophic flood or other event occurred in the area during this part of the Jurassic. Fraser also noted that some of the bones are scattered, while others are articulated. The fossils are well preserved and in some cases, the bones still exhibit the details of their original nerve and muscle openings.

A local, private fossil-digging enterprise originally discovered the site. This group was working on private lands and strayed onto Bureau of Land Management (BLM) managed public lands when the find was made. The BLM confiscated the excavated bones from the find and these bones have since been turned over to the Virginia Museum of Natural History. Crews from the Museum will continue work on this rich find during the summer field season of 2000.

NEW PUBLICATIONS OR ARTICLES ON WYOMING GEOLOGY

Stone (1999b) and Mitra and Mount (1999) recently authored a set of discussion and reply papers regarding foreland basement-involved structures in the Rocky Mountain area. The discussion paper by Stone refers to a paper prepared by Mitra and Mount (1998) which presented the authors' interpretations regarding the mechanics and relationships associated with foreland basement-involved structures. The paper was based on six case studies from the central Rocky Mountain area (specifically in the Bighorn and Uinta basins), and one from the Central Basin platform in Texas. As a result of the discussion written by Stone (1999b), Mitra and Mount's (1999) reply addressed some of Stone's questions regarding interpretations and presented some additional evidence for their own interpretations. The two articles are quite interesting and definitely provide insight into the interpretation of the structural geology of much of Wyoming.

The University of Wyoming's Department of Geology and Geophysics published a new issue of Rocky Mountain Geology in November, 1999. This issue focuses on plutonism in the Rocky Mountain area and localities in New Mexico and west Texas. Specific articles relating to Wyoming by Anderson and Cullers (1999) and Vasek and Kolker (1999) (see **Figure 21**) are listed in the **References cited** section below. Rocky Mountain Geology is the successor to the University of Wyoming's Contributions to Geology which ceased publication in 1995. Copies of this publication and the three earlier issues or subscriptions are available from the University of Wyoming Department of Geology and Geophysics. Subscription request forms are available from the Department at the following mailing address:

Rocky Mountain Geology subscriptions
Department of Geology and Geophysics
University of Wyoming
P. O. Box 3006
Laramie, WY 82071-3006

Also published in the last quarter of 1999 were three articles in the Rocky Mountain Association of Geologist's (RMAG's) publication The Mountain Geologist (Volume 36, Number 4) that dealt with Wyoming geology (either directly or indirectly). The first article (Hull, 1999) described the discovery of the Pineview oil field in Utah. Although this field is located in Utah (but just barely, being only 7 miles from Wyoming's southwestern corner – see **Figure 21**), its discovery in 1975 had a very significant impact on Wyoming and the Overthrust Belt. According to the article, the discovery "… inspired a major exploration play in the Laramide Overthrust Belt of the western North American Cordillera that resulted in the discovery of 17 fields in a productive fairway along the Utah-Wyoming border with a total reserve of 300 million barrels of oil (MMBO) and 7 TCF of gas." The article goes on to state "The discovery of Pineview kicked off a new exploration play, the Overthrust Belt, resulting in the most significant exploration discoveries onshore in the United States since Prudhoe Bay in Alaska in 1968."

The second article (Stone, 1999a) deals with a possible buried meteor crater (impact structure) on the Casper arch about 28 miles northwest of Casper in T37N, R82W (**Figure 21**). This structure, referred to as the Cloud Creek structure by

Stone (1999a), is the feature indicated on the Geologic map of Wyoming (Love and Christiansen, 1985) as the "Powder River Impact Structure." The author presents lithologic, stratigraphic, structural, seismic, and other geophysical evidence for the existence of a 4.4-mile-diameter terrestrial impact structure buried about 3800 feet below the surface. Evidence points to an impact event in the Late Triassic period from a projectile estimated at 1200 to 1500 feet in diameter. Evidently an extensive period of erosion after impact occurred, as neither an ejecta blanket nor shock-metamorphosed rocks have been found so far. The entire article is quite intriguing, and hopefully will result in further research on the feature.

The third article (Gay, 1999), which describes types of structural closure in thrust-fold anticlines, uses a number of Wyoming examples to illustrate various points. The examples include the Madden anticline and oil-producing structures on the western edge of the Wind River Basin; the Casper arch; the southwestern Bighorn Basin; and the Overthrust Belt in Utah and Wyoming. The author believes most asymmetrical anticlinal structures in the Rocky Mountains were formed by "transpressive" stress field thrusts rooted in pre-existing basement faults. Transpression is an intermediate stage of stress between compression and strike-slip motion. The article supports the idea of oblique compression, where the orientation of the stress field and consequently the direction of thrust fault motion is not perpendicular to the fault, but instead the motion contains a component of strike slip.

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HAZARDS SECTION DIGITAL MAPS (HSDMs) AND DIGITAL PRODUCTS

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Digital maps and data have become increasingly important in hazards analyses and characterizations. As a result, in 1997 the Geologic Hazards Section of the Wyoming State Geological Survey (WSGS) began generating digital maps in cooperation with the Spatial Data Visualization Center (SDVC) at the University of Wyoming. In 1998, the Section began generating interactive digital databases in cooperation with the Water Resources Data System (WRDS) at the University of Wyoming.

DIGITAL MAPS

From 1993 to 1995, the Geologic Hazards Section at the WSGS mapped the surficial geology of Wyoming at a scale of 1:100,000, which included most of the 56 quadrangles in the state (see Wyoming Geo-notes No. 59, September, 1998). In 1996 and 1997, the Section worked with SDVC to convert the paper-based surficial geologic maps to a 1:500,000-scale digital surficial geologic map of Wyoming. That map was released in 1998 as Hazards Section Digital Map (HSDM) 98-1.

In 1997, the Section received funding from the U.S. Geological Survey's (USGS's) STATEMAP program, which provides funding to state geological surveys to generate new and/or digital geologic maps at a scale of 1:100,000. From 1997 to 1998, the Section generated one digital bedrock geologic map and four digital surficial geologic maps. These maps were released in 1998 as HSDM 98-2 through HSDM 98-6. As with all future STATEMAP projects, the sources for the digital maps are mylar-based bedrock maps from the Geologic Mapping Section, and paper-based surficial geologic maps from the project described above.

In 1998, additional STATEMAP funding was obtained, and the Section generated one digital bedrock geologic map and five digital surficial geologic maps. The maps were released in 1999 as HSDM 99-1 through HSDM 99-6. In 1999, STATEMAP funding was again obtained to generate one digital bedrock geologic map and five digital surficial geologic maps. The maps will be released in 2000 as HSDM 00-1 through HSDM 00-6. STATEMAP funding for years 2000 to 2001 has been approved, and the Section is planning to generate two digital bedrock geologic maps and four digital surficial geologic maps. The published digital STATEMAP products are available on-demand as either CD-ROMs (as both viewable maps and as ArcView files) or as plotted color maps.

In 2000, the Section received funding from the U.S. Geological Survey, Denver Regional Office, to generate digital 1:24,000-scale geologic quadrangle maps of Dr. J. David Love's field mapping in Teton County. These maps will include the Cache Creek, Teton Village, Gros Ventre Junction, Granite Basin, Moose, Blue Miner Lake, and Shadow Mountain 7.5-minute quadrangles. As with the STATEMAP products, the maps will be supplied on-demand as either a CD-ROM or a plotted color map. It is expected that many more 1:24,000-scale geologic maps will be generated through this and similar WSGS projects in the future.

The HSDM-series maps that have been generated, are in production, or are planned are shown in **Figures 22** and **23**. The maps and CD-ROMs can be purchased by mail or in person at the WSGS sales office in Laramie (see **NEW PUBLICATIONS AVAILABLE** near the back of this publication).

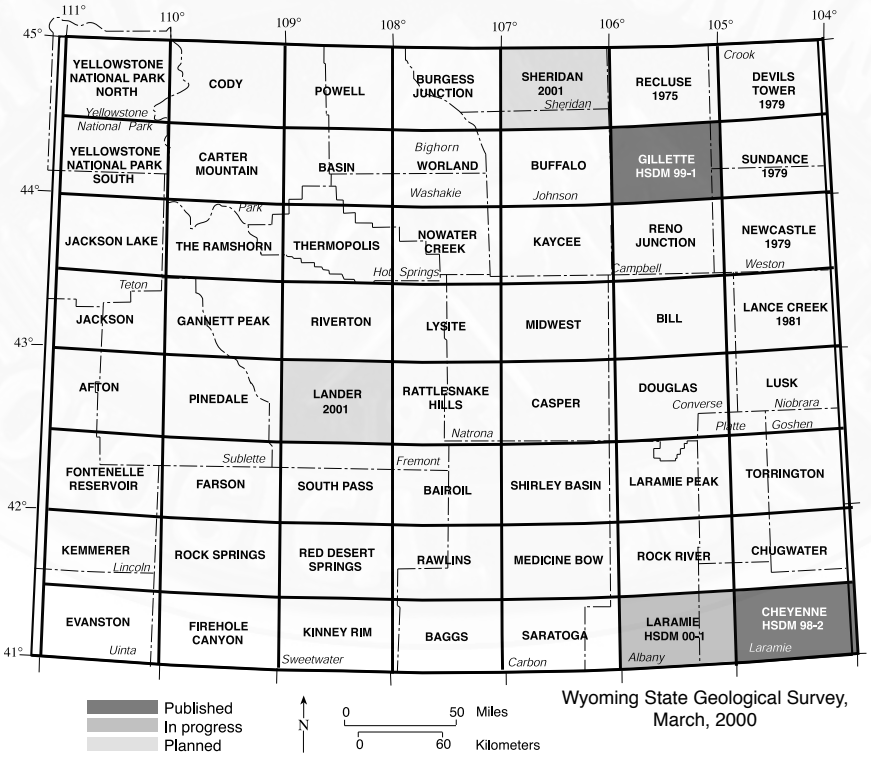


Figure 22. Digital bedrock geologic maps published, in progress, or planned, as of January 1, 2000. Number on published map or in progress map refers to Hazards Section Digital Map (HSDM). Number on planned maps indicates date of STATEMAP project.

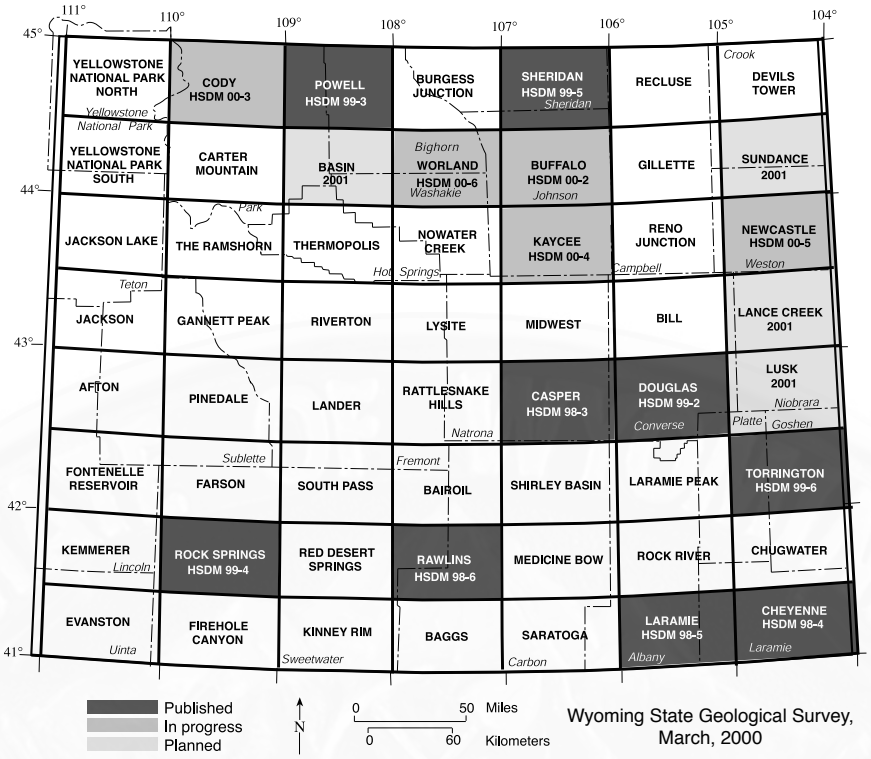


Figure 23. Digital surficial geologic maps published, in progress, or planned, as of January 1, 2000. Number on published map or in progress map refers to Hazards Section Digital Map (HSDM). Number on planned maps indicates date of STATEMAP project.

DIGITAL PRODUCTS

Interactive geologic, geohydrologic, and geochemical database and model for the Little Snake River drainage basin, Wyoming.

The WSGS, WRDS, and Wyoming State Engineer's Office have recently completed an interactive computer- and internet-based model for the Little Snake River drainage basin. The model allows the user to quickly determine the depth to over 32 geologic formations, the generalized aquifer characteristics of the formations, and the generalized water quality of formations where data have been collected. In addition, water well completion reports and driller's logs are available for approximately 1000 water wells.

The project began with the subsurface mapping of over 32 geologic formations by the Geologic Hazards, Oil and Gas, and Geologic Mapping Sections at the WSGS. Mapping was accomplished through the interpretation of hundreds

of electric logs from oil and gas wells and guided by recent mapping by the U.S. Geological Survey. Digital structure contour and drilled thickness maps were generated for all formations.

Copies of completion reports and driller's logs for all water wells were acquired from the Wyoming State Engineer's Office, scanned by WRDS, and incorporated into the program. Water quality data, where available, were also linked to the system.

The program user can selectively access a geologic map, the public land survey, transportation routes, streams, and water wells in the project area. The user can then "click" on a random location or on an existing water well. The geologic section at that point appears on the screen, along with a summary of hydrologic characteristics and a geologic legend. The geologic section includes the depth to and elevation of all mapped geological formations encountered. The completion reports and driller's logs can be displayed for any water well, along with available water quality data. The WRDS has developed a cross section routine which allows the user to define the orientation and length of any cross section.

The product is now being served through the WRDS at this web address: http://www.wrds.uwyo.edu/wrds/view/view.html.

Earthquakes in Wyoming

In 1999, with start-up funding provided by Wyoming's Earthquake Program, an interactive web page titled Earthquakes in Wyoming was developed by the WSGS and the WRDS. The web page allows the user to search and display many historic earthquakes in Wyoming, report an earthquake, or link to earthquake press releases, data sources, or other interesting web sites.

The web page user is presented with a variety of search and display options. All earthquakes in Wyoming, including those with magnitudes less than 1.0, can be displayed. Earthquakes with magnitudes greater than 2.5 are the default option, and earthquakes with magnitudes greater than 5.0 can also be selected. Two screen resolutions are allowed, 800x600 and 1024x768.

The data sources for the site are the USGS, the United States Bureau of Reclamation (USBR), and the University of Utah Seismograph Stations (UUSS). At the present time, data presented from the USGS and the UUSS ranges from 1998 to the present. Data presented from the USBR ranges from 1986 to the present. In 2000, the WSGS will attempt to include all historical data in the site, in addition to educational links and exercises.

The product is now being served through the WRDS at this web address: http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/quake.html .The site can also be accessed through the WSGS home page at http://wsgsweb.uwyo.edu through the On-line Data section.

ROCK HOUND'S CORNER

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

GRUNERITE

Grunerite (Fe, Mg)SiO_3, an iron-rich amphibole, is a tawny (yellow-brown), fibrous, acicular- to asbestos-form mineral. Grunerite forms a solid-solution series with cummingtonite (Mg, Fe)SiO_3, a more magnesian variety of grunerite, which is also fibrous, but is a dark-green amphibole.

Both grunerite and cummingtonite are found in Wyoming. There have been many specimens of grunerite found in the state that have been cut and polished to produce a lapidary stone with the appearance of low-quality "Tigers Eye." However, true "Tigers Eye" requires much of the asbestos-form mineral be replaced by quartz, and this replacement has not been reported in Wyoming.

Most grunerite has been collected from some of the Precambrian greenstone terrains and supracrustal belts in Wyoming. These areas include South Pass, the Seminoe Mountains, central Laramie Mountains, and the Owl Creek Mountains. And it is likely that some "Tigers Eye" has been, or will be found in these areas in the future.

Where found, grunerite is always associated with banded iron formation, and grunerite samples are generally weakly to strongly magnetic due to the presence of magnetite. Therefore, the collector will want to obtain geologic maps of the above mentioned areas, and search iron formation outcrops as well as the drainages downslope from the iron formations. Some of the better samples of grunerite have been found in the Copper Mountain district of the Owl Creek Mountains and in the Seminoe Mountains, including paleoplacers and alluvium along the southern and northern flanks of the Seminoe Mountains. Many rock hounds have searched for grunerite in the Miracle Mile area along the North Platte River north of the Seminoe Mountains with favorable results.

Maps showing locations of banded iron formations where one might expect to find grunerite are found in the following publications available from the Wyoming State Geological Survey:

Graff, P.J., Sears, J.W., Holden, G.S., and Hausel, W.D., 1982, Geology of Elmers Rock greenstone belt, Laramie Range, Wyoming: Wyoming State Geological Survey Report of Investigations 14, 22 p.

Hausel, W.D., Graff, P.J., and Albert, K.G., 1985, Economic geology of the Copper Mountain supracrustal belt, Owl Creek Mountains, Fremont County, Wyoming: Wyoming State Geological Survey Report of Investigations 28, 33 p., 3 plates (scale 1:24,000).

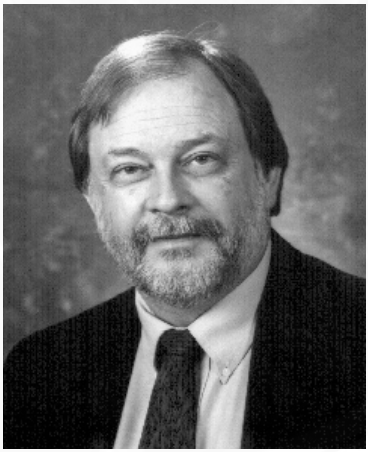
Hausel, W.D., 1991, Economic geology of the South Pass granite-greenstone belt, southern Wind River Range, western Wyoming: Wyoming State Geological Survey Report of Investigations 44, 129 p.

Hausel, W.D., 1994, Economic geology of the Seminoe Mountains mining district, Carbon County, Wyoming: Wyoming State Geological Survey Report of Investigations 50, 31 p.

Hausel, W.D., 1996, Geology and gold mineralization of the Rattlesnake Hills, Granite Mountains, Wyoming: Wyoming State Geological Survey Report of Investigations 52, 28 p.

STAFF PROFILE — JAMES C. CASE

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



James (Jim) C. Case is the head of the Geologic Hazards Section and the manager of the Wyoming Earthquake Program at the Wyoming State Geological Survey (WSGS). Jim wears any number of hats in dealing not only with geologic hazards but with related environmental geology and water resources issues. He works with environmental and hazards assessments, hydrogeology, site characterization, wellhead and aquifer protection, source water protection, geochemistry, and environmental health along with managing the Survey's projects and programs in these fields.

Some of the specific programs he has worked on include the National Landslide Reduction Program, the National Earthquake Hazard Reduction Program, the National Radon Reduction Program, the Clean Water Act, and the Safe Drinking Water Act. He has extensive experience in environmental impact statements and environmental analyses and has worked with private firms and state and federal agencies in generating documents under the National Environmental Policy Act (NEPA).

Born in Cheyenne, Jim is one of the few Wyoming natives on the Survey's staff. He grew up in Boone, Iowa where he developed an interest in geology and landforms. After graduating from Boone High School, he went on to earn a B.S. degree in Geology from Iowa State University. After another two years at Iowa State working on an advanced degree, he started his career as a geologist with Texaco,

followed by eight years with the Iowa Geological Survey. He joined the WSGS in March, 1981, where he has remained ever since. With the Iowa Geological Survey, he was involved with geology and hydrology of Iowa's caves; he used geophysics for aggregate studies; and he performed water quality studies. He also participated in a six-agency, five-state task force (under contract with the U.S. Army Corps of Engineers) evaluating resources and developing a resource management plan for the Upper Mississippi River corridor.

At the WSGS, Jim manages the Wyoming Earthquake Program as well as contracts for STATEMAP and Digital Map Generation. He serves as an intermediary between regulatory agencies and industry and provides technical assistance to consulting firms, local and state government, industry, and the public. He handles about 2500 inquiries a year on his specialities. He serves on a number of committees and task forces, including the Wellhead Protection Plan and Source Water Protection Advisory Committees, Wyoming Water Plan Scoping Committee, Aquifer Vulnerability to Contamination from Pesticides Committee, Abandoned Mine Lands Technical Review and Proposal Selection Committee, Wyoming Ambient Groundwater Quality Monitoring Plan Committee, Western States Seismic Policy Council, and Governor's Multi-Hazard Mitigation Task Force. He also chaired the Governor's Selenium Task Force and has been involved with a number of seismic hazard analyses and radon research studies in Wyoming.

Jim and his Geologic Hazards Section, along with several other sections at the WSGS recently completed a three-dimensional stratigraphic and hydrologic framework model for Little Snake River drainage basin in a cooperative project with the Wyoming Water Resources Data System. This study, which is accessed via interactive, Internet-based links, is the first of its kind. This project makes available and allows basic hydrogeologic analyses that can be used by other agencies, industry, water well drillers, and property owners.

Jim's section has led the WSGS in using Geographic Information Systems (GIS) for geologic, surficial geologic, and geologic hazards mapping. Under Jim's direction, his Section has mapped the surficial geology and geologic hazards for the entire State of Wyoming (which includes over 1000 7.5-minute quadrangle maps, and over 45 1:100,000-scale surficial geology maps). He is now involved in the generation of digital surficial and geologic maps based on this original mapping (see **HAZARDS SECTION DIGITAL MAPS (HSDMs) AND DIGITAL PRODUCTS** section).

Jim is a Registered Professional Geologist in Wyoming (PG-1138), Wisconsin (PG-850), and Minnesota. He is a member of the Wyoming Geological Association, the Wyoming Section of the American Water Resources Association, the Geologists of Jackson Hole, and the Wyoming Emergency Management Association.

According to Jim, "On a personal note, I collect cartoon animation cells, antique and collectible prints, wine, antique tools, and 1950's-vintage Buicks, in addition to many other items. I enjoy travelling to Mexico and the Napa Valley."

NEW PUBLICATIONS AVAILABLE

ATTENTION TOPOGRAPHIC MAP PURCHASERS!

The U.S Geological Survey (USGS) has increased the prices of several map series to their authorized dealers. We are forced to increase our prices on the following maps:

1. USGS 1:100,000-scale metric topographic maps of Wyoming, folded - $6.50 each.
2. USGS 1:250,000-scale AMS sheets of Wyoming, rolled or folded (Casper and Rawlins quadrangles are only available with metric contours, folded only) - $6.50 each.
3. U.S. Bureau of Land Management (BLM) Surface Management Status maps for the 1:100,000-scale metric topographic quadrangles in Wyoming, folded - $7.00 each.
4. Wall maps, 1:500,000-scale shaded relief and topographic maps of Wyoming, rolled - $7.50.
5. Wall map, 1:500,000-scale BLM Surface Management Status map of Wyoming, rolled - $7.50.

Fortunately, prices for USGS 7 1/2-minute quadrangle maps have not changed.

These maps are available over-the-counter at the Survey offices in Laramie or by mail. We do not offer quantity discounts and can make no exchanges or refunds on the USGS or BLM maps. Sales tax of 6% is added to all sales for Wyoming addresses.

NEW PUBLICATIONS BY THE WYOMING STATE GEOLOGICAL SURVEY

*Oil and gas fields map of 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 00-1 (supercedes CMM 99-1) - $30.00, rolled only; $100.00, digital version (ArcInfo/ArcView format) on CD-ROM.

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

*Earthquakes in Wyoming, by J.C. Case and J.A. Green, 2000: Information Pamphlet 6 - free on request.

Oil and gas fields map of central and northwestern Wyoming basins, by R.H. De Bruin, 1999: Map Series 53, 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 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 99-2 - $30.00, plotted color map, rolled only; $100.00, digital version (ArcInfo/ ArcView format) on CD-ROM.

New publications of the Wyoming State Geological Survey, November, 1999, by R.W. Jones, 1999: unnumbered pamphlet - Free (specify indexed or non-indexed version).

Geology of Wyoming, by D.L. Blackstone, Jr., and G.B. Glass, 1992: Information Pamphlet 2 (reprint) - Free.

Geologic map of Wyoming, 3" x 5" postcard, color (reprint) - 5 for $1.00.

Illustrated geologic history of the Medicine Bow Mountains and adjacent areas, Wyoming, S.H. Knight, 1990: Memoir 4 (second printing) - $6.00.

A review of Wyoming's coal mines and markets, 1999, by R.M. Lyman and L.L. Hallberg, 1999: Coal Report CR 99-1 - $15.00 (photocopies only).

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 Wyoming Oil and Gas Conservation Commission (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.

NEWS RELEASES FROM THE WYOMING STATE GEOLOGICAL SURVEY

The Wyoming State Geological Survey occassionaly issues press releases on new publications, developments in Wyoming's mineral industries, new discoveries, and activities involving Survey personnel. These news releases can be viewed on-line at the Survey's web site http://wsgsweb.uwyo.edu, at the Wyoming News Network web site http://wyomingnetwork.com, or at the Environmental News Network web site http://www.enn.com. (follow the links to the Wyoming State Geological Survey).

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