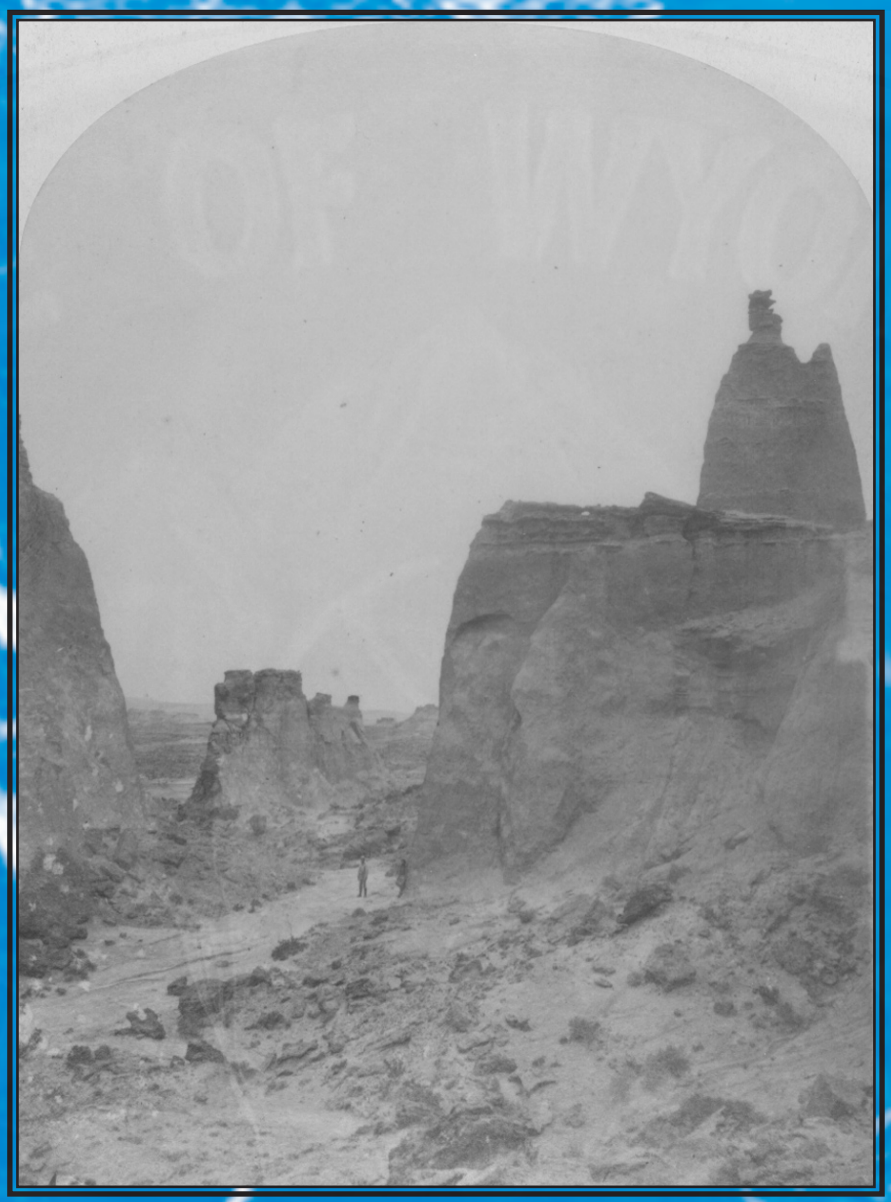
Wyoming Geo-notes

Number 77



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County Natural Hazards and Vulnerability Assessments

Wyoming State Geological Survey
Lance Cook, State Geologist

Laramie, Wyoming
June, 2003

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****Please note: all email addresses for WSGS staff have changed; the new addresses are included on the back cover.**

Richard W. Jones, Wyoming PG-2972
Editor

Jaime R. Moulton
Layout and design

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Front cover: Half of stereo pair #49 entitled "Washakie Badlands, Wyoming" by Timothy O'Sullivan, Photographer, circa 1870. Taken during the King Expedition: from an albumen print. From 1867 through 1870, Timothy O'Sullivan photographed the West as a member of the King Expedition. During the 1869 to 1870 field seasons, the King party passed through southern Wyoming, where O'Sullivan took a series of stereoscopic photographs in the Washakie badlands. Following his years with the King Expedition, O'Sullivan went on to continue his exploits as a member of the Wheeler Survey (1871, 1873 through 1874) and the Davien Expedition to Panama (1872). Photograph from the collection of Lance Cook.

MINERALS UPDATE

Overview

Lance Cook, Wyoming PG-2577

State Geologist, Wyoming State Geological Survey

Final mineral production figures for 2002 are now in for Wyoming. Nearly all commodities except oil, trona, and uranium showed production increases from last year (**Table 1**); production of oil, natural gas [which includes coalbed methane (CBM), helium, and carbon dioxide], and coal exceeded estimates made in January, 2003 by the State of Wyoming's Consensus Revenue Estimating Group (CREG). Refer to the individual update articles in this issue for details and analysis of the state's mineral industry.

Natural gas production was particularly strong in 2002 despite a substantial drop in price since last year (**Table 2**). Increased CBM production from the Powder River Basin (PRB) was once again responsible for much of the increase: by the end of the year, monthly CBM production was approaching one billion cubic feet and was accounting for almost one-fifth of the state's total natural gas production. In the latter part of 2002, natural gas prices were on the rebound and some of the excess production capacity was being relieved by increased pipeline capacity out of the state.

CBM production remains a bright spot in Wyoming's natural gas industry despite the drilling and development slowdown this past year in the PRB (related to delays in the federal leasing process). CBM production and development is moving to other Wyoming coal fields, with nearly every one now reporting some CBM production. This development and the resumption of federal leasing in the PRB will probably spur more statewide exploration, drilling, and development.

Coal production continues to set annual records and overall prices appear to have stabilized or increased slightly (**Tables 1** and **2**). Even a modest 1 or 2% increase in annual production now translates into 4 to 8 million short tons. Despite coal's competition with natural gas to fuel new or replacement electrical power generation capacity, Wyoming's low-sulfur coal appears to be holding its own in the fuel market place.

Oil production in Wyoming continues to decline, but probably not as

Table 1. Wyoming mineral production (1987 through 2002) with forecasts to 2008[1].

Calendar Year	Oil[2,3]	Methane[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[7]	*In situ* Uranium[8]
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3
1996	73.9	1023.4	149.0	1.10	278.4	18.6	1.9
1997	70.2	1040.7	151.0	1.10	281.5	19.4	2.2
1998	65.7	1072.6	151.0	1.10	315.0	18.6	2.3
1999	61.3	1133.1	161.0	1.10	336.5	17.8	2.8
2000	60.6	1293.3	161.0	1.10	338.9	17.8	2.1
2001	57.5	1437.6	174.0	1.20	368.8	17.7	1.6
2002	54.7	1571.0	174.0	1.20	373.2	17.6	1.4
2003	51.2	1602.8	196.0	1.20	380.5	18.0	1.5
2004	48.4	1682.8	196.0	1.20	384.3	18.0	1.5
2005	45.7	1762.8	196.0	1.20	388.1	18.5	1.5
2006	43.2	1842.8	196.0	1.20	392.0	18.5	1.5
2007	40.8	1922.8	196.0	1.20	395.9	18.5	1.5
2008	38.6	2002.8	196.0	1.20	399.9	18.5	1.5

[1]From CREG's Wyoming State Government Revenue Forecast, October, 2002 and January, 2003; [2]Millions of barrels; [3]Wyoming Oil and Gas Conservation Commission, 1987 through 2002; [4]Billions of cubic feet, estimates for methane include coalbed methane; [5]Based on ExxonMobil's estimate that the average helium content in the gas processed at La Barge is 0.5%; [6]Millions of short tons (Wyoming State Inspector of Mines, 1987 through 2002); [7]Millions of short tons (Wyoming Department of Revenue, 1987 through 2001; Wyoming State Inspector of Mines, 2002); [8]Millions of pounds of yellowcake (Wyoming Department of Revenue, 1987 through 1999; Wyoming State Inspector of Mines, 2000 through 2002).

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1987 through 2001 or 2002) with forecasts to 2008[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.78	42.29
1998	10.67	1.81	5.41	41.29
1999	16.44	2.06	5.19	38.49
2000	26.87	3.42	5.40	37.28
2001	21.59	3.66	5.75	38.00
2002	22.08	2.09	5.90	38.00
2003	20.00	2.00	5.90	38.00
2004	18.00	2.25	5.97	38.00
2005	18.00	2.25	6.04	38.00
2006	18.00	2.25	6.12	38.00
2007	18.00	2.25	6.20	38.00
2008	18.00	2.25	6.28	38.00

[1]From CREG's Wyoming State Government Revenue Forecast, October, 2002 and January, 2003; [2]First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1987-2002; [3]Wellhead price in dollars per thousand cubic feet (MCF), includes coalbed methane. Source: American Association, 1998-2002; Wyoming Office of State Lands and Investments, 1989-2002 (derived from State royalty payments); and Minerals Management Service, 1987-1988 (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, 1987-1990 and derived from Department of Revenue, 1991-2001; [5]Dollars per ton of trona, not soda ash. Source Wyoming Department of Revenue, 1987-2001.

much as predicted earlier. Uncertain oil supplies worldwide are holding oil prices up, and Wyoming's production for the short term may be bolstered by some planned carbon dioxide flood projects in the PRB.

Wyoming continued to lead the nation in bentonite, uranium, and trona production, with gypsum, construction aggregate, sulfur, and decorative/dimensional stone continuing to contribute to the state's economy. Gold, precious metals, gemstones, and diamonds played a minor role (although some cut iolites and sapphires are quite attractive and may be spurring some exploration/development).

The Wyoming State Geological Survey (WSGS) has received funding to continue our STATEMAP program for another year, and as described in the **Geologic Mapping, Paleontology, and Stratigraphy Update**, we have undertaken our most ambitious mapping program yet. The $90,000 grant monies will fund four separate mapping projects and will involve the Geologic Mapping, Publications, Metals and Precious Stones, and Industrial Minerals and Uranium sections at the WSGS. All these projects will ultimately produce nine digital 1:100,000-scale geologic maps of Wyoming areas.

The current WSGS digital mapping and data delivery effort uses geographic information systems (GIS) technology and software almost exclusively; nearly all our new maps or publications use GIS in one form or another. For example, the Geologic Hazards Section has an innovative program for providing every Wyoming county a series of GIS-derived maps that detail and assess natural and geologic hazards (see **Geologic Hazards Update: County Natural Hazards and Vulnerability Assessments**). The large Northern Powder River Basin database project for CBM development is nearing completion and it appears that there may be funds available to expand the project into the southern part of the basin.

...there is an increasing demand for delivery of our products via the Internet, and we need to expand our efforts to improve our web site services.

The **GIS Update** covers the wide variety of GIS projects underway at the WSGS. In recognition of the progress and accomplishments in GIS over the past few years, our agency will receive a Special Achievement in GIS (SAG) award from Environmental Science Research Institute (ESRI®). Joe Huss, GIS Coordinator for the WSGS, will accept the award in early July, 2003 at the ESRI® International Users Conference in San Diego.

The rapid growth in Internet "hits" to the WSGS web site from September, 2002 to May, 2003 (**Figure 1**) was a phenomenal 728%. This leads us to conclude that there is an increasing demand for delivery of our products via the Internet, and we need to expand our efforts to improve our web site services. Therefore, the Survey is investigating (and implementing in some cases) the addition of some new features to our web site in the coming year:

- Ability to accept credit cards for online orders (as well as for over-the-counter, telephone, and mail orders) before the end of the year;
- Revamping our online publications list to make it more user-friendly;
- Launching an online library of open file reports and maps that will be available for free in digital form. This will include maps from most geology theses at the Department of Geology and Geophysics, University of Wyoming;
- Working with ESRI® Corp. to improve our delivery of GIS data through an Internet Map Server;
- Distributing out-of-print publications and back issues of *Wyoming Geo-notes* from the web site;
- Offering selected photographs from historical geological surveys of the West (now in the public domain) for download;
- Serving county-by-county geologic hazards GIS coverages (containing up to 50 coverages per county) or linking them to another server; and
- Expanding the selection of maps available for preview.

Finally, we regret the recent poor access to the WSGS building in Laramie. Last fall, a major break in a water main caused collapse and extensive damage to the underground heat and utility tunnels that underlie the parking lot north of our building. Construction has closed the parking lot until at least late fall, 2003. In the meantime, we ask our customers and visitors to bear with us and use the parking options shown on the last page of this issue of *Wyoming Geo-notes*.

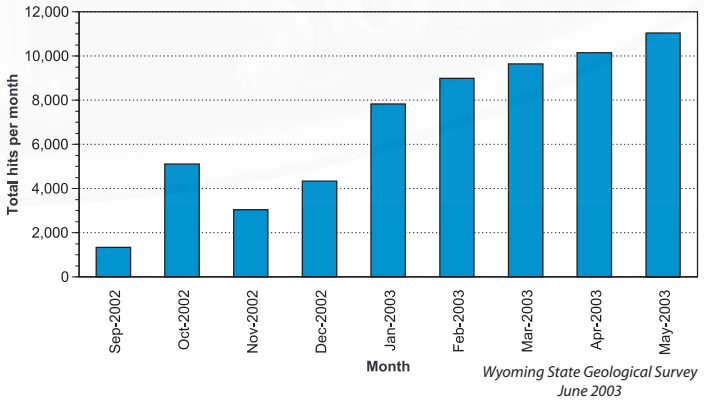

Figure 1. Internet "hits" by month on the Wyoming State Geological Survey web site, September, 2002 to May, 2003.

Oil and Gas Update

Rodney H. De Bruin, Wyoming PG-3045

Senior Staff Geologist–Oil and Gas, Wyoming State Geological Survey

Natural gas production in Wyoming for 2002 was about 1.75 trillion cubic feet (TCF), an increase of over 8% from 2001 and was another yearly production record. As in 2001, natural gas production for 2002 was bolstered by a large increase in coalbed methane (CBM) production in the Powder River Basin (PRB), which made up 18.7% of Wyoming's total gas production. Without the 73.2 billion cubic feet (BCF) increase in CBM production during 2002, Wyoming's natural gas production would have increased only 67.0 BCF, rather than the recorded increase of 133.4 BCF. Oil production for the state in 2002 was 54.7 million barrels, a decrease of nearly 5% from last year, continuing an annual decline that began after production reached about 130 million barrels in 1985. The highest annual production from Wyoming was in 1970 with 160.3 million barrels.

Wyoming oil and gas producers received higher prices for oil and for natural gas in the fourth quarter of 2002 compared to prices received during the fourth quarter of 2001. Average oil prices for the entire year of 2002 were up $.50 per barrel over average oil prices for 2001, while natural gas prices for the entire year of 2002 were $1.57 per thousand cubic feet (MCF) lower than for 2001.

In the fourth quarter, two federal lease sales brought in $1,445,158. The average price per acre at the two sales was only $9.95. One state lease sale brought in $1,222,823 with an average price of $25.77 per acre. The December state lease sale was cancelled because there were not enough good leases available to sell. The number of applications for permit to drill in 2002 remained healthy, although over 4000 lower than for last year. Geophysical activity for 2002 indicated that exploration drilling may increase next year, but production drilling may decrease somewhat. The number of conventional miles of seismic lines that were permitted in 2002 increased, while 3-D square miles that were permitted decreased significantly. The average rig count in 2002 was 15 less than the average for 2001 although still higher than expected, considering the very low price for natural gas in the first nine months of this year.

Prices and production

Spot prices for natural gas at Opal, Wyoming averaged $2.72 per MCF during the fourth quarter of 2002. This is $0.72 per MCF higher than the average price for the fourth quarter of 2001, and $1.37 higher than for the third quarter of 2002 (**Table 3** and **Figure 2**). The average price for 2002 was $2.09 per MCF, which was only $.09 higher than the latest Consensus Revenue Estimating Group (CREG) estimate (see *Wyoming Geo-notes No. 76*, April, 2003).

Natural gas production in Wyoming for 2002 was 1746.2 billion cubic feet (BCF) according to production figures from the Wyoming Oil and Gas Conservation Commission (WOGCC). This production is up 8.7% from 2001 (**Table 4**), but was 46.2 BCF higher than that estimated by CREG (see *Wyoming Geo-notes No. 76*, April, 2003). CBM production from the PRB accounted for 327.2 BCF and 18.7% of Wyoming's total natural gas production in 2002 (**Figure 3**). CREG estimated CBM production for 2002 at 330 BCF. Production from CBM in the PRB is now approaching one BCF per day, while daily natural gas production in Wyoming (from all sources) during the fourth quarter averaged nearly 5.1 BCF per day.

Prices paid to Wyoming oil producers during the fourth quarter of 2002 averaged $23.93 per barrel (**Table 5**). The average price for the quarter is $7.59 per barrel higher than

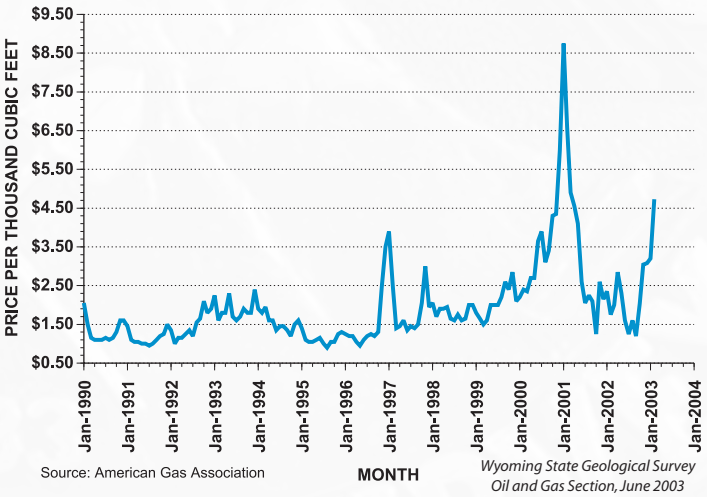

Figure 2. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through December, 2002).

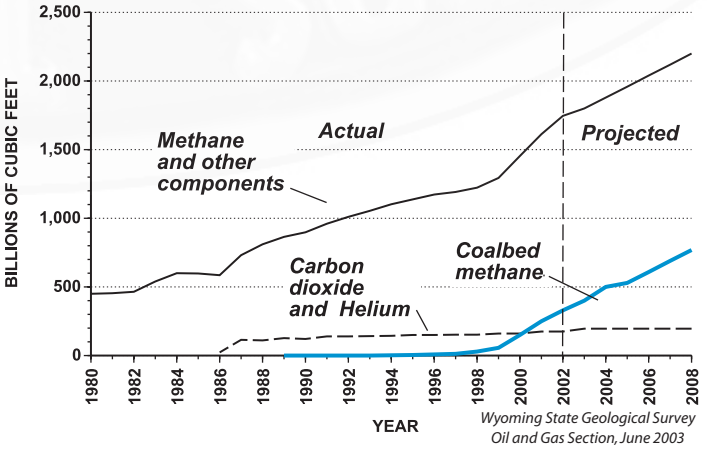

Figure 3. Annual natural gas production from Wyoming (1980 through 2002) with forecasts to 2008.

Table 3. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1998 through December, 2002).

	1998		1999		2000		2001		2002	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$2.05	$2.05	$1.80	$1.80	$2.20	$2.20	$8.75	$8.75	$2.35	$2.35
February	$1.70	$1.88	$1.65	$1.73	$2.40	$2.30	$6.60	$7.68	$1.75	$2.05
March	$1.90	$1.88	$1.50	$1.65	$2.35	$2.32	$4.90	$6.75	$2.00	$2.03
April	$1.90	$1.89	$1.60	$1.64	$2.70	$2.41	$4.55	$6.20	$2.85	$2.24
May	$1.95	$1.90	$2.00	$1.71	$2.70	$2.47	$4.10	$5.78	$2.30	$2.25
June	$1.65	$1.86	$2.00	$1.76	$3.65	$2.67	$2.60	$5.25	$1.60	$2.14
July	$1.60	$1.82	$2.00	$1.79	$3.90	$2.84	$2.05	$4.79	$1.25	$2.01
August	$1.75	$1.81	$2.20	$1.84	$3.10	$2.88	$2.25	$4.48	$1.60	$1.96
September	$1.60	$1.79	$2.60	$1.93	$3.40	$2.93	$2.10	$4.21	$1.20	$1.88
October	$1.65	$1.78	$2.40	$1.98	$4.30	$3.07	$1.25	$3.92	$2.04	$1.89
November	$2.00	$1.80	$2.85	$2.05	$4.35	$3.19	$2.60	$3.80	$3.04	$2.00
December	$2.00	$1.81	$2.10	$2.06	$6.00	$3.42	$2.15	$3.66	$3.08	$2.09
Average yearly price		**$1.81**		**$2.06**		**$3.42**		**$3.66**		**$2.09**

Source: American Gas Association's monthly reports. *Wyoming State Geological Survey, Oil and Gas Section, March, 2003.*

Table 4. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1998 through December, 2002).

	1998		1999		2000		2001		2002	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	103,640,214	103,640,214	108,524,793	108,524,793	122,078,095	122,078,095	135,968,875	135,968,875	143,510,891	143,510,891
February	94,501,819	198,142,033	94,288,888	202,813,681	114,204,669	236,282,764	123,372,642	259,341,517	132,981,761	276,492,652
March	103,906,999	302,049,032	111,012,987	313,826,668	121,104,908	357,387,672	138,969,778	398,311,295	143,707,799	420,200,451
April	98,201,007	400,250,039	102,363,550	416,190,218	118,775,280	476,162,952	132,559,769	530,871,064	141,016,463	561,216,914
May	96,741,237	496,991,276	104,746,697	520,936,915	118,462,106	594,623,058	138,100,005	668,971,069	146,950,768	708,167,682
June	98,413,520	595,404,796	102,717,295	623,654,210	116,887,377	711,512,435	126,733,129	795,704,198	141,368,350	849,554,032
July	102,055,968	697,460,764	106,733,493	730,387,703	120,690,168	832,202,603	131,151,216	926,855,414	145,796,954	995,350,986
August	105,378,334	802,839,098	107,536,099	837,923,802	122,412,623	954,615,226	132,329,266	1,059,184,680	139,407,056	1,134,758,042
September	98,474,782	901,313,880	108,200,542	946,124,344	119,730,975	1,074,346,201	130,725,850	1,189,910,530	142,448,905	1,277,206,947
October	96,470,624	997,784,504	118,545,893	1,064,670,237	127,507,997	1,201,854,198	136,704,129	1,326,614,659	151,247,991	1,428,454,938
November	103,445,859	1,101,230,363	110,904,046	1,175,574,283	122,846,630	1,324,700,828	136,260,720	1,462,875,379	155,751,286	1,584,206,224
December	99,339,043	1,200,569,406	119,648,215	1,295,222,498	130,711,331	1,455,412,159	142,912,497	1,605,787,876	162,039,833	1,746,246,057
Total MCF Reported[1]		**1,200,569,406**		**1,295,222,498**		**1,455,412,159**		**1,605,787,876**		**1,746,246,057**
Total MCF not Reported[2]		**22,955,142**								
Total MCF Produced[3]		**1,223,524,548**								

[1]Monthly production reports for 1998 from Petroleum Information/Dwights LLC.; 1999 through December, 2002 are from Wyoming Oil and Gas Conservation Commission; [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, March, 2003.*

for the fourth quarter of 2001. Over the last three years, the average monthly price for a barrel of Wyoming crude oil has been over $20 for all but the last three months of 2001 and the first two months of 2002 (**Table 5**). The posted sweet and sour crude oil prices and first purchase price for Wyoming oil averaged by month at year's end are near the price spikes seen in December, 2000 (**Figure 4**). The average price for crude oil in 2002 was $22.08 per barrel, which was only $.08 higher than the last CREG estimate (see *Wyoming Geo-notes No. 76*, April, 2003).

Oil production reported by the WOGCC for 2002 was 54.7 million barrels (**Table 6**), a drop of 4.8% from 2001. The production was 0.5 million barrels higher than expected, based on the last CREG estimate (see *Wyoming Geo-notes No. 76*, April, 2003).

Reports, projects, and transactions

In 2002, the U.S. Minerals Management Service (MMS) distributed more than $753 million to 33 states as their share of collected bonuses, rents, and royalties associated with mineral leases on federal lands located within each state and adjacent to their seaward boundaries. For the majority of federal lands, the federal government and those states where the resources are located share the revenues. The states receive approximately 50% of the revenues, the Reclamation Fund for Water Projects receives 40%, and the U.S. Treasury

Table 5. Monthly average price of a barrel of oil produced in Wyoming (1998 through December, 2002).

	1998		1999		2000		2001		2002	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$12.79	$12.79	$9.30	$9.30	$24.01	$24.01	$24.62	$24.62	$15.70	$15.70
February	$12.16	$12.47	$9.09	$9.20	$26.48	$25.25	$24.82	$24.72	$16.63	$16.17
March	$10.97	$11.97	$11.77	$10.05	$27.24	$25.91	$22.71	$24.05	$20.64	$17.66
April	$11.54	$11.87	$14.34	$11.12	$22.92	$25.16	$22.85	$23.75	$22.63	$18.90
May	$11.19	$11.73	$15.16	$11.93	$26.06	$25.34	$23.68	$23.74	$22.86	$19.69
June	$9.63	$11.38	$15.36	$12.50	$28.31	$25.84	$22.99	$23.61	$21.71	$20.03
July	$10.20	$11.21	$17.39	$13.20	$27.12	$26.02	$22.55	$23.46	$23.29	$20.49
August	$9.58	$11.01	$18.43	$13.86	$28.18	$26.29	$23.67	$23.49	$24.27	$20.97
September	$11.19	$11.03	$20.97	$14.65	$30.22	$26.73	$22.02	$23.32	$25.47	$21.47
October	$11.04	$11.03	$20.01	$15.18	$28.75	$26.93	$17.71	$22.76	$24.27	$21.75
November	$9.64	$10.90	$22.20	$15.82	$29.63	$27.17	$16.44	$22.19	$22.66	$21.83
December	$8.05	$10.67	$23.22	$16.44	$23.60	$26.88	$14.86	$21.58	$24.85	$22.08
Average yearly price		**$10.67**		**$16.44**		**$26.88**		**$21.58**		**$22.08**

All averages are derived from published monthly reports by the Energy Information Administration. *Wyoming State Geological Survey, Oil and Gas Section, March, 2003.*

CALENDAR OF EVENTS

Talks and courses

MINERAL RESOURCES AND POTENTIAL OF ALBANY COUNTY–*R.E. Harris*: Leadership Laramie, Tuesday, May 13, 2003.

CORDIERITE AND CORUNDUM IN WYOMING—NEW GEMSTONES FOR THE COWBOY STATE–*W.D. Hausel*: 39th annual Forum on the Geology of Industrial Minerals, Reno-Sparks, Nevada, May 21, 2003.

THE STATUS OF WYOMING'S DECORATIVE AND DIMENSIONAL STONE INDUSTRY–*R.E. Harris*: 39th annual Forum on the Geology of Industrial Minerals, Reno-Sparks, Nevada, May 21, 2003.

GEMSTONES AND COLLECTABLE ROCKS AND MINERALS OF WYOMING–*W.D. Hausel*: Rocky Mountain Prospectors and Treasure Hunters Club, Fort Collins, Colorado, June 4, 2003, 7 pm.

MINING DISTRICTS OF THE MEDICINE BOW MOUNTAINS–*W.D. Hausel*: Rocky Mountain Prospectors and Treasure Hunters Club, Fort Collins, Colorado, July 2, 2003, 7 pm.

A BRIEF REVIEW OF THE GEOLOGY OF THE HARTVILLE UPLIFT, WYOMING–*R.E. Harris*: Wyoming Geological Association luncheon meeting, July 25, 2003.

GEOLOGY AND GOLD MINERALIZATION OF THE SOUTH PASS AND TIN CUP DISTRICTS, WYOMING–*W.D. Hausel*: Rocky Mountain Prospectors and Treasure Hunters Club, Fort Collins, Colorado, August 6, 2003, 7 pm.

INTRODUCTION TO ARCGIS *I*, ESRI Certified Course–*J.M. Huss*: University of Wyoming, Laramie, Wyoming, August 18-19, 2003.

MIGRATING FROM ARCVIEW 3.X TO ARCVIEW 8, ESRI Certified Course–*J.M. Huss*: University of Wyoming, Laramie, Wyoming, August, 2003 (date to be announced).

Meetings, conferences, exhibits, etc.

WYOMING GEOGRAPHIC INFORMATION ADVISORY COUNCIL, WGIAC–*J.M. Huss*: Cheyenne, Wyoming, April 10, 2003 and May 8, 2003.

GIS EXPO— *J.M. Huss, F.H. Porter, P.A. Ranz*: Fort Collins, Colorado, May 8, 2003.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS (AAPG) 2003 ANNUAL MEETING–*L. Cook, R.H. De Bruin, R.W. Jones, and A.J. Ver Ploeg*: Salt Palace Convention Center, Salt Lake City, Utah, May 11-14, 2003.

INDUSTRIAL MINERALS FORUM 2003 ANNUAL MEETING–*R.E. Harris and W.D. Hausel*: John Ascuaga's Nugget, Reno-Sparks-Tahoe, Nevada, May 18-24, 2003.

EIGHTH INTERNATIONAL KIMBERLITE CONFERENCE–*W.D. Hausel*: Vancouver, British Columbia, Canada, June 22-27, 2003.

ESRI INTERNATIONAL USERS CONFERENCE–*J.M. Huss*: San Diego, California, July 7-11, 2003.

ROCKY MOUNTIAN FEDERATION OF MINERAL SOCIETIES SHOW AND ANNUAL MEETING–*L. Cook and R.W. Jones*: Parkway Hotel and Convention Center, Casper, Wyoming, July11-13, 2003.

WYOMING GEOLOGICAL ASSOCIATION FIELD CONFERENCE–*various WSGS staff*: Casper, Wyoming, September 7-12, 2003.

DENVER GEM AND MINERAL SHOW–*various WSGS staff*: Denver Merchandise Mart, Denver, Colorado, September 12-14, 2003.

SEVENTH ANNUAL WYOMING NATURAL GAS FAIR–*various WSGS staff*: SnowKing Resort, Jackson Hole, Wyoming, September 24-26, 2003.

ANNUAL ESRI SOUTHWEST USERS GROUP–*J.M. Huss, F.H. Porter, P.A. Ranz*: Jackson, Wyoming, October 27-30, 2003.

ASSOCIATION OF EARTH SCIENCE EDITORS (AESE) ANNUAL MEETING–*R.W. Jones*: Washington State Convention and Trade Center, Seattle, Washington, October 31-November 5, 2003.

GEOLOGICAL SOCIETY OF AMERICA (GSA) 2003 ANNUAL MEETING–*R.W. Jones*: Washington State Convention and Trade Center, Seattle, Washington, November 2-5, 2003.

Field Trips

KIMBERLITES AND LAMPROITES OF COLORADO AND WYOMING, USA–*H. Coopersmith, R. Mitchell, W.D. Hausel*: 8th International Kimberlite Conference, June 16-21, 2003.

GEOLOGY AND MINERALIZATION OF THE SOUTH PASS/TIN CUP DISTRICTS, CENTRAL WYOMING–*W.D. Hausel*: Rocky Mountain Prospectors and Treasure Hunters Club, August 9, 2003 (http://www.jymis.com/RMPTH/).

GEOLOGY AND GOLD AT CENTENNIAL RIDGE–*W.D. Hausel*: Gold Prospectors Association of America and Rocky Mountain Prospectors and Treasure Hunters Club, date and time to be announced.

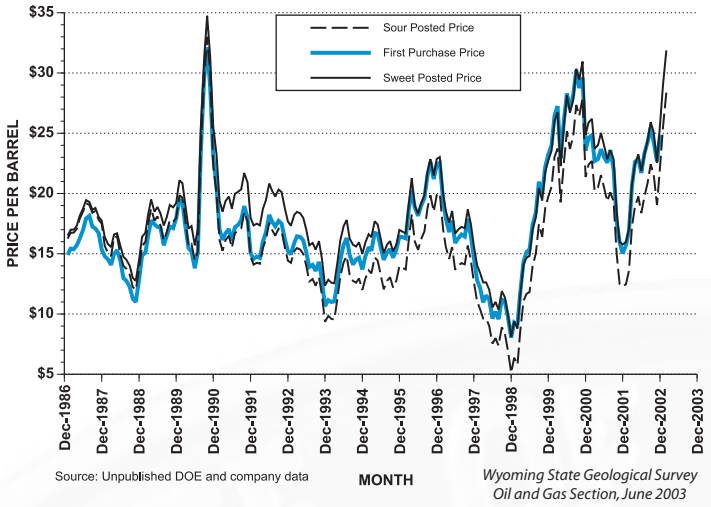

Figure 4. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through December, 2002).

receives 10%. Wyoming received just over $387.3 million, which was 51.4% of the U.S. total. The total distribution in 2001 was about $1 billion.

The U.S. Geological Survey (USGS) recently completed an assessment of undiscovered, technically recoverable oil and natural gas resources in five different basins in the Rocky Mountain region. The assessed basins are the Uinta-Piceance, southwestern Wyoming (Greater Green River Basin), San Juan, Montana Thrust Belt, and the Powder River. For the PRB, the USGS (2002a) estimated a mean of 16.5 TCF of undiscovered natural gas, a mean of 1.5 billion barrels of undiscovered oil, and a mean of 86.5 million barrels of natural gas liquids. For southwestern Wyoming, the USGS (2002b) estimated a mean of 84.6 TCF of undiscovered natural gas, a mean of 131 million barrels of undiscovered oil, and a mean of 2.6 billion barrels of undiscovered natural gas liquids. Supporting geologic studies and reports of the methodology used for these and other assessments are available at the USGS Central Energy Team web site at http://energy.cr.usgs.gov/oilgas/noga.

Anadarko Petroleum Corp. completed their acquisition of Howell Corp. during the fourth quarter of 2002. The acquisition of Howell gives Anadarko additional proved reserves of about 50 million barrels of oil equivalent. The proved reserves are primarily in Salt Creek and Elk Basin fields in Wyoming. [Note: Readers may wish to consult the new *Oil and gas map of Wyoming*, MS-55, for locations of fields, proposed pipelines, and gas plants discussed in the remainder of this section.]

After the acquisition, Anadarko announced plans to invest an additional $200 million over the next four years to develop and install an enhanced oil recovery (EOR) project in Salt Creek Field. Anadarko plans to buy carbon dioxide (CO_2) from ExxonMobil's Shute Creek Gas Plant in southwestern Wyoming to flood Salt Creek Field; they expect to recover an additional 150 million barrels of crude oil from the field. Anadarko expects an increase in production from Salt Creek to 35,000 barrels of oil per day by the end of 2006 from the present level of 5300 barrels of oil per day. At its peak, Salt Creek Field produced 96,717 barrels of oil per day in 1923. The increase in production from Salt Creek would go a long way toward turning around Wyoming's decline in oil production, at least for a few years.

Anadarko plans to buy carbon dioxide (CO_2) from ExxonMobil's Shute Creek Gas Plant in southwestern Wyoming to flood Salt Creek Field...

Anadarko also signed an agreement with Petro Source Investments giving Anadarko the right to purchase significant quantities of CO_2 and the exclusive rights to market and transport CO_2 production from ExxonMobil's plant into the PRB. Anadarko plans to build a $27 million, 125-mile-long pipeline from Bairoil to Midwest that would deliver CO_2 to Salt Creek Field and could also serve other potential EOR projects in the northeastern part of Wyoming. Anadarko paid Petro Source $3 million in cash and agreed to future considerations based on the performance of the pipeline. Initially, 125 million cubic feet (MMCF) of CO_2 per day will be sequestered by deliv-

Table 6. Monthly oil production from Wyoming in barrels (1998 through December, 2002).

	1998		1999		2000		2001		2002	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	5,846,364	5,846,364	5,333,257	5,333,257	5,185,683	5,185,683	5,001,928	5,001,928	4,711,532	4,711,532
February	5,233,502	11,079,866	4,744,527	10,077,784	4,871,733	10,057,416	4,493,565	9,495,493	4,238,372	8,949,904
March	5,759,176	16,839,042	5,297,674	15,375,458	5,202,533	15,259,949	4,969,821	14,465,314	4,629,468	13,579,372
April	5,534,568	22,373,610	5,065,591	20,441,049	5,003,812	20,263,761	4,802,352	19,267,666	4,565,445	18,144,817
May	5,626,125	27,999,735	5,200,031	25,641,080	5,201,564	25,465,325	4,930,856	24,198,522	4,687,127	22,831,944
June	5,335,463	33,335,198	5,000,039	30,641,119	5,001,932	30,467,257	4,664,829	28,863,351	4,495,524	27,327,468
July	5,464,514	38,799,712	5,164,705	35,805,824	5,077,548	35,544,805	4,846,220	33,709,571	4,595,080	31,922,548
August	5,287,415	44,087,127	5,190,052	40,995,876	5,093,558	40,638,363	4,761,492	38,471,063	4,626,308	36,548,856
September	5,109,053	49,196,180	5,081,384	46,077,260	4,983,126	45,621,489	4,718,493	43,189,556	4,492,324	41,041,180
October	5,274,269	54,470,449	5,163,165	51,240,425	5,156,755	50,778,244	4,821,224	48,010,780	4,623,348	45,664,528
November	5,232,287	59,702,736	5,010,985	56,251,410	4,877,512	55,655,756	4,645,045	52,655,825	4,456,006	50,120,534
December	5,078,909	64,781,645	5,090,959	61,342,369	4,970,686	60,626,442	4,744,316	57,400,141	4,596,150	54,716,684
Total Barrels Reported[1]		**64,781,645**		**61,342,369**		**60,626,442**		**57,400,141**		**54,716,684**
Total Barrels not Reported[2]		**897,131**								
Total Barrels Produced[3]		**65,678,776**								

[1]Monthly production reports for 1998 from Petroleum Information/Dwights LLC.; 1999 through December, 2002 are 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, March, 2003.*

ery and injection into Salt Creek Field. The planned pipeline could carry 250 MMCF of CO_2 per day if demand warrants the increase.

Burlington Resources Inc. completed its expansion project at the Lost Cabin Gas Plant in Madden Field (northeastern Wind River Basin). Volumes of gas flowing through the plant are being increased in phases with the ultimate goal of reaching 310 MMCF per day. The expansion required a $280 million capital investment, 1.5 million hours of work, and a workforce of up to 500 people. The project added inlet capacity of 180 MMCF per day to the existing capacity of 130 MMCF per day. The plant removes about 12% hydrogen sulfide (H_2S) and 19% CO_2 from the inlet gas produced from the Madison Limestone at depths of up to 25,000 feet. Six of these deep wells are now producing and a seventh and final well will soon be completed. These Madison wells are some of the most productive onshore gas wells in the United States; each well is capable of producing over 40 MMCF of gas per day. The Madison Limestone at Madden Field has estimated proved reserves of 2.5 TCF of natural gas.

Jonah Gas Gathering Co. (JGGC) plans to construct, operate, and maintain a natural gas processing plant, associated pipelines, and a 680-kilovolt power line near Opal in southwestern Wyoming. The project would allow JGGC to process natural gas from Jonah Field and the Pinedale anticline producing area and deliver it to markets. JGGC plans to build the gas plant in section 22, T21N, R114W. A 30-inch (diameter) pipeline of about 1 mile in length would then connect the plant to the Kern River meter station in section 28, T21N, R114W. A 4-inch natural gas liquids pipeline would also connect the proposed plant to an existing MAPCO liquids pipeline located in section 21, T21N, R114W. The power line would run west from the proposed plant and connect with an existing Pacific Power & Light substation in section 21, T21N, R114W. An Environmental Assessment (EA) is required for the project and possibly an Environmental Impact Statement (EIS) if significant impacts are identified.

Colorado Interstate Gas Co. (CIG) will build a new 30-inch natural gas pipeline capable of delivering 540 MMCF of gas per day. If the Federal Energy Regulatory Commission approves the pipeline this spring, it is scheduled to be in service by mid-2005. CIG held an open season for the pipeline last year and has long-term contracts for its full capacity. The pipeline would connect the Cheyenne Hub, in northeastern Colorado just south of Cheyenne, with major markets in the Midwest, and would access supplies of natural gas from Wyoming as well as other Rocky Mountain states.

Williston Basin Interstate Pipeline Co. (WBIPC) is holding an open season for expansion of its Grasslands Pipeline. The company is offering the opportunity to purchase additional capacity for expansion of the Grasslands Pipeline, which has an initial design capacity of 80 MMCF of gas per day and an in-service date of November 1, 2003. The targeted in-service date of the capacity increase would be November 1, 2004. WBIPC will construct 245 miles of 16-inch pipeline starting about 14 miles north of Gillette and ending near Kildeer, North Dakota. The pipeline will transport CBM from the PRB to large markets in the Midwest. The pipeline will be expanded to 200 MMCF per day if the open season is successful.

In other pipeline news, Questar Pipeline Co. purchased CIG's 10% interest in the Overthrust Pipeline. The $1.8 million transaction gives two Questar affiliates a combined 100% ownership in the pipeline. The Overthrust Pipeline is an 88-mile, 36-inch pipeline which transports natural gas from Whitney Canyon-Carter Creek Field eastward to Rock Springs. The pipeline is the westernmost segment of the 793-mile Trailblazer system that terminates in Beatrice, Nebraska, about 40 miles south of Lincoln.

Questar Market Resources agreed to purchase El Paso Gas Gathering & Processing's 50% interest in the Blacks Fork gas processing plant in southwestern Wyoming. Questar will now own 100% of the plant, which currently processes about 80 MMCF of natural gas per day.

The Pinedale office of the U.S. Bureau of Land Management (BLM) approved Questar Exploration & Production Co.'s request to conduct winter-long drilling from a single drill pad in designated mule deer crucial winter range. The pad location for the 4-33 Stewart Point well located in section 33, T33N, R109W, is about 5 miles south of Pinedale. Four additional wells were approved and a sixth well was proposed to be drilled from the same location with no additional surface disturbance. The BLM noted that it is necessary to drill the wells consecutively to accommodate this number of wells while minimizing the surface disturbance.

Devon Energy Corp. announced plans to merge with Houston-based Ocean Energy Inc. Devon is a major CBM producer in Wyoming and has drilled about 1600 CBM wells in the PRB. The company drilled 140 CBM wells in the PRB in 2002 and it expects to drill at least 113 more in 2003. The merger would create the largest oil and gas producing company based in the U.S. Oklahoma-based Devon will be the surviving company in the $5.3 billion merger and will keep the same name. The merger is expected to take place sometime after mid-year.

Lease sales

Leasing activity at the Wyoming Office of State Lands and Investments' October, 2003 sale was concentrated in southwestern Wyoming (**Figure 5**), but the high per-acre bid of $480 was paid by Kennedy Oil for an 80-acre parcel in the PRB that covers NW SW and SE SW section 28, T49N, R78W. Kennedy also paid $440 per acre for a 200-acre lease that covers parts of section 33, T49N, R78W (**location A, Figure 5**). The leases are in an area of CBM development from coals in the Fort Union Formation. This sale generated over $1.2 million in revenue and the per-acre bid averaged $25.77 (**Table 7**). There were 16 parcels at this sale that received bids of $50 or more per acre. The sale scheduled for December, 2003 was cancelled because the acreage available for lease was not of high quality. Three state lease sales in 2002 brought in only $2.2 million, the lowest total in over seven years (**Table 7**).

This lack of drilling permits should be alleviated somewhat when the Record of Decision (ROD) for the PRB Oil and Gas Project Final EIS is signed in 2003.

Leasing activity at the October BLM sale was the heaviest in the PRB (**Figure 6**). The high per-acre bid of $46 was made by Van K. Bullock for an 80-acre lease that covers NE NE and SW NE section 34, T39N, R76W (**location A, Figure 6**). The lease is 1 mile west of the Sand Creek North Field, which has produced from the Frontier and Dakota formations. The sale generated only $578,597 in revenue and the average per-acre bid was only $8.03 (**Table 7**). No parcels at this sale received a bid of $50 or more per acre.

Leasing activity at the December BLM sale was the heaviest in the Bighorn Basin (**Figure 6**). However, the high per-acre bid of $165 was made by Rincon Exploration for a 280-acre parcel in the Washakie Basin (southeastern Greater Green River Basin) that covers parts of section 32, T20N, R95W (**location A, Figure 6**). The lease is within a mile south of Lewis Shale and Almond Formation production on the southwestern flank of Wamsutter Field. Baseline Minerals made the sale's second highest per-acre bid of $150 for a 200-acre lease that covers parts of sections 13 and 24, T37N, R93W (**location B, Figure 6**). The lease is about 3 miles east of Fort Union production at Poison Creek Field. The sale generated only $866,561 in revenue and the average per-acre price was $11.83 (**Table 7**). There were 13 parcels at this sale that received bids of $50 or more per acre. The six BLM sales in 2002 generated only $11.6 million in revenue, which was the smallest amount since 1996 (**Table 7**). The State of Wyoming does receive half of the revenues from these bonus bids, however.

The slowdown in leasing and leasing income for the last two BLM sales is due more to a lack of parcels in general

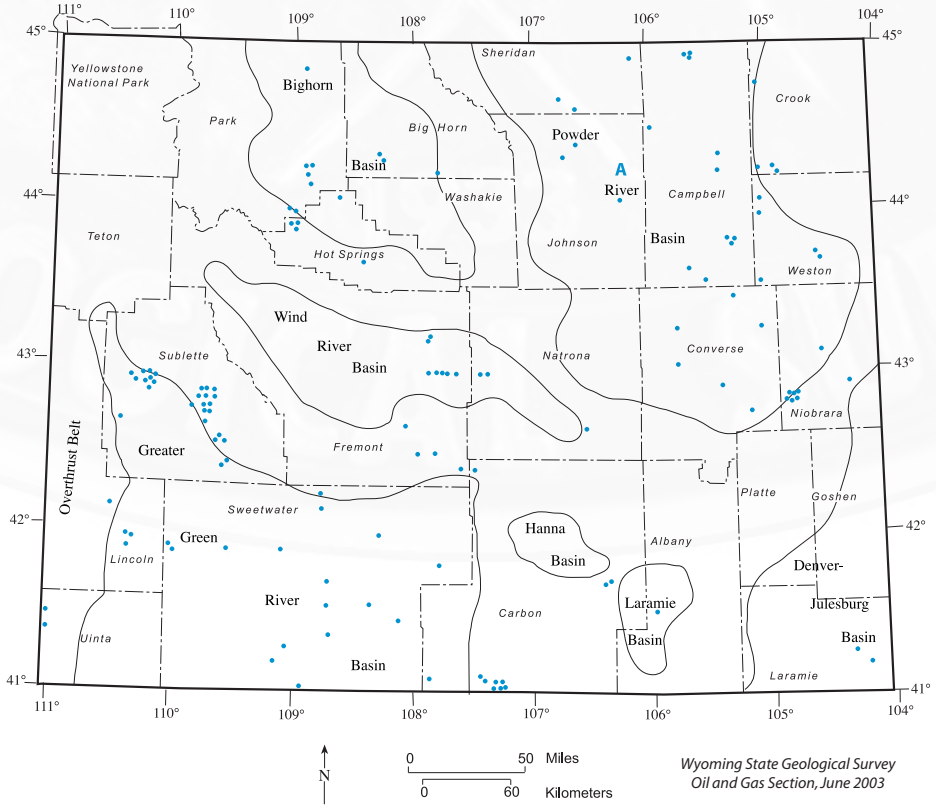

Figure 5. Locations of state oil and gas tracts leased by the Office of State Lands and Investments at its October, 2002 sale. Locations are approximate and may represent more than one tract.

Table 7. Federal and State competitive oil and gas lease sales in Wyoming (1996 through December, 2002).

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											
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											
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											
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00								
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00								
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00				**1998**				
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00	April	$1,203,792	300	161	115,646	63,848	$18.85	$320.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00	June	$1,660,438	300	148	108,654	52,501	$31.63	$600.00
December	$15,229,257	407	278	388,783	277,538	$54.87	$800.00	October	$1,313,792	298	178	98,856	65,212	$20.14	$590.00
								December	$1,045,447	300	187	121,551	77,852	$13.43	$215.00
TOTAL	$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											
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				**1999**				
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00	April	$1,815,526	299	196	123,119	89,194	$20.35	$890.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00	June	$1,002,039	300	190	108,310	69,858	$14.34	$400.00
Octoer	$4,395,288	214	175	195,827	142,525	$30.84	$580.00	October	$2,369,527	300	216	109,140	77,261	$30.67	$475.00
December	$5,598,020	176	164	128,480	124,093	$28.99	$410.00	December	$956,113	291	129	115,502	51,674	$18.50	$500.00
TOTAL	$24,197,991	1069	945	1,060,674	929,674	$26.03	$32,000.00	TOTAL	$6,143,205	1190	731	456,071	287,987	$21.33	$890.00
				2000											
February	$5,497,834	192	180	130,289	120,219	$45.73	$525.00								
April	$3,057,278	189	161	160,712	128,063	$23.87	$440.00				**2000**				
June	$6,387,887	230	184	260,294	190,306	$33.57	$410.00	April	$1,475,661	299	191	120,319	71,933	$19.54	$525.00
August	$5,213,595	240	222	174,040	154,920	$33.65	$475.00	June	$2,119,198	300	197	127,798	79,743	$26.58	$775.00
October	$5,028,610	147	129	149,934	124,724	$40.32	$510.00	October	$1,660,315	300	216	117,598	81,603	$20.35	$268.00
December	$6,352,525	185	179	182,935	180,380	$35.22	$725.00	December	$1,240,442	300	192	109,375	62,636	$19.80	$210.00
TOTAL	$31,537,729	1183	1055	1,058,204	898,612	$35.09	$725.00	TOTAL	$6,495,616	1199	796	475,090	295,915	$21.95	$775.00
				2001											
February	$9,138,921	202	159	224,225	148,972	$61.35	$1,475.00								
April	$10,976,580	185	184	221,147	221,067	$49.65	$530.00								
June	$3,088,796	158	149	144,738	138,088	$22.37	$360.00				**2001**				
August	$7,626,362	204	190	260,409	245,116	$31.11	$525.00	April	$2,250,353	300	212	112,379	82,834	$27.16	$450.00
October	$998,308	119	105	127,396	107,880	$9.25	$160.00	June	$1,754,320	300	192	111,507	66,829	$26.25	$650.00
December	$2,162,599	155	146	125,830	112,159	$9.28	$550.00	October	$679,343	300	129	112,255	53,396	$12.72	$120.00
TOTAL	$33,991,566	1023	933	1,103,745	973,282	$34.92	$1475.00	TOTAL	$4,684,016	900	533	336,141	203,059	$23.07	$650.00
				2002											
February	$5,137,024	219	164	271,248	177,117	$29.00	$345.00								
April	$2,969,094	142	127	136,864	117,852	$25.19	$375.00								
June	$1,183,222	91	63	82,958	55,808	$21.20	$185.00				**2002**				
August	$858,686	124	89	111,462	88,719	$9.68	$205.00	April	$465,104	200	90	74,321	35,084	$13.26	$105.00
October	$578,597	117	86	122,962	72,039	$8.03	$46.00	June	$517,143	200	124	74,608	46,841	$11.04	$525.00
December	$866,561	111	95	86,139	73,237	$11.83	$165.00	October	$1,222,823	198	133	70,800	47,436	$25.77	$480.00
TOTAL	$11,593,184	804	624	811,633	584,772	$19.83	$375.00	TOTAL	$2,205,070	598	347	219,729	129,361	$17.05	$525.00

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 Survey, Oil and Gas Section, April, 2003.*

and a lack of high quality parcels in particular than to lower natural gas prices.

The WOGCC approved 1646 Applications for Permit to Drill (APDs) in the fourth quarter of 2002, which is 1072 less than in the fourth quarter of 2001. The total for 2002 is 4097 less than for 2001, but higher than for any year prior to 2000 (**Table 8**). Campbell County again led with 43.5% of the total APDs that were approved in 2002, with Sheridan and Johnson counties combining for another 36.3% of the total. Nearly all of the approved APDs in these three counties were for CBM tests. The slowdown in APDs this past year when compared to 2001 is due to relatively lower prices for natural gas this past year and to a lack of CBM drilling locations on federal land. This lack of drilling permits should be alleviated somewhat when the Record of Decision (ROD) for the PRB Oil and Gas Project Final EIS is signed in 2003. The Final EIS was released in January, 2003.

The WOGCC permitted six seismic projects in the fourth quarter of 2002. The number of permits is five less than for the fourth quarter of 2001. The number of conventional miles permitted in 2002 was 366 higher than for 2001, but the total square miles of 3-D seismic is 725 less than that for 2001 (**Table 9**). Geophysical activity is a good indicator of future exploration and production drilling. Conventional seismic oftentimes is used as a preliminary exploration tool, while 3-D seismic may be used to define the limits of a reservoir and to locate optimum locations for production wells.

The average daily rig count for the fourth quarter of 2002 was 39. This average is 10 less than for the fourth quarter of 2001. The rig count does not include rigs drilling for CBM. According to **Figure 7**, which shows the Wyoming daily rig count averaged by month and by year, the average rig count of 40 for 2002 was 15 less than for 2001 and the same as in 2000.

Exploration and development

Company data, news releases, and information compiled and published by Petroleum Information/Dwights LLC. are used to track oil and gas exploration and development activity in Wyoming. **Table 10** reports the most significant activities exclusive of CBM (see the **Coalbed Methane Update** for development in that industry) during the fourth quarter of 2002. The numbers correspond to locations on **Figure 8**.

References cited

U.S. Geological Survey, 2002a, Assessment of undiscovered oil and gas resources of the Powder River Basin province of Wyoming and Montana, 2002: USGS Fact Sheet FS-146-02, 2 p.

U.S. Geological Survey, 2002b, Assessment of undiscovered oil and gas resources of the southwestern Wyoming province, 2002: USGS Fact Sheet FS-145-02, 2 p.

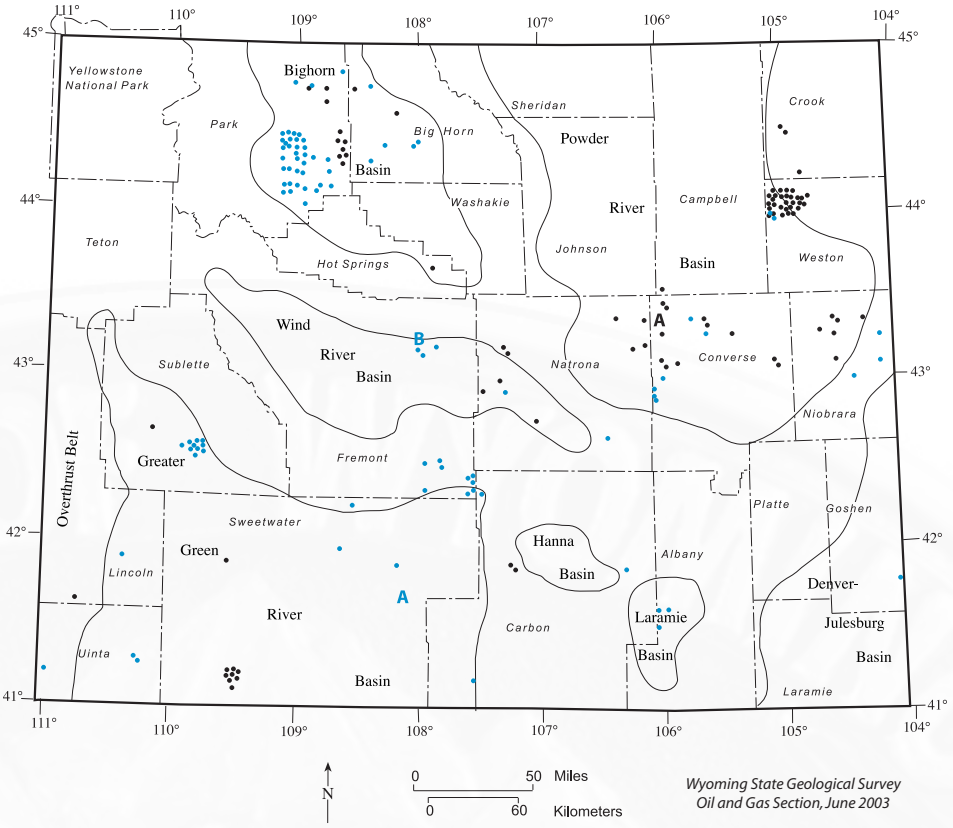

Figure 6. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its October, 2002 sale (locations in black) and its December, 2002 sale (locations in blue). Locations are approximate and may represent more than one tract.

Table 8. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1996 through December, 2002).

County	1996 APDs	1997 APDs	1998 APDs	1999 APDs	2000 APDs	2001 APDs	2002 APDs
Albany	1	0	0	0	0	1	1
Big Horn	53	59	13	6	11	23	8
Campbell	554	941	1586	4461	5580	6204	2793
Carbon	77	84	96	127	174	261	198
Converse	20	16	6	19	70	25	43
Crook	37	26	29	30	47	20	13
Fremont	26	58	76	67	136	149	62
Goshen	0	0	0	0	0	0	1
Hot Springs	24	42	1	8	6	2	9
Johnson	16	6	49	304	769	805	799
Laramie	2	3	2	0	2	3	3
Lincoln	55	122	105	51	70	87	51
Natrona	74	59	36	51	53	45	49
Niobrara	7	8	8	5	18	15	10
Park	30	25	11	12	18	45	23
Platte	0	0	0	0	0	0	0
Sheridan	0	2	35	416	891	1811	1531
Sublette	118	179	230	189	338	435	428
Sweetwater	136	210	181	124	335	534	379
Teton	0	0	0	0	0	0	0
Uinta	10	27	26	26	53	35	16
Washakie	30	36	9	0	7	10	1
Weston	10	5	6	4	20	7	2
Totals	**1280**	**1908**	**2505**	**5900**	**8598**	**10,517**	**6420**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, March, 2003.*

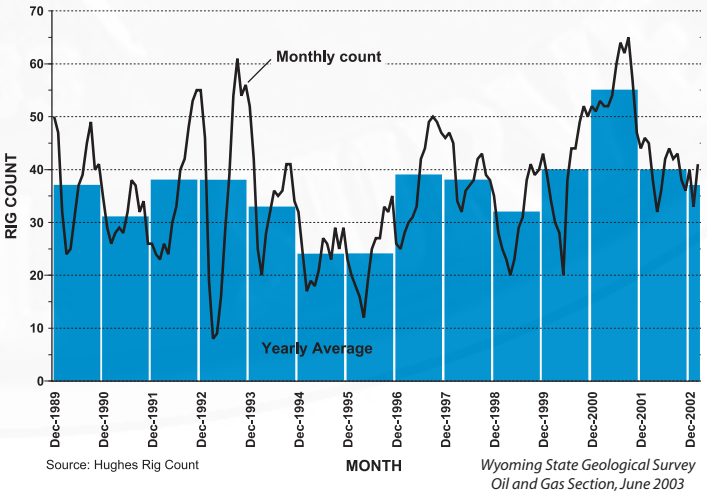

Figure 7. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month and year (December, 1989 through February, 2003).

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1998 through December, 2002).

	1998			1999			2000			2001			2002		
County	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0
Big Horn	1	0	16	0	0	0	1	387	0	1	0	4	0	0	0
Campbell	14	18	182	4	4	10	14	64	132	5	38	3	10	49	3
Carbon	4	0	318	5	77	57	0	0	0	1	500	0	4	419	3
Converse	4	12	239	1	0	50	1	15	0	0	0	0	2	6	47
Crook	2	2	4	1	0	10	7	16	22	4	32	0	1	0	2
Fremont	2	100	0	1	0	88	4	25	116	2	70	15	1	160	0
Goshen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	4	19	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnson	1	4	0	0	0	0	4	35	0	2	4	4	1	16	0
Laramie	0	0	0	0	0	0	0	0	0	0	0	0	1	0	18
Lincoln	1	10	0	1	0	32	0	0	0	1	0	25	0	0	0
Natrona	6	12	214	2	0	230	5	36	135	2	19	63	4	11	72
Niobrara	0	0	0	5	16	31	1	0	25	1	0	16	3	3	52
Park	3	16	132	3	25	32	1	13	0	4	21	20	0	0	0
Platte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	1	14	0	0	0	0	0	0	0	2	0	81	0	0	0
Sublette	2	1	115	3	0	308	4	77	44	10	261	374	1	464	0
Sweetwater	6	214	66	9	0	530	13	54	1004	11	129	802	7	348	485
Teton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	2	0	147	1	0	26	0	0	0	1	259	0	2	196	0
Washakie	4	41	35	1	0	8	0	0	0	0	0	0	1	21	0
Weston	1	0	35	1	40	0	0	0	0	0	0	0	0	0	0
Totals	**58**	**463**	**1503**	**38**	**162**	**1412**	**55**	**722**	**1478**	**47**	**1333**	**1407**	**39**	**1699**	**682**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, March, 2003.*

Table 10. Significant exploration and development wells in Wyoming, fourth quarter of 2002[1]. Number corresponds to location on Figure 8.

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
1	Chevron USA	4-32M Chevron-Federal	SE NE sec 32, T19N, R119W	Mission Canyon Ls.	14,276-15,115	2.1 MMCF	New producer on the north end of Whitney Canyon-Carter Creek Field
2	True Oil	32-22 Klaenhammer-Federal	SW NE sec 22, T32N, R115W	Frontier Fm.	11,806-11,114	1.6 MMCF 27 BBL cond 55 BBL H_2O	New producer in Soda Field
3	Burlington Resources	33-27 Muddy Creek Unit	NW SE sec 27, T30N, R111W	Mesaverde Fm. Lance Fm.	8264-8887 undisclosed	594 MCF undisclosed	Wildcat discovery, company will commingle production from Mesaverde and Lance
4	Anschutz Exploration	1-28D Mesa	NE NE sec 28, T32N, R109W	Lance Fm.	20 intervals 8616-13,800	17.8 MMCF 1 BBL cond 8 BBL H_2O	New Pinedale anticline producer
	Anschutz Exploration	4-27 Mesa	NW NW sec 27, T32N, R109W	Lance Fm.	19 intervals 8661-14,194	9.4 MMCF 8 BBL cond 13 BBL H_2O	New Pinedale anticline producer
	Anschutz Exploration	5-35 Mesa	SW SW sec 35, T32N, R109W	Lance Fm.	20 intervals 8144-13,638	8.8 MMCF 8 BBL cond 11 BBL H_2O	New Pinedale anticline producer
	Anschutz Exploration	15-35 Mesa	SW SE sec 35, T32N, R109W	Lance Fm.	12 intervals 9478-12,536	7.5 MMCF 7 BBL cond 18 BBL H_2O	New Pinedale anticline producer
	Anschutz Exploration	6-27 Mesa	SE NW sec 27, T32N, R109W	Lance Fm.	16 intervals 8435-12,695	4.5 MMCF 1 BBL cond 7 BBL H_2O	New Pinedale anticline producer
	Ultra Resources	7-19 Boulder	SW NE sec 19, T31N, R108W	Lance Fm.	several intervals 8040-12,255	10.1 MMCF 54 BBL cond 407 BBL H_2O	New Pinedale anticline producer
	Ultra Resources	9-2 Riverside	NE SE sec 2, T31N, R109W	Lance Fm.	14 intervals 8608-12,711	10.2 MMCF 57 BBL cond 135 BBL H_2O	New Pinedale anticline producer
	Ultra Resources	9-34 Mesa	NE SE sec 34, T32N, R109W	Lance Fm.	18 intervals 8188-13,482	11.3 MMCF	
	Burlington Resources	41-8 Grindstone	NE NE sec 8, T32N, R111W	Lance Fm. Mesaverde Fm.	3 intervals 10,169-11,035 11,608-11,783	485 MCF 800 MCF 120 BBL H_2O	Pinedale anticline wildcat discovery
	Shell Rocky Mountain Production	2-14 Riverside	NW NE sec 14, T31N, R109W	Lance Fm.	6 intervals 10,927-12,014	8.3 MMCF 57 BBL cond 6 BBL H_2O	New Pinedale anticline producer

Table 10. *Continued*.

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
4	Questar Exploration & Production	7-21 Mesa	SW NE sec 21, T32N, R109W	Lance Fm.	12 intervals 8526-12,813	17.5 MMCF 82 BBL cond 60 BBL H_2O	New Pinedale anticline producer
5	McMurry Oil	8-25 Cabrito	SE NE sec 25, T29N, R108W	Lance Fm.	10 intervals 8949-11,816	7.6 MMCF 210 BBl cond 40 BBL H_2O	New producer in Jonah Field
	McMurry Oil	16-30 Corona-SHB	SE SE sec 30, T29N, R108W	Lance Fm.	10 intervals 7416-10,436	6.9 MMCF 85 BBL cond 95 BBL H_2O	New producer in Jonah Field
6	GMT Energy	34-1R Federal	SW NW sec 34, T20N, R101W	Frontier Fm.	6939-6946	408 MCF	Wildcat discovery
7	Davis Petroleum	1-3 Red Lake-Federal	NE NW sec 1, T23N, R98W	Rock Springs Fm.	9987-10,580		Wildcat discovery
8	Forest Oil	9-18 Wild Rose-Federal	NE SE sec 18, T17N, R94W	Almond Fm.	2 intervals 10,740-10,819 10,973-11,071	5.8 MMCF 198 BBL cond 40 BBL H_2O	New producer in Wild Rose Field
9	True Oil	11-18 Mull-Federal	NW NW sec 18, T15N, R94W	Almond Fm.	12,625-12,643	6.7 MMCF 17 BBL H_2O	New producer in Mulligan Draw Field area
10	Bill Barrett Corp	4-29 East Cave Gulch	SE SW sec 29, T37N, R86W	Lance Fm.	5 intervals 8791-9358	1.4 MMCF 8 BBL cond 63 BBL H_2O	New producer on eastern flank of Waltman Field
11	Ute Oil	4-1 VE Bar	NE NE sec 4, T42N, R92W	Phosphoria Fm.	2906-2920	15.5 MCF 35 BBL oil	Wildcat discovery
12	True Oil	33-8 Thompson-Federal	NW SE sec 8, T52N, R69W	Minnelusa Fm.	7482-7510	290 BBL oil	New producer in Gibbs Field
13	EOG Resources	2-30 Crotalus	NE NW sec 30, T38N, R75W	Frontier Fm.	12,742-12,762	433 BBL oil 491 MCF 1 BBL H_2O	Stepout from Snake Charmer Draw Field discovery

[1]Abbreviations include: MCF=thousands of cubic feet of natural gas; MMCF=millions of cubic feet of natural gas; BBL=barrels; cond=condensate; H_2O=water; Ls.=Limestone; Fm.=Formation. *Wyoming State Geological Survey, April, 2003.*

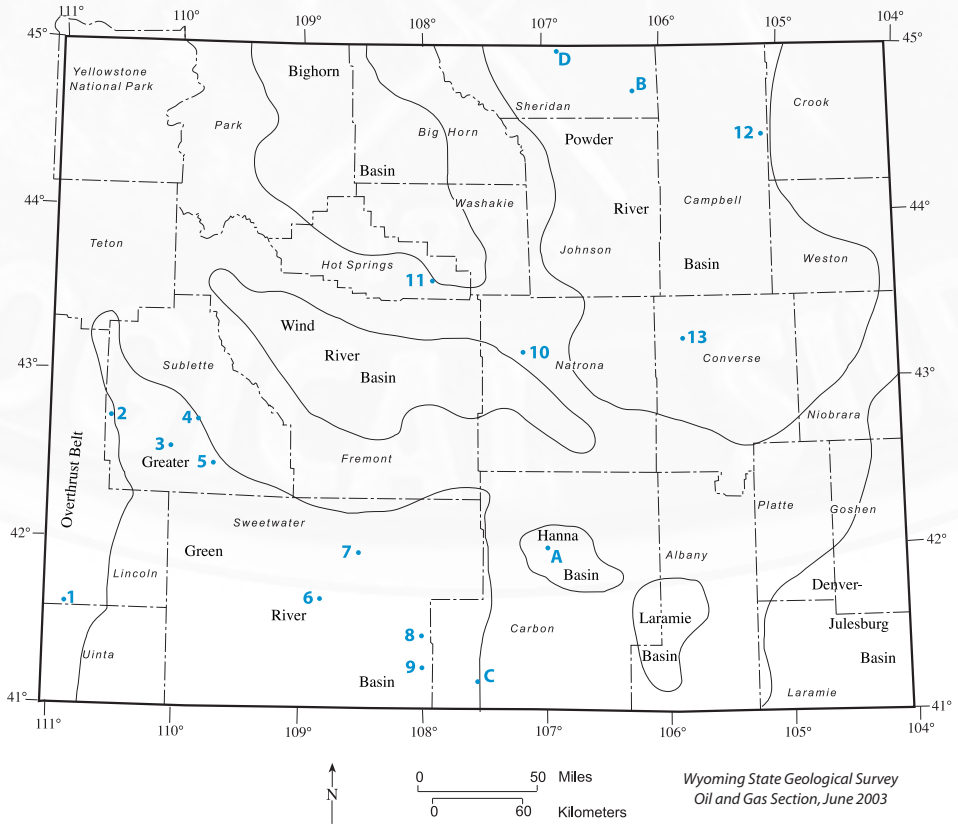

Figure 8. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 2002. Letters indicate coalbed methane developments described in the Coalbed Methane Update. Locations are approximate and may represent more than one well location or project.

Coal Update

Robert M. Lyman, Wyoming PG-656

Staff Geologist–Coal, Wyoming State Geological Survey

By the end of the fourth quarter, 2002, Wyoming coal mines had once again set an annual coal production record. The final production figure was about 373.2 million short tons, an increase of about 1.23% over production in 2001 (**Table 1**). U.S. coal production reached nearly 1.1 billion short tons in 2002 (according to the U.S. Office of Surface Mining), with Wyoming coal accounting for 34.5% of the national total. We currently estimate a modest 2% increase in Wyoming coal production for 2003, for a lofty total of 380 million short tons.

Our outlook for 2003 is somewhat clouded by the lack of activity in the Powder River Basin (PRB) coal market. In the last quarter of 2002, demand for Wyoming coal slackened, as little spot coal was available and the price doldrums seen earlier in the year returned. When "sold out" signs were hanging on the mines after the scramble for spot coal in the third quarter, 2002, coal buyers didn't stop by in the fourth quarter.

How Wyoming's PRB mines react to the market slowdown could vary. Thinking that current prices could be too soft, some operators may trim back production plans for 2003. Other operators may ramp up production, figuring that troubled Central and Eastern U.S. mines may not be able to supply the needs of their customers due to the Haden ruling. This could provide Wyoming operators the opportunity for further market inroads.

U.S. coal production reached nearly 1.1 billion short tons in 2002 (according to the U.S. Office of Surface Mining), with Wyoming coal accounting for 34.5% of the national total.

During the fourth quarter, Kfx Inc. announced a partnership to continue their coal enhancement project, Peabody Energy shifted some of its employees from the Caballo mine to the North Antelope/Rochelle complex to facilitate increased coal production at the latter mine, and Triton Coal's PRB mines were still up for sale. In southern Wyoming, an underground mine property is being revived and a surface mine once proposed for Uinta County is now being reconsidered for development.

The U.S. Department of Energy (DOE) announced their intent to fund several projects that could involve or present opportunities for Wyoming coal, including gasification technologies for low rank coals and lignite; cleaning contaminants from syngas made from coal; sequestration of carbon dioxide from coal-fired power plants; and ways to reduce water use in steam generating plants fueled by coal. Finally, the federal government increased the acreage of federal coal leases in Wyoming and the U.S. that can be held by a single company. Recent mine consolidations and property transactions, especially in the PRB, prompted the regulation changes.

Production and prices

Final state production figures by mine for 2002 (Stauffenberg, 2002) show that over 96% of the total, or about 359.6 million short tons, was from mines in the PRB (**Table 11**). Campbell County mines produced 332.8 million short tons, an increase of 3.3 million short tons over 2001. Converse County mines produced 26.8 million short tons, 2.2 million short tons more than in 2001. The Belle Ayr, Rawhide, and Jacobs Ranch mines showed the largest increases while the Cordero-Rojo, Black Thunder, Caballo, and Buckskin mines showed decreases. The final production for the PRB was slightly more than what we predicted (compare **Table 12** with Table 14 in *Wyoming Geo-notes No. 76*, April, 2003).

Southern Wyoming mines produced about 13.6 million short tons of coal in 2002, down 6.6% from the 14.5 million short tons in 2001 (**Table 11**). Sweetwater County mines led southern Wyoming with 8.6 million short tons, followed by Lincoln County with 4.2 million short tons, and Carbon County with 0.7 million short tons. The final production for southern Wyoming was slightly less than we had predicted (compare **Table 12** with Table 14 in *Wyoming Geo-notes No. 76*, April, 2003).

Reported coal deliveries to electric utilities from Wyoming mines for the fourth quarter, 2002, were 85.3 million short tons, a decrease of over 10 million short tons from the third quarter and a decrease of about 4 million short tons from the fourth quarter, 2001 (**Table 13**). Monthly deliveries for October and December were the lowest in the last few years (**Figure 9**) and reflect the market downturn discussed above. Contract coal deliveries for the last three months of 2002 were a few million short tons less than those made over the same period in 2001, but spot coal deliveries for the last three months of 2002 were below those for the same period in 1999, 2000, and 2001 (**Figure 10**).

Prices for PRB spot coal (**Figure 11**) improved slightly from the third to the fourth quarter, 2002: the average price for 8400-Btu coal in the third quarter was $4.99 per short ton, compared to $5.07 per short ton in the fourth quarter; 8800-Btu coal sold for an average $6.01 per short ton in the third quarter compared to $6.14 in the fourth quarter. Average

prices for spot coal are from $1.05 per short ton (for 8400-Btu coal) to $1.51 per short ton (for 8800-Btu coal) lower for the fourth quarter of 2002 than for the same period in 2001. Unfortunately, the higher spot prices noted in October, 2002 were short lived as prices fell in both November and December.

Despite the fluctuations seen in the spot coal market, we are still expecting the overall price of Wyoming coal to remain about the same in 2003 as in 2002 and then increase slightly each year after. Our price forecasts for Wyoming coal remain as reported in *Wyoming Geo-notes No. 76* (April, 2003) and estimated by CREG.

Developments in the Powder River Basin (PRB)

Kfx Inc. announced it was forming a partnership with Lurgi South Africa to aid in the commercialization of new K-Fuel plants and to enhance the economics of future plants. The partners' first joint project is the 700,000 ton-per-year K-fuel Plus plant near Gillette (**Figure 12**). Kfx is currently reviewing bids for construction of the plant's major components and is hoping for a start-up date sometime in late 2003. The proprietary K-Fuel process enhances the heat value of low-Btu coals by removing moisture (Coal Outlook, 12/16/2002).

The Encoal plant, idle since 1997, is to be torn down and the site reclaimed (**Figure 12**). Horizon Exploitation Inc. recently assumed ownership of the plant from SGI Interna-

Table 11. Wyoming's coal production by mine from 2001 and 2002*.

County	Mine	2001	2002
Campbell	Belle Ayr	11,750,497	17,452,45
	Black Thunder	67,627,498	65,125,564
	Buckskin	19,176,796	18,334,186
	Caballo	27,116,000	25,965,042
	Cordero-Rojo	43,487,182	38,231,961
	Dry Fork	4,029,100	4,891,403
	Eagle Butte	24,826,910	24,888,124
	Jacobs Ranch	29,334,900	31,728,341
	North Antelope/Rochelle	74,777,460	74,792,642
	North Rochelle	23,872,327	23,883,760
	Rawhide	0	3,484,619
	Wyodak	3,518,162	4,052,374
	Cambell County Total	**329,516,832**	**332,830,461**
Carbon	Medicine Bow	406,806	455,872
	Seminoe II	98,987	258,705
	Carbon County Total	**505,793**	**714,577**
Converse	Antelope	24,643,293	26,808,504
	Converse County Total	**24,643,293**	**26,808,504**
Lincoln	Kemmerer	4,495,265	4,242,456
	Lincoln County Total	**4,495,265**	**4,242,456**
Sweetwater	Black Butte	3,406,256	2,817,419
	Jim Bridger	6,110,696	5,782,014
	Sweetwater County Total	**9,516,952**	**8,599,433**
	State Total	**368,678,135**	**373,195,431**

*Data from 2001 and 2002 Annual Reports of the State Inspector of Mines of Wyoming. *Wyoming State Geological Survey, Coal Section, February, 2003.*

Table 12. Wyoming coal production by county[1,2] (in millions of short tons), 1997 through 2001 with forecasts to 2008.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Powder River Basin												
Campbell County	246.3	274.1	294.3	299.5	329.5	332.8	338.5	341.3	344.1	347.0	349.9	352.9
Converse County	17.8	23.4	25.6	23.6	24.6	26.8	26.0	27.0	28.0	29.0	30.0	31.0
Sheridan County	M	M	M	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	264.1	297.5	320.0	323.1	354.1	359.6	364.5	368.3	372.1	376.0	379.9	383.9
Southern Wyoming												
Carbon County	5	3.5	2.7	2.0	0.5	0.7	2.0	2.0	2.0	2.0	2.0	2.0
Sweetwater County	7.8	9.2	9.4	10.0	9.5	8.6	9.0	9.0	9.0	9.0	9.0	9.0
Lincoln County	4.6	4.7	4.3	3.7	4.5	4.2	5.0	5.0	5.0	5.0	5.0	5.0
Subtotal	17.4	17.4	16.4	15.7	14.5	13.5	16.0	16.0	16.0	16.0	16.0	16.0
Total Wyoming[3]	**281.5**	**314.9**	**336.5**	**338.9**	**368.6**	**373.1**	**380.5**	**384.3**	**388.1**	**392.0**	**395.9**	**399.9**
Annual change	**1.1%**	**11.9%**	**6.9%**	**0.7%**	**8.8%**	**1.2%**	**2.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**

[1]Reported tonnage from the Wyoming State Inspector of Mines (1997 through 2002). [2]County estimates by the Wyoming State Geological Survey, February, 2003 for 2003 through 2008. Totals may not agree because of independent rounding. [3]Estimate modified from CREG's Wyoming State Government Revenue Forecast, October, 2002 and January, 2003. M=minor tonnage (less than a million tons). *Wyoming State Geological Survey, Coal Section, April, 2003.*

Table 13. Estimated monthly coal deliveries from Wyoming's mines in short tons (January, 1998 through December, 2002).

	1998		1999		2000		2001		2002	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
January	26,536,217	26,536,217	27,105,791	27,105,791	27,773,610	27,773,610	27,743,000	27,743,000	28,406,666	28,406,666
February	23,196,152	49,732,369	25,803,390	52,909,181	25,594,109	53,367,719	27,827,000	55,570,000	30,041,748	58,448,414
March	23,861,472	73,593,841	28,222,743	81,131,923	28,262,696	81,630,415	33,739,000	89,309,000	33,409,797	91,858,211
April	24,768,989	98,362,830	25,965,867	107,097,791	25,549,039	107,179,454	27,302,000	116,611,000	27,534,057	119,392,268
May	25,278,960	123,641,790	28,698,498	135,796,288	26,222,515	133,401,969	27,752,000	144,363,000	34,704,299	154,096,567
June	24,450,835	148,092,625	24,753,829	160,550,118	25,085,516	158,487,485	33,968,000	178,331,000	26,674,488	180,771,055
July	25,663,577	173,756,202	28,266,458	188,816,576	28,881,862	187,369,347	29,200,000	207,531,000	27,885,210	208,656,265
August	26,591,950	200,348,152	28,346,757	217,163,333	29,075,295	216,444,642	27,662,000	235,193,000	35,670,535	244,326,800
September	26,041,099	226,389,251	27,373,417	244,536,749	25,865,389	242,310,032	35,369,000	270,562,000	32,234,471	276,561,271
October	26,659,121	253,048,372	26,837,295	271,374,045	26,441,615	268,751,646	29,869,000	300,431,000	26,101,957	302,663,228
November	25,620,216	278,668,588	26,843,021	298,217,066	27,400,245	296,151,892	29,308,000	329,739,000	32,767,619	335,430,847
December	26,102,620	304,771,208	26,834,927	325,051,993	28,300,773	324,452,665	29,984,000	359,723,000	26,476,240	361,907,087
Total Utility Tonnage[1]		**304,771,208**		**325,051,993**		**324,452,665**		**359,723,000**		**361,907,087**
Total Tonnage Other [2]		**10,190,883**		**11,407,945**		**14,399,483**		**8,955,135**		**11,288,344**
Total Tonnage Produced[3]		**314,962,091**		**336,459,938**		**338,852,148**		**368,678,135**		**373,195,431**

[1]From Federal Energy Regulatory Commission (FERC) Form 423 for 1998; FERC Form 423 as modified by WSGS for 1999 through December, 2002. [2]Includes estimates of residential, industrial, and exported coal. [3]Wyoming State Mine Inspector's Annual Reports. *Wyoming State Geological Survey, Coal Section, April, 2003.*

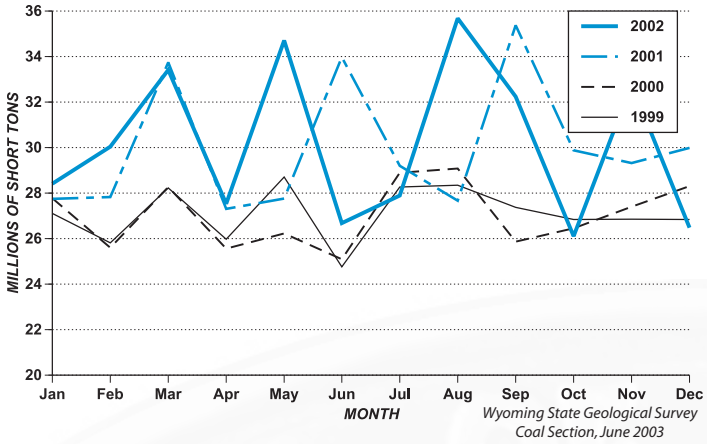

Figure 9. Reported monthly deliveries from Wyoming coal mines (1999 through December, 2002). From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the Wyoming State Geological Survey for 1999 through December, 2002.

tional and has negotiated a back tax settlement of 25 cents on the dollar with the State of Wyoming. The original back tax due from the project was $179,098 accumulated from 2000 through 2002, pending bankruptcy approval. The plant was completed in 1992 as a liquids-from-coal development process (U.S. Coal Review, 12/2/2002).

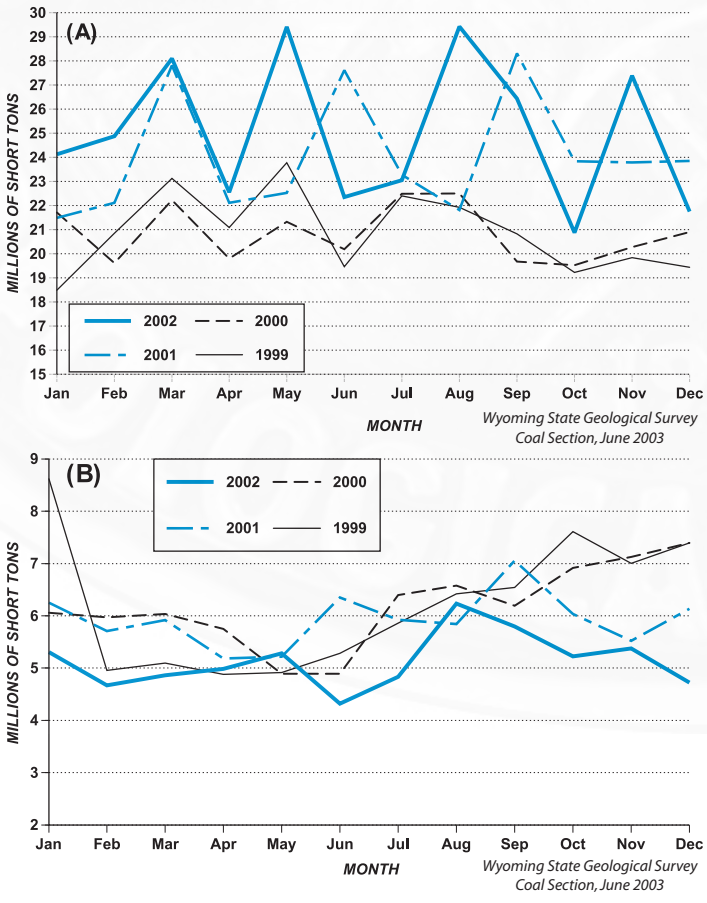

Figure 10. Monthly coal deliveries from Wyoming (1999 through December, 2002). (A) Coal sold on contract and (B) coal sold on the spot market. From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the Wyoming State Geological Survey for 1999 through December, 2002.

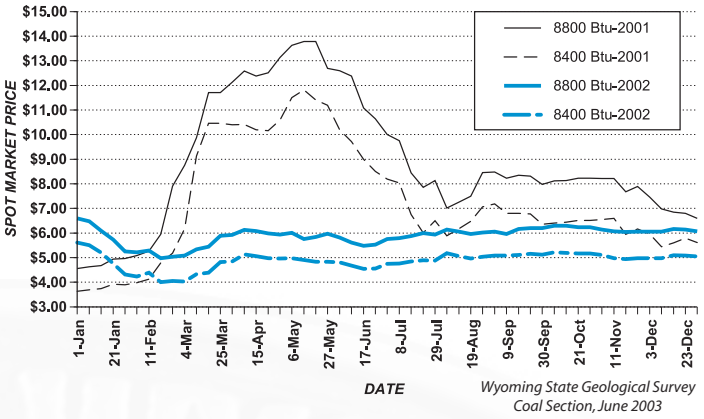

Figure 11. Wyoming Powder River Basin coal spot price watch (January 1, 2002 through December 31, 2002). Modified from COAL Daily's spot market index and Coal Week's short-term spot market price index.

Arch Coal's Black Thunder Mine won the U.S. Mine Safety and Health Administration's Sentinels of Safety Award for achieving America's best surface mine safety record for 2001. Black Thunder employees worked 1.24 million hours in 2001 with no reported injuries (U.S. Coal Review, 9/23/2002).

The Black Thunder mine reached a new production milestone–the first mine in the world believed to have shipped 750 million short tons of coal. The feat involved 25 years of mining at the site and the movement of over 6.9 million railcars. In perspective, Black Thunder produces roughly the same amount of energy daily as a 600,000 barrel-per-day oil field (U.S. Coal Review, 12/9/2002).

Peabody Energy's North Antelope/Rochelle mine complex received the Wyoming Game and Fish Department's Reclamation and Wildlife Stewardship award for the mine's innovative programs promoting wildlife habitat conservation on Wyoming lands.

Peabody reportedly shifted some of its workforce to boost production of 8800-Btu-per-ton coal at the North Antelope/Rochelle complex. The transferees were to come from their Caballo operation, which would decrease its annual production rate from 25 million short tons to 20 million short tons. The North Antelope/Rochelle complex would then increase its annual production from 74.8 million short tons in 2002 to about 84 million short tons in 2003 (U.S. Coal Review, 10/21/2002).

Peabody also announced it would close its Gillette office as part of a cost-cutting plan. The company's 26 Gillette-based employees were to be transferred to Peabody's mine offices south of Gillette. The move was planned for the end of 2002 to trim costs and to better integrate staff support with their area mining operations (U.S. Coal Review, 11/4/2002). Peabody also operates the Rawhide mine north of Gillette.

Black Hills Corp. and Mallon Resources in October announced the planned merger of Black Hills Acquisition Corp. and Mallon. Upon completion of the merger, Mallon would be the surviving entity and a wholly-owned subsidiary of Black Hills Corporation. Black Hills Corp. owns Wyodak Resources Development Corp., operator of the Wyodak mine.

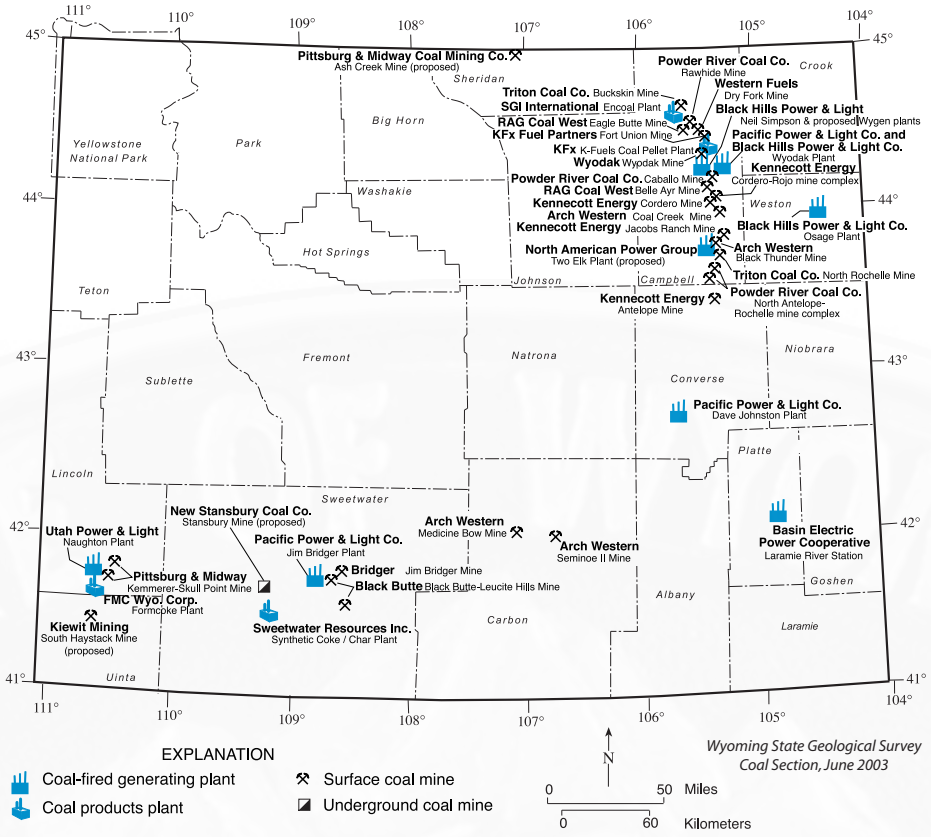

Figure 12. Map of active and proposed coal mines, active and proposed coal-fired power plants, and plants making coal-derived products in Wyoming. Locations are approximate and may represent more than one site.

Mallon is an oil and gas exploration and production company operating primarily in the San Juan Basin of New Mexico (Coal Trader, 12/3/2002).

Triton Coal is still seeking a buyer for its PRB mines. Westmoreland, Peabody Energy, RAG Coal, and even Consol Energy have been mentioned as possible suitors for the company's Buckskin and North Rochelle mines. Peabody Energy may have their eye on the North Antelope operation and Westmoreland may have interest in the Buckskin mine. One scenario is that Peabody would buy both mines then spin off Buckskin and their Rawhide mine to a third party, perhaps Westmoreland or RAG. Consol, who has been frustrated in their attempts at entry into the southern PRB coal scene, may test the waters with Triton. Consol's current Chief Operating Officer, Pete Lily, was formerly head of Triton's coal operations, but Consol (and Lily) may be too busy solving its eastern coal problems (U.S. Coal Review, 12/23/2002). [Author's note: As this issue of *Wyoming Geo-notes* went to press, Arch of Wyoming announced they had purchased both of Triton's properties, pending federal regulatory approval.]

Developments in southern Wyoming

Kiewit Mining is rumored to be dusting off its file on plans to develop a new coal mine in Uinta County, southwest Wyoming (**Figure 12**). The South Haystack property was proposed as a possible mine site by Rocky Mountain Energy and Kiewit back in the late 1970s. At that time, the companies identified nearly 58 million short tons of recoverable coal in the Adaville Formation (Upper Cretaceous) lying under an overburden-to-coal ratio of 6:1. Projected as-received coal quality was 9650 Btus per pound and 0.33% sulfur. The coal is now controlled by Anadarko Petroleum, which acquired the property from Rocky Mountain Energy during the merger of Anadarko and UP Resources in 2000 (U.S. Coal Review, 10/7/2002).

A group of Utah businessmen are believed close to reopening the idle Stansbury deep mine located north of Rock Springs (**Figure 12**). The Utah group formed New Stansbury Coal Company LLC., and hopes to reopen the mine sometime in 2003, with full production (designed for 3 million short tons per year) in the next three years. Coal would be mined from the Upper Cretaceous Rock Springs Formation of the Mesaverde Group. The scheduled reopening is dependent on the group finding a market for the coal. The company plans to use its patented, surface-assisted, continuous underground-mining conveyor system in the operation. Company officials believe this new system (to be showcased at the mine), which runs a conveyor along the coal seam on a monorail, may increase production rates by nearly 30% (U.S. Coal Review, 12/23/2002). The mine, which produced coal as late as 1988, was one of the last large underground mines that operated in the Rock Springs area.

Transportation developments

Effective October 1, 2002, the Western Coal Transportation Association changed its name to the National Coal Transportation Association. With this action, the organization expanded its scope of interest and membership to include transportation of all coal originated and delivered in North America. An Associated Press news release said "the primary mandates of the association to provide education for its members and the public, and to cooperate with carriers to achieve improvements in operating efficiency and in the coal transportation infrastructure, remain unchanged."

A federal judge in Sioux Falls, South Dakota issued an order that prevents South Dakota officials from enforcing some provisions of the law that required the Dakota, Minnesota & Eastern Railroad (DM&E) to get state permission before taking right-of-ways from unwilling owners (see *Wyoming Geo-notes No. 75*, December, 2002). The judge agreed with the railroad that a 1999 law dealing with eminent domain is an illegal hindrance to DM&E's planned project to build into the Wyoming PRB. The judge ruled that portions of the law that required the railroad to prove they have the necessary funding to complete the project is not enforceable by the state. However, the judge did uphold other portions of the law such as that requiring railroads who wish to condemn property to first get state approval by showing that it is a public use and necessity (U.S. Coal Review, 11/16/2002).

...the limit of federal coal lease acreage that can be held in Wyoming by a single company [was increased] from 46,080 to 75,000 acres.

Regulatory developments

The DOE in early December sent out bid solicitations for research projects that can lead to near-term deployment of coal gasification technologies. One research priority will be for technologies that help boost the use of subbituminous coals and lignite in gasification systems, as well as for technologies to find less expensive ways to clean contaminants from syngas made from coal. A pool of $3.6 million will award from three to six grants. DOE is restricting the grants to research universities, but said industry can participate by helping the universities chosen for the grants (Coal Outlook, 12/9/2002).

In a separate announcement, DOE is looking for bids to form Regional Carbon Sequestration Partnerships that will find ways to permanently dispose of carbon dioxide (CO_2) emissions from coal-fired power plants. The goal of these partnerships is to support the President's Global Climate Change Initiative to reduce greenhouse gas intensity 18% by 2012 (Coal Outlook, 12/9/2002).

The DOE also announced a solicitation to fund research projects that look at ways to reduce the amount of water used to generate steam in coal-fired power plants. The research will provide for the development of cost-effective solutions to emerging regulations and restrictions on water use and impacts on water quality. DOE hopes to reduce power plant water consumption per kilowatt-hour by 25% (Coal Outlook, 12/16/2002).

The BLM has amended its regulations to increase the limit of federal coal lease acreage that can be held in Wyoming by a single company from 46,080 to 75,000 acres. Similarly, the national limit was increased from 100,000 acres to 150,000 acres per company. The change was made to help some of the larger coal companies who had neared their national lease limits. Mine consolidations in the PRB had also pushed several operating companies up against the acreage limitations in Wyoming (U.S. Coal Review, 11/25/2002).

Market developments and opportunities

North American Power Group appealed the loss of its construction permit for its Two Elk One coal-fired power plant in Campbell County, Wyoming (**Figure 12**). DTE Energy Services has been named as a potential partner in the construction of the 300-Megawatt (MW) unit. Cost of the project is estimated to be near the $400 million level, with Bechtel mentioned as the contractor. The planned plant will use approximately 2 million tons per year of waste coal, mainly from mines in the area including Black Thunder, Jacobs Ranch, North Rochelle, and the North Antelope/Rochelle complex (U.S. Coal Review, 10/28/2002).

Sunflower Electric Power reported they have found a backer for the $600 to $800 million coal-fired power plant to be constructed in Garden City, Kansas. The new 600-MW plant, which Sunflower hopes will be online by 2007, would be fired by PRB coal (Coal Trader, 10/4/2002).

Table 14 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal, announced during the fourth quarter of 2002.

References cited

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

Stauffenberg, D.G., 2002, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 2002: Office of the State Inspector of Mines, Rock Springs, 87 p.

Table 14. Marketing activities for Wyoming coal producers during the fourth quarter of 2002*.

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
Central Louisiana Electric	System	Jacobs Ranch/PRB	C	2 mt/y	Delivery in 2003
Entergy Services	Independence & White Bluff	PRB	So	1.4 mt	Delivery in 2003
FirstEnergy	System	PRB	So	600,000 to 3 mt/y	Start delivery in 2004 for up to 3 years
Grand River Dam Authority	Chouteau	Caballo/PRB	Sp	210,000 t	Late 2002 through first quarter of 2003
Lansing Board of Water and Light	Eckert	Black Thunder/PRB	C	1.2 mt	Delivery in 2003
Lansing Board of Water and Light	Erickson	Black Thunder/PRB	T	30,000 t	Test
MidAmerican Energy	System	PRB	C	1.5 mt/y	For up to 3 years starting in 2003
Northern Indiana Public Service	Bailly and Schahfer	PRB	So	750,000 t/y	For up to 5 years beginning in 2003
San Antonio City Public Service	System	PRB	C	1.5 mt	Delivery in 2003
San Antonio City Public Service	System	PRB	C	2 mt/y	2004 through 2007
Springfield City Utilities	Springfield (MO)	PRB	So	1.5 mt	1 to 5 year contract
Texas Genco	Limestone	PRB	C	1 mt/y	Up to 3 years

*Data obtained from: Coal Outlook, COAL Daily, U.S. Coal Review, FERC database, and personal contacts. Note: C = contract; mt = million short tons; mt/y = million short tons per year; PRB = Powder River Basin; Sp = spot coal; So = solicitation; t = short tons; and T = test burn. *Wyoming State Geological Survey, Coal Section, April, 2003.*

Coalbed Methane Update

Nicholas R. Jones

Geological Research Assistant–Coal, Wyoming State Geological Survey

Robert M. Lyman, PG-656

Staff Geologist–Coal, Wyoming State Geological Survey

Rodney H. De Bruin, PG-3045

Senior Staff Geologist–Oil and Gas, Wyoming State Geological Survey

Production of coalbed methane (CBM) for 2002 was 327.2 billion cubic feet (BCF), up 28.7% from the previous year (**Table 15**). Wyoming CBM producers nearly reached the State of Wyoming's Consensus Revenue Estimating Group's (CREG's) prediction of 27.5 BCF for monthly CBM production in 2002. Production of methane averaged 27.3 BCF per month during 2002, up from an average 21.2 BCF per month in 2001. The end of 2002 showed 10,737 producing and 3328 shut-in CBM wells in Wyoming. The number of producing wells averaged 9603 per month compared to an average of 6531 producing wells per month in 2001.

Activities

The U.S. Bureau of Land Management (BLM) approved the Seminoe Road Pipeline proposal in the western Hanna Basin. Dudley & Associates, LLC. submitted a proposal to construct 20 miles of natural gas pipeline, access roads, a compressor station, and a storage yard. The project area is located in Carbon County, Ts23 and 24N, R85W (**location A, Figure 8**). The pipeline will transport natural gas from the Seminoe Road CBM pilot project in coals of the Almond Formation in the Mesaverde Group to a distribution network center near Walcott, Wyoming (PI/Dwights Plus Drilling Wire, 11/8/2002).

Galaxy Energy Corp. signed an agreement with Horizon Exploitation Inc. in which Horizon will finance the drilling costs for up to 120 new CBM wells on Galaxy's Powder River Basin (PRB) property in Sheridan County (**location B, Figure 8**). The agreement calls for a pilot program of at least 30 wells with an expected cost of $4.5 million. The anticipated cost for all 120 wells will be nearly $18 million. The working interest in each well will be split, with 85% to Horizon and the remaining 15% to Galaxy. Two years after the pilot program is implemented, Galaxy will have the option to repurchase 50% of the working interest (PI/Dwights Plus Drilling Wire, 12/12/2002).

The Atlantic Rim area of the eastern Washakie Basin in southern Wyoming will see a joint exploration effort between Anadarko Petroleum Corp. and Warren Resources Inc. The area of mutual interest (AMI) is in Carbon County and covers approximately 211,000 acres (**location C, Figure 8**). In December, 2002 it was reported that Anadarko is purchasing 87,700 acres from Warren for $18 million, with $12 million paid in cash and the remaining $6 million in deferred drilling credits. Warren will be assigned contractual interests in 46,600 net acres by Anadarko so that both companies will have 50% undivided interest in 134,300 net acres within the AMI (PI/Dwights Plus Drilling Wire, 12/23/2002).

Table 15. Monthly and cumulative Wyoming coalbed methane production[1] in MCF[2] (1998 through December, 2002).

	1998		1999		2000		2001		2002	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	1,962,669	1,962,669	3,660,434	3,660,434	8,461,780	8,461,780	18,201,908	18,201,908	25,565,938	25,565,938
February	1,882,421	3,845,090	3,462,685	7,123,119	8,706,458	17,168,238	16,892,486	35,094,394	23,307,520	48,873,458
March	2,134,042	5,979,132	4,110,431	11,233,550	9,872,362	27,040,600	19,707,066	54,801,460	25,906,264	74,779,722
April	2,154,252	8,133,544	4,040,989	15,274,539	10,565,807	37,606,407	19,541,037	74,342,497	25,261,800	100,041,522
May	2,254,160	10,387,257	4,422,581	19,697,120	11,831,227	49,437,634	20,620,560	94,963,057	27,147,588	127,189,110
June	2,369,015	12,756,559	4,605,167	24,302,287	12,199,486	61,637,120	20,411,571	115,374,628	26,315,894	153,505,004
July	2,455,931	15,212,490	4,877,924	29,180,211	13,024,856	74,661,976	21,418,942	136,793,570	28,123,520	181,628,524
August	2,654,655	17,867,145	4,793,060	33,973,271	14,180,161	88,842,137	22,250,477	159,044,047	28,844,705	210,473,229
September	2,988,544	20,855,689	5,125,811	39,099,082	14,390,965	103,233,102	21,550,038	180,594,085	28,451,541	238,924,770
October	3,158,168	24,013,857	5,961,192	45,060,274	15,393,978	118,627,080	23,996,891	204,590,976	29,474,971	268,399,741
November	3,188,985	27,202,842	5,947,893	51,008,167	15,220,163	133,847,243	23,768,106	228,359,082	29,183,514	297,583,255
December	3,434,905	30,637,747	7,180,697	58,188,864	16,852,924	150,700,167	25,622,941	253,982,023	29,876,270	327,459,525
Total		**30,637,747**		**58,188,864**		**150,700,167**		**253,982,023**		**327,459,525**

[1]Data from the Wyoming Oil and Gas Conservation Commission. Totals for 2002 now include production in the Powder River Coal Field plus production from other fields in Wyoming. [2]MCF=thousands of cubic feet. *Wyoming State Geological Survey, April, 2003.*

A report by the U.S. Department of Energy (DOE) raised previous estimates of the amount of economically recoverable CBM in the PRB. The DOE commissioned a study through its National Energy Technology Laboratory (see http://www.netl.doe.gov/scng/policy/refshelf/PowderRiverBasin.pdf) to help federal and state agencies plan for future development. According to the study, the amount of CBM to be produced will depend mainly on the choice of water disposal method. The report concluded that more than 29 trillion cubic feet (TCF), or 75% of the estimated 39 TCF of technically recoverable gas, can be economically produced using a surface-discharge disposal method. The study did not include deep reinjection as a disposal method because of its cost and did not assess the amount of produced water which would meet permitting standards for this type of disposal method. The study considered other water disposal methods and their effects on recoverable CBM. Construction of infiltration impoundment ponds would likely yield 28 TCF of recoverable CBM. Reinjection of water into shallow, fresh-water zones would likely yield 27 TCF of recoverable CBM. Using the reverse osmosis process for treating produced water would cut the amount of recoverable CBM to between 18 and 22 TCF (PI/Dwights Plus Drilling Wire, 12/18/2002).

In November, 2002, an article in the Casper Star-Tribune highlighted a prototype fish farm that plans to use produced CBM water to fill its tanks. The company, AquaMatrix, has already started work on the project. The fish farm is located 15 miles northeast of Sheridan (**location D, Figure 8**). The Jackson-based company received $296,000 from a federal small business grant to build the prototype. Sheridan College is partner in the project that anticipates producing up to two million pounds of fish per year. The fishery plans to be stocking the first fish in April or May of 2003. President John Woiwode of AquaMatrix, said that this project is a great way to make an asset from the perceived liability of CBM-produced water.

The Bush Administration is emphasizing increased development of natural gas...BLM will receive $1 million to enhance, expedite, and enforce the regulation, implementation, and administration of drilling.

Wyoming Governor Dave Freudenthal spent time with gas producers and industry representatives in a meeting focused on streamlining the regulatory and permitting processes in Wyoming. Freudenthal stated that the CBM Coordination Coalition (CBMCC) will continue to receive support and funding from the State of Wyoming during his four-year term.

Campbell County, founding county of the CBMCC, has dropped out of the organization, leaving four remaining counties, two conservation districts, and industry and state representatives to continue. Campbell County commissioners voted three to one in favor of withdrawing from the CBMCC. The coalition was established two years ago in an effort to smooth out effects of the booming CBM development in the state.

Regulatory issues

The Bush Administration is emphasizing increased development of natural gas. To help get the ball rolling, the BLM will receive $1 million to enhance, expedite, and enforce the regulation, implementation, and administration of drilling. The total allotment will be divided into $350,000 specifically to be used to process drilling applications, and the remaining $650,000 put into an inspection and enforcement fund that will also be used to speed up the application process.

The BLM released the final PRB Oil and Gas Environmental Impact Statement (EIS). The final draft of the report had been delayed because the Environmental Protection Agency's perceived concerns about deficiencies in air and water impact analysis. The EIS covers oil and gas recovery and development in the PRB and is available at BLM field offices in Wyoming and online at http://www.prb-eis.org.

Industrial Minerals and Uranium Update

Ray E. Harris, Wyoming PG-46

Senior Staff Geologist–Industrial Minerals and Uranium, Wyoming State Geological Survey

Production of the major industrial minerals mined in Wyoming continued to remain steady or increased slightly during the last quarter of 2002. Bentonite production was nearing an all-time record, construction aggregate production was strong, and trona production was at least equal to the previous year. Despite a nationwide economic slowdown, Wyoming's industrial mineral industries continue to prosper. Some prices have declined, but production remained high.

Uranium continued to be produced at two *in situ* localities in Wyoming. Production of yellowcake decreased from 1.6 million pounds in 2001 to 1.4 million pounds in 2002. The price of yellowcake remained steady at $9.90 per pound during the fourth quarter of 2002.

Bentonite

Bentonite production continued at near-record levels. The U.S. Geological Survey (USGS) reported that an estimated 4.1 million short tons of bentonite were mined in Wyoming in 2002, down less than 0.25% from 2001. Bentonite is used in a variety of products and materials from foundry molds, taconite pellet binders, absorbents of hazardous material spills, mineral fillers, water isolation barriers, drilling mud, and many others. As in the past several years, the greatest use of bentonite from Wyoming is in kitty litter.

Construction aggregate

Construction aggregate production in Wyoming is mainly seasonal and peaks during the summer highway and outdoor structure construction season. With the onset of winter, construction aggregate production declined. However, 2002 production was very strong.

Decorative and dimensional stone

Raven Quarries Mirage® and Raven® production remained closed during the fourth quarter of 2002. At the end of the year, quarrier Toby SerVoss purchased the company. Raven Quarries continued to produce fieldstone for the Front Range market.

Vermont Quarries scheduled a test-drilling program north of Laramie for January 2 and 3, 2003 (**Figure 13**). Due to inclement weather and other conditions, only a few feet of core were recovered. The program, which is investigating a blue iridescent anorthosite (see *Wyoming Geo-notes No. 76*, April, 2003), will be reevaluated at the end of the first quarter of 2003.

Shoshone Oil & Gas shipped a block of travertine from the Wind River Indian Reservation (**Figures 13** and **14**) to Strid Marble and Granite in Cheyenne for cutting and polishing. The finished pieces will be exhibited for market testing and if the material appears to be of economic value, quarrying may be contracted.

Trona

Trona mining and soda ash production in Wyoming in 2002 was slightly less than the 17.7 million short tons of mined trona in 2001 (**Table 1**). Statistics from the USGS (http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/610303.pdf) show the 2002 production of soda ash by U.S. producers was identical to 2001. Trona production slumped during the third quarter of 2002 due to a West Coast dock workers lockout, but rebounded slightly during the fourth quarter despite the continuation of the lockout into November. The price of soda ash declined slightly during the fourth quarter.

Trona is mined in Wyoming at five underground mines and refined into soda ash and other sodium compounds at mine-mouth plants. Four companies (FMC, General Chemical Soda Ash Partners, OCi, and Solvay Minerals) operate the mines and refining plants (**Figure 13**).

Thorium

One of the world's largest thorium resources is located in the Bear Lodge Mountains of northeast Wyoming (**Figure 13**). Thorium is a radioactive element that has been tested in nuclear power plants and proposed as a source of energy in breeder reactor technology. It is currently used in small quantities in gas lantern mantles. Unlike uranium, thorium is not soluble in water-based solutions at standard temperatures and pressures. Instead, it is processed using physical separation techniques due to its high specific gravity. Large-scale commercial use of thorium as an energy source is probably many years away.

Uranium

The spot market price of yellowcake (oxidized uranium—the product of Wyoming's uranium mills) remained steady during the fourth quarter of 2002 at $9.90 per pound of yellowcake, according to the Ux Consulting Company, LLC., The Uranium Exchange Company (http://www.uxc.com/review/uxc_prices.html), and the Rocky Mountain Minerals Scout. Yellowcake is uranium oxide with a varying amount

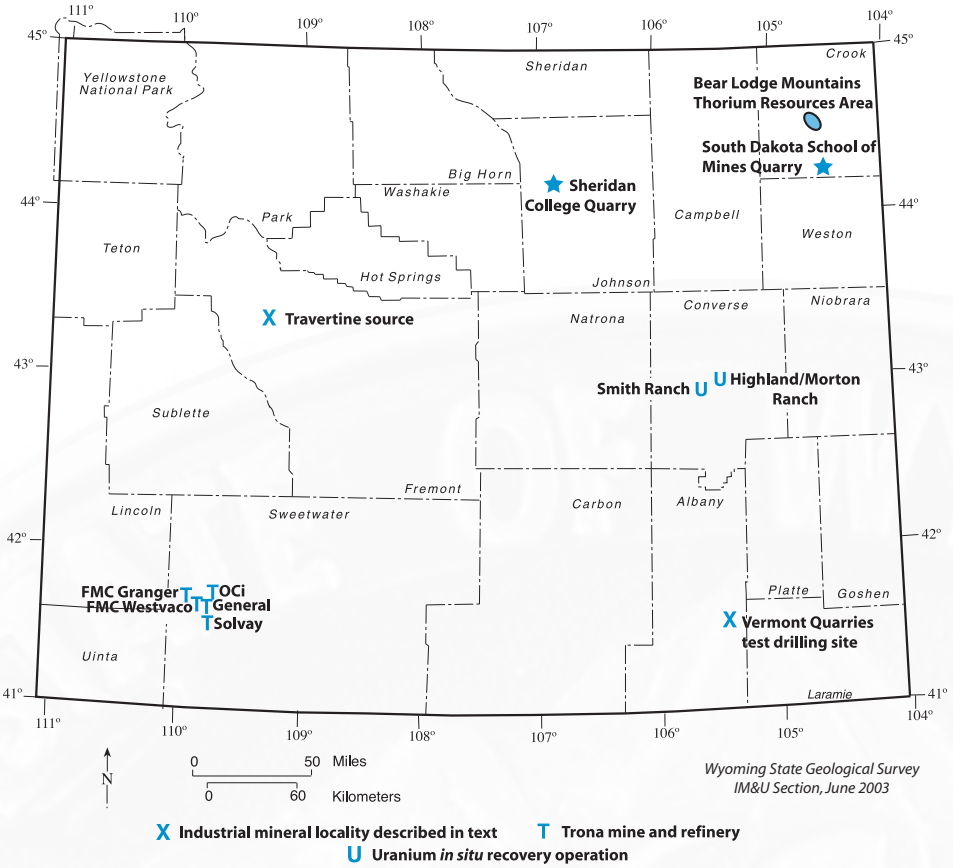

Figure 13. Index map of Wyoming showing the location of industrial mineral sites, radioactive mineral sites, and State of Wyoming permitted dinosaur quarries (blue stars). Locations are approximate and may represent more than one site.

Figure 14. Cut travertine from the Wind River Indian Reservation. The slab is a light sand color with darker markings. Pen for scale.

of other elements, having no definite chemical formula (**Figure 15**).

Wyoming's uranium production for 2002 was 1,405,353 pounds of yellowcake (Stauffenberg, 2002), a decrease from the 1.6 million pounds in 2001 (**Table 1**). Uranium is produced in Wyoming at two *in situ* recovery sites, Smith Ranch and Highland/Morton Ranch by CAMECO (**Figure 13**). CAMECO, of Saskatoon, Saskatchewan, also owns the only other current uranium production in the U.S. at Crow Butte, Nebraska.

The Wyoming Water and Waste Advisory Board approved changes to a rule requiring uranium *in situ* producers to restore groundwater uranium levels. The current rule requires that groundwater in former *in situ* mined areas be restored to 1 part per million (ppm) uranium in water. The new rule will require that restoration to pre-existing groundwater levels not exceed 5 ppm. The rule change means that uranium producers do not have to significantly increase the water quality from original values upon site restoration, but must return the area to its original groundwater quality, not to exceed 5 ppm uranium in water.

Reference cited

Stauffenberg, D.C., 2002, Annual report of the State Inspector of Mines of Wyoming, for the year ending December 31, 2002: Wyoming Department of Employment, Office of the State Inspector of Mines, Rock Springs, Wyoming, 87 p.

Figure 15. Yellowcake in final processing stages at CAMECO's Highland-Morton Ranch operation. From this vat, yellowcake is dried and shipped in steel drums. Since uranium gives up only alpha particles at its first stage of decay, heavy shielding is not necessary for yellowcake storage and transport.

Metals and Precious Stones Update

W. Dan Hausel, Wyoming PG-1025

Senior Economic Geologist–Metals and Precious Stones, Wyoming State Geological Survey

With the increased price for gold, some deposits in Wyoming are receiving attention. Besides the usual interest in South Pass, the Carissa mine still contains considerable gold mineralization and remains a viable gold prospect. The Rattlesnake Hills area of central Wyoming contains many gold anomalies in a variety of host rocks but most have not been fully tested. Other areas include the Silver Crown area in southeastern Wyoming, the Oregon Buttes region in western Wyoming, and the Bear Lodge Mountains and Mineral Hill areas in northeastern Wyoming.

Exploration for platinum-group metals (PGMs) is expected to continue in the Medicine Bow Mountains and Sierra Madre. Several areas south of the Palmer Canyon cordierite and corundum deposit are geologically similar to Palmer Canyon and will be investigated further by the Wyoming State Geological Survey (WSGS).

The Metals and Precious Stones Section supports and builds its extensive database on gemstones and metal resources through a combination of compilation, field mapping, and sampling projects. A STATEMAP 2002 project for the Keystone 1:24,000-scale Quadrangle will be completed this summer and a STATEMAP 2003 project for the Saratoga 1:100,000-scale Quadrangle will begin this August.

Exploration activities

Exploration for gold, PGMs, and gemstones is anticipated for the 2003 field season. Base metal prices remain depressed and we do not anticipate any exploration for base metals (other than possibly nickel) this summer.

During the fourth quarter of 2002, various companies showed interest in a few Wyoming gold deposits due to price increases for gold. Some of these include a deposit in the Silver Crown district, anomalies and prospects in the Rattlesnake Hills, the Carissa mine at South Pass, the Oregon Buttes paleoplacer near South Pass, a prospect in the Bear Lodge Mountains, and a prospect at Mineral Hill.

One area of recent interest is the Copper King gold-copper deposit located in the Silver Crown district between Cheyenne and Laramie (**Figure 16**). Past exploration activities on this property identified an *in situ* resource of about 770,000 ounces of low-grade gold mineralization (Hausel, 1997). The property was recently leased to investigate the possibility of identifying additional resources.

In 1981, the WSGS identified a significant gold anomaly in a greenstone belt in the Rattlesnake Hills west of Casper (**Figure 16**). The WSGS later mapped and identified several additional anomalies in a region that was unknown for gold (Hausel, 1996). Three companies also identified several prospects (with some significant anomalies) in this district during the 1980s and 1990s. One of the prospects, Goat Mountain, was estimated to potentially host more than 1.0 million ounces of gold, based on sparse drilling (Hausel and others, 2000). In addition to the Goat Mountain prospect, dozens of prospects and potential targets remain to be fully tested in this region. The known gold anomalies are associated with alkalic intrusives, breccias, exhalites (chert and banded iron formation), veins, and stockworks. More than 42 Tertiary alkalic intrusives have been mapped in this district. Some intrusives are gossaniferous, but only a few have been sampled; exhalites have been traced over a few thousand feet of

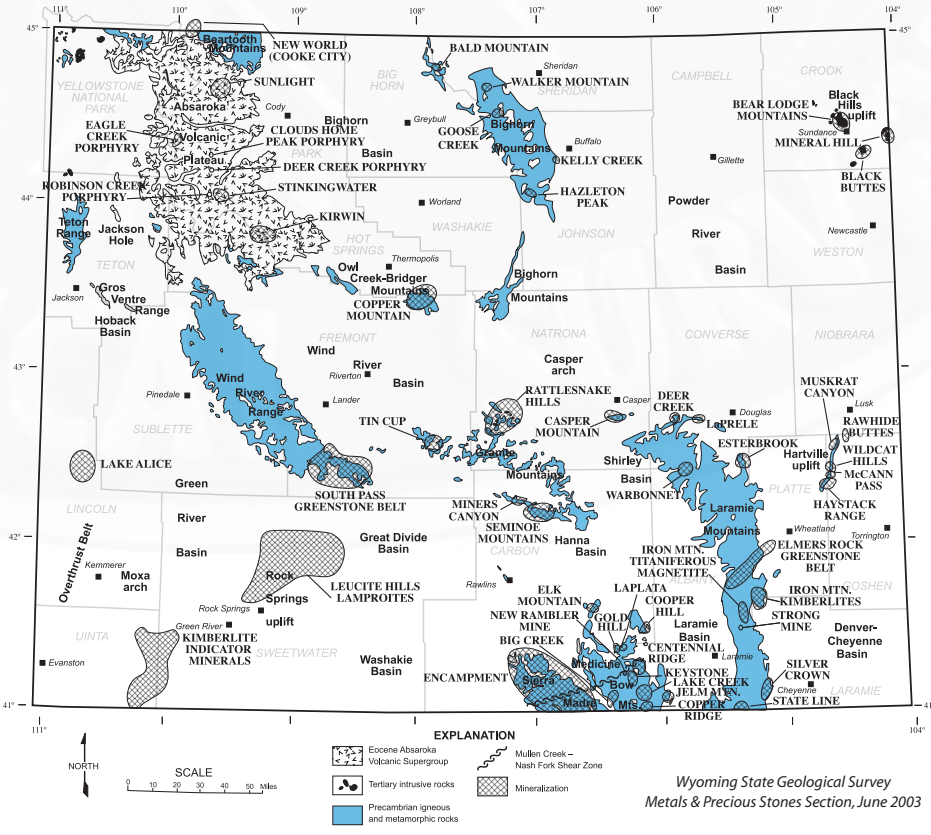

Figure 16. Principal mineralized areas and base and precious metal mining districts in Wyoming.

strike. A gold company based in South Dakota acquired the Goat Mountain prospect in 2003.

High-grade gold mineralization occurs at the Carissa mine near South Pass City (**Figure 16**). The Carissa mine was Wyoming's largest lode gold producer. Based on assay and mine maps along with drilling and surface sampling, this deposit still contains considerable gold mineralization and may be one of the better gold prospects in the state (Hausel, 1991).

An Atlanta-based company that is leasing properties in Wyoming in search of iolite gemstones recently contacted the WSGS.

During the 1980s, Hecla Mining investigated the Oregon Buttes-Dickie Springs paleoplacer near South Pass trying to find the source of the estimated 28.5-million-ounce gold resource. The company identified distinct IP geophysical anomalies associated with a prominent magnetic high, and interpreted the anomalies to represent a buried Homestake-type gold deposit. Due to legal problems, the company was unable to drill the primary targets. However, interest in exploring these anomalies was recently developed by the former project geologist and his clients. Other gold deposits of interest include the Smith Ridge prospect in the Bear Lodge Mountains and the Treadwell open cut at Mineral Hill (**Figure 16**) (Hausel, 1989; 1997).

Exploration for commercial PGMs is expected to continue into the 2003 field season. Several metal anomalies have been identified in the Medicine Bow Mountains and Sierra Madre, and more than $2.5 million has been spent in Wyoming to search for PGMs in southeastern Wyoming in the past few years. PGMs are quite rare and only found in restricted geological environments. Wyoming is considered favorable for discovering significant PGM occurrences (Hausel, 2000).

Continued interest for gemstones is expected throughout 2003. In 1995, the WSGS discovered a deposit of gem-quality cordierite (iolite) with some sapphire (corundum); some of the first faceted stones (**Figures 17** and **18**) from this deposit (Palmer Canyon) are displayed on the WSGS web site at: http://wsgsweb.uwyo.edu/metals/gemstones.asp. Based on similar geology to the Palmer Canyon deposit, the WSGS expects to find more sapphire, ruby, and iolite deposits in the state. The Section will conduct field research on aluminous-rich metamorphic rocks in two regions south of Palmer Canyon that are considered geologically favorable for discovering both cordierite and corundum. An Atlanta-based company that is leasing properties in Wyoming in search of iolite gemstones recently contacted the WSGS.

Services provided by the Metals and Precious Stones Section

The Metals and Precious Stones Section of the WSGS is available to assist government agencies, the general public, prospectors, consultants, private companies, etc. Over the past few decades, the section has developed an extensive database on Wyoming's gemstone and metal resources, igneous and metamorphic geology, and mining districts. The database includes both published and unpublished reports and maps on mineral resources and associated geology, and can be used to generate ideas and concepts for finding potential mineral deposits. Parts of the database, along with field work by the section, have been compiled into publications (both in-house and outside journals) that give prospectors, rock hounds, exploration geologists, and others an overview of where to find certain commodities, mineral localities, and regions of mineral potential.

The Section has mapped many historical mining districts and related geology to support the services provided. Research in these areas is important as

Figure 17. A 3.9-carat Palmer Canyon cordierite necklace. Photograph courtesy of Chuck Mabarak.

Figure 18. A 1.1-carat Palmer Canyon pink sapphire necklace. Photograph courtesy of Chuck Mabarak.

Rock Hound's Corner: Wyomingite and Other Lamproites

W. Dan Hausel, Wyoming PG-1025

Senior Economic Geologist–Metals and Precious Stones, Wyoming State Geological Survey

Wyomingite, one of the rarest rock types found on Earth's surface, was first described in the Leucite Hills of southwestern Wyoming. This rock is scattered throughout a geologically young volcanic field north and east of Rock Springs (**Figure 16**). U.S. Interstate Highway I-80 is a short distance south of the southernmost volcano in the field and a few of the lamproitic volcanoes are visible from various points along I-80. Pilot Butte, a prominent landmark on top of White Mountain northwest of Rock Springs; Boar's Tusk, north of Rock Springs; and Zirkel Mesa (the type-section for wyomingite), north of Superior, are all part of this volcanic field.

The Leucite Hills volcanic field consists of 22 known lamproite flows, dikes, necks, plugs, cinder cones, and pumice cones. Lamproites are ultrapotassic mafic igneous rocks that sometimes contain diamonds (Hausel, Sutherland, and Gregory, 1995). Radiometric dates indicate volcanic activity commenced at about 3.1 million years ago and continued to about 900,000 years ago (Coopersmith and others, 2003). The age of the volcanic activity shows a progression from the northwest (oldest) to the southeast (youngest). Even though the field is considered to be inactive, the range of ages and the amount of time between each eruption may indicate that future eruptions could occur to the southeast. The volcanic centers include lavas, scoria, breccias, tuffs, and agglomerates. Individual flows are limited in size, and vary from 8 inches to 122 feet thick.

The Leucite Hills were first described by Samuel F. Emmons of the 40th Parallel Survey of the U.S. (1867 through 1873). Emmons explored the volcanic field in 1871 and provided samples of the unusual rocks to Professor Ferdinand Zirkel of the University of Leipzig. Zirkel identified the mineral leucite in several of the rock specimens, which was the first report of leucite-bearing rocks on the North American continent.

Six years following Emmons's excursion into the Leucite Hills, F.M. Endlich of the Hayden Survey mapped the northern part of the Leucite Hills. John Wesley Powell of the U.S. Geological Survey (USGS) visited the volcanic field at about the same time and collected samples from Pilot Butte at the extreme western margin of the Leucite Hills. Powell's samples were examined by Whitman Cross of the USGS along with other samples that Cross collected in 1884.

Cross (1897) published a detailed petrographic study on the volcanic field and noted the presence of phlogopite mica in the rocks. Cross also noted an unusual microscopic mineral, which in his words formed small, pale-yellow, amphibole prisms with "...optical characters...unlike any of which I can find on record." This rare amphibole was identified years later as potassium-titanium-richterite, and is essentially restricted to lamproites. The petrographic and chemical studies by Cross resulted in the recognition of three new rock types termed *wyomingite* (**Figure 19**), *orendite* (type-section at Spring Butte), and *madupite* (type-section at Pilot Butte).

Figure 19. Sample of wyomingite displayed in the lobby of the Dan Miller Building (home of the Wyoming State Geological Survey in Laramie. The specimen is a light brown, vesicular rock with glittering crystals of leucite and phlogopite. One-foot-square floor tiles for scale. Photograph by Jaime R. Moulton.

In 1896, J.F. Kemp visited the Leucite Hills and noted the presence of olivine in some of the lamproites. He revisited the volcanic field in 1902 with Wilbur C. Knight of the University of Wyoming. Many years later, Ian Carmichael from the University of California at Berkeley completed cursory studies of these rocks and recommended that a fourth rock type be recognized. Carmichael (1967) termed this rock type *olivine orendite*, for the olivine-bearing flows at North and South Table mountains. [Author's note: olivine also occurs in the lamproites at Wortman dike, Endlich Hill, and Black Rock.] Hausel (1998) collected two anthills near Black Rock to examine the olivine. These two anthills yielded 13,000 carats of olivine as well as a large percentage of gem-quality olivine known as peridot. This was the first known report of peridot in Wyoming (view some of the gemstones on the WSGS web site: http://wsgsweb.uwyo.edu/metals/gemstones.asp).

During 1907 and 1908, the lamproite volcanoes were mapped by the USGS under the direction of Alfred Schultz during a regional study of coal deposits in the Rock Springs uplift. The USGS in 1912 evaluated the volcanics as a poten-

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tial source for potash and during World War I, a quarry was developed on Zirkel Mesa to mine the lamproite for potash.

Additional mapping and geological investigations were completed by Smithson (1959) and Johnston (1959). Ogden (1979) completed a detailed study of the physical geology and geochemistry of the Leucite Hills lamproites and recognized many classical volcanic features including basal rubble zones, lava tubes, spines, dikes, cinder cones, plug domes, and lava rings. Hausel (in preparation) will present a summary of the Leucite Hills volcanic field along with a new geologic map of the area.

Lamproites contain some very unusual minerals. One that is even rare in lamproites is the mineral armalcolite [$(Mg,Fe)Ti_2O_5$]. A research group studying lunar rocks from the Apollo missions identified this mineral from rocks collected at Tranquility Base. The mineral was named armalcolite to honor the Apollo 11 crew. The name of the mineral was made by combining the initials from the last names (Armstrong, Aldren, Collins) of the three Apollo 11 astronauts. As extraordinary as it may sound, this mineral was later discovered in lamproite on Earth!

Other minerals often found in lamproite include diopside ($CaMgSi_2O_6$), phlogopite [$KMg_3AlSi_3O_{10}(OH)_2$], richterite [$K_2(Ti,Mg)_6Si_8O_{22}(OH)_2$], leucite ($KAlSi_2O_6$), sanidine ($KAlSi_3O_8$), wadeite ($K_2ZrSi\neq_3O_9$), and priderite [$(K,Ba)(Ti,Fe)_8O_{16}$]. Some of these minerals are so uncommon, that it is a rare mineralogy book that contains information on them.

In the past, researchers provided local geographic names for the lamproites. Three rock types (wyomingite, orendite, and madupite) were used in Wyoming for the Leucite Hills volcanics, with olivine orendite proposed years later. This system of local names resulted in lamproites with similar chemistry and mineralogy from different localities around the world receiving more than one name.

Mitchell and Bergman (1991) suggested modernizing lamproite nomenclature using descriptive mineralogical classifications to eliminate confusion generated by the type-locality nomenclature. For example, wyomingites from the Leucite Hills are equivalent to fitzroyites in Western Australia.

Because Carmichael (1967) concluded that kimberlite magma and lamproite magma in the Leucite Hills may have a similar origin, the author initiated field reconnaissance in the early 1980s to study the region for diamond potential. Although no diamonds were found, it was reported a short time later that diamonds had been discovered in similar rocks in northern Australia.

References cited

Carmichael, I.S.E., 1967, The mineralogy and petrology of the volcanic rocks from the Leucite Hills, Wyoming: Contributions to Mineralogy and Petrology, v. 15, p. 24-66.

Coopersmith, H.G., Mitchell, R.H., and Hausel, W.D., 2003, Kimberlites and lamproites of Colorado and Wyoming, USA: Field Excursion Guidebook for the 8th International Kimberlite Conference, Geological Survey of Canada, 24 p.

Cross, W., 1897, Igneous rocks of the Leucite Hills and Pilot Butte, Wyoming: American Journal of Science, v. 4, no. 20, p. 115-141.

Hausel, W.D., 1998, Field reconnaissance of the Leucite Hills peridot (olivine) occurrence, Rock Springs uplift, Wyoming: Wyoming State Geological Survey Mineral Report MR98-2, 6 p.

Hausel, W.D. (in preparation) Geology and geochemistry of the Leucite Hills volcanic field, Rock Springs uplift, Greater Green River Basin, southwestern Wyoming: Wyoming State Geological Survey Report of Investigations.

Hausel, W.D., Sutherland, W.M., and Gregory, R.W., 1995, Lamproites, diamond indicator minerals, and related anomalies in the Green River Basin, Wyoming: Wyoming Geological Association 1995 Field Conference Guidebook, p. 137-151.

Johnston, R.H., 1959, Geology of the northern Leucite Hills, Sweetwater County, Wyoming: M.A. thesis, University of Wyoming, Laramie, 83 p.

Mitchell, R.H., and Bergman, S.C., 1991, Petrology of lamproites: Plenum Press, New York, New York, 447 p.

Ogden, P.R., Jr., 1979, The geology, major element geochemistry, and petrogenesis of the Leucite Hills volcanic rocks, Wyoming: Ph.D. dissertation, University of Wyoming, Laramie, 137 p.

Smithson, S.B., 1959, The geology of the southeastern Leucite Hills, Sweetwater County, Wyoming: M.A. thesis, University of Wyoming, Laramie, 92 p.

new ore deposits are most often found in historical mining districts. Many individual properties and/or mines have also been mapped to assist in mineral potential evaluation, e.g., during mapping of the South Pass greenstone belt, more than two dozen underground mines were also mapped and many were sampled in detail.

The Metals and Precious Stones Section is mapping the Keystone district and the Keystone 1:24,000-scale Quadrangle in the Medicine Bow Mountains as a STATEMAP 2002 project (see *Wyoming Geo-notes No. 75*, December, 2002). This district has known gold deposits, platinum-group mineralization, and occurrences of chromium, titanium, vanadium, and iron. One of the only historical commercial palladium mines in North America, the New Rambler, lies within the quadrangle, and areas of the quadrangle along Douglas Creek are popular for gold prospectors. The quadrangle also includes some intensely sheared mylonites and ultramylonites that are part of the Mullen Creek-Nash Fork shear zone (Cheyenne Belt) that has been interpreted by various researchers to represent an ancient Proterozoic subduction zone.

The Section received a new grant under STATEMAP 2003 to compile a geologic map of the Saratoga 1:100,000-scale Quadrangle (see related article on all the WSGS STATEMAP projects in the **Geologic Mapping Paleontology, and Stratigraphy Update**). Work on this project is scheduled to begin in August, 2003. The Saratoga Quadrangle has scientific interest, as parts of the Cheyenne Belt (initially recognized and described by Dr. Robert S. Houston, Professor Emeritus, University of Wyoming) are located within the map area. Like the Keystone area, this region is also considered to have high potential for the discovery of significant diamond, gold, PGMs, base metals, and rare earth metals. The potential for diamond mineralization in this region is especially high due to the presence of numerous fractures along the edge of the Wyoming craton.

Mineral and rock identification is an important part of the Section's service and many people (the general public as well as professional geologists) seek assistance. During a typical year, the Section makes 200 to 500 mineral and rock identifications. Many of these are common variety minerals, but periodically, some unusual to rare minerals are found in Wyoming by prospectors and rock hounds.

Efforts are made to educate the public and the geological community on the state's mineral resources and unique geology. The Section is typically requested to give 40 to 50 talks, lectures, and field trips each year. However, due to conflicts and time constraints, only about two- or three-dozen talks are actually scheduled each year (see http://wsgsweb.uwyo.edu/calendar.asp). The Section also leads field trips and arranges short courses on subjects related to diamond and gold prospecting. In a typical year, the Section may communicate with 3000 to 5000 people directly (not including information provided in published reports or data listed on the Survey's web site).

The Section's objective is to attract industry and promote the state's metal and precious stone resources, and to identify and catalogue these resources for present and future generations. During the past 25 years, the Section has successfully contributed to this objective by: 1) mapping most of the state's metal and gemstone districts; 2) identifying and discovering a gold district and several mineral resources; 3) categorizing many of the state's metal and gemstone resources; and 4) attracting numerous mining companies, consultants, and prospectors to Wyoming.

Mineral and rock identification is an important part of the Section's service and many people (the general public as well as professional geologists) seek assistance.

Recognition

W. Dan Hausel was notified that his scientific accomplishments would be highlighted in the 7th Edition of Marquis' *Who's Who in Science and Engineering* as well as the 58th Edition of *Who's Who in America*.

References cited

Hausel, W.D., 1989, The geology of Wyoming's precious metal lode and placer deposits: Wyoming State Geological Survey Bulletin 68, 287 p.

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., 2 plates (scale 1:24,000).

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., 1 plate (scale 1:24,000).

Hausel, W.D., 1997, Copper, lead, zinc, molybdenum, and associated metal deposits of Wyoming: Wyoming State Geological Survey Bulletin 70, 224 p.

Hausel, W.D., 2000, The Wyoming platinum-palladium-nickel province: geology and mineralization: Wyoming Geological Association Field Conference Guidebook, p. 15-27.

Hausel, W.D., Miller, D.R., Sutherland, W.M., 2000, Economic diversification through mineral resources: Wyoming Geological Association Field Conference Guidebook, p. 209-225.

GEOLOGIC MAPPING AND HAZARDS UPDATE

Geologic Mapping, Paleontology, and Stratigraphy Update

Alan J. Ver Ploeg, Wyoming PG-1587

Senior Staff Geologist–Geologic Mapping, Wyoming State Geological Survey

The Wyoming State Geological Survey (WSGS) was recently notified that four mapping projects proposed for the STATEMAP 2003 Program had been funded. The projects are 1) to compile and map the Casper 1:100,000-scale Quadrangle; 2) to digitize bedrock geologic maps of the Kinney Rim, Evanston, Kemmerer, and Nowater Creek 1:100,000-scale quadrangles, and digitize surficial geologic maps of the Nowater Creek and Chugwater 1:100,000-scale quadrangles; 3) to compile and map the Saratoga 1:100,000-scale Quadrangle; and 4) to compile and map the Torrington 1:100,000-scale Quadrangle. These funded mapping projects will support efforts to complete mapping in the Powder River Basin, contribute toward the completion of mapping for populated areas in Wyoming, and provide needed mapping to support exploration by the state's mineral industry.

In a related note, the Mapping Section of the WSGS is completing the Kaycee 1:100,000-scale STATEMAP 2002 project. The geology for the eastern three quarters of the quadrangle has been compiled, digitized, and is currently being edited. Seven quadrangles mapped under the earlier COGEOMAP Program were digitized at 1:24,000 scale, edited down to 1:100,000 scale, and seamed together to complete the western quarter of the Kaycee map.

Sheridan College recently submitted their annual report for 2002 field activities on their State of Wyoming permitted dinosaur quarry near Buffalo. The quarry yielded some interesting dinosaur bones and continued to serve as an outdoor classroom for Sheridan College students.

STATEMAP 2003 geologic mapping proposal funded

The U.S. Geological Survey (USGS) recently announced funding for the STATEMAP 2003 Program and the WSGS received a total of $90,058 (**Table 16**). This represents the largest amount of funding that the Wyoming Geologic Mapping Program has received from either the COGEOMAP or the STATEMAP cooperative funding programs since we began participating in 1984 and 1994, respectively. The four funded mapping projects (**Figure 20**) are: 1) to map and compile a bedrock geologic map of the Casper 1:100,000-scale Quadrangle; 2) to digitize bedrock geologic maps of the Kinney Rim, Evanston, Kemmerer, and Nowater Creek 1:100,000-scale quadrangles, and digitize surficial geologic maps of the Nowater Creek and Chugwater 1:100,000-scale quadrangles; 3) to map and compile a bedrock geologic map of the Saratoga 1:100,000-scale Quadrangle; and 4) to compile and map a bedrock geologic map of the Torrington 1:100,000-scale

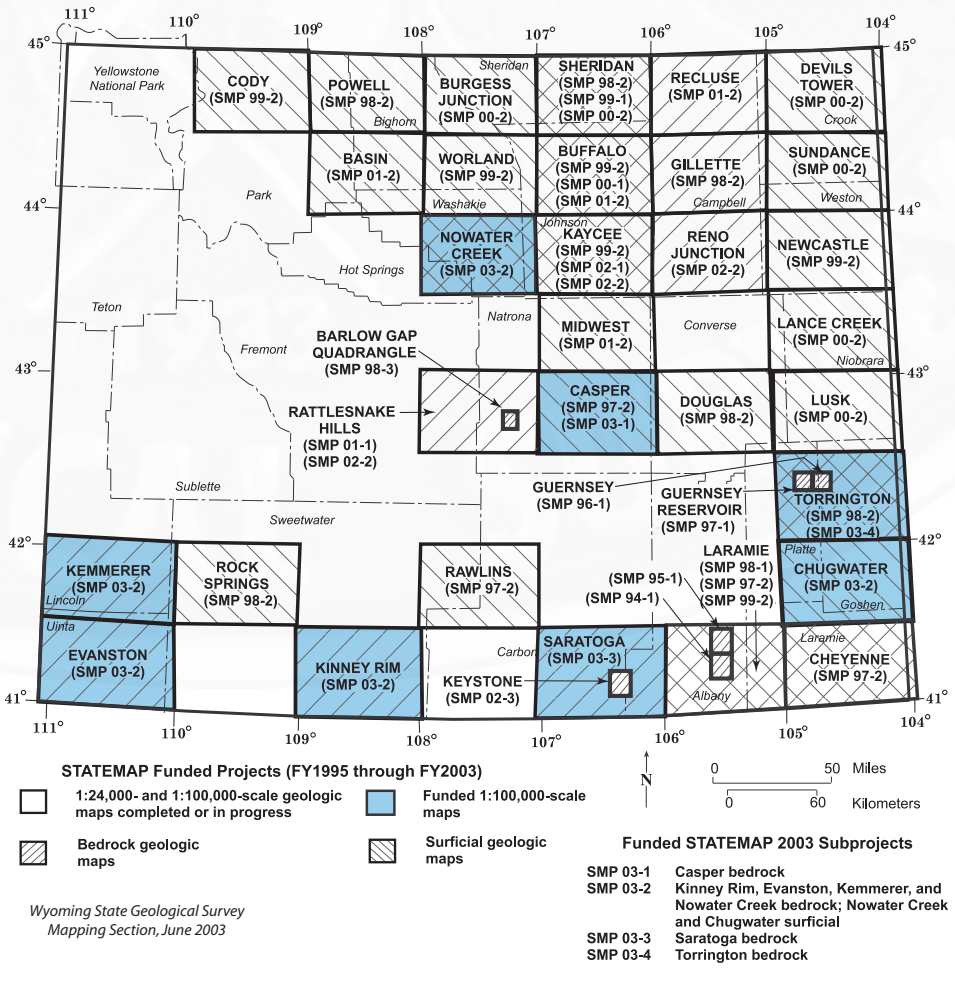

Figure 20. Index to funded, in-progress, and completed STATEMAP projects in Wyoming.

Table 16. Summary of the STATEMAP-funded geologic mapping program in Wyoming.

Fiscal Year	Project Description and Map Scale	State Dollars	Federal Dollars	Total Project Dollars
1995	Geologic map of the Laramie Quadrangle, 1:24,000-scale STATEMAP94	**$12,000**	**$12,000**	**$24,000**
1996	Geologic map of the Howell Quadrangle, 1:24,000-scale STATEMAP95	**$10,000**	**$10,000**	**$20,000**
1997	Geologic map of the Guernsey Quadrangle, 1:24,000-scale STATEMAP96	**$8,499**	**$8,499**	**$16,998**
1998	1-Geologic map of the Guernsey Reservoir Quadrangle, 1:24,000-scale STATEMAP97			
	2-Digital geologic map of the Cheyenne Quadrangle and digital surficial geologic maps	$14,000	$14,000	$28,000
	of the Casper, Cheyenne, Laramie, and Rawlins Quadrangles, 1:100,000-scale STATEMAP97	$17,000	$17,000	$34,000
	Total 1998 Funds	**$31,000**	**$31,000**	**$62,000**
1999	1-Geologic map of the Laramie Quadrangle, 1:100,000-scale STATEMAP98	$18,500	$18,500	$37,000
	2-Digital geologic map of the Gillette Quadrangle and surficial geologic maps of the Douglas,			
	Powell, Rock Springs, Sheridan, and Torrington Quadrangles, 1:100,000-scale STATEMAP98	$20,000	$20,000	$40,000
	3-Geologic map of the Barlow Gap Quadrangle, 1:24,000-scale STATEMAP98	$18,650	$18,650	$37,300
	Total 1999 Funds	**$57,150**	**$57,150**	**$114,300**
2000	1-Geologic map of the Sheridan Quadrangle, 1:100,000-scale STATEMAP99	$19,500	$19,500	$39,000
	2-Digital geologic map of the Laramie Quadrangle and digital surficial geologic maps of the			
	Buffalo, Cody, Newcastle, Kaycee, and Worland Quadrangles, 1:100,000-scale STATEMAP99	$20,000	$20,000	$40,000
	Total 2000 Funds	**$39,500**	**$39,500**	**$79,000**
2001	1-Geologic map of the Buffalo Quadrangle, 1:100,000-scale STATEMAP00	$20,500	$20,500	$41,000
	2-Digital geologic map of the Sheridan Quadrangle and digital surficial geologic maps of the Burgess			
	Junction, Devils Tower, Lance Creek, Lusk, and Sundance Quadrangles, 1:100,000-scale STATEMAP00	$24,500	$24,500	$49,000
	Total 2001 Funds	**$45,000**	**$45,000**	**$90,000**
2002	1-Geologic map of the Rattlesnake Hills Quadrangle 1:100,000-scale STATEMAP01	$24,133	$24,133	$48,266
	2-Digital geologic maps of the Buffalo and Recluse Quadrangles and digital surficial geologic maps			
	of the Midwest and Basin Quadrangles 1:100,000-scale STATEMAP01	$24,796	$24,796	$49,592
	3-Entering map data in National Geologic Map Database STATEMAP01	$6,500	$6,500	$13,000
	Total 2002 Funds	**$55,429**	**$55,429**	**$110,858**
2003	1-Geologic map of the Kaycee Quadrangle 1:100,000-scale STATEMAP02-in progress	$23,500	$23,500	$47,000
	2-Digital geologic maps of the Kaycee, Reno Junction, and Rattlesnake Hills Quadrangles			
	1:100,000-scale STATEMAP02-in progress	$18,437	$18,437	$36,874
	3-Geologic map of the Keystone Quadrangle 1:24,000-scale STATEMAP02-in progress	$28,976	$28,976	$57,952
	Total 2003 Funds	**$70,913**	**$70,913**	**$141,826**
2004	1-Geologic map of the Casper Quadrangle 1:100,000-scale STATEMAP03-funded	$21,889	$21,889	$43,778
	2-Digital geologic maps of the Kinney Rim, Evanson, Kemmerer, and Nowater Creek quadrangles;			
	digital surficial geologic maps of the Nowater Creek and Chugwater quadrangles			
	1:100,000-scale STATEMAP03-funded	$16,745	$16,745	$33,490
	3-Geologic map of the Saratoga Quadrangle 1:100,000-scale STATEMAP03-funded	$27,532	$27,532	$55,064
	4-Geologic map of the Torrington Quadrangle 1:100,000-scale STATEMAP03-funded	$23,892	$23,892	$47,784
	Total 2004 Funds	**$90,058**	**$90,058**	**$180,116**
	TOTALS	**$419,549**	**$419,549**	**$839,098**

Quadrangle. The projects will begin August 1, 2003. These mapping projects were selected based on current mapping priorities established by the WSGS in cooperation with the Wyoming Geologic Mapping Advisory Committee, including: 1) producing geologic maps to support coalbed methane exploration/production activities and associated ground and surface water protection needs in the Powder River Basin, Wyoming and 2) mapping the more populated areas of the state to provide assistance to city and county planners in siting and land-use planning, as well as providing information to support mineral and water resource development.

Funding from STATEMAP 2003 will enable the Mapping Section of the WSGS to map and compile the geology for the Casper 1:100,000-scale Quadrangle. The completion of this map is needed to augment expansion to the south of the Northern Powder River Basin geologic, hydrologic, and water quality database project. This map will also satisfy the priority of mapping the populated areas. Although a large part of this map has already been compiled, work is needed to complete the northeastern corner of the map and the southwestern part of the map in the Shirley Basin area. In addition, the geology on the west side of the map needs to be reconciled with the recently completed Rattlesnake Hills Quadrangle (WSGS Open File Report 2002-02). Some field checking of the Casper map will be required.

The Casper Quadrangle is located in central Wyoming (**Figure 20**) and includes bedrock ranging in age from Precambrian to Oligocene. The dominant structural features included in the map area are the Casper arch and the Casper Mountain uplift, with their associated structures. The Casper Mountain uplift includes Precambrian, Paleozoic, and Mesozoic outcrops. This feature and its associated structures cover the south half of the map. Much of the remainder of the quadrangle includes Cretaceous outcrops dipping east/northeast into the Powder River Basin, capped by Tertiary rocks in the southwestern and southeastern corners.

The Publications Section will use funds from STATEMAP 2003 to digitize the Kinney Rim, Evanston, Kemmerer, and Nowater Creek 1:100,000-scale bedrock geologic maps (**Figure 20**). These four maps are currently published paper maps available from the USGS (Miscellaneous Investigations Series I-1615, I-2079, and I-2168) and the WSGS (Map Series MS-39). In addition, the Section will digitize surficial geologic maps of the Nowater Creek and Chugwater quadrangles. Mapping of these two unpublished maps was completed by the Hazards Section of the WSGS. For each map, the geology layer will be scanned, converted from a raster image to a vector image, and edited to be consistent with National Digital Mapping Standards. Digital topography and public land survey data exist for each map and will be acquired from the EROS Data Center.

The Metals and Precious Stones Section of the WSGS will map and compile the bedrock geology for the Saratoga 1:100,000-scale Quadrangle, as the second year of a two-year

project. The first year of this project (STATEMAP 2002) entails mapping the Keystone 1:24,000-scale Quadrangle (**Figure 20**) in the Medicine Bow Mountains and will be completed by August, 2003. The second year of the project will involve compiling the geology of the 1:100,000-scale Saratoga Quadrangle (**Figure 20**) located in south central Wyoming. The map covers parts of the Medicine Bow and Sierra Madre uplifts and the bedrock exposures are primarily Precambrian (in the mountains) and Tertiary (in North Platte River valley) with some Mesozoic and Paleozoic outcrops in Centennial Valley. Much of the quadrangle has already been compiled at a scale of 1:50,000, but the southern Medicine Bow Mountains and Saratoga Valley will need some additional work.

The Industrial Minerals and Uranium Section of the WSGS will use the funding to map and compile the bedrock geology for the Torrington 1:100,000-scale Quadrangle in southeastern Wyoming (**Figure 20**). The quadrangle includes Paleozoic and Tertiary rock outcrops with some Precambrian and Mesozoic exposures. The primary structural feature in the area is the Hartville uplift. The Section completed the Guernsey and Guernsey Reservoir 1:24,000-scale quadrangles as part of STATEMAP 1996 and 1997. These two maps, along with other existing mapping in the Torrington Quadrangle, will be used to compile the geology. Some fieldwork will be required to fill in gaps in the existing mapping.

Completed, in progress, and funded STATEMAP projects are shown in **Figure 20** and the funding received to date by the WSGS is shown in **Table 16**. The STATEMAP Program, part of the USGS National Cooperative Geologic Mapping Program (NCGMP), has significantly expanded and driven the mapping efforts of the WSGS, contributing $419,549 in funding, including the recently funded STATEMAP 2003 project. The WSGS has completed 35 maps using funding from the STATEMAP program since it began involvement in 1994; an additional 11 maps were completed independent of the program's funding.

Update on Kaycee geologic map

The Mapping Section is continuing work on the Kaycee 1:100,000-scale STATEMAP 2002 project (**Figure 20**). The geology for the eastern three quarters of the quadrangle has been compiled, digitized, and is currently being edited. The Mapping Section previously completed 1:24,000-scale geologic maps of Packsaddle Canyon, Fraker Mountain, Barnum, Poker Butte, Hole-in-the-Wall, Red Fork Powder River, and the Mayoworth quadrangles, which make up the western quarter of the map, through the COGEOMAP Program in the mid to late 1980s. These seven quadrangles were digitized at 1:24,000 scale, edited down to 1:100,000 scale, and then digitally seamed together to complete the western quarter of the Kaycee map. These individual maps are currently WSGS open file reports and will be available later as 1:24,000-scale color digital maps.

The Kaycee Quadrangle is located in northeast Wyoming and includes bedrock ranging in age from Precambrian to Oligocene. The eastern flank of the southern Bighorn Mountains and the adjacent western side of the Powder River Basin are interrupted by a series of northwest-trending anticlines, which are asymmetrical with steep west limbs. These structural features and the Bighorn uplift itself were created by a Laramide-age, northeast-oriented (N40 to 65°E) compressional event. These features cover the western one-fourth of the map. The remainder of the quadrangle includes Cretaceous and Tertiary outcrops dipping toward the east/northeast. The axis of the Powder River Basin runs northwest to southeast through the northeastern corner of the quadrangle.

The completion of the Kaycee map, scheduled for July, 2003, is needed to augment southward expansion of the Northern Powder River Basin geologic, hydrologic, and water quality database project. The Reno Junction Quadrangle, immediately east of the Kaycee Quadrangle, will also be compiled to augment the Powder River Basin project. This map will be digitized as part of STATEMAP 2002 and completed in July, 2003.

Activities on State of Wyoming dinosaur quarries

There are currently two dinosaur quarries holding scientific permits on State Lands in Wyoming. One quarry is located southwest of Buffalo; the other is in an Interstate 90 road cut west of Sundance (see **Figure 13**). Mike Flynn of Sheridan College operates the quarry southwest of Buffalo and Dr. James Martin of South Dakota School of Mines and Technology operates the quarry west of Sundance. Both quarries are located in paleostream channels in the dinosaur-fossil-rich Jurassic Morrison Formation and are used for student instruction in paleontology and fossil removal methods, as well as fossil specimen collection, preparation, and research.

Dr. Martin was on sabbatical during 2002 and as a result, the quarry near Sundance was inactive during the 2002 field season (**Figure 21**). He does, however, anticipate collecting and student instruction activity to resume during the upcoming field season.

Figure 21. View of inactive Martin dinosaur quarry adjacent to I-90 west of Sundance, Wyoming.

Mike Flynn submitted his annual report in February, 2003, outlining quarry activities during the 2002 field season. The quarry southwest of Buffalo was used for instructing two sessions of a Sheridan College class in recognizing paleoenvironments, geology, and training in fossil collecting procedures during the summer field season. Research continued on the stratigraphy, paleobiology, paleogeography, and paleoenvironments of the Late Jurassic Morrison Formation in the quarry area (**Figure 22**) and in exposures of the Morrison along the eastern flank of the Bighorn Mountains. A total of 12 specimens of camarasaur and sauropod bones (including caudal and cervical vertebra, tarsal, and rib fragments) were catalogued and removed from the quarry during the 2002 field season. Flynn indicated that the quarry would continue to be excavated with accompanying fossil removal, as well as continuing to serve as a field methods classroom in the 2003 field season.

Figure 22. Flynn dinosaur quarry excavation in variegated shales and sandstones of the Morrison Formation south of Buffalo, Wyoming. Quarry is in the foreground with Lower Cretaceous Cloverly Sandstone forming ridge on skyline.

Geologic Hazards Update: County Natural Hazards and Vulnerability Assessments

James C. Case, Wyoming PG-1138

Senior Staff Geologist–Geologic Hazards, Wyoming State Geological Survey

Jeffrey C. Baxter

GIS Specialist, Wyoming State Geological Survey

The Wyoming Office of Homeland Security–Emergency Management and the Federal Emergency Management Agency (FEMA) has funded the Geologic Hazards Section at the Wyoming State Geological Survey (WSGS) to generate complete natural hazards assessments and vulnerability assessments for all Wyoming counties and municipalities. Section personnel met with representatives of most Wyoming counties to review hazards assessments for earthquakes, landslides, floods, wildland fires, mined-out areas, windblown deposits, and storms. After each meeting, most of which lasted a full day, the WSGS provided the county with completed and revised reports and maps delineating the hazards and their potential effects.

After the initial meetings with the counties, the Section generated vulnerability assessments for earthquakes, landslides, floods, and wildland fires. Vulnerability assessments differ from hazards assessments in that potential damage is determined, either through detailed modeling or through estimating the value of structures that may be exposed to the hazard (building exposure value). This article summarizes the hazards and vulnerability assessments for each hazard.

Earthquakes and active faults

Seismological characterizations were generated for each county. The characterizations were generated by assembling and analyzing data on historical (and historic) seismicity, active faults and their potential effects upon activation, building codes, random earthquakes, and earthquake probabilities (see *Wyoming Geo-notes No. 75*, December, 2002, p. 29-33, for an example from Park County). Active faults with a surface expression (**Figure 23**) were recently mapped and converted to a digital coverage and a map, and these were provided to the counties. A summary sheet for each county was also generated, using a 2500-year probability map (*Wyoming Geo-notes No. 67*, September, 2000) as the primary basis for damage estimates. The summary addressed the maximum type of damage expected in communities and at significant features, such as dams, throughout the county. The county seismological reports can be viewed at http://www.wrds.uwyo.edu/data.

After the seismological characterizations were generated, more detailed vulnerability assessments with associated

Figure 23. An active fault scarp in the town of Afton forms the ridge in the middle distance. This active fault on the east side of Star Valley exhibits recent movements—the road on the left side of the photograph is on a surface that was once at the same level as the house above the ridge.

casualty and damage cost estimates were prepared using HAZUS 99 (see *Wyoming Geo-notes No. 73*, April, 2002). The default HAZUS program was enhanced with soils and landslide layers and new critical facilities databases generated by the Section. Each county received a HAZUS Earthquake Event Report, which provides details on building inventories, damage, and casualties.

Landslides

A landslide map, landslide summary, and analysis of damage potential were generated for each county, using landslide maps on file at the WSGS. During the last 20 years, the Geologic Hazards Section has mapped over 850 7.5-minute quadrangles for landslides. Each landslide map in a county was closely examined by Section and county personnel in order to determine which landslides could potentially cause damage to roads, buildings, streams, dams, pipelines, or other structures. A summary report was then generated listing all the 7.5-minute quadrangles in which significant damage could occur, and for each 7.5-minute quadrangle, the location and types of features that could be affected by specific landslides.

A digital and paper landslide map was generated for each county (**Figure 24**). The maps were a composite of 1:24,000-, 1:100,000-, and 1:500,000-scale digital landslide maps. A 100-foot buffer was then digitally created around each landslide, and the landslide and buffer were digitally crossed with census block data from 2000. Building values and types associated with the census blocks were proportionally assigned to the area of the census blocks intersected by the landslide and buffer. The final products supplied to the counties were building exposure values for landslides by census block and for each county as a whole.

Digitized 1:24,000-scale landslide maps can be viewed and downloaded at http://www.wrds.uwyo.edu/wrds/wsgs/hazards/landslides/lshome.html. Also available are 3-D "fly through" images with superimposed landslides, which can be viewed at http://www.wrds.uwyo.edu/wrds/wsgs/hazards/landslides/ls-3d.html.

Floods

Flood Insurance Rate Maps for all counties were scanned, digitized, and converted to GIS coverages by the Geologic Hazards Section. The Section then digitally crossed 100- and/or 500-year floodplain boundaries with census block data from 2000. Building values and types associated with the census blocks were proportionally assigned to the area of the census blocks that were intersected by the floodplain boundaries. The final products supplied to the counties were building exposure values for floodplains by census block and for each county as a whole. In addition, larger scale maps of specific communities (**Figure 25**) were also provided.

Wildland fires

The State of Wyoming and the U.S. Forest Service generated a wildland fire hazard assessment map for the state. The map was generated by assessing slope, aspect, disturbance regime, fuel hazard, lightning strike density, roads and railroads, historic fires, and housing density. The final map showed relative hazard as well as a red zone which delin-

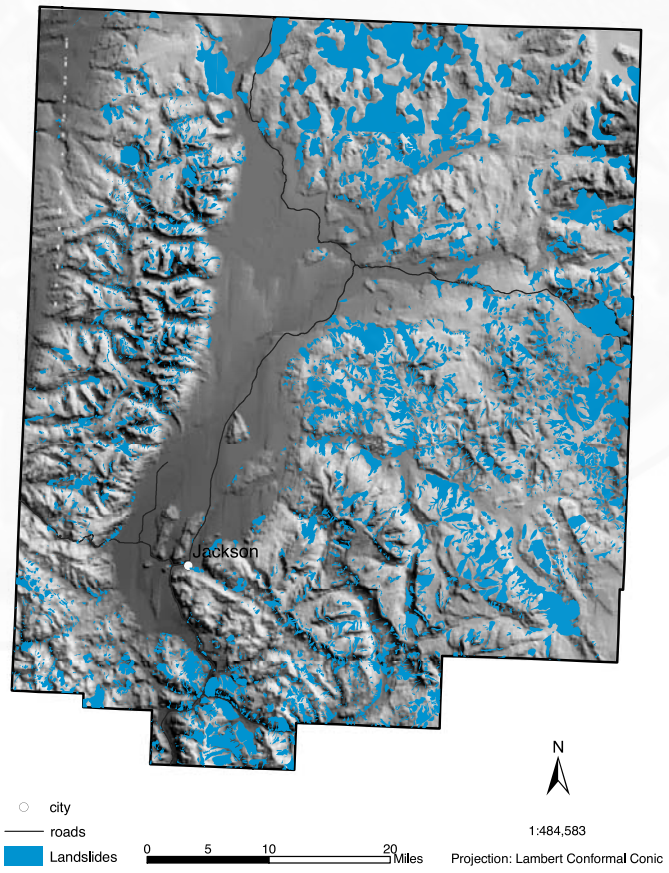

Figure 24. Landslide map of Teton County, Wyoming (excluding Yellowstone National Park) superimposed on a digital elevation model (DEM) of the county.

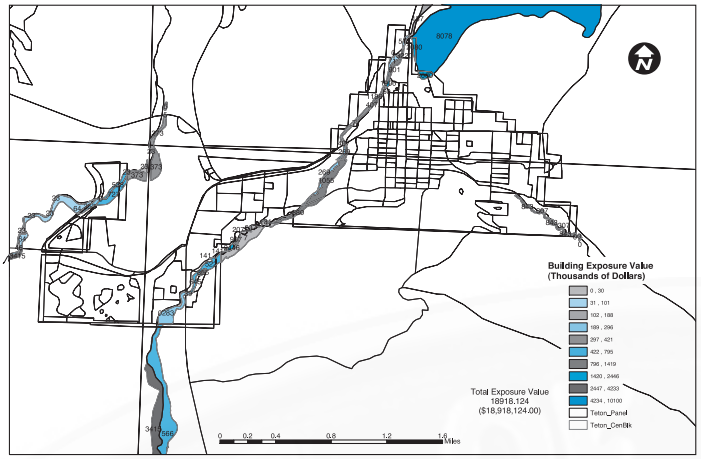

Figure 25. Map of the Town of Jackson, Wyoming showing building exposure values for a 100-year flooding event on Spring Creek and Flat Creek.

eated the highest hazard areas with property at risk. The Geologic Hazards Section refined the red zone boundaries (**Figure 26**) while meeting with each of the counties.

The Section then digitally crossed the red zone areas with census block data from 2000. Building values and types associated with the census blocks were proportionally assigned to the area of the census blocks intersected by the red zones. The final products supplied to the counties were building exposure values for wildland fire red zones by census block and for each county as a whole (**Figure 27**).

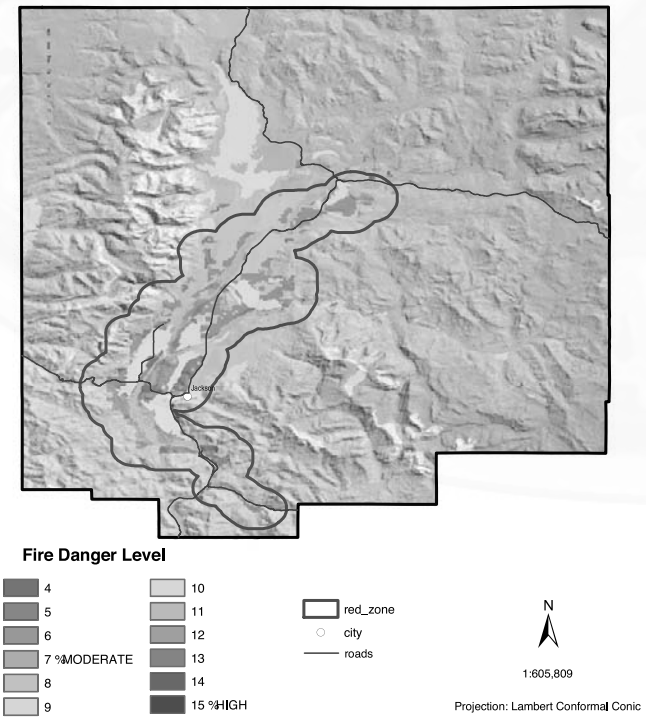

Figure 26. Wildland fire hazard map of Teton County, Wyoming superimposed on a digital elevation model (DEM) of the county. Data derived from Wyoming State Forestry Division and the U.S. Forest Service.

Mined-out areas

A mined-out-area summary report was generated for each county with abandoned coal mines (**Figure 28**) or hard rock mines. The report was based upon mined-out-area maps and reports on file at the WSGS. Over the last 20 years, the Geologic Hazards Section has mapped all abandoned coal mines and mine subsidence areas in Wyoming. Each of the mined-out-area maps in a county was closely examined by Section and county personnel in order to determine which abandoned mines could potentially cause damage to roads, buildings, streams, dams, pipelines, or other structures. A summary report was then generated that consisted of a list of all the 7.5-minute quadrangles that contained mined-out areas, a description of specific areas in which significant damage could occur, and for each 7.5-minute quadrangle, the location and types of features that could be affected by specific mines.

Windblown deposits

A summary report and map of windblown deposits (**Figure 29**) was generated for each county, using windblown deposit maps on file at the WSGS. Over the last 20 years, the Geologic Hazards Section has mapped most windblown

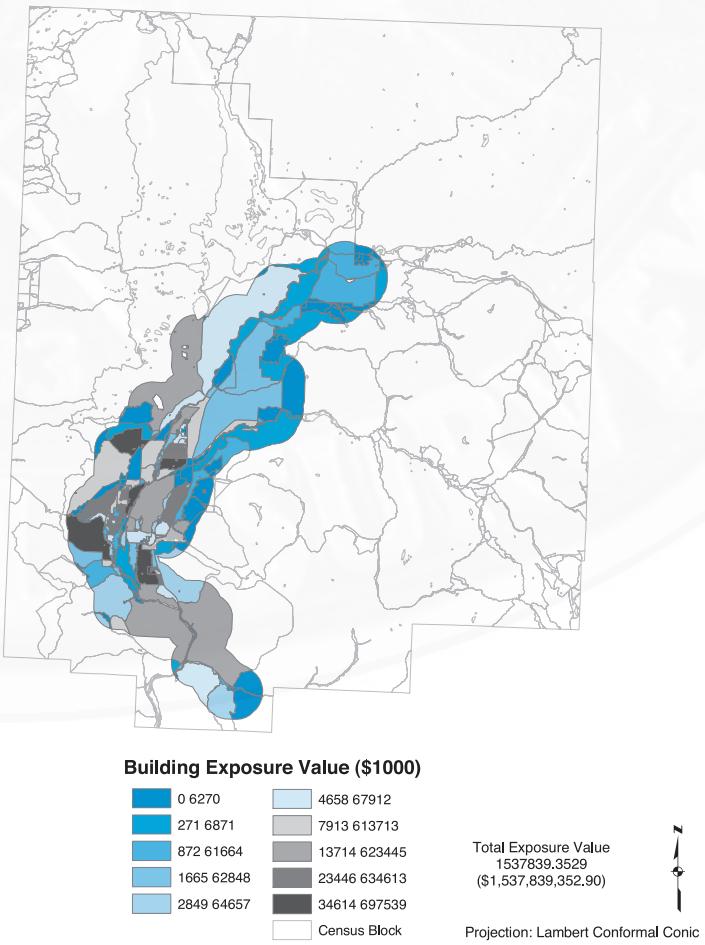

Figure 27. Map of Teton County, Wyoming showing building exposure values for critical wildland fire hazard areas. Data derived from Wyoming State Forestry Division and the U.S. Forest Service.

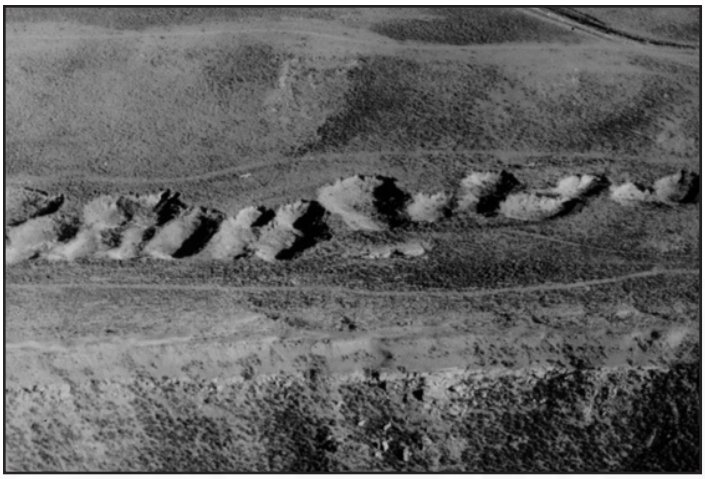

Figure 28. Oblique air photograph of surface subsidence features over abandoned underground coal mines near Hanna. Photograph by Gary B. Glass.

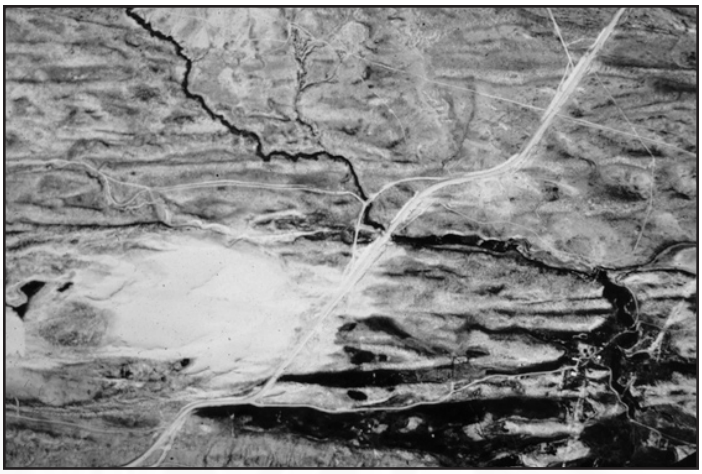

Figure 29. A large active sand dune encroaches the Seminoe Dam road north of Sinclair, Wyoming. This area is part of the Seminoe sand dune field.

deposits in the state at a scale of 1:24,000 or 1:100,000. Each of the windblown deposit maps was closely examined by Section and county personnel in order to determine which windblown deposits could potentially cause a problem with roads or buildings if the deposits destabilize. A summary report was then generated listing all the 7.5-minute quadrangles that contained windblown deposits.

Storms

A generalized text on winter storms, tornadoes, thunderstorms, and wind storms was generated by the Geologic Hazards Section and presented to all counties. In addition, a 50-year summary of storms with dollar damage estimates from the National Climatic Data Center was provided to each county.

Summary

This hazards mitigation project let to a successful collaboration between the WSGS, the Wyoming Office of Homeland Security–Emergency Management, FEMA, and all counties in Wyoming. The data exchange and close working relationships that developed have led to a strong foundation for all future hazards mitigation work in Wyoming. In addition, because of the success of the approach, Wyoming is now being referred to as an innovator in the hazards mitigation field.

PUBLICATIONS UPDATE

Publications Section News

Publications Sales Manager

Lisa J. De Bruin, Publications Sales Manager, left the Wyoming State Geological Survey (WSGS) in December, 2002 to pursue other opportunities. Lisa also worked as Administrative Assistant at the WSGS for about a year before joining the Publications Section in July, 2001. We will miss her, but wish her the best.

Our new Publications Sales Manager is Nancy S. Elliott (**Figure 30**), who joined the WSGS in March, 2003. Nancy is a graduate of Laramie Senior High School and the University of Wyoming, and most recently was employed at Laramie GM Auto Center. Welcome aboard, Nancy.

Figure 30. Nancy S. Elliott is the new Publications Sales Manager at the Wyoming State Geological Survey. Photograph by Jaime R. Moulton.

Wyoming State Geological Survey map release information

Maps released by the WSGS are always available in hard copy (paper) format; most of our newer maps are also available in digital formats. Hard copy maps may be printed on paper in large numbers by a commercial printing company or they may be plotted on paper as "on-demand" products via Hewlett Packard™ plotters used at the WSGS. Commercially printed maps are usually fade resistant and somewhat moisture resistant, depending on the paper and ink used, and are often custom folded to WSGS specifications. These maps are usually much cheaper because of the large numbers printed, but cannot be updated or revised easily or inexpensively. Maps that are plotted at the WSGS are much more expensive to produce because of the cost of the equipment and supplies (including custom paper and inks) and the limited numbers printed. In addition, they cannot be folded easily or efficiently, which requires that they must be shipped rolled in a map tube, also adding to the cost. The biggest advantage to "on-demand" plotted maps is that they can be constantly revised, updated, and improved as new data is received, more work is incorporated into them, and earlier errors or inconsistencies corrected. However, the ease of creating a new map using digital GIS techniques comes with a higher price tag, and we must charge for it.

Our digital map products are released on CD-ROM and include the GIS data and imagery of the map purchased. Some maps may be viewed on our web site, and some new products may even be interactive or user-defined. The digital release consists of ESRI® Shapefiles that can be accessed by ESRI® ArcGIS™ 8.x, ArcView® 3.x, and most major GIS and CAD (computer aided drafting) software. All digital maps may be viewed by the included ESRI® ArcReader™ or ArcExplorer™ software and the published map image viewed by the included LIZARDTECH© MrSID Geo Viewer® software. Most WSGS digital products also include TIFF and EPS files of the map image for the convenience of our users. All WSGS digital map products include complete metadata and full documentation of the information and software utilized to produce the published map.

New Publications Available from the Wyoming State Geological Survey

Wyoming State Geological Survey publications

Coalbed methane activity in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, L.L. Hallberg, and N.R. Jones, 2003: Map Series MS-56 (updated in March, 2003, replaces CMM 02-4), on-demand plotted color map, rolled only – $30.00.

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, M.M. Harrison, and N.R. Jones, 2003: Map Series MS-57 (updated in March, 2003, replaces CMM 02-5), on-demand plotted color map, rolled only – $30.00.

Coalbed methane activity in the Powder River Basin, Campbell, Converse, Johnson, Natrona, and Sheridan Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, L.L. Hallberg, M.M. Harrison, and N.R. Jones, 2003: Map Series MS-58 (this is a reduced and combined version of MS-56 and MS-57 at 1:250,000 scale), on-demand plotted and laminated color map, rolled only – $50.00; on-demand plotted color map, rolled only – $40.00; ESRI ArcGIS®/ArcReader® format on CD-ROM (including MrSid® viewable files) – $50.00.

*Geologic cross sections of the northern Overthrust Belt and Hoback Basin, Wyoming, by L. Cook, 2002: Open File Report 2002-03 (revised) – $15.00 (includes 1 oversize sheet and 15 p. text) + $5.00 shipping and handling.

Geology of the Iron Mountain kimberlite district and nearby kimberlitic indicator mineral anomalies in southeastern Wyoming, by W.D. Hausel, R.W. Gregory, R.H. Motten, and W.M. Sutherland, 2003: Wyoming State Geological Survey Report of Investigations No. 54, 42 p. plus 3 oversized plates – $10.00.

*Preliminary digital geologic map of the Buffalo 30′ x 60′ Quadrangle, Johnson and Campbell Counties, Wyoming, by A.J. VerPloeg and C.S. Boyd (digital cartography by J.T. Carreno, R.W. Lyons, and J.M. Mulbay), 2003, Map Series 59 (scale 1:100,000), on-demand plotted color map, rolled only – $25.00; CD-ROM under development – $10.00.

*Preliminary digital geologic map of the Recluse 30′ x 60′ Quadrangle, Campbell and Crook Counties, Wyoming, by L.L. Hallberg, R.M. Lyman, C.S. Boyd, R.W. Jones, and A.J. VerPloeg (digital cartography by J.M. Mulbay, J.T. Carreno, and R.W. Lyons), 2003, Map Series 60 (scale 1:100,000), on-demand plotted color map, rolled only – $25.00; CD-ROM under development – $10.00.

*Preliminary digital geologic map of the Midwest 30′ x 60′ Quadrangle, Natrona, Converse, and Johnson Counties, Wyoming, by L.L. Hallberg and J.C. Case (digital cartography by R.W. Lyons, J.T. Carreno, and J.M. Mulbay), 2003, Map Series 61 (scale 1:100,000), on-demand plotted

color map, rolled only – $25.00; CD-ROM under development – $10.00.

*Preliminary digital geologic map of the Basin 30′ x 60′ Quadrangle, Big Horn, Park, Washakie, and Hot Springs Counties, Wyoming, by L.L. Hallberg and J.C. Case (digital cartography by J.M. Mulbay, J.T. Carreno, and R.W. Lyons), 2003, Map Series 62 (scale 1:100,000), on-demand plotted color map, rolled only – $25.00; CD-ROM under development – $10.00.

*Publications Catalog, 2003: Wyoming State Geological Survey – FREE.

Searching for Gold in Wyoming, by W.D. Hausel, 2002: Wyoming State Geological Survey Information Pamphlet 9 – FREE.

Please contact the Staff Geologists for coverage, availability, prices, or further information on specific commodities or topics (see **STAFF DIRECTORY** on back cover).

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

Other publications

The Wyoming State Geological Survey now sells all U.S. Geological Survey (USGS) map series available for the state of Wyoming. This includes maps in the C (Coal Investigations), GP (Geophysical Investigations), GQ (Geologic Quadrangle), HA (Hydrologic Atlas), I (Miscellaneous Investigations), MF (Miscellaneous Field Studies), OC (Oil and Gas Investigations Chart), and OM (Oil and Gas Investigations) series. See our new Publications Catalog for a complete listing of these maps. A number of these maps are no longer in print and are not available through the USGS. [Note: We do not handle USGS books (such as Professional Papers, Bulletins, Circulars, etc.) or open file reports. Contact the USGS directly at 303-236-5900 for these items.]

GIS Update

Joseph M. Huss

GIS Coordinator–Publications, Wyoming State Geological Survey

The geographic information systems (GIS) unit of the Publications Section of the Wyoming State Geological Survey (WSGS) has continued a fast pace of projects during the last half of 2002. The GIS/Cartographic personnel have been involved in numerous projects ranging from the digitization of data to full cartographic layouts to development of a new Internet Map Serving (IMS) site.

Personnel

The GIS Unit and Publications Section welcomed back Abby Kirkaldie from Alaska where she worked for the U.S. Fish and Wildlife Service during the summer and fall. Abby is working on a variety of projects including the Love Map Series, STATEMAP projects, organizing and archiving the J.D. Love collections, and as a troubleshooter for all GIS challenges. Justin Mulbay and Robin Lyons completed their internships in the GIS Unit in December, 2002 and will continue on as contract employees with the WSGS for the STATEMAP projects.

The project entails digital compilation and development of four 1:100,000-scale bedrock geologic quadrangle maps and two 1:100,000-scale surficial geologic quadrangle maps.

STATEMAP projects

The Section's portion of STATEMAP 2002 is well underway with four 1:100,000-scale quadrangle maps being constructed for distribution in hard copy and digital formats. The Kaycee, Rattlesnake Hills, and Reno Junction bedrock geologic quadrangle maps, and the Bill surficial geologic quadrangle map are on track to be completed August, 2003.

Funding for the Section's portion of STATEMAP 2003 has been approved. The project entails digital compilation and development of four 1:100,000-scale bedrock geologic quadrangle maps and two 1:100,000-scale surficial geologic quadrangle maps. Bedrock geologic maps include the Nowater Creek, Kinney Rim, Kemmerer, and Evanston quadrangles; the two surficial geologic maps are Nowater Creek and Chugwater quadrangles. See the **Geologic Mapping, Paleontology, and Stratigraphy Update** for more details on STATEMAP 2003.

Love Map Series

The hard copy map of J.D. Love's Two Ocean Lake 1:24,000-scale Quadrangle was completed by Phyllis A. Ranz, GIS Specialist/Cartographer. This map is the eighth in the Love Map Series (LMS) in the Jackson Hole/Teton area. These maps are available as plotted color maps, and digital versions on CD-ROM are being completed. Contact the WSGS Publications Sales Office for availability. More quadrangle maps in the planned 45-map series are presently being produced: Colter Bay, Jackson, Jenny Lake, Moran, Davis Hill, Whetstone Mountain, and Turquoise Lake.

Both the northeastern and southwestern Wyoming geologic maps will be full-color, printed geologic maps as well as digital maps available on CD-ROM.

Oil and gas well Internet Map Server

The Wyoming Oil and Gas Conservation Commission (WOGCC), Environmental Systems Research Institute (ESRI®), and the WSGS have constructed a cooperative IMS for public access. This IMS allows the users to toggle (i.e., turn on and turn off) associated GIS data layers and identify specific oil and gas wells to be analyzed. Additionally, the site allows location by American Petroleum Institute (API) number or for a specific oil or gas field name. This site will be further enhanced with a locater by Public Land Survey System (PLSS) (section, township, and range) and additional data sources.

For ESRI® GIS users, the *Oil and gas well IMS* may be added directly into an ESRI® ArcMap™ session as a map service. This IMS thus enables the ESRI® GIS user additional access to data sources for analysis without constraint of data storage or access. The IMS website can be accessed at http://wsgsweb.uwyo.edu/wsgs/mapframe.asp.

Graduate Assistantships

Justin Carreno is compiling a new geologic map of northeastern Wyoming as the first graduate assistant (GA) for the WSGS in cooperation with the Department of Geography and Recreation, University of Wyoming (UW). He has compiled and digitized the Gillette and Newcastle 1:250,000-scale quadrangles and is continuing with the Sheridan and Arminto quadrangles. He is working hard to complete the project by the end of summer, 2003 and to defend his thesis and achieve a Masters of Arts (M.A.) degree this fall.

The second WSGS GA in cooperation with the Department of Geography and Recreation at UW is being selected and will initiate work this fall semester. The planned project is for compiling a new 1:250,000-scale geologic map of southwestern Wyoming to include the 1:250,000-scale quadrangles of Lander, Ogden, Preston, and Rock Springs. This new digital mapping will augment areas with digital 1:100,000-scale geologic coverage. The project is to last one year with completion by the end of summer, 2004. Both the northeastern and southwestern geologic maps will be full-color, printed geologic maps as well as digital maps available on CD-ROM.

GIS certification and courses

Joseph Huss, GIS Coordinator at the WSGS, is now certified to instruct two ESRI® (www.esri.com) courses, *Introduction to ArcGIS I* and *Migrating from ArcView 3.x to ArcView 8*. He became ESRI® certified in a cooperative effort with the Wyoming Geographic Information Science Center (WyGISC) at UW to promote GIS knowledge and professionals in Wyoming.

Huss instructed *Introduction to ArcGIS I* in January and the *Migrating from ArcView 3.x to ArcView 8* in February. These courses are additionally planned for August, 2003. Information on the cooperative courses is available on the WyGISC web site located at http://www.wygisc.uwyo.edu/education.html; or contact Joseph Huss at (307) 766-2286 ext. 234 or Email at jhuss@uwyo.edu.

Annual ESRI® Southwest Users Group

The GIS Unit is helping organize and will participate in the Annual Southwest Users Group (SWUG) to be held in Jackson, Wyoming October 27 and 28, 2003. This is an annual GIS user's conference for the five state region of Arizona, Colorado, New Mexico, Utah, and Wyoming. This year's conference will focus on natural resource management, planning and legal issues, imagery, and government. The address for future SWUG conference information is http://www.swuggis.org/index.shtml.

Staff Profile: Jaime R. Moulton

Richard W. Jones, Wyoming PG-2972

Editor/Geologist–Publications, Wyoming State Geological Survey

Jaime R. Moulton (**Figure 31**) is the Editorial Assistant at the Wyoming State Geological Survey (WSGS). As the editorial assistant she assists with most aspects of publication production, including some editing of format, style, and usage; proofreading and correcting manuscripts; producing graphs, figures, and maps for use in publications; layout and design; and providing commercial printers with final print files. She also designs, compiles, and produces final versions of all WSGS digital data on CD-ROM. Jaime works closely with WSGS staff to prepare articles and manuscripts for editing. She uses information from the staff geologists to produce useful illustrations, maps, and other graphics. In addition to editorial tasks, Jaime assists the Editor with training and supervising the Publications Sales Manager and a student intern, as well as assisting with publication sales, ordering, and bookkeeping.

Jaime was born in Laramie, where she has resided most of her life. She was raised on her grandparents' ranch located just west of town, where she had the opportunity to raise animals for show in 4-H and FFA. Jaime graduated from Laramie Senior High School in 1996, and was a valedictorian for her graduating class. She was listed in Who's Who Among American High School Students all three years of high school. She attended the University of Wyoming (UW) on the President's Honor Scholarship, and graduated from the College of Agriculture with a B.S. degree in Animal Science with a Communications option in December, 2000. She actually took geology and maps and mapping courses. While attending UW, she was named to the Dean's List four semesters, and the President's List two semesters.

Jaime began working for the Publications Section part-time while she was still attending UW. Upon graduating from UW, she then became a full-time employee. Since she began WSGS employment, she has become an Adobe Photoshop expert as well as a competent graphics designer. She brought a lot of experience to the Survey and augmented it with extensive expertise gained while on the job. Jaime is responsible for designing new attractive formats for a number of our publications and has produced some very flashy publications. Our brochure on coalbed methane in Wyoming has set the standard for state geological survey publications and received a national award from a printing association.

Although she enjoys her work at the WSGS, horses are her passion. Her family breeds, raises, and sells American Quarter Horses and Appaloosa Horses. She spends a great deal of her free time on her family's ranch working with foals and training 2-year-old horses. Her other hobbies include drawing, cooking, working on her new house, and playing with her Border Collie named Sully.

Jaime had the privilege of representing her hometown for 3 years straight, by reigning as the Laramie Jubilee Days (LJD) Princess (1994), LJD Lady-in-waiting (1995), and Miss Laramie Jubilee Days (1996). She traveled around the state of Wyoming and surrounding states to represent Jubilee Days and the sport of rodeo. She rode in parades and rodeo grand entries (**Figure 32**) in a number of towns. She says "The entire week of Jubilee Days was pretty much a blur to me. Once the first event arrived, it seemed like I didn't even have time to sleep, but I would not have traded the experience for anything!" The best experience she had was trying out for Miss Rodeo Wyoming during Wyoming State Fair in Douglas. It was a week full of intense competitions including horsemanship, modeling, interviews, and speech contests.

Figure 31. Jaime R. Moulton is the Editorial Assistant at the Wyoming State Geological Survey.

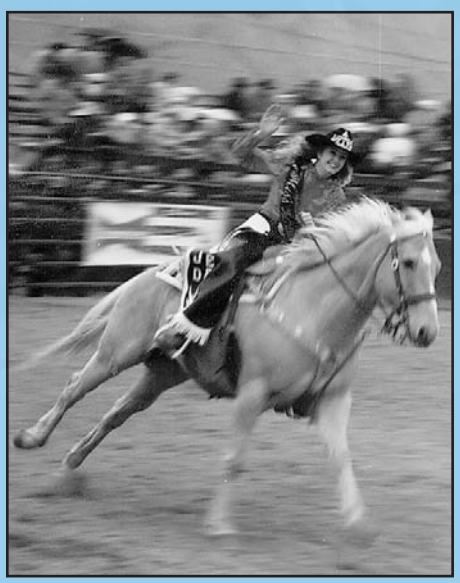

Figure 32. Jaime rides in a grand entry during a rodeo in Jackson, Wyoming during her 1996 reign as Miss Laramie Jubilee Days.

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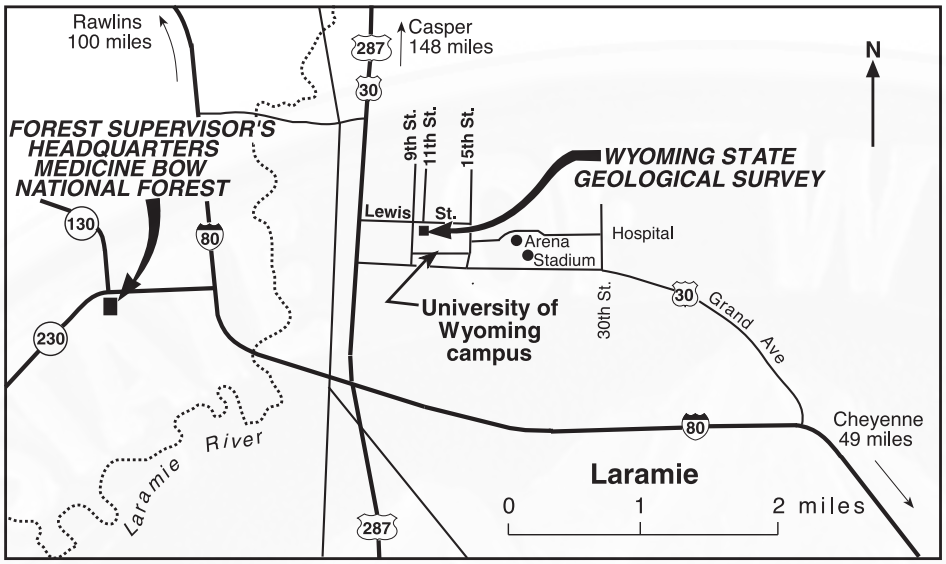
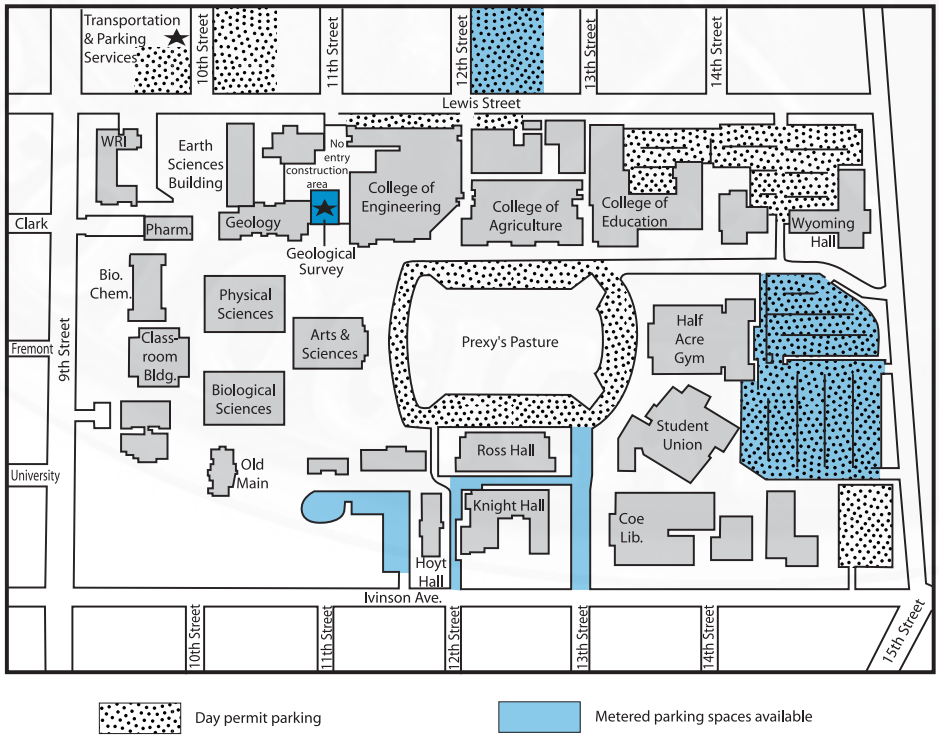
STATE OF WYOMING
1933
GEOLOGICAL SURVEY

Location Maps for the Wyoming State Geological Survey





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Metered Parking: Metered parking is available at various locations on campus to provide short-term parking. Meters are available at the following locations: Hoyt Hall, Knight Hall, Coe Library, Wyoming Union, Fine Arts, Corbett Gym, Arena-Auditorium, Beta House, 12th & Lewis, and Animal Science. The fee for metered parking is 25 cents per half hour.

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City Streets: Parking may be found on some of the surrounding city streets. This parking is free, however some areas are reserved for resident permit parking only.

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Email: ccook@uwyo.edu

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Susan McClendon - *Manager*
Email: smccle@uwyo.edu

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Email: rjones@uwyo.edu
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Wyoming State Geological Survey
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