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Number 75

In this issue:

Wyoming State Geological Survey
Lance Cook, State Geologist

Laramie, Wyoming
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Featured Articles

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WYOMING GEO-NOTES: This quarterly digest on the state's geology, mineral resources, and activities of the Wyoming State Geological Survey is available by subscription (four issues for $15.00) or as single copies at $5.00 each. Two-year subscriptions are accepted.

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Richard W. Jones, Wyoming PG-2972
Editor

Jaime R. Moulton
Layout and design

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Front cover: "Rapids Above Upper Falls of the Yellowstone" is taken from an 8" x 11" negative (#258) photograph taken by William Henry Jackson, photographer for the 1871 Hayden Survey of Yellowstone National Park. This early photograph of the Yellowstone River is described in W.H. Jackson's (1875) Descriptive Catalog of the Photographs of the USGS of the Territories as "A quarter of a mile farther up the stream, showing the huge detached masses of basalt that have been left standing in the middle of the river." From the personal collection of Lance Cook.

MINERALS UPDATE

Overview

Lance Cook, Wyoming PG-2577

State Geologist, Wyoming State Geological Survey

Production and prices of Wyoming minerals in the second quarter of 2002 continued to be on track with our projections made for the State of Wyoming's Consensus Revenue Estimating Group (CREG) last year (**Tables 1** and **2**), but there are indications that our forecasts beyond 2002 will have to be revised. See the individual mineral update sections for discussions of prices and production. Our next issue of *Wyoming Geo-notes* will contain CREG's latest production and price forecasts.

Nearly all the minerals produced in Wyoming so far in 2002 are exceeding last year's production, but the price increases we had hoped for are not occurring. Final 2001 prices for coal and trona were finally received (**Table 2**): the good new is that coal prices were slightly more than we predicted; the bad new is that trona prices were slightly less.

As described in this issue of *Wyoming Geo-notes*, all the sections in the Wyoming State Geological Survey (WSGS) are extremely busy with a number of projects and activities, not to mention the number of events, talks, meetings, field trips, etc. in which the staff also participates (see **Calendar of Events**).

Our new digital oil and gas maps of Wyoming have been completed, with hard copies becoming available in mid-September and CD-ROMs in early December. Information on the digital data we have prepared for these maps is described in Wyoming Geo-Bytes, a new feature on the WSGS web site. The **GIS Update** section in this issue provides additional information on these new oil and gas maps. With our new large-format color plotter, we are now able to offer an updated 1:500,000-scale statewide oil and gas map, and with our conversion of all the map data into digital format, we are now able to quickly update any of the five maps. The new digital maps will be an extremely powerful analysis tool, especially when combined with other data such as the well data from the Wyoming Oil and Gas Conservation Commission.

This issue of *Wyoming Geo-notes* describes our plans for completing a

Table 1. Wyoming mineral production (1985 through 2001) with forecasts to 2006[1].

Calendar Year	Oil[2,3]	Methane[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[7]	*In situ* Uranium[7,8]	Sulfur[3,9]
1985	131.0	597.9			140.4	10.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	11.9	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3	1.20
1996	73.9	1023.4	149.0	1.10	278.4	18.6	1.9	1.22
1997	70.2	1040.7	151.0	1.10	281.5	19.4	2.2	1.23
1998	65.7	1072.6	151.0	1.10	315.0	18.6	2.3	1.20
1999	61.3	1133.1	161.0	1.10	336.5	17.8	2.8	1.20
2000	60.6	1292.9	161.0	1.10	338.9	17.8	2.1	1.20
2001	57.4	1430.6	174.0	1.20	368.8	17.7	2.0	1.20
2002	54.0	1504.8	174.0	1.20	361.0	18.0	2.0	1.20
2003	51.0	1562.8	196.0	1.20	372.0	18.5	2.0	1.20
2004	48.2	1642.8	196.0	1.20	375.7	18.5	2.0	1.20
2005	45.6	1722.8	196.0	1.20	379.5	18.5	2.0	1.20
2006	43.1	1802.8	196.0	1.20	383.3	18.5	2.0	1.20

[1]Modified from CREG's Wyoming State Government Revenue Forecast, October, 2001; [2]Millions of barrels; [3]Wyoming Oil and Gas Conservation Commission, 1985 through 2001; [4]Billions of cubic feet, includes 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, 1985 through 2001); [7]Millions of short tons (Wyoming Department of Revenue, 1985 through 2001; Wyoming State Inspector of Mines, 2001); [8]Millions of pounds of yellowcake (Wyoming Department of Revenue, 1986 through 1999; Wyoming State Inspector of Mines, 2000 and 2001) (not available [N/A] for 1985 and previous years because it was only reported as taxable value; [9]Millions of short tons, estimated.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985 through 2001) with forecasts to 2006[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.78	42.29
1998	10.67	1.81	5.41	41.29
1999	16.44	2.06	5.19	38.49
2000	26.87	3.42	5.45	37.28
2001	21.58	3.66	5.75	37.51
2002	18.00	2.35	5.75	38.00
2003	18.00	2.35	5.86	38.00
2004	18.00	2.35	5.91	38.00
2005	18.00	2.35	6.00	38.00
2006	18.00	2.35	6.07	38.00

[1]Modified from CREG's Wyoming State Government Revenue Forecast, October, 2001; [2]First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-2001; [3]Wellhead price in dollars per thousand cubic feet (MCF), includes coalbed methane. Source: American Association, 1998-2001; Wyoming Office of State Lands and Investments, 1989-2001 (derived from State royalty payments); and Minerals Management Service, 1985-1988 (derived from Federal royalty payments); [4]Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1990 and derived from Department of Revenue, 1991-2000; [5]Dollars per ton of trona, not soda ash. Source Wyoming Department of Revenue, 1985-1999.

number of 1:100,000-scale and 1:24,000-scale geologic mapping projects in the state (see **Geologic Mapping, Paleontology, and Stratigraphy Update**), as well as resurrecting the 1:250,000-scale map series. The detailed 1:100,000-scale geologic maps are being compiled and prepared mainly through the STATEMAP program and will eventually be incorporated into a new statewide geologic map. The 1:250,000-scale maps fulfill the need for interim geologic maps of the state with more detail than that shown on the 1:500,000-scale *1985 Geologic map of Wyoming*. The **GIS Update** describes this effort, which mutually benefits the WSGS and the University of Wyoming students, who get hands-on experience.

This summer the WSGS had the opportunity to participate in the State of Wyoming's Internship Program. This program is funded separately by the State of Wyoming and does not impact an agency's budget. One intern has been working with the Industrial Minerals and Uranium Section and two interns have been working with the GIS/Cartographic unit of the Publications Section (see **GIS Update**). We have had excellent results with the program, as the three interns have been of great help on several of our projects. We hope to participate in the program again next year.

Finally, this issue of *Wyoming Geo-notes* contains the fourth installment of our series on the work of the Wyoming Department of Transportation (WYDOT) in stabilizing landslides in Snake River Canyon. WYDOT's geotechnical and engineering work on the state's highways is an important example of applied geology that is being used to make our highways safer. Much of their work is on the cutting edge of applied research and a number of their projects have received national recognition and prestigious awards. We hope to continue publishing articles highlighting geology and the state's highways.

Oil and Gas Update

Rodney H. De Bruin, Wyoming PG-3045

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

Prices received for oil and natural gas were lower in the second quarter of 2002 than in the second quarter of 2001, but higher than in the first quarter of 2002. Oil production declined 5.5% while natural gas production increased 5.8% during the first half of 2002 as compared to the first half of 2001. Natural gas production for the first half of 2002 was again boosted by a large increase in coalbed methane production in the Powder River Basin, which accounted for 18.1% of Wyoming's total gas production. The state's natural gas production increased by 46.4 billion cubic feet (BCF) in the first half of 2002. Without a 38.9 BCF increase in coalbed methane production during the first six months of 2002 when compared to the first six months of 2001, Wyoming's natural gas production would have increased only 7.5 BCF.

A number of pipeline expansions proposed for or completed in the second quarter should help Wyoming natural gas producers obtain higher prices than they would receive without the expansions. In the second quarter, two federal lease sales brought in over $4.1 million, with an average price per acre of $23.91. Two state sales in the second quarter brought in a little less than $1.0 million, but the average price per acre was only $11.88. The number of applications for permit to drill remained healthy although lower than for the second quarter of last year. Geophysical activity was about the same as for the second quarter of last year. The average rig count in the second quarter of 2002 was 18 less than the average for the second quarter of last year although the count was still higher than expected, considering the very low price for natural gas in the first six months of this year.

Prices and production

Our latest price and production forecasts did not change in the first half of 2002 (see *Wyoming Geo-notes No. 73*, April, 2002, p. 5-8) but we expect to make some substantial revisions in our forecasts before the year ends. Our current estimates for production and prices (**Tables 1** and **2**) and their graphical representation (**Figures 1** through **4**) are provided for comparison with projections that we make later this year.

Prices paid to Wyoming oil producers during the second quarter of 2002 averaged $22.33 per barrel (**Table 3**). The average price for the quarter is $0.84 lower than for the second quarter of 2001, but $4.67 higher than for the first quarter of

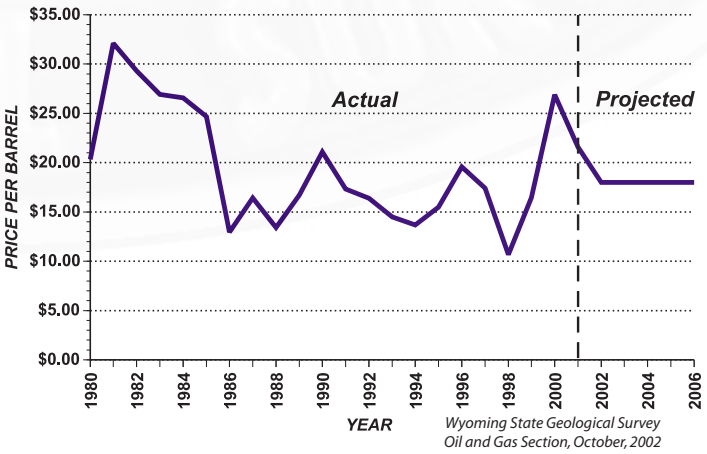

Figure 1. Average prices paid for Wyoming crude oil (1980 through 2001) with forecasts to 2006.

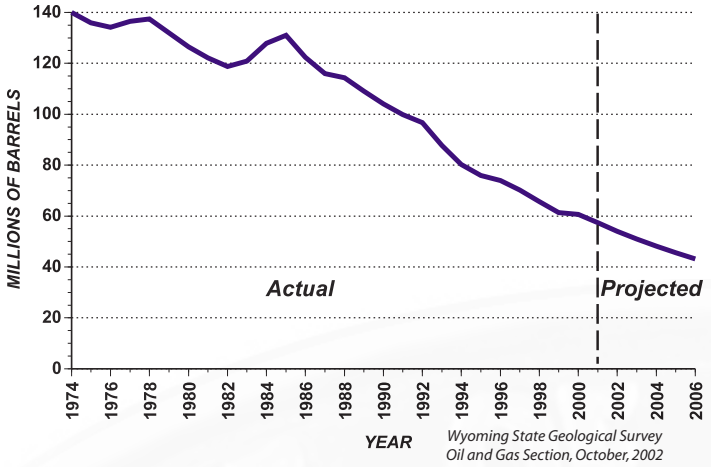

Figure 2. Annual crude oil production from Wyoming (1974 through 2001) with forecasts to 2006.

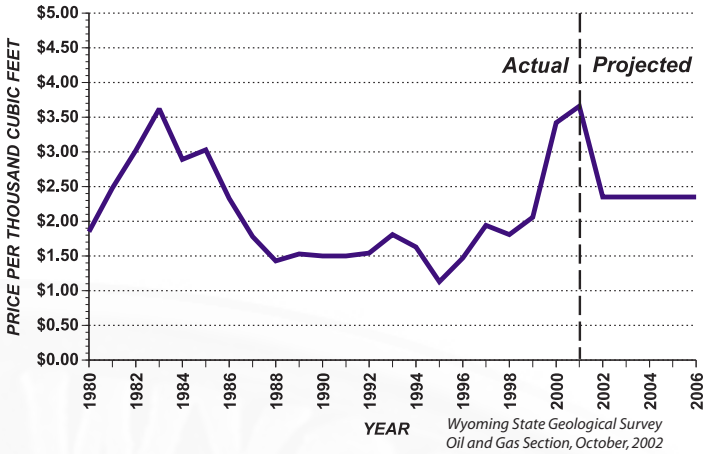

Figure 3. Average prices paid for Wyoming methane (1980 through 2001) with forecasts to 2006.

2002. Posted sweet and sour crude and first purchase prices for Wyoming oil (**Figure 5**), averaged by month, have risen steadily since bottoming out in December of last year.

Oil production reported by the Wyoming Oil and Gas Conservation Commission (WOGCC) for the first six months of 2002 was almost 27.3 million barrels (**Table 4**). This is a decrease of 5.6% from production in the first half of 2001.

Spot prices for natural gas at Opal, Wyoming averaged $2.25 per thousand cubic feet (MCF) during the second quarter of 2002. This is $1.50 per MCF lower than the average price for the second quarter of 2001, and $0.22 per MCF higher than for the first quarter of 2002. (**Figure 6** and **Table 5**).

Natural gas production in Wyoming for the first six months of 2002 was 844.1 BCF, according to production figures from the WOGCC. This production is up 6.1% from the first half of 2001 (**Table 6**). Coalbed methane production from the Powder River Basin accounted for 152.9 BCF of the 844.1 BCF and was 18.1% of Wyoming's natural gas production.

Reports, projects, and transactions

The Minerals Management Service (MMS) distributed more than $318 million to 32 states during the first six months of 2002. These are revenues from royalties, taxes, bonus bids from lease sales, and other sources collected by MMS from mineral production and leasing on federal lands. For the majority of federal lands, the federal government and those states where the resources are located share the revenues. The states receive 50%, the Reclamation Fund for water projects receives 40%, and the U.S. Treasury receives 10%. Wyoming received just under $164.7 million, almost 52% of the U.S. total. The mid-year total distributed to 32 states last year was a record $656 million.

Kern River Transmission Co., acquired by MidAmerican Energy Holdings Co. in the first quarter, completed a $31.4 million expansion project that provides an additional 125 million cubic feet (MMCF) per day of long-term, firm natural gas transportation service. The expansion included adding a compressor unit at an existing facility in southwestern Wyoming, upgrading a meter station in southwestern Wyoming, and installing a new electric motor-driven compressor at an existing facility in southern California. This expansion was the second major Kern River expansion in the last two years. The system is now capable of transporting 845 MMCF of natural gas per day.

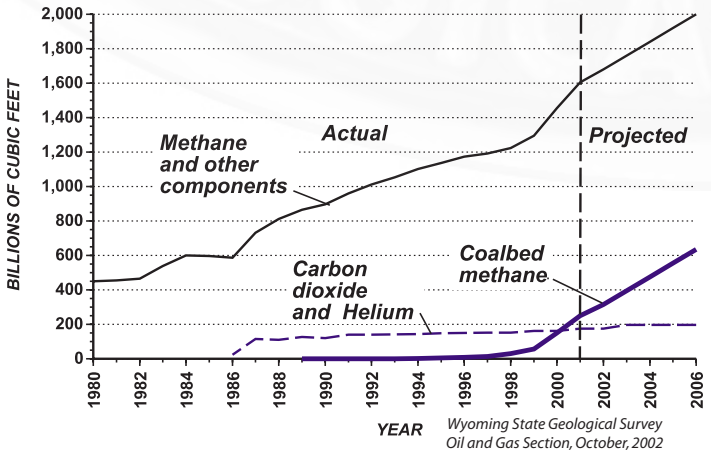

Figure 4. Annual natural gas production from Wyoming (1980 through 2001) with forecasts to 2006.

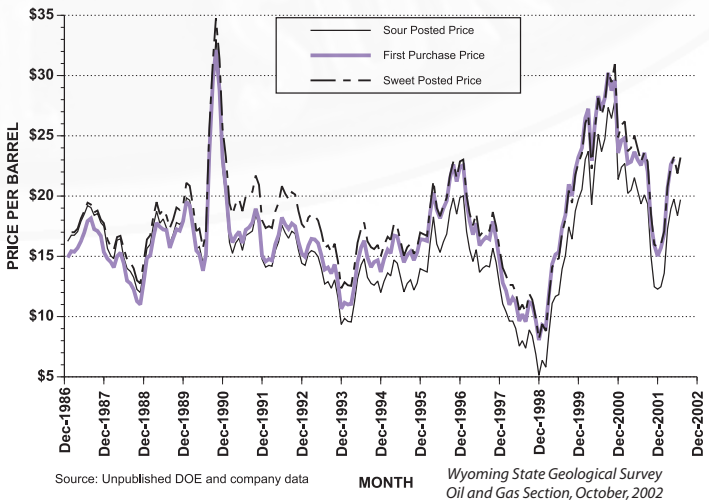

Figure 5. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through July, 2002).

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1998 through July, 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	$23.10	$19.74
June	$9.63	$11.38	$15.36	$12.50	$28.31	$25.84	$22.99	$23.61	**$21.25**	**$19.99**
July	$10.20	$11.21	$17.39	$13.20	$27.12	$26.02	$22.55	$23.46	**$22.80**	**$20.39**
August	$9.58	$11.01	$18.43	$13.86	$28.18	$26.29	$23.67	$23.49		
September	$11.19	$11.03	$20.97	$14.65	$30.22	$26.73	$22.02	$23.32		
October	$11.04	$11.03	$20.01	$15.18	$28.75	$26.93	$17.71	$22.76		
November	$9.64	$10.90	$22.20	$15.82	$29.63	$27.17	$16.44	$22.19		
December	$8.05	$10.67	$23.22	$16.44	$23.60	$26.88	$14.86	$21.58		
Average yearly price		**$10.67**		**$16.44**		**$26.88**		**$21.58**		

All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 2002 are estimated from various unpublished bulletins listing posted prices. *Wyoming State Geological Survey, Oil and Gas Section, October, 2002.*

Table 4. Monthly oil production from Wyoming in barrels (1998 through June, 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	4,713,000	4,713,000
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	4,243,939	8,956,939
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	4,624,227	12,581,166
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	4,553,021	18,134,187
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	4,669,105	22,803,292
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	4,454,064	27,257,356
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		
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		
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		
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		
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		
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		
Total Barrels Reported[1]		**64,781,645**		**61,342,369**		**60,626,442**		**57,400,141**		
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 June, 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, October, 2002.*

Kern River also received financing for $875 million, which completes all necessary funding to support construction of the $1.2 billion 2003 Kern River Expansion Project. The project includes placing a second natural gas pipeline in the right-of-way adjacent to their existing pipeline, constructing three new compressor stations, and installing additional compression and modifications at six existing facilities. When this expansion is completed, the entire Kern River system will have the capability to transport about 1.7 BCF per day. Kern River has binding agreements for over 900 MMCF per day of incremental service. Due for completion on May 1, 2003, this expansion should help Wyoming natural gas producers obtain higher prices than they are presently receiving. The existing 926-mile long pipeline currently delivers natural gas to expanding markets in Utah, Nevada, and California.

Kinder Morgan Energy Partners L.P. (KMEP) completed a $59 million expansion project on their Trailblazer Pipeline, which increases transportation capacity on the pipeline by 60%, to 846 MMCF per day. KMEP installed two new compressor stations and added 10,000 additional horsepower at an existing compressor station. The expansion project began in August, 2001 and was completed in May of this year. Trailblazer Pipeline is a 436-mile long natural gas pipeline that runs from Rockport, Colorado, just south of the Wyoming-Colorado border, to Beatrice, Nebraska. The additional capacity will allow transporting part of the coalbed methane from the Powder River Basin to markets in the Midwest.

KMEP also reported a successful open season for its new Cheyenne Market Center service. The additional 6 BCF of gas storage capacity created by the project is fully subscribed under 10-year contracts. Pending approval by the Federal Energy Regulatory Commission, a subsidiary of KMEP will construct pipeline, compression, and storage facilities at a cost of $30 million. The new service offers firm storage capabilities that will allow for the receipt, storage, and subsequent redelivery of natural gas at applicable points

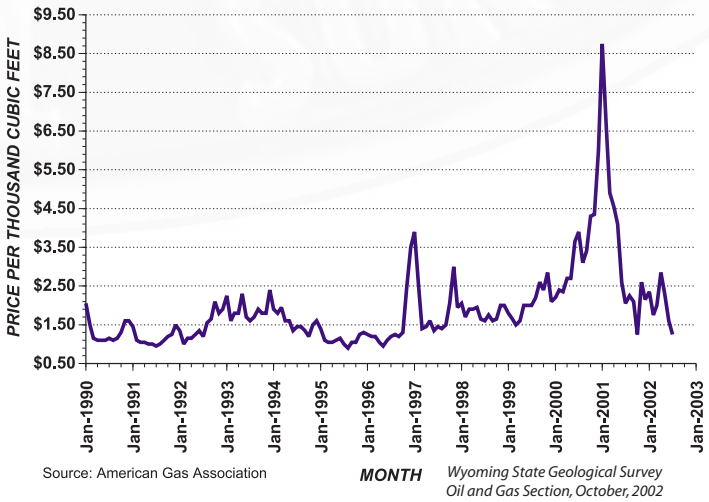

Figure 6. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through July, 2002).

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1998 through July, 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		
September	$1.60	$1.79	$2.60	$1.93	$3.40	$2.93	$2.10	$4.21		
October	$1.65	$1.78	$2.40	$1.98	$4.30	$3.07	$1.25	$3.92		
November	$2.00	$1.80	$2.85	$2.05	$4.35	$3.19	$2.60	$3.80		
December	$2.00	$1.81	$2.10	$2.06	$6.00	$3.42	$2.15	$3.66		
Average yearly price		**$1.81**		**$2.06**		**$3.42**		**$3.66**		

Source: American Gas Association's monthly reports. *Wyoming State Geological Survey, Oil and Gas Section, October, 2002.*

CALENDAR OF EVENTS

Talks

DISCUSSION OF THE CONTRIBUTION OF MINERAL PRODUCTION TO ALBANY COUNTY–*R.E. Harris*: Leadership Laramie, Laramie, Wyoming, September 10, 2002.

GEMSTONES AND LAPIDARY COLLECTING SITES IN WYOMING–*W.D. Hausel*: Cheyenne Mineral Club, Laramie County Library, Cheyenne, Wyoming, October 9, 2002.

PROSPECTING METHODS FOR GOLD AND DIAMONDS–*W. Dan Hausel*: Central Wyoming Community College, Riverton, Wyoming, October 16, 2002.

GEOGRAPHIC INFORMATIONS SYSTEMS AT WSGS–*J.M. Huss*: Wyoming Business Council, Cheyenne, Wyoming, October 29, 2002.

WYOMING MINERAL RESOURCES–*W.D. Hausel*: Central Wyoming Community College, Riverton, Wyoming, November 20, 2002.

OVERVIEW OF WYOMING'S MINERAL INDUSTRY–*R.E. Harris*: Northwest Mining Association Annual Convention, Spokane, Washington, December 4, 2002.

PROSPECTING METHODS FOR OIL AND GAS–*R.H. De Bruin*: Central Wyoming Community College, Riverton, Wyoming, December 5, 2002.

PROSPECTING METHODS FOR COAL–*R.M. Lyman*: Central Wyoming Community College, Riverton, Wyoming, December 5, 2002.

GEOGRAPHIC INFORMATION SYSTEMS–*J.M. Huss*: Maps and Mapping class, Geography and Recreation, University of Wyoming, Laramie, Wyoming, December 12, 2002.

HINTS FOR GOLD PROSPECTING–*W.D. Hausel*: Cheyenne Chapter of Gold Prospectors of America, Cheyenne, Wyoming, January 7, 2003, 7 pm.

Meetings, conferences, exhibits, etc.

GEOLOGICAL SOCIETY OF AMERICA (GSA) 2002 ANNUAL MEETING–*R.W. Jones, R.H. De Bruin, L. Cook*: Colorado Convention Center, Denver, Colorado, October 27-30, 2002.

GEOLOGIC INFORMATION SYSTEMS (GIS) DAY–*J.M. Huss, P.R. Ranz, and F.H. Porter*: Laramie County Community College, Cheyenne, Wyoming, November 23, 2002.

NORTHWEST MINING ASSOCIATION ANNUAL CONVENTION–*R.E. Harris*: Spokane, Washington, December 2-6, 2002.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS (AAPG) 2003 ANNUAL MEETING–*various WSGS staff*: Salt Palace Convention Center, Salt Lake City, Utah, May 11-14, 2003.

INDUSTRIAL MINERALS FORUM 2003 ANNUAL MEETING–*various WSGS staff*: 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.

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.

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

ASSOCIATION OF EARTH SCIENCE EDITORS (AESE) ANNUAL MEETING–*R.W. Jones*: Seattle, Washington, November 1-3, 2003.

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1998 through June, 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	143,041,447	143,041,447
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	132,537,672	275,579,119
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	143,265,073	418,844,192
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	140,574,372	559,418,564
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	144,972,174	704,390,738
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	139,661,300	844,052,038
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		
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		
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		
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		
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		
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		
Total MCF Reported[1]		**1,200,569,406**		**1,295,222,498**		**1,455,412,159**		**1,605,787,876**		
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 June, 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, October, 2002.*

located in the vicinity of the Cheyenne Hub (just south of Cheyenne) in northern Colorado. The additional infrastructure will have an injection capability of about 38 MMCF per day and withdrawal deliverability of about 62 MMCF per day. The new service is expected to be operational during the summer of 2004.

TEPPCO Partners L.P. are planning a $45 million pipeline expansion in southwestern Wyoming that will increase the gathering capacity of the Pinedale Field lateral and the mainline capacity of the Jonah Field system. The Pinedale Field lateral's capacity will increase from 55 to 250 MMCF of gas per day and the mainline capacity of the Jonah Field system will increase from 730 to 880 MMCF per day to handle the growth in gas production from Pinedale Field and to significantly reduce the operating pressures on the gathering lines in Jonah Field. The expansion will include installation of 43 miles of 20-inch and 24-inch diameter pipeline, 9000 horsepower additional compression, and enhanced liquid-handling facilities at two compressor stations. The project should be in service in the fourth quarter of 2002.

Williams Gas Processing proposed a new pipeline project that would connect the area around the abandoned Merna Field in T36N, R112W, with a pipeline approximately 7 miles north of Big Piney. The project would consist of a 32-mile long, 8-inch and 10-inch diameter pipeline. Williams Production RMT plans to carry out a drilling program in the Mesaverde Formation near Merna Field and has already staked four 13,500-foot tests.

In a related item, Veritas DGC Land Inc. plans to conduct a 3-D geophysical surveying project near Merna. The 3-D project would be 4 to 9 miles wide, about 35 miles long, and would encompass 290 square miles. The U.S. Bureau of Land Management (BLM) will need to approve that part of the project that is on federal land.

The BLM will allow Quantum Geophysical Inc. to conduct a 2-D geophysical project on existing federal oil and gas leases within the Adobe Town Wilderness Study Area southwest of Wamsutter. The line is only 6.82 miles long; Quantum will be required to use helicopter-transported drills for its shot holes. No vehicular traffic will be allowed off designated existing roads.

Veritas and Western-Geco plan to conduct a 411 square mile 3-D geophysical project south of Jonah Field. A new gas discovery was recently completed 2 miles southeast of Jonah Field. The seismic survey is expected to last four to five months. The BLM will need to approve that part of the project that is on federal land.

Veritas also plans to conduct a 210 square mile 3-D geophysical project in the Hay Reservoir Field area northwest of Wamsutter. About 90% of the project is on BLM-administered land, with about 55% of the project on land administered by BLM's Rock Springs Field Office and about 45% on land administered by BLM's Rawlins Field Office.

Anschutz Corp. plans a 155 linear mile 2-D geophysical project that would consist of 12 separate lines that would cover Whiskey Peak, Green Mountain, Crooks Gap, and Crooks Mountain, as well as the northern part of the Great Divide Basin. The area includes lands in Ts26 through 29N, Rs89 through 94W that extend west and northwest from Bairoil.

KMEP completed two transactions that give it 100% of Trailblazer Pipeline Co. KMEP bought Enron's one-third stake in the pipeline for $68 million and paid $12 million to an affiliate of El Paso Corp. in exchange for the stake in Trailblazer that the affiliate would have received for participation in the $59 million expansion project mentioned earlier.

Williams Companies Inc. completed the sale of exploration and production properties in the Wind River Basin of

central Wyoming. The properties include the Cave Gulch Unit that was part of Williams' $2.8 billion acquisition of Barrett Resources Corp. last year. Williams sold the Wind River Basin properties to the newly formed Bill Barrett Corp. for $73 million.

Lease sales

Leasing activity at the Wyoming Office of State Lands and Investments' (State Lands') April sale was heaviest in the Powder River Basin and southwestern Wyoming (**Figure 7**). Ann Trujillo made the high per-acre bid of $105 for a 320-acre parcel that covers the S/2 section 8, T56N, R76W (**location A, Figure 7**). The lease is about a half mile east of coalbed methane production from the Fort Union Formation. There were only seven parcels at this sale that received bids of $50 or more per acre. The sale generated over $465,000 in revenue and the average per-acre bid was $13.26 (**Table 7**).

Leasing activity at the April BLM sale was heaviest in the Powder River Basin and southwestern Wyoming (**Figure 8**). The high per-acre bid of $375 was made by Hanson & Strahn for a 79.14-acre lease that covers parts of section 23, T46N, R76W (**location A, Figure 8**). The lease is in an area of coalbed methane development from the Fort Union Formation. Marshall & Winston made the second high per-acre bid of $125 for a 1280-acre parcel that covers all of sections 12 and 14, T22N, R97W (**location B, Figure 8**). The parcel is about 3 miles east and southeast of Almond gas production and about 2 to 3 miles north of Frontier gas production at Sheep Camp Field. There were 24 leases at this sale that received bids of $50 or more per acre. The sale generated nearly $3 million in revenue and the average per-acre bid was $25.19 (**Table 7**).

Leasing activity at State Lands' June sale was scattered throughout the state (**Figure 7**). Sage Oil & Gas made the sale's high per-acre bid of $525 for a 40-acre lease in SE SE section 21, T50N, R74W (**location A, Figure 7**). The parcel is in an area of coalbed methane development from the Fort Union Formation. There were only four parcels at this sale that received bids of $50 or more per acre. The sale generated over $517,000 in revenue and the average per-acre bid was $11.04 (**Table 7**).

Leasing activity at the June BLM sale was heaviest in the Powder River Basin and southwestern Wyoming, although only 63 parcels were sold at this sale (**Figure 8**). S. Burritt Boynton made the high per-acre bid of $185 for a 160-acre lease that covers SW SW section 5 and S/2 SE section 9, T28N, R111W (**location A, Figure 8**). The lease is just east of production from the Wasatch, Almy, and Mesaverde formations at McDonald Draw Field. Rincon Exploration made the sale's second high per-acre bid of $170 for a 640-acre lease that covers all of section 28, T25N, R98W (**location B, Figure 8**). The lease is about 2 miles south of abandoned Mesaverde Formation gas production at Lost Valley Field. There were

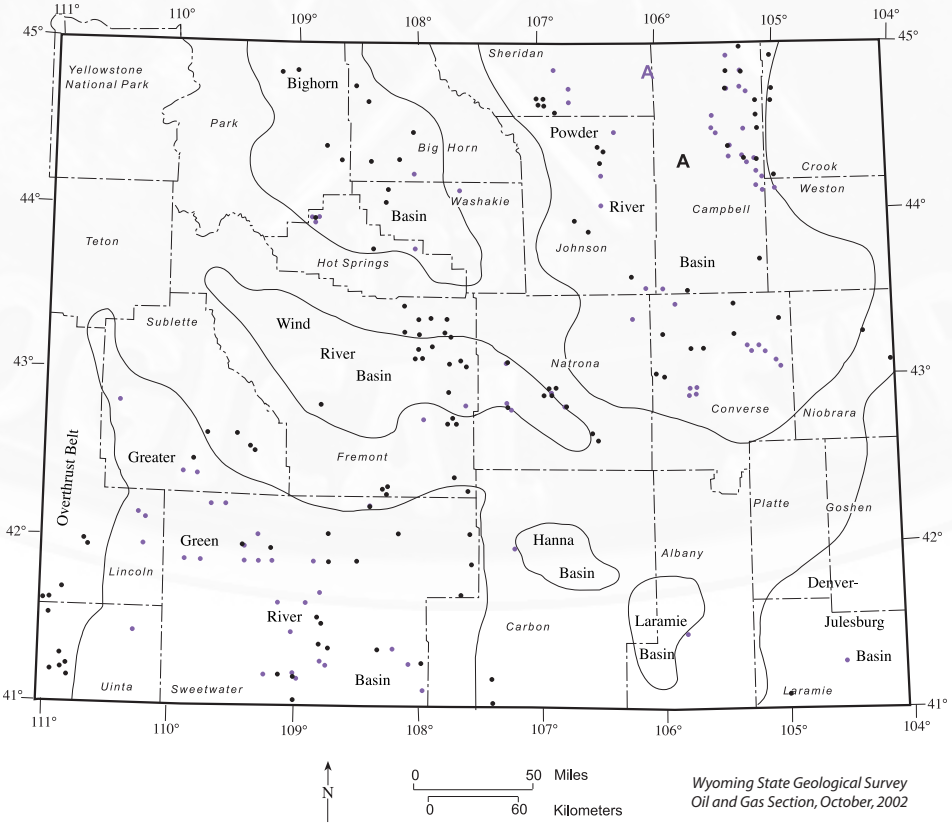

Figure 7. Locations of state oil and gas tracts leased by the Office of State Lands and Investments at its April, 2002 sale (locations in violet) and its June, 2002 sale (locations in black). Locations are approximate and may represent more than one tract.

Table 7. Federal and State competitive oil and gas lease sales in Wyoming (1996 through June, 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								**1996**			
TOTAL	$11,487,567	1828	1125	1,403,444	739,505	$15.53	$1,450.00	TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
				1997								**1997**			
TOTAL	$31,976,603	1787	1485	1,578,938	1,206,642	$26.50	$600.00	TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	$340.00
				1998											
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00					**1998**			
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00	April	$1,203,792	300	161	115,646	63,848	$18.85	$320.00
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00	June	$1,660,438	300	148	108,654	52,501	$31.63	$600.00
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00	October	$1,313,792	298	178	98,856	65,212	$20.14	$590.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00	December	$1,045,447	300	187	121,551	77,852	$13.43	$215.00
December	$15,229,257	407	278	388,783	277,538	$54.87	$800.00								
TOTAL	$63,800,496	2247	1710	2,217,975	1,621,637	$39.34	$800.00	TOTAL	$5,223,469	1198	674	444,707	259,413	$20.14	$600.00
				1999											
February	$2,734,442	170	138	157,779	124,880	$21.90	$325.00					**1999**			
April	$2,121,220	124	116	129,358	121,421	$17.47	$280.00	April	$1,815,526	299	196	123,119	89,194	$20.35	$890.00
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00	June	$1,002,039	300	190	108,310	69,858	$14.34	$400.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00	October	$2,369,527	300	216	109,140	77,261	$30.67	$475.00
Octoer	$4,395,288	214	175	195,827	142,525	$30.84	$580.00	December	$956,113	291	129	115,502	51,674	$18.50	$500.00
December	$5,598,020	176	164	128,480	124,093	$28.99	$410.00								
TOTAL	$24,197,991	1,069	945	1,060,674	929,674	$26.03	$32,000.00	TOTAL	$6,143,205	1,190	731	456,071	287,987	$21.33	$890.00
				2000											
February	$5,497,834	192	180	130,289	120,219	$45.73	$525.00					**2000**			
April	$3,057,278	189	161	160,712	128,063	$23.87	$440.00	April	$1,475,661	299	191	120,319	71,933	$19.54	$525.00
June	$6,387,887	230	184	260,294	190,306	$33.57	$410.00	June	$2,119,198	300	197	127,798	79,743	$26.58	$775.00
August	$5,213,595	240	222	174,040	154,920	$33.65	$475.00	October	$1,660,315	300	216	117,598	81,603	$20.35	$268.00
October	$5,028,610	147	129	149,934	124,724	$40.32	$510.00	December	$1,240,442	300	192	109,375	62,636	$19.80	$210.00
December	$6,352,525	185	179	182,935	180,380	$35.22	$725.00								
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					**2001**			
April	$2,969,094	142	127	136,864	117,852	$25.19	$375.00	April	$465,104	200	90	74,321	35,084	$13.26	$105.00
June	$1,183,222	91	63	82,958	55,808	$21.20	$185.00	June	$517,143	200	124	74,608	46,841	$11.04	$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, October, 2002.*

only nine parcels at this sale that received bids of $50 or more per acre. The sale generated nearly $1.2 million in revenue and the average per-acre bid was $21.20 (**Table 7**).

Permitting and drilling

The WOGCC approved 1648 Applications for Permit to Drill (APDs) in the second quarter of 2002. The total is 1421 less than in the second quarter of 2001, but more than for the full years of 1995 and 1996 (**Table 8**). Campbell County again led with 56.1% of the total APDs that were approved in the second quarter. Sheridan and Johnson counties combined for another 24.8%. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

The WOGCC permitted 17 seismic projects in the second quarter of 2002 (**Table 9**). The number of permits is two more than for the second quarter of 2001. The number of conventional miles permitted is 156 miles higher than for the second quarter of 2001, but 3-D square miles permitted is 101 square miles less than that for the second quarter of 2001. Geophysical activity is a good indicator of future exploration and production drilling.

The average daily rig count for the second quarter of 2002 was 37. This average is 18 less than for the second quarter of 2001. The rig count does not include rigs drilling for coalbed methane. **Figure 9** shows the Wyoming daily rig count averaged by month and by year.

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 coalbed methane (see the **Coalbed Methane Update** for development in that industry) during the second quarter of 2002. The numbers correspond to locations on **Figure 10**.

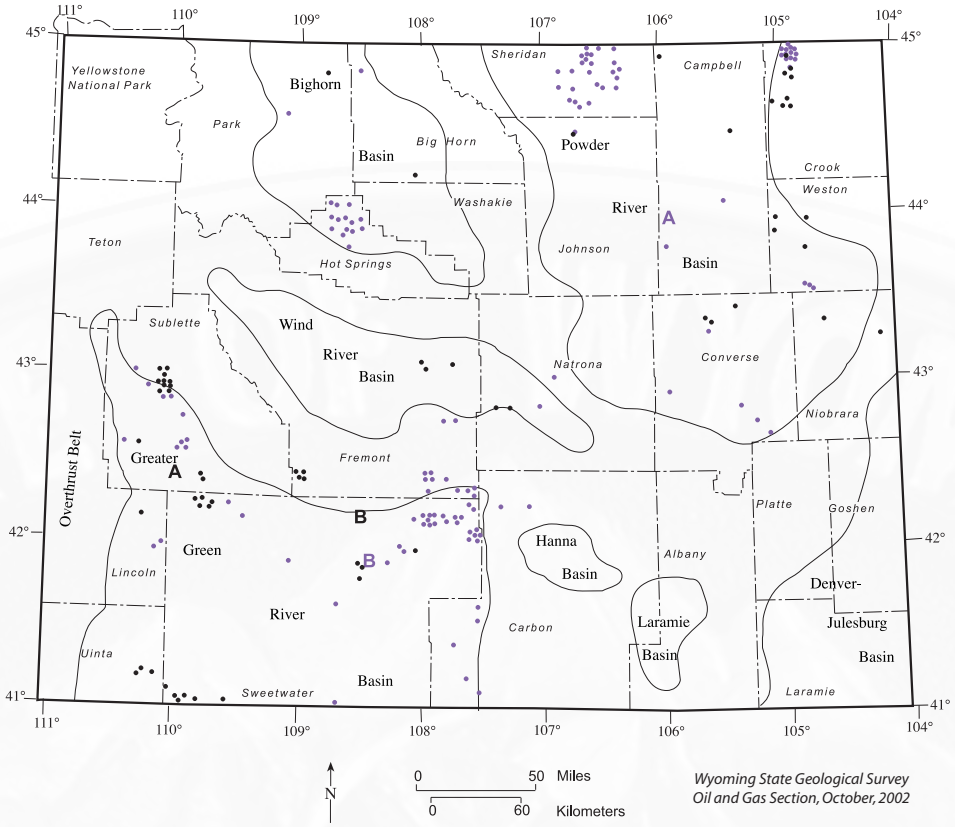

Figure 8. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its April, 2002 sale (locations in violet) and its June, 2002 sale (locations in black). Locations are approximate and may represent more than one tract.

Table 8. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1996 through June, 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	5
Campbell	554	941	1586	4461	5580	6204	1677
Carbon	77	84	96	127	174	261	87
Converse	20	16	6	19	70	25	30
Crook	37	26	29	30	47	20	12
Fremont	26	58	76	67	136	149	37
Goshen	0	0	0	0	0	0	1
Hot Springs	24	42	1	8	6	2	4
Johnson	16	6	49	304	769	805	319
Laramie	2	3	2	0	2	3	0
Lincoln	55	122	105	51	70	87	25
Natrona	74	59	36	51	53	45	21
Niobrara	7	8	8	5	18	15	0
Park	30	25	11	12	18	45	6
Platte	0	0	0	0	0	0	0
Sheridan	0	2	35	416	891	1811	719
Sublette	118	179	230	189	338	435	197
Sweetwater	136	210	181	124	335	534	195
Teton	0	0	0	0	0	0	0
Uinta	10	27	26	26	53	35	6
Washakie	30	36	9	0	7	10	0
Weston	10	5	6	4	20	7	0
Totals	**1280**	**1908**	**2505**	**5900**	**8598**	**10,517**	**3339**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, October , 2002.*

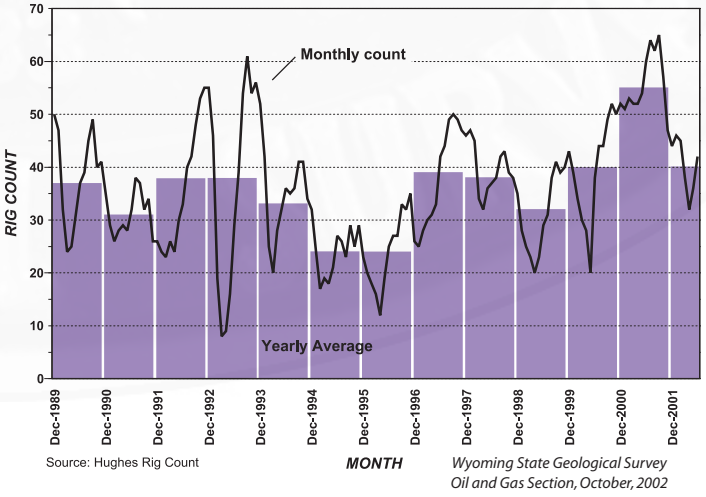

Figure 9. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month and year (December, 1989 through June, 2002).

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1998 through June, 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	0	0	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	9	49	0
Carbon	4	0	318	5	77	57	0	0	0	1	500	0	1	1	0
Converse	4	12	239	1	0	50	1	15	0	0	0	0	0	0	0
Crook	2	2	4	1	0	10	7	16	22	4	32	0	1	0	1
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	0	0	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	2	1	32
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	201	0
Sweetwater	6	214	66	9	0	530	13	54	1004	11	129	802	4	213	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	1	168	0
Washakie	4	41	35	1	0	8	0	0	0	0	0	0	0	0	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**	**24**	**796**	**589**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, October, 2002.*

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

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
1	Anschutz Exploration	13-24ST Thief Creek	SE NE sec 26, T13N, R121W	Nugget Ss.	15,700-16,712	11.6 MMCF 293 BBL cond two BBL H_2O	Directional redrill in Anschutz Ranch East Field, surface location is in Utah
2	Chevron USA	3-29M Chevron-Federal	SW SE sec 29, T19, R119W	Mission Canyon Ls.	14,752-15,444	3.6 MMCF 19 BBL cond	New producer on the north end of Whitney Canyon-Carter Creek Field
3	Chevron USA	28A La Barge Unit sec 34, T27N, R113W	NW irregular	2nd Frontier Ss. 1st Frontier Ss. 1st Frontier Ss.	6603-6794 6126-6152 4763-4795	3.1 MMCF 6.7 MMCF 7.2 MMCF	Infill well in La Barge Field; uppermost Frontier Ss. in over-thrust; lower 2 Ss. in subthrust
4	EOG Resources	187-25 BPMVU "B"	SE NW sec 25, T29N, R113W	transition zone	3367-3496	55 MCF 120 BBL oil 68 BBL H_2O	infill well in Big Piney Field
5	Williams Production RMT	14-33F Riley Ridge Unit	SE SW sec 33, T30N, R114W	2nd Frontier Ss.	7952-7964	1.3 MMCF 18 BBL cond 3 BBL H_2O	Exploratory test in Prospect Thrust area
6	Wexpro Co	9-17D Mesa	NW SW sec 16, T32N, R109W	Lance Fm.	10 intervals 9073-13,091	12.5 MMCF 84 BBL cond 60 BBL H_2O	Directional producer on Pinedale anticline
	Wexpro Co	12-16 Mesa	NW SW sec 16, T32N, R109W	Lance Fm.	nine intervals 8654-12,786	10.4 MMCF 72 BBL cond 60 BBL H_2O	New producer on Pinedale anticline
	Shell Rocky Mountain Production	10-11D Jensen	NW SE sec 11, T31N, R109W	Lance Fm. Mesaverde Fm. Ericson Ss. Mbr.	10 intervals 10,598-13,365	3.1 MMCF 20 BBL cond	Directional producer on Pinedale anticline
7	Ultra Resources	4-25 Warbonnet Unit	NW NW sec 25, T30N, R108W	Lance Fm. Mesaverde Fm.	13 intervals 8806-13,552	6.3 MMCF 47 BBL cond 486 BBL H_2O	New producer in Warbonnet Field on Pinedale anticline
8	McMurry Oil	10-14 Yellow Point	NW SE sec 14, T28N, R109W	Lance Fm.	10 intervals 7394-9724	9.1 MMCF 144 BBL cond 13 BBL H_2O	New producer on southeastern flank of Jonah Field
	McMurry Oil	1-29 Stud Horse Butte	NE NE sec 29, T29N, R108W	Lance Fm.	eight intervals 8097-10,140	2.0 MMCF 18 BBL cond 39 BBL H_2O	New producer in Jonah Field
	McMurry Oil	2-33 Stud Horse Butte	NW NE sec 33, T29N, R108W	Lance Fm.	11 intervals 8097-10,140	3.3 MMCF 41 BBL cond 23 BBL H_2O	New producer in Jonah Field
	McMurry Oil	11-33X Stud Horse Butte	NE SW sec 33, T29N, R108W	Lance Fm.	12 intervals 7744-10,651	3.6 MMCF 40 BBL cond 14 BBL H_2O	New producer in Jonah Field

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

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
8	McMurry Oil	6-33 Stud Horse Butte	SE NW sec 33, T29N, R108W	Lance Fm.	six intervals 9378-10,642	1.9 MMCF 35 BBL cond 29 BBL H_2O	New producer in Jonah Field
	McMurry Oil	10-11 Yellow Point	NW SE sec 11, T28N, R109W	Lance Fm.	seven intervals 8286-9776	1.2 MMCf 35 BBl cond 17 BBL H_2O	New producer in Jonah Field
	McMurry Oil	16-28 Stud Horse Butte	SE SE sec 28, T29N, R108W	Lance Fm.	11 intervals 7878-10,754	5.2 MMCF 55 BBL cond 42 BBL H_2O	New producer in Jonah Field
	McMurry Oil	2-28 Stud Horse Butte	NW NE sec 28, T29N, R108W	Lance Fm.	12 intervals 7971-11,116	4.9 MMCF 56 BBL cond 18 BBL H_2O	New producer in Jonah Field
	McMurry Oil	2-33 Stud Horse Butte	NW NE sec 33, T29N, R108W	Lance Fm.	11 intervals 7798-10,820	4.7 MMCF 74 BBL cond 12 BBL H_2O	New producer in Jonah Field
	McMurry Oil	16-26 Stud Horse Butte	SE SE sec 26, T29N, R108W	Lance Fm.	12 intervals 9154-11,680	5.0 MMCF 87 BBL cond 5 BBL H_2O	New producer on eastern flank of Jonah Field
	McMurry Oil	11-14 Yellow Point	NW SE sec 14, T28N, R109W	Lance Fm.	nine intervals 7767-9499	4.0 MMCF 50 BBL cond 5 BBL H_2O	New producer on southwestern flank of Jonah Field
	McMurry Oil	10-13 Yellow Point	NW SE sec 13, T28N, R109W	Lance Fm.	eight intervals 7322-9768	3.3 MMCF 30 BBL cond 23 BBL H_2O	New producer on southwestern flank of Jonah Field
	McMurry Oil	11-7 Jonah-Federal	NE SW sec 7, T28N, R108W	Lance Fm.	12 intervals 7531-10,409	7.8 MMCF 111 BBL cond 22 BBL H_2O	New producer on southwestern flank ofJonah Field
	McMurry Oil	16-35R Stud Horse Butte	SE SE sec 35, T29N, R108W	Lance Fm.	12 intervals 8901-11,368	8.1 MMCF 144 BBL cond 28 BBL H_2O	New producer in Jonah Field
9	McMurry Oil	5-29 Hacienda-Federal	SW NW sec 29, T28N, R108W	Lance Fm. Mesaverde Fm.	four intervals 8750-9139 10,553-10,557	1.0 MMCF 60 BBL cond 88 BBL H_2O	Wildcat discovery 2 1/2 miles southeast of Jonah Field
10	Amoco Production	13-16 Whale	SW SW sec 16, T25N, R106W	Almond Fm.	9859-10,049	512 MCF 607 BBL H_2O	Wildcat discovery 12 miles north-northeast of Stagecoach Draw Field
11	RME Petroleum	35-1 Laney Rim	C NW sec 35, T18N, R97W	Almond Fm.	10,388-10,408	4.7-8.5 MMCF 54 BBL H_2O	Wildcat discovery four miles east-southeast of Delaney Rim Field
12	BP America Production	36-2 Delaney Rim	NW NE sec 36, T18N, R95W	Mesaverde Gp.	10,705-11,048	1.3 MMCF 39 BBL cond	New producer on the western flank of Wild Rose Field
	BP America Production	11-2 Eightmile	C SW sec 11, T18N, R94W	Mesaverde Gp.	three intervals 9540-9926	1.6 MMCF 56 BBL cond	New producer in Wild Rose Field
13	RME Petroleum	2-30 Federal-BF	NW NE sec 30, T19N, R91W	Almond Fm.	8676-8778	1.5 MMCF 192 BBL cond 248 BBL H_2O	New producer in Fillmore Field
14	BP America Production	7-1 Fivemile	SW NE sec 7, T21N, R93W	Lewis Sh.	two intervals 9554-9787	1.2 MMCF 14 BBL cond	New wildcat dual producer one mile southwest of Five Mile Gulch discovery
				Mesaverde Gp.	two intervals 10,915-11,168	1.9 MMCF 15 BBL cond	
15	BP America Production	36-5 C. G. Road Unit	NE SW sec 36, T21N, R94W	Lewis Sh.	8900-8973	1.9 MMCF 22 BBL cond 577 BBL H_2O	New dual producer in Wamsutter Field
				Mesaverde Gp.	10,401-10,454	2.0 MMCF 28 BBL cond 73 BBL H_2O	
16	EOG Resources	1-19 Crotalus	SE NW sec 19, T38N, R75W	Frontier Fm.	12,671-12,691	640 BBL oil 700 MCF	Stepout from Snake Charmer Draw field discovery
17	O'Brien Energy Resources	1 Greasewood	"SW NW sec 1, T38N, R64W"	Dakota Ss.	6613-6619	150 BBL oil	Wildcat discovery six miles west-southwest of Greasewood Field

[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; Ss.=Sandstone; Ls.=Limestone; Fm.=Formation; Sh.=Shale. *Wyoming State Geological Survey, September, 2002.*

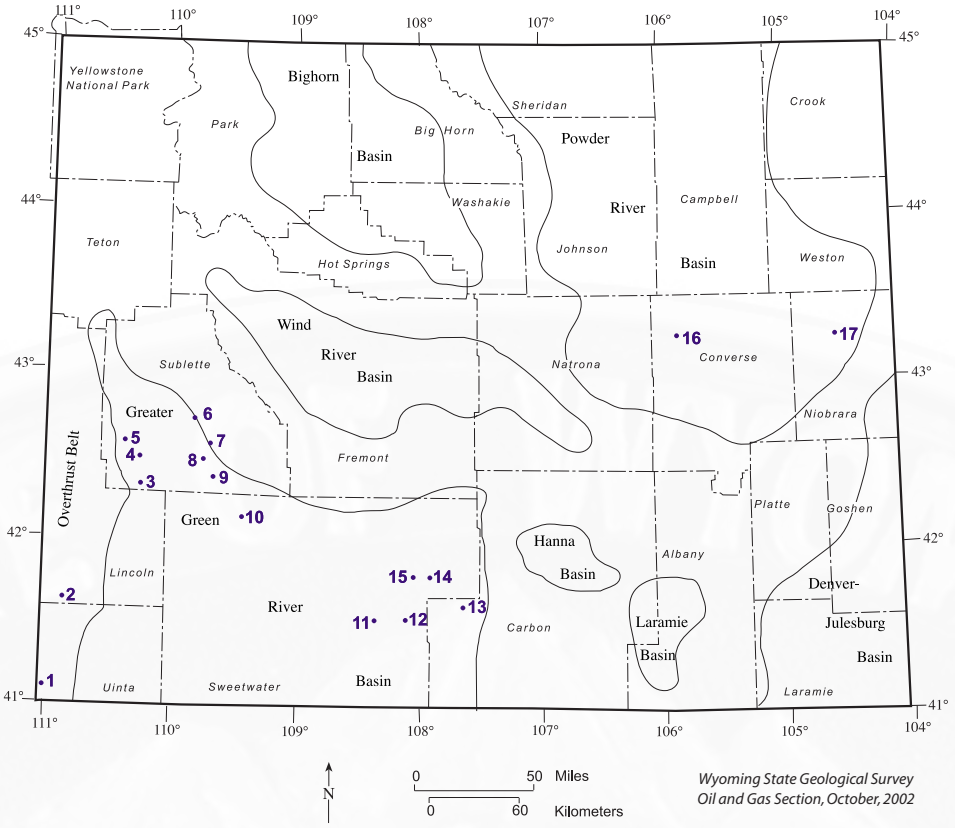

Figure 10. Oil and gas exploration and development activities in Wyoming during the second quarter of 2002. Locations are approximate and may represent more than one well location or project.

Coal Update

Robert M. Lyman, Wyoming PG-656

Staff Geologist–Coal, Wyoming State Geological Survey

A number of factors appear to be influencing Wyoming's coal production (and prices) and will contribute to a slight decrease (2%) in tonnage from 2001 to 2002 but probably a slight increase in price. The mild weather and high stockpiles at electric utilities have affected movements of spot coal especially, with only 15% of the state's production now from spot sales, as opposed to the normal 20%. From a price standpoint, selling less of the lower-priced spot coal and concentrating more on term coal sales is expected to positively affect the state's overall coal prices.

Federal coal leasing activity in Wyoming's Powder River Basin (PRB) increased in the second quarter. Two companies are requesting noncompetitive leases to access additional federal coal adjacent to active mining operations, thus extending the life of the mines. A number of lease by applications (LBAs) are still being processed for competitive sales, with one tract now at the environmental impact statement stage. Also, the federal government is processing a coal exploration application for the eastern PRB and a proposed land exchange in Sheridan County (which could possibly result in a new coal mine for that county).

A new power plant near Gillette is due to go on line next year and another power plant planned for south of Gillette is now apparently going ahead, with two other plants still in the permitting stage. Also during the second quarter, two train wrecks involving unit trains carrying Wyoming coal were reported. Unfortunately, with the sheer numbers of coal unit trains moving between Wyoming and the large market area Wyoming's coal producers serve, accidents are bound to happen even with all the safety precautions that are taken.

Production and prices

In the five-year period from 1997 through 2001, coal production from Wyoming's PRB has exhibited growth of just over 90 million short tons, an increase of 34% during the period (**Table 11**). This year, however, we have projected PRB production to decrease approximately 2% from the record production in 2001 (**Table 12** and **Figure 11**). Mild weather and high stockpile levels at many utilities within Wyoming's market area through June further support this estimate.

Table 11. Coal production from the Powder River Basin, Wyoming, 1997 through 2001.

Mine	1997	1998	1999	2000	2001
Antelope	13,564,831	19,418,684	22,685,000	22,968,729	24,643,293
Belle Ayr	22,800,736	22,479,368	17,885,338	15,016,000	11,750,497
Big Horn	44,202	65,909	76,401	38,411	0
Black Thunder	37,669,516	42,683,014	48,670,418	60,101,578	67,627,498
Buckskin	14,443,165	17,290,730	15,587,569	15,833,179	19,176,796
Caballo	19,946,861	25,984,949	26,468,718	25,596,000	27,116,000
Coal Creek	2,921,242	7,068,322	11,229,923	4,190,148	0
Cordero-Rojo	28,062,574	36,979,025	45,674,755	38,623,180	43,487,182
Dave Johnston	4,180,407	3,964,694	2,956,038	631,126	0
Dry Fork	918,224	1,030,718	1,219,590	2,268,720	4,029,100
Eagle Butte	17,921,000	18,074,546	17,416,240	18,622,992	24,826,910
Fort Union	600,998	48,945	33,028	0	0
Jacobs Ranch	27,112,931	29,078,333	29,081,030	28,284,776	29,334,900
North Antelope/Rochelle	59,918,886	64,639,932	68,865,691	70,769,071	74,777,460
North Rochelle	0	41,083	8,171,479	17,187,000	23,872,327
Rawhide	10,705,680	5,390,400	807,892	0	0
Wyodak	3,250,969	3,280,157	3,179,585	3,050,325	3,518,162
Total	**264,062,222**	**297,518,809**	**320,008,695**	**323,181,235**	**354,160,125**

Data from Annual Reports of the State Inspector of Mines of Wyoming, 1997 through 2001.

Spot prices continued to be caught in low price doldrums through the second quarter and well into the third quarter of this year, causing many operators to withdraw production from the spot arena and concentrate on term coal contracts. During the same period a year ago, term coal contracts contributed to an overall increase in coal prices. Around 20% of the state's coal production traditionally moves on the spot market, but this year spot sales have moved closer to 15% of the production. Wyoming producers are rethinking their production schedules; incremental sales may be waning as supply-side discipline reacts to the lack of demand.

Further erosion of the PRB coal market may be on the horizon as a result of the number of mandated scrubbers on large generating units that are currently part of the Bush Administration's "Clear Skies Initiative." Some market gurus are predicting that upwards of 25% of the PRB market will be negatively impacted by this year-2005 requirement (see ***Regulatory developments***, below). Despite these cautions, we expect that real growth in PRB coal production will resume in 2003, with a stable to modest growth in overall Wyoming coal production over the next five years.

For the first half of 2002, coal production from Wyoming mines was up by 1.37% over the first half of 2001. During the second quarter, Wyoming mines shipped 88,912,844 tons of coal (**Figure 12** and **Table 13**). Contract coal deliveries for the first six months of 2002 were ahead of last year by about 7.7 million short tons (**Figure 13A**) while spot coal deliveries were about 5.2 million short tons less (**Figure 13B**).

While ahead of last year's record setting pace at the end of June, softness in the spot market for PRB coals as discussed above indicates that production should slow during the third quarter of 2002. Despite this early gain, we still expect Wyoming coal production for 2002 to come in about 2% less than in 2001 (**Table 12**).

Spot prices for PRB coal were very flat during the second quarter of 2002 (**Figure 14**). After a modest rally in April, spot prices for both 8400- and 8800-Btu coal had stabilized. The month of June saw a very quiet spot market as producers put little of their production on the market. At the end of the quarter, estimated PRB spot coal prices were $4.55 and $5.54 per ton FOB mine for 8400-Btu and 8800-Btu products, respectively (**Figure 14**). At the end of June, 2001, these same coals in the spot market held prices of $8.19 and $10.00 (**Figure 14**), showing how quickly the worm can turn in the spot market.

Overall Wyoming coal prices for 2002 are expected to increase slightly over prices in 2001 (**Table 2** and **Figure 15**). These estimates, provided here for comparison purposes, are the same made in *Wyoming Geo-notes No. 73* (April, 2002, p. 16), and are not expected to be much different when our new forecasts are published later this year.

Developments in the Powder River Basin

In response to a petition from Peabody Energy, the U.S. Bureau of Land Management (BLM) is studying a possible noncompetitive federal coal lease sale involving just under 20 acres containing roughly 2 million short tons

Table 12. Wyoming coal production by county[1,2] (in millions of short tons), 1996 through 2001 with forecasts to 2007.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Powder River Basin												
Campbell County	245.3	246.3	274.1	294.3	299.5	329.5	322.0	330.0	332.7	335.5	338.3	341.1
Converse County	15.8	17.8	23.4	25.6	23.6	24.6	25.0	26.0	27.0	28.0	29.0	30.0
Sheridan County	M	M	M	M	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	261.1	264.1	297.5	320.0	323.1	354.1	347.0	356.0	359.7	363.5	367.3	371.1
Southern Wyoming												
Carbon County	4.7	5	3.5	2.7	2.0	0.5	M	2.0	2.0	2.0	2.0	2.0
Sweetwater County	8.2	7.8	9.2	9.4	10.0	9.5	9.0	9.0	9.0	9.0	9.0	9.0
Lincoln County	4.4	4.6	4.7	4.3	3.7	4.5	5.0	5.0	5.0	5.0	5.0	5.0
Subtotal	17.3	17.4	17.4	16.4	15.7	14.5	14.0	16.0	16.0	16.0	16.0	16.0
Total Wyoming[3]	**278.4**	**281.5**	**314.9**	**336.5**	**338.9**	**368.6**	**361.0**	**372.0**	**375.7**	**379.5**	**383.3**	**387.1**
Annual change	**5.5%**	**1.1%**	**11.9%**	**6.9%**	**0.7%**	**8.8%**	**-2.1%**	**3.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**
Higher-priced coal[4]	**24%**	**22%**	**17%**	**13%**	**9%**	**6%**	**4%**	**4%**	**4%**	**4%**	**1%**	**1%**

[1]Reported tonnage from the Wyoming State Inspector of Mines (1995 through 2001). [2]County estimates by the Wyoming State Geological Survey, February, 2001 for 2001 through 2006. Totals may not agree because of independent rounding. [3]Estimate modified from CREG's Wyoming State Government Revenue Forecast, October, 2001. M=minor tonnage (less than a million tons). *Wyoming State Geological Survey, Coal Section, October, 2002.*

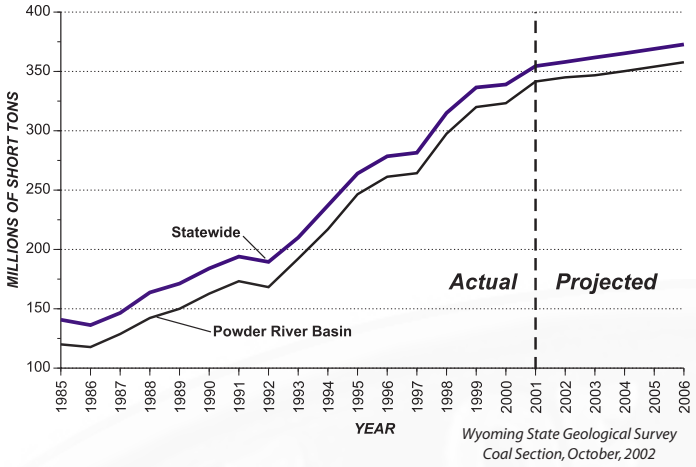

Figure 11. Annual coal production from Wyoming and the Powder River Basin (1985 through 2001) with forecasts to 2006. Sources: Wyoming State Inspector of Mines (1985 through 2001), CREG (2002 through 2006), and the Wyoming State Geological Survey.

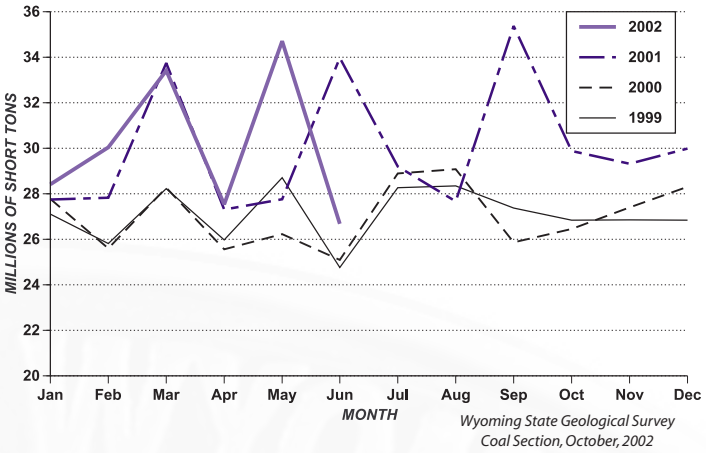

Figure 12. Reported monthly deliveries from Wyoming coal mines (1997 through June, 2002). From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the WSGS for 1999 through 2002.

of coal. The tract is located adjacent to Powder River Coal's North Antelope/Rochelle mine complex in Campbell County (COAL Daily, 4/15/02).

On May 30, BLM held a public hearing in Casper to review an application from Triton Coal to add 156 acres to an existing federal lease near their North Rochelle mine. The BLM may allow a coal company to add up to 160 acres to an existing lease without triggering the competitive lease sale process. The applied for land contains approximately 13 million tons of federal coal (Coal Outlook, 5/5/02).

If the exchange is made, the company hopes to begin mining at their so-called Ash Creek site by 2008.

BLM's Powder River Regional Coal Team (RCT) also held a public meeting on May 30 to review pending coal LBAs. Agenda items included: Cordero Mining Company's application for the 7247-acre Mt. Logan tract, which contains an estimated 614 million short tons of coal; RAG Wyoming Land Company's application for the West Extension Eagle Butte tract, consisting of 1666 acres with an estimated 200 million short tons of coal; and Jacobs Ranch Coal's application for the Big Thunder tract, which contains an estimated 715 million short tons of coal underlying 5634 acres.

Just prior to the RCT meeting, Kennecott Energy (the parent company for Jacobs Ranch Coal) withdrew their Big Thunder LBA. While reasons for the withdrawal where not given, several observers said that the problem may have been the amount of overlap with Arch's Little Thunder LBA. Kennecott's withdrawal will solve many of the questions concerning the overlap area (Coal Outlook, 5/27/02).

Kennecott Energy (the parent company for Cordero) also trimmed their LBA for the Mt. Logan coal tract located next to their Cordero-Rojo mine complex. The revised tract, now known as the Maysdorf tract, covers only 2809 acres and contains an estimated 296.3 million short tons of federal coal. The mining company eliminated part of the original LBA which bordered Arch Coal's Coal Creek mine (Coal Week, 3/17/02).

Table 13. Estimated monthly coal deliveries from Wyoming's mines in short tons (January, 1998 through June, 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		
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		
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		
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		
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		
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		
Total Utility Tonnage[1]		**304,771,208**		**325,051,993**		**324,452,665**		**359,723,000**		
Total Tonnage Other [2]		**10,190,883**		**11,407,945**		**14,399,483**		**8,955,135**		
Total Tonnage Produced[3]		**314,962,091**		**336,459,938**		**338,852,148**		**368,678,135**		

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

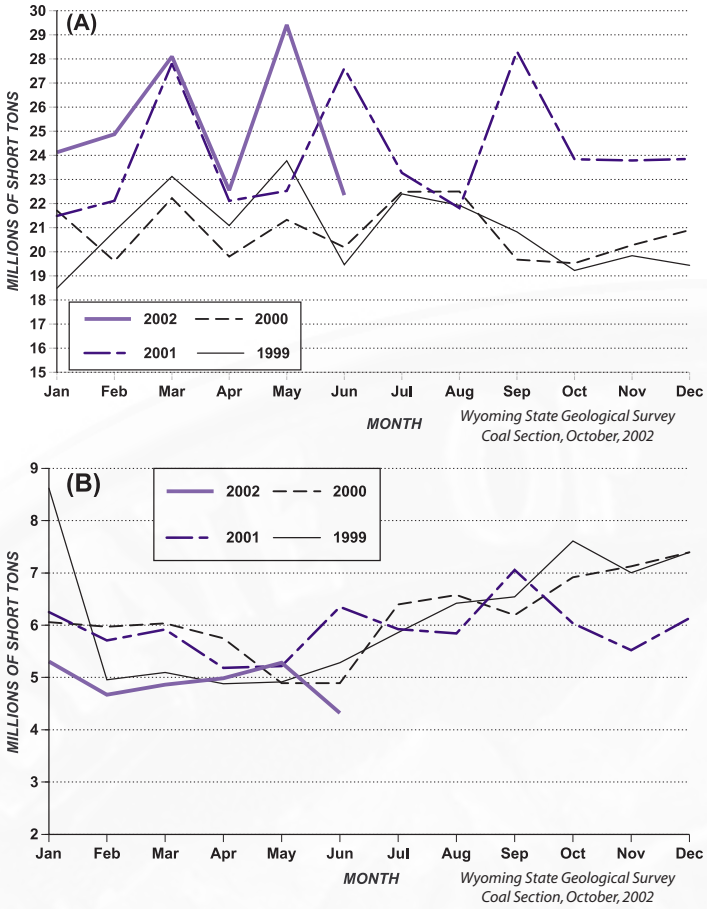

Figure 13. Monthly coal deliveries from Wyoming (1997 through June, 2002). (A) Coal sold on contract and (B) coal sold on the spot market. From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the WSGS for 1999 through 2002.

Cordero Mining Company asked BLM for permission to explore a 3860-acre tract of federal coal lands within Campbell County. As required under BLM guidelines, other interested parties shall be invited to join Cordero in the exploration (COAL Daily, 5/15/02).

The Wyoming State BLM office began work in June on a draft environmental impact statement (DEIS) for the West Hay Creek LBA tract being sought by Triton Coal. Adjacent to Triton's Buckskin mining operation, the 933-acre tract is estimated to contain 135 million short tons of federal coal. The company hopes to get the Hay Creek reserves, which would extend Buckskin's mine life by approximately nine years (COAL Daily, 6/7/02).

BLM was taking public comments though July 26 on the DEIS concerning a proposed land exchange from Pittsburg and Midway Coal Mining Company. The company proposes exchanging 3620 acres of their surface land in Sheridan, Carbon, and Lincoln counties for a 2045-acre tract of federal coal located in Sheridan County. The federal tract contains an estimated 107 million short tons of coal. If the exchange is made, the company hopes to begin mining at their so-called Ash Creek site by 2008. The final exchange is still several years from completion (Coal Outlook, 6/3/02).

Black Hills Corporation, in its annual report, expected its new 90-megawatt (MW) coal-fired plant to be up and running within a year. The new Wygen unit, located at the company's Wyodak Complex, is identical to their Neil Simpson II facility (also at the complex). The new unit will be a leased mine-mouth plant, which will use pulverized coal on a conveyer belt from the company's nearby Wyodak mine. The plant is designed to burn 1.5 million tons annually. The company reported that 80 MW of the plant's power is already under contract. Proposed new power generation at the Wyodak complex would raise their overall fuel needs to 5 million tons annually (U.S. Coal Review, 5/20/02).

North American Power Group (NAPG) reported that DTE Energy, an affiliate of Detroit Edison, will help build the 300-MW Two Elk One coal-fired power plant in Wyoming's PRB. The $300 to $400 million project is now expected to proceed after being stalled while NAPG sought a partner for the enterprise. Two Elk One is the first of three power plants the company wants to build in the area. The others, Two Elk Two and Middle Bear, are currently under review in the permitting process. Bechtel will serve as the contractor in the construction project (Coal Outlook, 5/13/02).

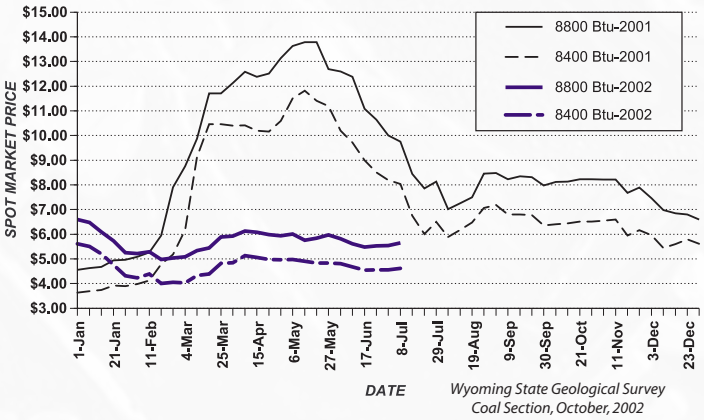

Figure 14. Wyoming PRB coal spot price watch (January 1, 2001 through July 8, 2002). Modified from COAL Daily's spot market index, and Coal Week's short-term spot market price index.

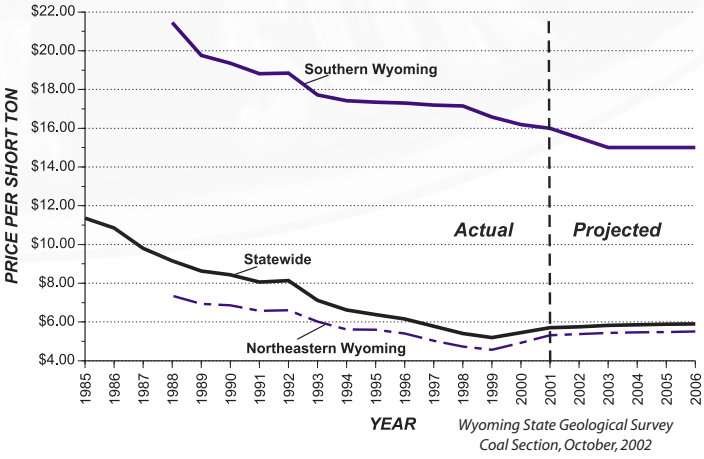

Figure 15. Average prices paid for Wyoming coal by producing area (1985 through 2001) with forecasts to 2006. Sources: U.S. Energy Information Administration (1985 through 1990); Wyoming Department of Revenue (1991 through 2000); and CREG (2001 through 2006).

Westmoreland Coal, in a financial statement, reported that in 2006 it should start receiving royalties of $0.10 per short ton for coal mined on the Rocky Butte coal area in the southern PRB. That is the year targeted in their mine plan that Powder River Coal's Caballo mine will begin recovering the tract's reserves. Approximately 225 million short tons of coal are subject to the royalty. The land is the site of the Rocky Butte mining tract, which was permitted by Montana Power in the mid-1990s. Before the mine was developed, Montana Power sold the property to Peabody (Coal Outlook, 4/8/02).

After the Air Quality Division at the Wyoming Department of Environmental Quality sampled dust collected near the Jacobs Ranch mine, the results appear to confirm the mine's belief that most of the dust resulted from local traffic. Testing done by a coalition formed to find a solution to the dust problem (see *Wyoming Geo-notes No.74*, July, 2002, p.16) near mines in Campbell County apparently revealed that the coal mines are minor contributors to the dust problem. About 75% of the dust is believed to be coming from local roads, while less than 20% is from organic carbon (coal) (U.S. Coal Review, 4/15/02).

The EPA report predicts that western coal production will decline from 510 million short tons to 481 million short tons annually between the years 2000 and 2020.

Arch Coal's Black Thunder mine received approval from the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) for their new Ground Control Plan, which addresses several changes in the design and maintenance of highwalls. After a worker was severely injured and another worker was killed in separate highwall incidents early this year, Arch said that highwalls at the mine will be constructed at a reduced angle (60° maximum angle of highwall face instead of 70°) and mine employees will be moved farther back (minimum of 30 feet) away from the toe of the highwalls (Casper Star-Tribune, 5/27/02).

Developments in southern Wyoming

Scottish Power in their May earnings release said that their U.S utility company, PacifiCorp, continues to benefit from low fuel cost due to in-house, captive coal production. PacifiCorp operates the Jim Bridger power plant and its associated mine in southern Wyoming, as well as some other operations in Utah. The company stated that they produce 33% of its coal needs and has the third lowest cost of delivered coal ($0.81 per million Btu) for all electric utility companies burning over 10 million short tons per year (Coal Outlook, 5/13/02).

Transportation developments

Southern Company's subsidiary, Georgia Power, signed a long-term contract with the Burlington Northern Santa Fe Railroad (BNSF) for delivering western coal to their Scherer, Georgia power plant. Starting in January, 2004, BNSF will transport the coal to Memphis where the Norfolk Southern will pick it up for final delivery to the plant. BNSF viewed the new haulage contract as an important expansion of the railroad's coal business. Union Pacific Railroad (UP) currently hauls about 6 million short tons of PRB coal annually to the plant, but their contract only runs through 2003.

BNSF was very aggressive in going after the haulage contract to the Scherer plant in light of Georgia Power's recent announcement that they would significantly increase the plant's burn of low-sulfur western coal. The utility aims to increase its PRB burn at Scherer to between 12 and 14 million short tons annually by 2004. Although neither party gave details of the transportation rate granted in the contract, many experts believe the utility gained a 10 to 15% decrease over the current rate charged by UP (COAL Daily, 5/22/02).

In May, the Dakota, Minnesota & Eastern Railroad (DM&E) filed a lawsuit in U.S. District Court in Pierre, South Dakota, requesting the court strike down a South Dakota law passed in 1999 regarding use of eminent domain. The company contends that the subject law prevents them from obtaining financing for its $1.4 billion PRB build-in expansion. The law provides that a railroad may exercise the right of eminent domain only by first obtaining the authority from the Governor or the state Transportation Commission. The lawsuit contends that the law is unconstitutional because it interferes with interstate commerce and discriminates against the DM&E (Coal Outlook, 5/6/02).

The City of Winona in southeastern Minnesota is looking at expanding its local port facilities in hopes that it could participate in increased coal traffic from the proposed DM&E line. State funding to support a $12.6 million port expansion project is hoped for. Under DM&E's proposed project, coal would be shipped from Wyoming's PRB to the Mississippi River at Winona. A terminal facility to handle coal would be needed to allow the city to benefit from the expected increase in coal traffic (U.S. Coal Review, 4/15/02).

A loaded 116-car BNSF unit train crashed into a BNSF intermodal train 55 miles southeast of Amarillo, Texas. Four engines and 25 cars were derailed in the accident, which killed one crew member and injured three others. The coal train was hauling PRB coal from the Rawhide mine to West Texas Utilities' Oklaunion plant. Twenty-two coal cars were among those derailed as a result of the accident (Coal Outlook, 6/3/02).

Four railroad employees were injured in another accident when an empty BNSF coal train collided head-on with a parked, loaded BNSF coal train 12 miles southeast of Wright. The 119-car empty train was traveling from Guernsey to the Black Thunder mine. The loaded 123-car train was carrying

coal from the North Rochelle mine headed for Superior, Wisconsin. Traffic on the line was disrupted for about 8 hours. About 200 yards of track was damaged in the mishap (Casper Star-Tribune, 5/12/02)

Regulatory developments

U.S. Environmental Protection Agency (EPA) report on coal and the Clear Skies Initiative indicates that coal production for power generation will grow in the U.S. from 905 million short tons in 2000 to 994 million short tons per year by 2020. Coal's share of the national electric generation market is estimated to be 45% in 2020 under the President's Clear Skies program. However, EPA's figures show the West to be a loser under the program. The EPA report predicts that western coal production will decline from 510 million short tons to 481 million short tons annually between the years 2000 and 2020. EPA believes Clear Skies programs could dampen the ongoing boom in the PRB. The program calls for mandatory scrubbing of plant units that are 300 MW or larger by 2005; this could swing the market advantage back to the Appalachian and Midwest producers (Coal Outlook, 6/3/2002).

MSHA will provide free chest X-rays to selected miners in MSHA's attempt to determine the extent of black lung disease in the nation's coal producing regions. The agency will inform all miners who are eligible for the free X-ray, and the test will be done via mobile X-ray vans at the work site of the miners. The results of the screenings will be gathered to help gauge progress and plan future programs to prevent the disease. MSHA reports that there are 6700 miners eligible for the X-rays, of which 1774 are mine workers in Wyoming (U.S. Coal Review, 5/13/02).

A January ruling by the Wyoming Supreme Court could result in coal companies filing amended tax returns from 1996 on to receive sizeable tax refunds. The issue at question was the treatment of lease bonus payments. Prior to the ruling, the State of Wyoming considered lease bonus payments as a direct mining cost. The new ruling said the payments should be treated as indirect costs, which can be deducted from the taxable value of the produced coal, resulting in lower tax revenues for Wyoming (U.S. Coal Review, 6/3/02).

Market developments and opportunities

Springfield (Missouri) City Utilities has begun discussions with local regulators about adding 250 MW of new capacity to its Missouri-based system. The utility is hoping to expand its system by adding the new unit by 2007 to help meet the growing needs of its customers. Although it is in the very early stage of development, the utility currently is looking at coal-fired generation options. The company currently operates two coal-fired units served by BNSF (COAL Daily, 5/24/02).

After a full year of operation, Kennecott Energy's web site (www.kennecottdirect.com) reported 135 transactions involving 3.3 million short tons of coal. The site was launched to facilitate small tonnages sold on a short- to medium-term basis to customers that wished to trade on the password-protected site (Coal Outlook, 4/15/02).

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

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

Stauffenberg, D.G., 2001, Annual report of the State Inspector of Mines of Wyoming, for the year ending December 31, 2001: Wyoming Department of Employment, Office of the State Inspector of Mines, Rock Springs, Wyoming, 81 p.

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

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
Aliant Energy	System	PRB	C	1.5 mt	Delivery in 2003
City Public Service of San Antonio	Deely and Spruce	PRB	So	up to 300,000 t	Delivery in 2003
Consumers Energy	System	4 PRB suppliers	C	1.7 to 5.7 mt/y	1 to 3 years beginning in 2003
Detroit Edison	System	PRB	So	up to 1 mt	Delivery in 2003
Energy Services	White Bluff and Independence	Cabally/PRB	C	1.4 mt	Delivery over 3 years; beginning in 2003
Lower Colorado River Authority	System	PRB	Sp	200,000 to 300,000 t	Delivery in second half of 2002
MidAmerican Energy	System	PRB	So	1 mt	Delivery in 2003
Reliant Energy	Limestone	PRB	T	1 mt	Delivery in second half of 2002
Southern Company Services	Scherer	Black Thunder/PRB	C	up to 3 mt/y	Up to 3 years beginning in 2003

*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, October, 2002.*

Coalbed Methane Update

Nick R. Jones

Geological Research Assistant–Coal, Wyoming State Geological Survey

Robert M. Lyman, Wyoming PG-656

Staff Geologist–Coal, Wyoming State Geological Survey

Rodney H. De Bruin, Wyoming PG-3045

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

Coalbed methane (CBM) is currently being produced in five of Wyoming's ten coal fields. The Hams Fork, Hanna, Green River, Powder River, and Wind River coal fields have all reported CBM production. The Bighorn Coal Field is expected to join the other five soon. The Powder River Basin (PRB) dwarfs all the other CBM areas in terms of the concentration of wells. According to the Wyoming Oil and Gas Conservation Commission (WOGCC), as modified by the Wyoming State Geological Survey's Coal Section, the producing coal zones currently of most interest in the PRB are shown in **Table 15**. These coals are presented in stratigraphic order. The list includes coals of the Wasatch Formation (Eocene) and the thick coals of the Fort Union Formation (Paleocene).

As of June, 2002, there were 9443 producing and 3586 shut in CBM wells across the state. The 153.0 billion cubic feet (BCF) of methane produced through June, 2002 was up 34.2% from the same period in 2001 (**Table 16**). The number of producing wells in 2001 averaged 6525 per month; during the first half of this year, there were an average of 8912 producing wells per month, an increase of 36.6%

Coalbed methane production from Wyoming in the first six months is averaging 25.5 BCF per month. This is 2.9% less than the 26.25 BCF monthly average predicted by the Consensus Revenue Estimating Group (CREG) (*Wyoming Geo-Notes No. 74*, July, 2002, p.18).

Activities of coalbed methane companies

The very low natural gas prices this summer have presented the CBM industry with new challenges in terms of management, planning, and production. The issue is whether to shut in producing wells or to continue producing methane gas at a loss. Shutting in a well requires a lag time before production can begin again. Gas-bearing coal beds would require a second dewatering stage prior to producing the methane gas. Also, shut in wells face the threat of having the gas migrate to neighboring wells that are still producing. Kennedy Oil reported that nearly half their wells were shut in at the beginning of the summer (Casper Star-Tribune, June 30, 2002). Western Gas Resources, a partner of Williams Production Co., stated that they would continue with production and drilling.

Rocky Mountain Gas Inc. (RMG) has finalized acquisition of 60% of the working interests on the Bobcat property from Big Basin Petroleum, LLC. of Gillette for $1.3 million. The Campbell County property is located 25 miles north of Gillette and contains about 1940 (gross) acres of CBM production in the PRB. The acquisition includes those developments made to date plus various water discharge, storage, and disposal permits (Dwights Plus Drilling Wire, 6/6/2002).

Williams Production RMT Co. announced that they would terminate dewatering operations in the Hanna Basin. The decision came about from dewatering results; the company is considering divesting its interest in the Hanna Basin project (Dwights Plus Drilling Wire, 6/11/2002).

Regulatory issues

In the past, fugitive dust wasn't much of a concern, but now in Campbell County the increase in CBM activ-

Table 15. Coals in the Powder River Basin, Wyoming with producing CBM wells.

Formation	Coal zone	Coal beds
Wasatch	Lake De Smet	Healy
		Ucross
	Felix	Bull Creek
		Felix Upper
		Felix
	School	School
Fort Union	Wyodak Rider	Roland Rider
		Roland
		Norfolk
		Smith
		Swartz
	Upper Wyodak	Dietz 1
		Anderson
		Big George
		Dietz 2
		Wyodak Upper
		Wyodak
		Canyon Upper
		Canyon
		Canyon Lower
		Dietz 3
	Lower Wyodak	Monarch
		Werner
		Cook
		Gates
		Wyodak Lower
		Carney-Wall
		Carney Lower
		Kennedy-Pawnee
		Pawnee Lower
		Cache
	Moyer	Moyer
	Sawyer	Dannar

ity has raised those concerns. Air quality monitors are in place near PRB coal mines and it seems that more monitors may be on the way. Coal producers contend that the increased CBM activities result in more traffic and are responsible for the new problems (U.S. Coal Review, 6/24/2002).

Soil scientist Joe Meyer of the U.S. Bureau of Land Management (BLM) reported preliminary findings from an ongoing BLM methane-well monitoring program in the Belle Fourche drainage (Casper Star-Tribune, July 10, 2002). The program found that almost 80% of the water put on the surface from CBM activity is finding its way down to shallow aquifers (instead of staying on the surface). Initially the BLM had suspected that only 2% of CBM-generated water would infiltrate into the shallow aquifer systems.

Wyoming ranchers, CBM producers, and the Wyoming Department of Environmental Quality (DEQ) have been discussing water releases and water quality issues in Wildcat Creek. The effort was brought about by ranchers in the area and focused on developing a schedule for CBM reservoir releases. The new schedule will prohibit CBM reservoir releases from April through October. The DEQ will implement changes in water quality standards: they will limit discharged CBM water to an electrical conductivity (EC) of 2300 mmhos/meter and a sodium absorption ratio (SAR) of 7.5. Producers have been asked by the DEQ to voluntarily comply with the new water management plan. A CBM company's water discharge permits are valid for five years and most were granted in 2000 and 2001.

Table 16. Monthly Wyoming coalbed methane production in MCF (1998 through June, 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	17,870,205	17,870,205	25,411,345	25,411,345
February	1,882,421	3,845,090	3,462,685	7,123,119	8,706,458	17,168,238	16,741,272	34,611,477	23,228,145	48,639,490
March	2,134,042	5,979,132	4,110,431	11,233,550	9,872,362	27,040,600	19,271,964	53,883,441	25,852,033	74,491,523
April	2,154,252	8,133,544	4,040,989	15,274,539	10,565,807	37,606,407	19,216,625	73,100,066	25,174,227	99,665,750
May	2,254,160	10,387,257	4,422,581	19,697,120	11,831,227	49,437,634	20,390,450	93,490,516	27,118,120	126,783,870
June	2,369,015	12,756,559	4,605,167	24,302,287	12,199,486	61,637,120	20,078,486	113,569,002	26,230,391	153,014,261
July	2,455,931	15,212,490	4,877,924	29,180,211	13,024,856	74,661,976	20,993,443	134,562,445		
August	2,654,655	17,867,145	4,793,060	33,973,271	14,180,161	88,842,137	21,906,856	156,469,301		
September	2,988,544	20,855,689	5,125,811	39,099,082	14,390,965	103,233,102	21,385,829	177,855,130		
October	3,158,168	24,013,857	5,961,192	45,060,274	15,393,978	118,627,080	23,717,045	201,572,175		
November	3,188,985	27,202,842	5,947,893	51,008,167	15,220,163	133,847,243	23,635,973	225,208,148		
December	3,434,905	30,637,747	7,180,697	58,188,864	16,852,924	150,700,167	25,377,179	250,585,327		
Total Utility Tonnage[1]		**30,637,747**		**58,188,864**		**150,700,167**		**250,585,327**		

[1]Data from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, July, 2002.*

Industrial Minerals and Uranium Update

Ray E. Harris, Wyoming PG-46

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

In the second quarter of 2002, increased production of bentonite, construction aggregate, trona, and uranium was noted. Wyoming bentonite that has been ground extremely fine is now being used in paper manufacture. Two new aggregate quarries have opened in the state and some of Wyoming's building stones used in the past are being considered for renovation and restoration projects. Trona and uranium production are both ahead of last year and 2002 year-end production is now estimated to exceed last year's production.

Bentonite

Bentonite production in Wyoming is increasing due to its use in a wide variety of products. Bentonite has many uses, including foundry molds, as a binder in taconite pellets used in steelmaking, kitty litter, a wide variety of mineral fillers such as powdered pesticides, powdered lubricants, etc., environmental barriers, adsorbents, and more (hence its nickname "the clay of a thousand uses"). Wyoming bentonite in an extremely fine-ground form is now being used as a filler in paper. This produces a smooth surface texture. Finely ground bentonite from Wyoming has been shipped to some Japanese paper producers this year for this purpose.

Construction aggregate

The production of construction aggregate increased during the second quarter of 2002 with road and other construction projects increasing throughout the state. Crushed limestone is the preferred aggregate for use in paving materials. New aggregate quarries have opened in some areas, including a crushed limestone quarry 2 miles south of Manville operated by Boatright Construction (**Figure 16**), and a crushed limestone quarry operated by the Wyoming Department of Transportation north of Rawlins (**Figures 16** and **17**). The Wyoming State Geological Survey (WSGS) published a report on the limestone at the Manville site (Harris, 1987).

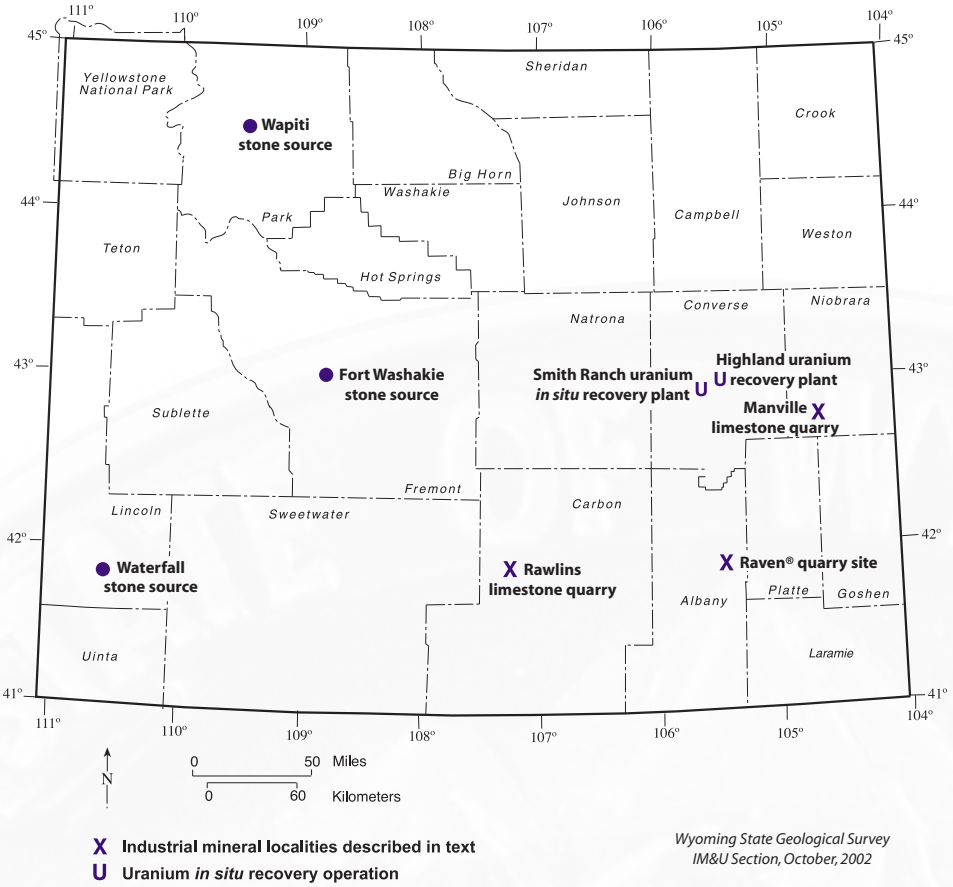

Figure 16. Index map of Wyoming showing the location of industrial mineral and uranium sites mentioned in the text. Localities are approximate and may represent more than one site.

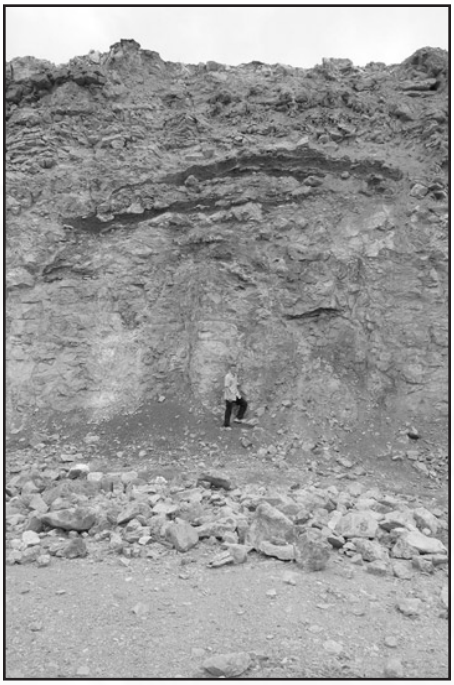

Figure 17. Limestone quarry in the Mississippian Madison Limestone north of Rawlins.

Decorative and dimensional stone

Dimensional stone is produced by Gallegos Wyoming (Gallegos) at the Raven Quarry site in northern Albany County (**Figure 16**). Gallegos is leasing the quarry from Raven Quarries, LLC. Mirage®, a pink swirled granite, and Raven®, a black granite (**Figure 18**), are quarried at the site and shipped to Gallegos' fabricating plant near Carbondale, Colorado, for processing into polished tile and slab.

During the second quarter of 2002, the Industrial Minerals and Uranium (IM&U) Section at the WSGS received some requests to locate original quarries for the restoration of existing and historical structures. The Firefighters Memorial near Wapiti west of Cody (**Figure 16**) is being restored with some of the original stone, which came from andesite and amphibolite boulders from alluvial deposits nearby. The Agency Building in Fort Washakie (**Figure 16**) is also being renovated. The original stone on that building is a Cretaceous sandstone which was quarried locally. The City Hall in Portland, Oregon is faced with stone from Waterfall, Wyoming, just east of Kemmerer (**Figure 16**). The original quarry site contains houses today, but the sandstone unit from which the stone was quarried crops out to the north, and is being considered as a source for replacing weathered stone on the Portland building. Finally, some of the buildings in Camp Guernsey are faced with a local stone. There is a proposal to apply the same stone to all of the buildings in the camp to give a unifying look to the facility. The original quarry is in a Pennsylvanian sandstone located in Guernsey State Park. However, the IM&U Section located a quarry site in the same sandstone unit at Camp Guernsey itself (**Figure 16**), which could be used to supply the facing material if the project is approved.

Trona

According to statistics released by the U.S. Geological Survey, soda ash production in Wyoming was 8.55 million short tons for the first six months of 2002 (Kostick, 2002). That represents roughly 10 million short tons of mined trona. If this production rate continues, 2002 could be a record year for trona mining in Wyoming.

Uranium

The spot market price of yellowcake (oxidized uranium—the product of Wyoming's uranium mills) decreased in July from $9.90 per pound to $9.85 per pound, 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. Wyoming's uranium production for 2002 is estimated to be around 1.75 million short tons of yellowcake, up from 1.64 million short tons in 2001, about a 7% increase. Uranium is produced by CAMECO

in Wyoming at two *in situ* recovery sites, Smith Ranch and Highland/Morton Ranch. CAMECO, of Saskatoon, Saskatchewan, also owns the only other active uranium producer in the U.S., Crow Butte, Nebraska.

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Kostick, D., 2002, Soda ash in June, 2002: U. S. Geological Survey Mineral Industry Surveys, 4 p.

Figure 18. Raven® quarry, northern Albany County, Wyoming, July, 2002.

Metals and Precious Stones Update

W. Dan Hausel, Wyoming PG-1025

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

Wayne M. Sutherland, Wyoming PG-2767

Contract Geologist–Metals and Precious Stones, Wyoming State Geological Survey

The Metals and Precious Stones Section at the Wyoming State Geological Survey (WSGS) continued to work on STATEMAP projects, completing the Rattlesnake Hills 1:100,000-scale geologic map, and proposing a project for the Saratoga 1:100,000-scale geologic map.

In addition to the already known gold, uranium, and jade-ruby deposits in the Rattlesnake Hills Quadrangle, the new mapping revealed occurrences of banded iron formation, jade prospects, black schorl (tourmaline), potential gem-quality corundum, and spectacular massive red and tawny jasper and jasperized breccia.

Despite access problems, mapping on the Keystone Quadrangle continued during the summer, focusing on the Keystone mining district and mineralized trends at some of the historical mine areas.

Interest in the state's corundum and cordierite occurrences continues, especially where gem quality stones are being cut from recovered material. This includes rubies, sapphires, and iolite gems found in corundum schist and iolite-gneiss.

STATEMAP projects

Rattlesnake Hills

Mapping of the Rattlesnake Hills 1:100,000-scale Quadrangle was completed on August 1, 2002 (see *Wyoming Geo-notes No. 74*, July, 2002, p. 22). The map was released as WSGS Open File Report 02-02, and includes two color maps and a text summary that can be purchased from the WSGS publications sales office for $6.00 (see **New Publications Available from the WSGS**, p. 35). The project was partially funded by a U.S. Geological Survey STATEMAP 2002 grant.

The open file report includes two oversize color maps (plates), a geologic map of Phanerozoic rocks and a geologic map of Precambrian rocks. Because of the many geologic map units (formations), only the Phanerozoic rock units are colored on the first plate, and only the Precambrian units are colored on the second plate. Otherwise the two plates are the same.

The Rattlesnake Hills Quadrangle includes much of the Granite Mountains (**Figure 19**). Prior to this project, much of the Precambrian complex in the Granite Mountains remained undifferentiated even though large areas of Phanerozoic outcrops had been mapped. Because of this project's time limitations, the Precambrian complex (which includes part of the core of the Wyoming craton) could only be mapped on a reconnaissance scale.

The Granite Mountains has been an area of interest to mining companies and to rock hounds. For example, the Rattlesnake Hills Quadrangle includes the Rattlesnake Hills gold district (Hausel, 1996a), the Gas Hills uranium district (Love, 1970), and the Tin Cup jade-ruby district (Hausel and Sutherland, 2000).

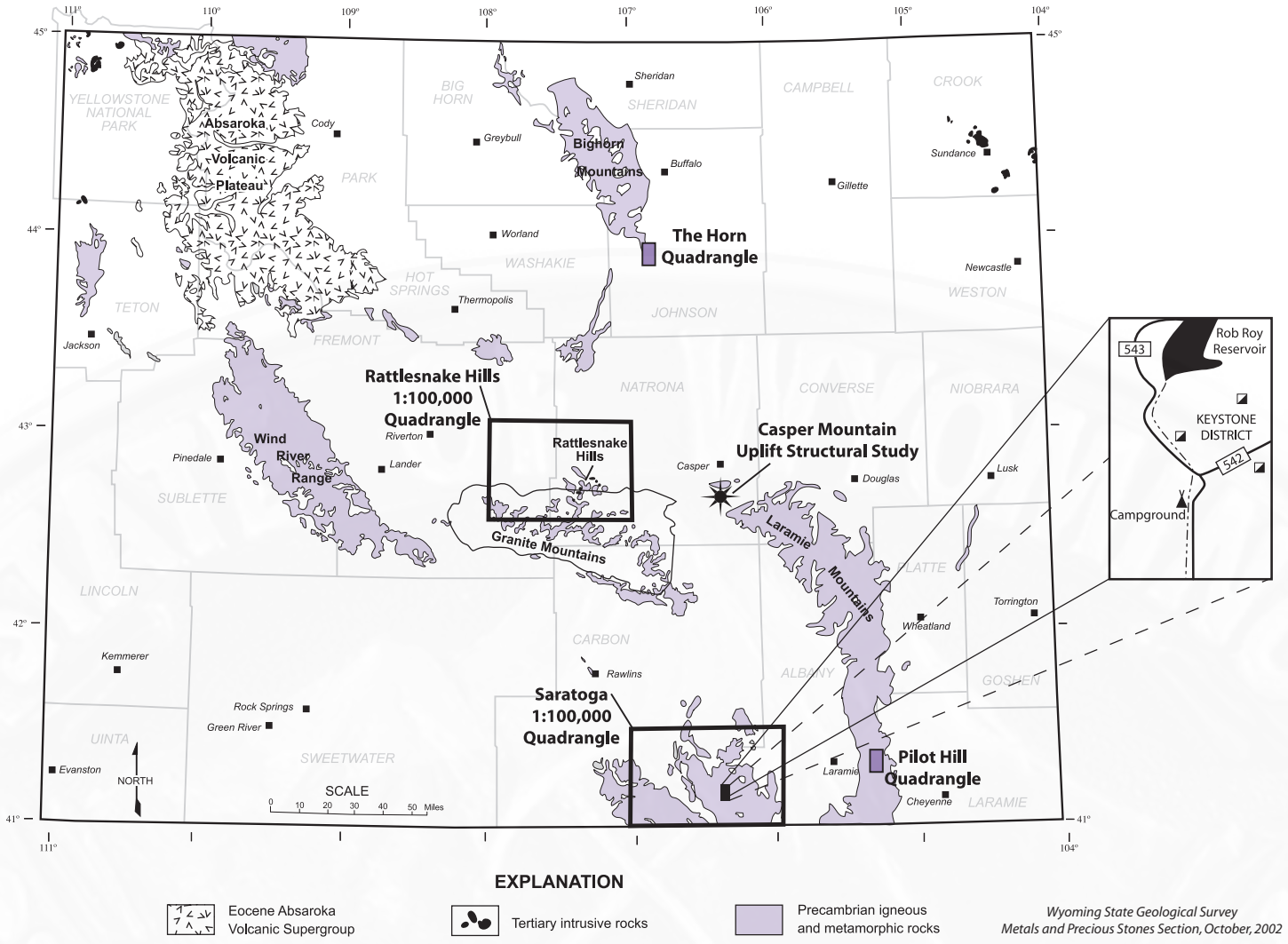

Figure 19. Index map of Wyoming showing STATEMAP projects of the Metals and Precious Stones Section, ongoing geologic mapping projects of the Mapping Section, and recently completed geologic studies in Wyoming.

During field investigations in this region, the authors collected several specimens of Sweetwater agate in the agate beds northeast of Jeffrey City (**Figure 20**) and came across some other interesting mineral occurrences. One of the more interesting occurrences includes a zone of potassic alteration within a broad alteration halo of pervasive propylitic alteration that enclosed a narrow shear zone in the center of a north-trending antiform west of Black Rock Gap in NE SE SW section 32, T31N, R91W. A two-foot-long channel sample taken across the shear yielded 655 parts per billion (ppb) Au, >10,000 parts per million (ppm) Cu, 522 ppm Zn, and 13 ppm Pb. A grab sample yielded 385 ppb Au, >10,000 ppm Cu, 299 ppm Zn, and 11 ppm Pb.

Oxide facies banded iron formation (banded magnetite-chert) was found at several localities. These included a prospect that was dug in oxidized, low-grade iron formation with some yellow and red jasper in the SW section 36, T31N, R92W. Some supracrustal rocks (including iron formation, quartzite, and pelitic schist) were found in SW NE section 36, T31N, R89W. Banded iron formation was identified in the NW NW section 27 and in the SE NE section 28, T31N, R93W, and two prospects were also found in banded iron formation in the NE SW and SE NW section 30, T31N, R92W.

Several jade prospects are located in sections 9 and 10, T30N, R87W. The jade occurrences lie within a broad alteration halo, which includes secondary sericite, clinozoisite, zoisite, chlorite, and epidote. Mineral collectors will want to note that jade pseudomorphs after quartz (as well as quartz) were found at the Fiesta Mine (NW SE section 9, T30N, R87W). These occur as hexagonal, light-green, nephrite replacements of quartz. Some specimens collected by the authors were 1.5 inches in diameter and 3 inches in length. Jade found in the nearby Fiesta #2 prospect (S/2 NW NW section 2, T30N, R88W) includes some apple green jade slicks within the ultramafic schist. Some dark green and black jade slicks were also found at the prospect. Several other jade prospects are scattered in the Precambrian terrain in the southern half of the Rattlesnake Hills Quadrangle within the Tin Cup district (see Hausel, 1996b).

Nice crystallized tourmaline (black schorl) was also discovered in serpentinite in the SW SE section 12, T31N, R89W. Specimens of tourmaline 1.5 inches across and 3 inches in

Figure 20. Sweetwater agates from central Wyoming.

length were recovered from the serpentinite. Larger crystals were found in place and not removed.

Corundum has been reported by various prospectors from several localities in the quadrangle. According to some prospectors, gem-quality corundum has been found in alluvium along the Sweetwater River both east and west of Jeffrey City. Hausel (1997) described a 50-foot-wide ruby-corundum gneiss and schist (Red Dwarf ruby deposit) that has a 5000-foot strike length. Nearby, a corundum-bearing serpentinite (sections 13 and 24, T30N, R93W) was found by Robert Odell, a geological consultant from Casper. The corundum at the Red Dwarf for the most part is low-quality, translucent to transparent, purplish-red corundum with some ruby enclosed in distinct, emerald green reaction rims. X-ray diffraction (XRD) analysis of the reaction rims provided a match for fuchsite, even though much of the material has a similar appearance to zoisite. Possibly, the reaction rim is a mixture of fuchsite and zoisite, or it may occur as massive fuchsite. Further studies are warranted, especially since some of the reaction rim material is translucent to transparent and of potential gem quality. Some of the other corundum from the deposit is potentially of gem quality. Specimens have been cut into cabochons, and specimens with asterism have been reported by prospectors.

The nearby serpentinite contains crystals of light-grayish blue, opaque to translucent corundum (sapphire) that average only 2 mm in diameter, but are locally abundant. Pinkish red sapphires up to one-quarter inch in diameter were found within a pelitic schist in SE NE section 31, T31N, R89W. The corundum at this locality is very limited in extent.

Spectacular specimens of massive red and tawny jasper and jasperized breccia occur as replacements of fault breccia and gouge along a group of parallel faults in gneiss in the Tin Cup Mountain area (see Hausel, 1996b) (**Figure 21**). Several other localities with agate and jasper were found within the quadrangle during this project.

Keystone

The Metals and Precious Stones Section is currently mapping the Keystone 1:24,000-scale Quadrangle in the Medicine Bow Mountains (**Figure 19**). This quadrangle is strategically located within an area considered to have moderate to high potential for the discovery of significant palladium, platinum, gold, and diamond resources and includes all or parts of the

Rock Hound's Corner: Grunerite

W. Dan Hausel, Wyoming PG-1025

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

Grunerite, (Fe, Mg)SiO_3, is an iron-rich amphibole, that typically produces tawny (yellow-brown), fibrous, acicular to asbestos-form mineral specimens. The more magnesian-rich varieties are termed cummingtonites, which typically are fibrous, dark-green amphiboles (Mg, Fe)SiO_3. Mineralogically, grunerite occurs in the monoclinic mineral system; it has a specific gravity of 3.54; and may exhibit good cleavage parallel to the {110} face and twinning parallel to the {100} face.

Some grunerites in Wyoming have been cut and polished, producing a lapidary stone with the appearance of "Tigers Eye" agate. However, true "Tigers Eye" (which has not yet been reported in Wyoming) requires much of the asbestos-form mineral to be replaced by quartz.

Since Wyoming has many deposits of grunerite in its greenstone terrains and supracrustal belts (i.e., South Pass, Seminoe Mountains, Elmers Rock, Copper Mountain), it is likely that some "Tigers Eye" will be found. Wyoming grunerite is found associated with banded iron formation. Therefore, the collector will want to obtain geologic maps of the above mentioned areas, and search the iron formation outcrops, as well as the drainages downslope from the outcrops, for grunerite and "Tigers Eye." Some of the better samples of grunerite have been collected in the Copper Mountain district and in the Seminoe Mountains, particularly in paleoplacers and alluvium along the northern flank of the Seminoe Mountains extending from Deweese Creek eastward all the way to the Miracle Mile on the Platte River.

Grunerite has also been reported in Colorado, Arizona, South Dakota, Minnesota, Michigan, Massachusetts, Canada, Africa, Australia, Finland, and France.

Figure 21. .Gossan and jasper replacements in fault zone in the Tin Cup district.

Figure 22. Historical photo of the Keystone mine with Douglas Creek in the foreground. More than 5000 feet of underground workings were developed in this mine, and it has been estimated that between 5000 and 10,000 ounces of gold were recovered from the mine. (Photograph from the S.H. Knight collection, American Heritage Center, University of Wyoming, used with permission.)

Keystone, New Rambler, and Douglas Creek districts and the Mullen Creek layered complex (see Hausel, 1989; 2000). The Keystone area is fairly accessible; however, some problems have been encountered by the authors since mapping started on August 1. These include the permanent closure of many U.S. Forest Service roads within the quadrangle, which is considerably slowing down the progress of mapping; lack of access to the New Rambler district due to extensive areas of private property; and poor access to large parts of the Mullen Creek layered complex due to enclosure of large parts of the complex within wilderness areas.

The Keystone Quadrangle, named for the Keystone mine and district (**Figure 22**), includes a group of mineralized trends with some significant gold anomalies. For example, some samples collected from the Florence trend in the past contained visible gold. A select sample collected on this trend by the authors this fall assayed 2.79 ounces per ton (opt) in gold! The adjacent Douglas Creek, a historical productive gold placer (**Figure 23**), has also been a very popular area for gold prospectors during the past several years.

In about one cubic yard of material, it was estimated that more than 10,000 carats of iolite were exposed!

The Mullen Creek layered complex is a viable exploration target for gold, palladium, platinum, chromium, vanadium, and titanium, and several anomalies have been detected within the complex by other researchers. Most significant was the location of the New Rambler district in a sheared part of the complex—the New Rambler mine was a commercial palladium-platinum, copper, gold, and silver mine from 1900 to 1918.

Initial mapping in the district by the WSGS has focused on the Keystone district and the mineralized trends at the Florence, Gold Crater, and Independence mines. The Gold Crater and Independence mine areas include several mines and prospects along a group of mineralized trends.

Saratoga

The Metals and Precious Stones Section has proposed a STATEMAP project to map the Saratoga 1:100,000-scale Quadrangle for next year (see STATEMAP 2003 proposals summarized in the **Geologic Mapping, Paleontology, and Stratigraphy Update**, p. 26). This map would include much of the Medicine Bow Mountains and part of the Sierra Madre, and is an area considered to have significant Precambrian geology and structure as well as significant mineral deposits.

Gemstone investigations

The section has recently received several leads on reported occurrences of corundum and cordierite. When gem quality, corundum can produce ruby or sapphire (depending on its color), and transparent cordierite can produce iolite gems (referred to as water sapphire by collectors). In the geological past, the Wyoming craton was subjected to moderate- to high-grade metamorphism (>500°C temperature and >4 kilobars (kb) pressure), which was favorable for the production of these gemstones in some aluminous (mica-rich) schists and gneisses. As a result, the WSGS expects to identify some new localities for these minerals over the next five years.

In 1995, the WSGS discovered a source for sapphire and iolite west of Wheatland (Hausel, 2002). The discovery led to the first faceted, high-quality sapphire gemstones and iolites from Wyoming. Mapping of the deposit by the WSGS led to the identification of two potentially productive rock units. Recent exploration by Eagle-Hawk Mining on the rock units has supported the geological interpretations of the

Figure 23. Historical photo of placer gold mining along Douglas Creek. (Photograph from the S.H. Knight collection, American Heritage Center, University of Wyoming, used with permission.)

WSGS. Trenching of the iolite-gneiss led to the discovery of a relatively rich vein of iolite. In about one cubic yard of material, it was estimated that more than 10,000 carats of iolite were exposed! Trenching of the corundum schist exposed several sapphires.

Colorado Friends of Mineralogy Symposium

From September 7 to 10, 2002, W. Dan Hausel attended the Gemstones of Colorado and the Rocky Mountains Region Symposium at the Colorado School of Mines in Golden. According to Hausel, this was one of the best scientific symposiums of the year and included several excellent papers on mineral collecting localities and gemstones in the West. At the symposium, Hausel presented a paper co-authored by Wayne Sutherland (see Hausel and Sutherland, 2002, in ***Recent publications***, below) on Wyoming gemstones and lapidary minerals that included discussions on diamonds, sapphires, iolite, labradorite, garnets, jade, agates, jasper, and some other interesting minerals and mineral localities.

Saturday evening, the symposium banquet featured a presentation by Hausel (co-authored by Sandy Stahl, an engineer with PMPC in Saratoga) on the Great Diamond Hoax of 1872 (see Hausel and Stahl, 2002, in ***Recent publications***, below). The great diamond hoax (or probably better worded as the great diamond "scam") has apparently all been forgotten by historians, even though this event stirred great excitement in the West. It led to the formation of more than 25 companies with a total capitalization of more than $250 million in 1871. Several affluent individuals were "scammed" by a small group of prospectors. These individuals included such notable people as General George B. McClelland, Charles Tiffany, Horace Greeley, Senator Ben Butler, George Dodge, and William Lent. The "scam" left its imprint in history in the form of geographic place names with the modifier of "Diamond," such as Diamond Peak, etc. It may have been responsible for inclusion of patenting of federal land as part of the 1872 mining law.

During the third quarter, Hausel also presented slide programs on *Prospecting for Gemstones* and *Prospecting for Gold* to the Rocky Mountain Prospectors & Treasure Hunters Club. He led field trips for the Rocky Mountain Prospectors & Treasure Hunters Club on July 12 and August 16 to the Encampment district in the Sierra Madre and the South Pass district in the Wind River Mountains, respectively. He led public field trips on July 20 and August 10 to South Pass and the State Line kimberlite district. Another well-attended field trip to the State Line district was led by Hausel for the Rocky Mountain Association of Geologists on August 24. Hausel and Sutherland also taught a gold panning class to about 30 children of the UW Lab School at the University of Wyoming Recreational Camp on September 13.

Recent publications

Erlich. E.I., and Hausel, W.D., 2002, Diamond deposits: Origin, exploration, and history of discovery: Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 374 p.

Hausel, W.D., 2002, A new source of gem-quality cordierite and corundum in the Laramie Range of southeastern Wyoming: Rocks & Minerals, v. 77, no. 5, p. 334-339.

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Hausel, W.D., and Sutherland, W.M, 2002, Gemstones, semi-precious stones, lapidary materials, ornamental stones and other unique minerals and rocks of Wyoming: Gemstone Deposits of Colorado and the Rocky Mountain Region, Programs and Abstracts, Friends of Mineralogy, Colorado Chapter, Golden, Colorado, p. 23-24.

Hausel, W.D., and Stahl, S., 2002, The 1872 Diamond Hoax: Gemstone Deposits of Colorado and the Rocky Mountain Region, Programs and Abstracts, Friends of Mineralogy, Colorado Chapter, Golden, Colorado, p. 53-54.

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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) submitted a proposal for four mapping projects to the STATEMAP 2003 Program in late October. The projects include compilation and geologic mapping of three 1:100,000-scale quadrangles (Casper, Saratoga, and Torrington), dititizing four 1:100,000-scale bedrock geologic maps (Kinney Rim, Evanston, Kemmerer, and Nowater Creek) and digitizing two 1:100,000-scale surficial geologic maps (Chugwater and Nowater Creek). These proposed maps will help complete mapping in the Powder River Basin (PRB) in support of ongoing and planned WSGS projects, contribute to our mapping of populated areas in Wyoming, and provide needed mapping to support exploration by the state's mineral industry.

Two detailed mapping projects, one near Laramie and the other in the southern Bighorn Mountains, are progressing as spin-off projects from related STATEMAP-sponsored efforts. These two maps, the Pilot Hill and The Horn 1:24,000-scale quadrangles, should be completed by next summer.

A new article relating to Wyoming structural geology was released recently. The article characterizes the structural geology of the Casper Mountain uplift, as well as adjacent, subsidiary structural features.

STATEMAP 2003 proposal

Staff members of the WSGS met with the Wyoming Geologic Mapping Advisory Committee on August 29 to discuss submittals to the STATEMAP 2003 Program. Based on consultation with the committee, the four proposed mapping projects are: 1) map and compile the Casper 1:100,000-scale Quadrangle; 2) digitize the Kinney Rim, Evanston, Kemmerer, and Nowater Creek 1:100,000-scale bedrock geologic maps, and digitize the Nowater Creek and Chugwater 1:100,000-scale surficial geologic maps; 3) map and compile the Saratoga 1:100,000-scale Quadrangle; and 4) compile and map the Torrington 1:100,000-scale Quadrangle. Current mapping priorities established by the WSGS in cooperation with the Wyoming Geologic Mapping Advisory Committee include producing geologic maps to support coalbed methane exploration/production activities and associated ground and surface water protection needs in the PRB, and 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.

The Mapping Section of the WSGS proposes to map and compile the bedrock geology for the Casper 1:100,000-scale Quadrangle, with funding from STATEMAP 2003. The completion of this map is needed to augment southward expansion of the ongoing Northern PRB geologic, hydrologic, and water quality database project. This map will also satisfy the priority of mapping the populated areas in the state. John Hunter, a geologist with Power Resources, initiated work on this map in 1997 as part of our Volunteer Mapping Program. The map was approximately 75% completed when John and his family moved back to England and he turned the map over to the WSGS. Work is needed to complete the northeastern corner of the map and the southwestern segment of the map in the Shirley Basin area. In addition, geologic contacts need to be reconciled with the recently completed Rattlesnake Hills Quadrangle to the west. Some field checking of the map will be required.

The Casper Quadrangle is located in the central part Wyoming (**Figure 24**). The quadrangle includes bedrock ranging in age from Precambrian to Oligocene. The dominant structural features included in the map area are the Casper

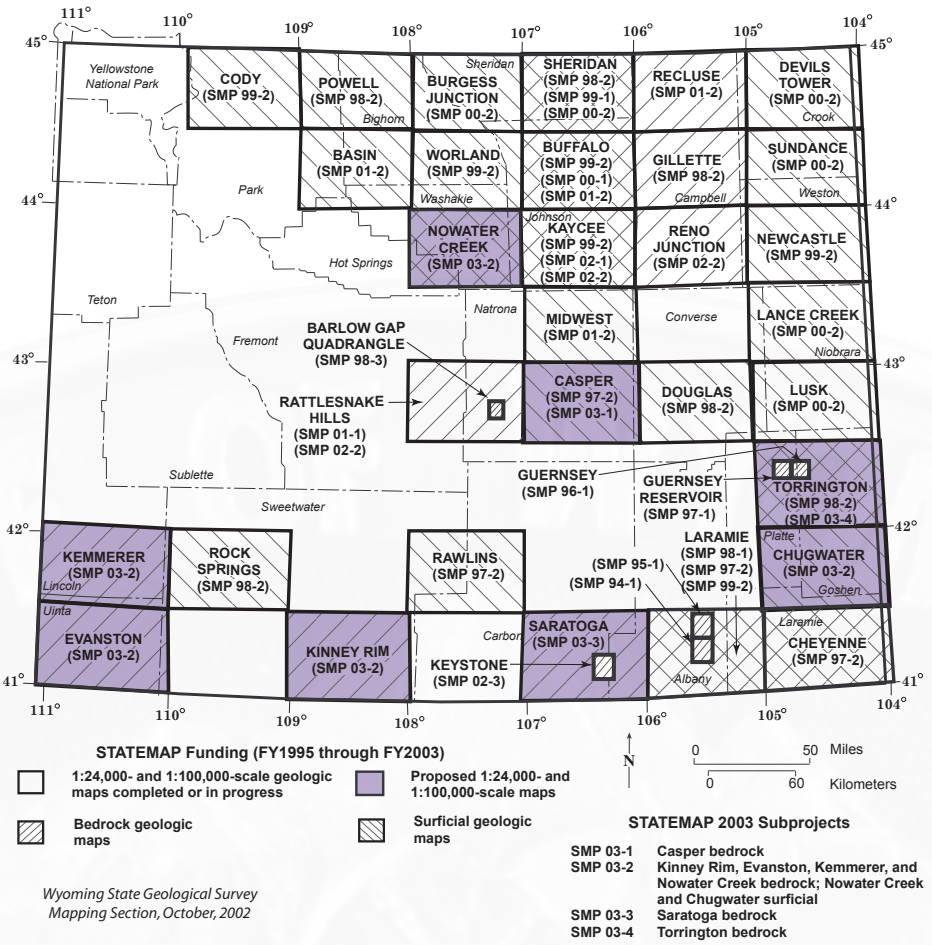


Figure 24. Index to proposed, in-progress, and completed STATEMAP projects in Wyoming.

arch and the Casper Mountain uplift, with their associated structures. The latter includes outcrops of Precambrian, Paleozoic, and Mesozoic rocks covering the south half of the map. Much of the remainder of the quadrangle includes Cretaceous rocks dipping toward the east/northeast into the PRB, capped by Tertiary rocks in the southwestern and southeastern corners.

The Mapping Section will complete the unmapped part of the quadrangle and review the 75%-completed portion of the map. A preliminary black line (uncolored) geologic map will be prepared. Funding from STATEMAP 2003 will be used to acquire any needed aerial photography, negatives, and orthophoto sheets for the 1:24,000/1:100,000-scale base maps; one geological assistant's salary; a GIS technician's salary to begin digitizing efforts; and for field vehicle rental and travel expenses. The map will then be digitized and published in color as part of our proposal for STATEMAP 2004.

The Publications Section proposes to digitize the Kinney Rim, Evanston, Kemmerer, and Nowater Creek 1:100,000-scale bedrock geologic maps (**Figure 24**). These four published maps are currently available from the U. S. Geological Survey (USGS) and the WSGS. The Section also proposes to digitize surficial geologic maps of the Nowater Creek and Chugwater 1:100,000-scale quadrangles. These two maps are unpublished and were 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. STATEMAP 2003 funding will be used to acquire existing 1:100,000-scale digital topographic and public land survey data, to pay the salary of a GIS assistant, and for map scanning and plotting costs.

The Metals and Precious Stones Section proposes to 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 24**) in the Medicine Bow Mountains; this is currently in progress. The second year of the project would involve compiling the geology of the Saratoga 1:100,000-scale Quadrangle (**Figure 24**), located in the south central part of Wyoming. The map includes parts of the Medicine Bow Mountains and Sierra Madre. The bedrock exposures are primarily Precambrian and Tertiary (North Platte River valley) with some Mesozoic and Paleozoic outcrops in the Centennial Valley. A large part of the quadrangle including the Sierra Madre and northern Medicine Bow Mountains has already been compiled. However, the southern Medicine Bow Mountains

and Saratoga Valley will need some additional work. Funding from STATEMAP 2003 will be used to acquire needed aerial photography, negatives, and orthophoto sheets for the 1:24,000/1:100,000-scale bases; to provide salary for one geological assistant; and for field vehicle rental and travel expenses.

The Industrial Minerals and Uranium Section proposes to map and compile the bedrock geology for the Torrington 1:100,000-scale Quadrangle. This quadrangle is located in southeastern Wyoming (**Figure 24**). The quadrangle includes outcrops of Paleozoic and Tertiary rocks 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. Funding from STATEMAP 2003 will be used to acquire needed aerial photography, negatives, and orthophoto sheets for the 1:24,000/1:100,000-scale bases; to provide salary for one geological assistant; and for field vehicle rental and travel expenses.

Completed and in-progress STATEMAP projects and proposed STATEMAP 2003 projects are shown in **Figure 24** and the funding received to date by the WSGS is shown in **Table 17**. 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 $329,491 in funding through the present STATEMAP 2002. The WSGS completed 35 maps using funding from this program since it began involvement in 1994; an additional 11 maps were completed independent of the program's funding.

Spin-offs from STATEMAP projects

The Mapping Section is continuing work on two 1:24,000-scale geologic maps as spin-offs of associated STATEMAP projects. The Pilot Hill Quadrangle is nearly completed as a spin-off from the STATEMAP-sponsored Laramie geologic mapping project. The Section mapped the quadrangle in preliminary form while compiling the Laramie 1:100,000-scale geologic map for STATEMAP 1998. The Pilot Hill mapping effort supports the Laramie Drinking Water Protection Plan that was developed by the City of Laramie's Environmental Advisory Committee. This plan is designed to protect the aquifer recharge area for the Casper Formation from contamination. Much of the recharge area for the Casper Formation is exposed on the Pilot Hill Quadrangle (**Figure 19**) and detailed geologic mapping of the quadrangle is needed to outline zones or outcrops in need of special protection. More detailed information on faulting in the aquifer recharge area is especially important to augment the protection plan. The Section will complete

Table 17. 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
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
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
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
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
2003	1-Geologic map of the Kaycee Quadrangle 1:100,000-scale STATEMAP 02-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 STATEMAP 02-in progress	$18,437	$18,437	$36,874
	3-Geologic map of the Keystone Quadrangle 1:24,000-scale STATEMAP 02-in progress	$28,976	$28,976	$57,952
	TOTALS	**$329,491**	**$329,491**	**$658,982**

The STATEMAP Program, part of the National Cooperative Geologic Mapping Program (NCGMP), has significantly expanded and driven the mapping efforts of the Wyoming State Geological Survey (WSGS) over the past seven years. The WSGS completed 35 maps using funding from this program since it began involvement in 1994; an additional 11 maps were completed independent of the program's funding. Four additional maps are in progress with STATEMAP 2002 funding. Current STATEMAP-supported mapping priorities established by the WSGS in cooperation with Wyoming Geologic Mapping Advisory Committee include: 1) producing geologic maps to support coalbed-methane exploration/production activities and associated ground-and surface-water protection needs in the Powder River Basin 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.

efforts with airphoto interpretation and fieldwork this fall to substantiate the interpretations and provide dip and strike information to better define the structural geology on the quadrangle. Special emphasis has been given to the location and better definition of faulting in the outcropping Casper Formation, as some of these faults may serve as conduits for contaminants. Plans are to complete the map over the winter months with a preliminary digital version of it being available by next summer.

As a spin-off to the Kaycee 1:100,000-scale STATEMAP 2002 project (**Figure 24**) currently in-progress, the Mapping Section is completing work on The Horn 1:24,000-scale Quadrangle (**Figure 19**). Earlier work by the Mapping Section on the south part of The Horn Quadrangle identified previously unrecognized folds masked by Quaternary cover. Air photo interpretation and fieldwork this fall will complete the north part of the quadrangle and provide a revised structural interpretation of The Horn structure and adjacent features to the south. With the completion of this quadrangle, a total of eight 1:24,000-scale maps will have been completed on the west side of the Kaycee 1:100,000-scale map. The Mapping Section has already completed and published as WSGS open file reports the Packsaddle Canyon, Fraker Mountain, Barnum, Poker Butte, Hole-in-the-Wall, Red Fork Powder River, and Mayoworth 1:24,000-scale quadrangles, funded through the COGEOMAP Program in the 1980s and early 1990s. These maps are now being digitized and will be incorporated into the compilation of the Kaycee 1:100,000-scale geologic map as part of STATEMAP 2002.

New article on Wyoming geology

Stone (2002) recently published a comprehensive discussion of the structural geology of the Casper Mountain uplift and subsidiary structures (**Figure 19**). Stone has interpreted this east-west trending fault-related structure as a Laramide compressional feature that was controlled by pre-existing Precambrian fabric. Initial displacement on the Casper Mountain fault zone probably predates displacement on the intersecting, northwest-trending Casper arch. The Casper Mountain structure is defined by accessible Phanerozoic exposures, numerous borehole penetrations, and seismic control around the margins, allowing a prototype model to be constructed that can be applied to the interpretation of other so-called anomalous east-west Laramide uplifts in the Rocky Mountain foreland.

Reference cited

Stone, D. S., 2002, Morphology of the Casper Mountain uplift and related, subsidiary structures, central Wyoming—implications for Laramide kinematics, dynamics, and crustal inheritance: American Association of Petroleum Geologists Bulletin, v. 86, no. 8, p. 1417-1440.

Basic Seismological Characterization for Park County, Wyoming

James C. Case, Wyoming PG-1138

Senior Staff Geologist–Geologic Hazards, Wyoming State Geological Survey

Rachel N. Toner

Research Geologist–Geologic Hazards, Wyoming State Geological Survey

Robert Kirkwood

Research Geologist–Geologic Hazards, Wyoming State Geological Survey

The Geologic Hazards Section at the Wyoming State Geological Survey (WSGS) is generating updated seismological characterizations for all counties in Wyoming. Seismological characterizations include a discussion of historical seismicity, an analysis of exposed active faults, and an analysis of probabilistic seismic hazards. This article presents an analysis of historical seismicity and current short- and long-term probabilistic seismic hazard analyses for Park County, Wyoming, exclusive of that part of the county in Yellowstone National Park. No exposed active faults are present in the county (Case and others, 1997), and as a result, no exposed active fault analysis can be conducted. All earthquakes in Park County are associated with faults that are deeply buried.

Historical seismicity in Park County

Twelve magnitude 2.5 and greater earthquakes have been recorded in Park County (**Figure 25**). The first earthquake recorded occurred on February 2, 1920. This intensity III event was located in north-central Park County, approximately 18 miles northwest of Cody. Several people reported feeling it and hearing a rumbling sound (Humphreys, 1921). On October 3, 1944, an intensity IV earthquake occurred in south-central Park County approximately 6 miles north of

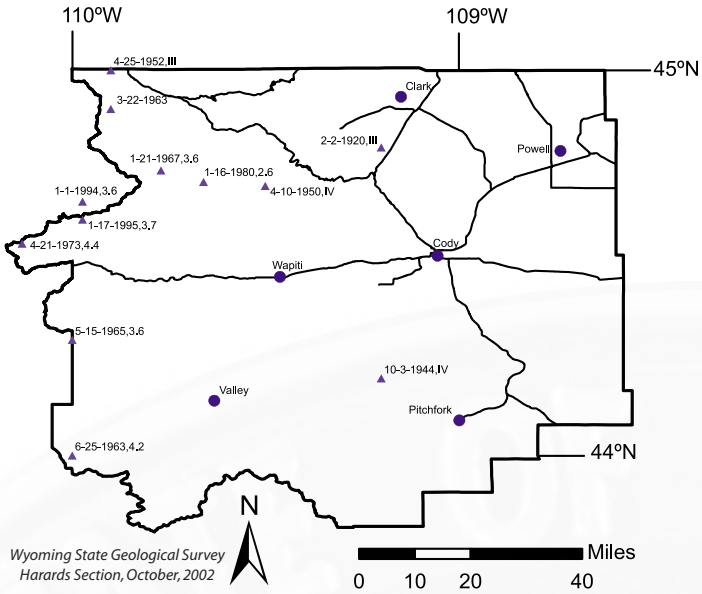


Figure 25. Earthquake map of Park County, Wyoming (exclusive of Yellowstone National Park). Earthquakes are shown with date and intensity (Roman numerals) or magnitude; other lines are roads.

Pitchfork. Several people in Yellowstone National Park and at Flagg Ranch reported feeling three distinct tremors that rattled dishes and canned goods, swung suspended objects, and even caused buildings to sway. "Subterranean sounds" were also reported from the Flagg Ranch (Bodle, 1946).

Two earthquakes occurred in Park County during the 1950s. A third earthquake outside the county was felt in Park County. The first, recorded on April 10, 1950, was 18 miles north of Wapiti. This intensity IV event shook lamps, rattled loose objects, and caused buildings in Wapiti to creak (Murphy and Ulrich, 1952). On April 25, 1952, an intensity III earthquake occurred approximately 35 miles west-northwest of Clark near the Wyoming/Montana border. The earthquake lasted for a few seconds and was felt by only one person (Murphy and Cloud, 1954). On August 17, 1959, a magnitude 7.5, intensity X earthquake occurred just outside of Yellowstone National Park near Hebgen Lake, Montana. The earthquake was felt by most Park County residents, although no significant damage occurred in the county.

Four earthquakes occurred in Park County during the 1960s. All four were recorded near the Yellowstone National Park border, but no one reported feeling the earthquakes (U.S. Geological Survey National Earthquake Information Center). A March 22, 1963 event was reported approximately 40 miles west-northwest of Clark in the extreme northwestern corner of Park County. On June 25, 1963, a magnitude 4.2 earthquake occurred 22 miles southwest of Valley. A magnitude 3.6 earthquake was recorded on May 15, 1965, approximately 22 miles southwest of Valley and another magnitude 3.6 earthquake occurred 25 miles north-northwest of Wapiti on January 21, 1967.

On April 21, 1973, a magnitude 4.4 earthquake was recorded on the western edge of Park County approximately 36 miles west-northwest of Wapiti. People in the area reported feeling the earthquake (Coffman and others, 1975).

On January 16, 1980, a magnitude 2.6 earthquake occurred 20 miles north-northwest of Wapiti. No one reported feeling this event (U.S. Geological Survey National Earthquake Information Center).

Most recently, two earthquakes occurred in Park County during the 1990s. A magnitude 3.6 earthquake was recorded on January 1, 1994, and a year later, a magnitude 3.7 earthquake was felt on January 17, 1995. The earthquakes had epicenters approximately 29 and 28 miles west-northwest of Wapiti, respectively. No damage was reported and nobody reported feeling either event (University of Utah Seismograph Station Epicenter Listings).

Probabilistic seismic hazard analyses

When an earthquake occurs, the ground moves and experiences acceleration in terms of percent of gravity (%g). The accelerations can also be described as "g" forces. Relationships between ground accelerations (%g) and earthquake intensities have recently been refined, leading to a better understanding of what a "g" force means in regards to potential for building damage (**Table 18**). The ground accelerations are converted to earthquake intensities in the table. A discussion of earthquake intensities was presented in *Wyoming Geo-notes No. 67* (September, 2000, p. 50-55).

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2500-year time frames. The maps show what ground accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that accelerations may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming, as discussed and shown in *Wyoming Geo-notes No. 67* (September, 2000, p. 50-55). The recent maps include a 500-year map (10% probability of exceedance in 50 years), a 1000-year map (5% probability of exceedance in 50 years), and a 2500-year map (2% probability of exceedance in 50 years). Until recently, the 500-year map was often used for planning purposes for designing average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2500-year map as the basis for building design.

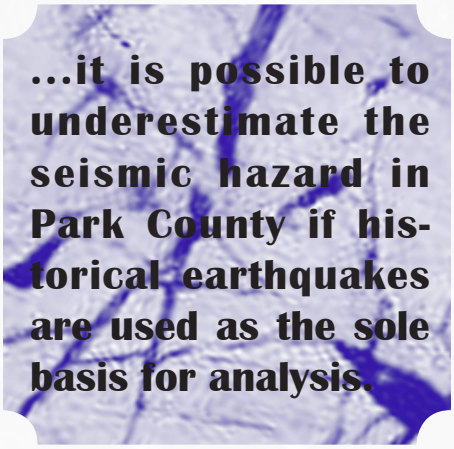
Table 18. Modified Mercalli Intensity and peak ground acceleration (PGA) after Wald and others (1999).

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	Not felt	None
II	0.17-1.4	Weak	None
III	0.17-1.4	Weak	None
IV	1.4-3.9	Light	None
V	3.9-9.2	Moderate	Very light
VI	9.2-18	Strong	Light
VII	18-34	Very Strong	Moderate
VIII	34-65	Severe	Moderate to heavy
IX	65-124	Violent	Heavy
X	>124	Extreme	Very heavy
XI	>124	Extreme	Very heavy
XII	>124	Extreme	Very heavy

As mentioned in *Wyoming Geo-notes No. 67* (September, 2000, p. 50-55), the maps reflect current perceptions on seismicity in Wyoming.

In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface.

Based upon the 500-year map (10% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Park County ranges from approximately 5%g in the northeastern corner of the county to nearly 20%g in the western part of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9 to 9.2%g), intensity VI earthquakes (9.2 to 18%g), and intensity VII earthquakes (18 to 34%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures. Chimneys may be broken. The town of Cody would be subjected to an acceleration of approximately 6 to 7%g or intensity V.



Based upon the 1000-year map (5% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Park County ranges from 6%g in the northeastern corner of the county to approximately 30%g in the western part of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9 to 9.2%g), intensity VI earthquakes (9.2 to 18%g), and intensity VII earthquakes (18 to 34%g). The town of Cody would be subjected to an acceleration of approximately 8 to 9%g or intensity V.

Based upon the 2500-year map (2% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Park County ranges from approximately 8%g in the northeastern corner of the county to over 40%g in the southwestern corner of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9 to 9.2%g), intensity VI earthquakes (9.2 to 18%g), intensity VII earthquakes (18 to 34%g), and intensity VIII earthquakes (34 to 65%g). Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, and factory stacks may fall. Heavy furniture may be overturned. The town of Cody would be subjected to an acceleration of approximately 12%g or intensity VI.

As the historical record is limited, it is nearly impossible to determine when a 2500-year event last occurred in the county. Because of the uncertainty involved, and based upon the fact that the new International Building Code utilizes 2500-year events for building design, it is suggested that the 2500-year probabilistic maps be used for Park County analyses. This conservative approach is in the interest of public safety.

Summary

There have been twelve historic earthquakes with a magnitude greater than 2.5 recorded in Park County. Because of the limited historical record, it is possible to underestimate the seismic hazard in Park County if historical earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps give a more reasonable estimate of damage potential in areas without exposed active faults at the surface, such as Park County.

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate damage to buildings and their contents, with damage increasing from the northeast to the west. More specifically, the probability-based worst-case scenario could result in the following damage at points throughout the county:

Intensity VII earthquake areas

Includes the settlements nearest to Yellowstone National Park, namely Valley and Wapiti. In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, and considerable in poorly built or badly designed structures such as unreinforced masonry buildings. Some chimneys will be broken.

Intensity VI earthquake areas

Includes nearly all the major towns and settlements in the county, namely Clark, Cody, Elk Basin, Garland, Meeteetse, Pitchfork, and Powell. In intensity VI earthquakes, some heavy furniture can be moved. There may be some instances of fallen plaster and damaged chimneys.

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Highway-affecting landslides of the Snake River Canyon—Part IV, Deer Creek Slide

G. Michael Hager, Wyoming PG-12–Chief Engineering Geologist, WYDOT, Cheyenne, Wyoming

James M. Dahill, Wyoming PG-603–Project Geologist, WYDOT, Cheyenne, Wyoming

Bret D. Boundy, Wyoming PG-2460–Geologist, WYDOT, Cheyenne, Wyoming

John P. Turner–Professor of Civil and Architectural Engineering, University of Wyoming

This is the fourth and final installment of a series of articles detailing work by the Wyoming Department of Transportation (WYDOT) on landslides in Snake River Canyon and WYDOT's efforts to mitigate potential damage and protect the highway and its travelers. Part I of this series was an overview and background on the canyon highway and discussed the Elbow Slide (see *Wyoming Geo-notes No. 72*, December, 2001, p. 30-34). Part II emphasized the Wolf Mountain Slide, which blocked access through the canyon for weeks (see *Wyoming Geo-notes No. 73*, April, 2002, p. 33-40). Part III was on the Blue Trail Slide (see *Wyoming Geo-notes No. 74*, July, 2002, p. 30-33). We thank the staff at the Wyoming State Geological Survey for helping prepare these articles and we appreciate their interest in our work.

Deer Creek Slide

The Deer Creek Slide is located at the eastern end of Snake River Canyon between mileposts 139.63 and 139.81 on U.S. Highway 26/89, approximately one mile southwest of Hoback Junction (**Figure 26**). The slide is named for Deer Creek, which enters the Snake River from the southeast and across the river from the slide. This landslide is one of the more challenging landslides in Snake River Canyon requiring stabilization.

Subsurface materials consist of 66 feet (20 m) of sandy clay with gravel and scattered boulders, underlain by very hard siltstone with interbedded shale and sandstone of the Bear River Formation. The soils are colluvial, residual, and man-made fill materials derived from the underlying Bear River

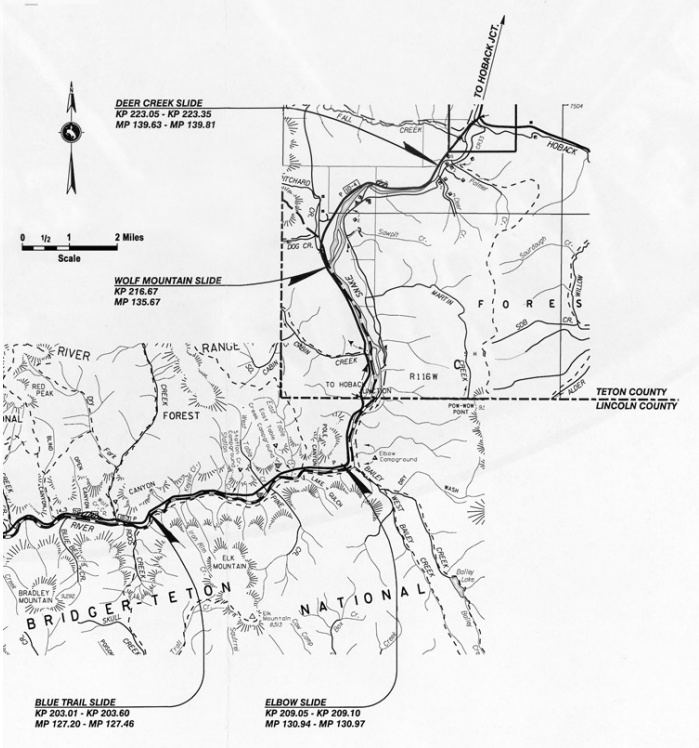

Figure 26. Detailed map of part of the Snake River Canyon showing locations of four major landslide stabilization projects.

Formation. Many of the major landslides in the canyon occur where the highway intersects the Bear River Formation and soils derived from it, which in general are highly plastic and possess very low residual shear strength when they become saturated. The slide plane at Deer Creek is located at the contact between the soil and the bedrock.

...this highly engineered and expertly constructed facility is completely out of sight to the traveling public.

The slide has had a history of resisting various attempts at stabilization. One of the major causes of this slide is seepage of groundwater from the subsurface formations above the active slide area (**Figure 27**). In 1996, WYDOT designed and constructed a permeable drainage wall above the roadway (**Figure 28**) intended to intercept and divert subsurface groundwater. The wall failed to stop movement of the slide. A stabilizing berm constructed below the roadway slowed the rate of movement, but was not sufficient to prevent damaging settlement of the roadway. In consultation with Federal Highway Administration (FHWA) engineers, WYDOT designed a system of permanent ground anchors to stop the movement of the slide prior to the roadway reconstruction.

Design and construction

The system was designed in-house by WYDOT and called for four rows of tieback anchors (Rows A, B, C, and D), as shown in **Figure 29**. In the lower two rows, anchors are battered (i.e., at an angle) 30° from horizontal, while anchors in the upper rows are battered 15° to 20° from horizontal. Each anchor was stressed and locked off against a structural reaction element consisting of a reinforced concrete panel 10 feet wide by 12 feet high by 2 feet thick. A total of 139 anchors ranging in length from 92 to 184 feet were required. Anchor work commenced during the first week in May, 2000.

At each row (A, B, C, and D) a working bench was excavated (**Figure 30**). The heavily-reinforced concrete panels were constructed as follows: timber forms were constructed, reinforcing steel placed in the forms, and concrete (5000 pounds per square inch) cast into the forms. When the concrete had cured, the forms were stripped and each panel was tilted into place against the cut (**Figure 31**). Anchors were installed through an 8-inch diameter hole in the center of each panel. Drilling was accomplished using the Klemm 806 tieback drilling rig with double rotary heads (**Figure 32**). The outer casing was 7-inch diameter and drilling through overburden soil was accomplished by a cutting shoe on the end of the casing. A down-the-hole hammer attached to the inner rod was activated whenever cobbles were encountered and was also used to drill the 50-ft long bond length into hard siltstone, shale, and sandstone. Cuttings were flushed with air.

Anchor materials provided by Con-Tech Systems, Ltd. of Delta, British Columbia, consisted of 18-strand tendons. Because the anchors are permanent, double corrosion protection was specified by WYDOT. In the bond length, this consisted of grout-encapsulated strands, a corrugated plastic sheath (PVC), and outer grout encapsulation. Along the unbonded length, corrosion protection consisted of a grease-filled sheath around each strand, a grout-filled smooth outer sheath of polyethylene encapsulating all 18 strands, and an outer layer of grout. Following tendon installation, the outer casing was removed while the hole was fully grouted. After curing, each anchor was performance load tested to 125% of design load, then locked off to design load of 530 kips (1 kip=1000 pounds per square inch) (**Figure 33**). Selected

Figure 27. The Deer Creek Slide above the highway near the entrance to Snake River Canyon. The highway (dashed line) is located near the toe of this landslide; the Snake River is just off the bottom of the photograph.

Figure 28. Vertical photograph of the Deer Creek Slide before stabilization project began. The two linear features below the highway are drainage walls and ditches constructed in an attempt to divert subsurface water from the slide. View is to the east with the Snake River at the top of the photograph.

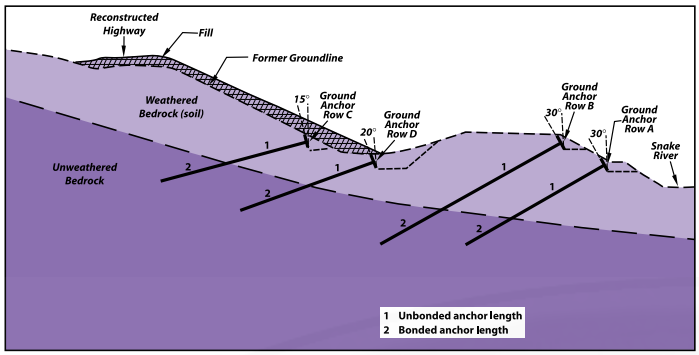

Figure 29. Diagrammatic cross section through the lower part of the Deer Creek Slide showing anchor locations and construction details. Modified from Turner (2001).

anchors in each row were subjected to a proof load test that required loading to 150% of design load.

Some of the reaction panels in Rows A and B were bearing against compressible soils that comprised the stabilizing berm (compacted fill) and underwent significant settlement when the anchors were stressed. This required adjustment (reduction) of the design loads for some anchors and required good communication between the contractor and WYDOT engineering, geology, and inspection personnel.

Design improvements during construction

During anchor drilling it was observed that some holes were producing large amounts of water. A contract modification allowed the contractor to install horizontal drains at these locations. The ability to make this type of observation during construction and to respond by adding features that improve the performance of the geo-support system, illustrate the application of the observational method in geotechnical engineering. The drains improve stability of the slide by relieving high pore water pressures that would otherwise reduce shear strength on the slide plane. Nine horizontal drains were installed (**Figure 34**) using 6-inch diameter perforated PVC pipe, with lengths ranging from 246 to 279 feet.

Figure 30. Beginning construction on the stabilization project for the Deer Creek Slide. The lower rows of anchors are near the equipment in lower left; the upper rows of anchors will be placed in the temporary construction trenches cut below and to the left of the roadway.

Temporary excavations were backfilled and compacted and the areas graded and seeded. The Deer Creek slide stabilization part of the project and horizontal drains were completed in August, 2000 at a cost of $2,172,003. Reconstruction of the highway over the slide area then commenced with additional reinforced fill to the final highway level. As is often the case in the geo-construction field, this highly engineered and expertly constructed facility is completely out of sight to the traveling public. However, in an environment such as the Snake River Canyon we wouldn't want it any other way!

Monitoring anchor performance

The Deer Creek project is the first by WYDOT in which high-capacity anchors were used as the only means of support to stabilize a large landslide. The project was therefore designated an "Experimental Feature" by the FHWA. The University of Wyoming (UW) Department of Civil and Architectural Engineering was asked to participate in monitoring and evaluation of the permanent ground anchors. In each of the four rows of anchors, three anchors are instrumented

Figure 31. Large anchor panels were lifted by crane and tilted into place against cut material.

Figure 32. Drilling holes for the battered ground anchors was accomplished with a Klemm 806 tieback drilling rig with double rotary heads.

Figure 33. Installed tieback ground anchors attached to the ground anchor panels with steel bearing plates. After the grouting had cured each anchor was performance tested and locked off to design load.

Figure 34. Installing horizontal drains above ground anchor plates alleviated some of the water in the slide and improved its stability.

with load cells to monitor long-term loads. Piezometers were installed to monitor pore water pressures and groundwater elevations, and slope inclinometers are being used to monitor slope movement.

It was observed that anchor loads decreased immediately after lock-off and that the magnitude of decrease is related to the settlement characteristics of the individual anchor plates. Where the concrete anchor panels are bearing on more compressible soils, the drop-off in anchor load has been significant, up to 50% of the design load in a few cases. Where the underlying soils are stiffer and drier, decreases in anchor load are less significant, on the order of 10 to 15% of the design load. To date, the Deer Creek slide appears to be stable and there is no evidence that the decrease in anchor loads has affected the ability of the system to control ground movements. WYDOT and UW engineers will continue monitoring this site for the next several years in order to assess the effectiveness of using individual anchors and reaction panels for slide stabilization.

Readers who have field data pertaining to long-term loads in anchors used for slide stabilization and are willing to share information or to participate in this study should contact the authors. A more technical article on this project was published by Turner (2001).

Reference cited

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PUBLICATIONS UPDATE

New Publications Available from the Wyoming State Geological Survey

Wyoming State Geological Survey publications

*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), 2002, Digital Map Series 2002-01 (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), 2002, Digital Map Series 2002-02 (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), 2002, Digital Map Series 2002-03 (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), 2002, Digital Map Series 2002-04 (scale 1:100,000), on-demand plotted color map, rolled only – $25.00; CD-ROM under development – $10.00.

*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, 2002: Coalbed Methane Map CMM 02-4 (updated in August, 2002, replaces CMM 02-1), 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, 2002: Coalbed Methane Map CMM 02-5 (updated in August, 2002, replaces CMM 02-2), 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, 2002: Coalbed Methane Map CMM 02-6 (this is a reduced and combined version of CMM 02-4 and CMM 02-5 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.

*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, 2002: Coalbed Methane Map CMM 02-7 (updated August, 2002, replaces CMM 02-1 and CMM 02-2), digital version (ESRI ArcInfo®/ESRI ArcView® format) on CD-ROM – $50.00.

Oil and gas map of the Powder River Basin, Wyoming, by R.H. De Bruin, 2002: Map Series MS-51 (scale 1:350,000), on-demand plotted color map, rolled only – $25.00; ESRI ArcInfo®/ESRI ArcView® format on CD-ROM (including MrSid® viewable files), – $20.00.

Oil and gas map of the Greater Green River Basin and Overthrust Belt, Wyoming, by R.H. De Bruin, 2002: Map Series MS-52 (scale 1:350,000), on-demand plotted color map, rolled only – $25.00; ESRI ArcInfo®/ESRI ArcView® format on CD-ROM (including MrSid® viewable files), – $20.00.

Oil and gas map of the central and northwestern Wyoming basins, Wyoming, by R.H. De Bruin, 2002: Map Series MS-53 (scale 1:350,000), on-demand plotted color map, rolled only – $25.00; ESRI ArcInfo®/ESRI ArcView® format on CD-ROM (including MrSid® viewable files), – $20.00.

Oil and gas map of the southeastern Wyoming basins, Wyoming, by R.H. De Bruin, 2002: Map Series MS-54 (scale 1:350,000), on-demand plotted color map, rolled only – $25.00; ESRI ArcInfo®/ESRI ArcView® format on CD-ROM (including MrSid® viewable files), – $20.00.

*Oil and gas map of Wyoming, by R.H. De Bruin, 2002: Map Series MS-55 (scale 1:500,000), on-demand plotted color map, rolled only – $30.00; ESRI ArcGIS®/ArcReader® format on CD-ROM (including MrSid® viewable files) - $80.00.

Oil and gas resource assessment of the Jack Morrow Hills and surrounding areas, southwestern Wyoming, by L. Cook, R.H. De Bruin, C.S., Boyd, and R.W. Jones, 2002: Open File Report 2002-01 – $25.00 (includes 3 oversized sheets) + $6.00 shipping and handling.

*Preliminary geologic map of the Rattlesnake Hills 1:100,000 Quadrangle, Fremont and Natrona Counties, central Wyoming, by W.M. Sutherland and W.D. Hausel, 2002: Open File Report 2002-02 – $30.00 (includes 2 oversized sheets and 32 p. text) + $6.00 shipping and handling.

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

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

Topo! Wyoming, Seamless USGS topographic maps on CD-ROM, 2000, National Geographic Maps, 6 CD-ROMs. Contains full-state coverage with TOPO! Mapping Software, GPS ready, with 3-D digital shading (toggles off and on) and photo-quality output. Five map scales include general reference map, National atlas series, 1: 500,000 map series, 1:100,000 map series, and 1:24,000 map series. Coverages extend outside state boundaries and include all boundary areas contiguous to Wyoming - $99.95.

GIS Update

Joseph M. Huss

GIS Coordinator–Publications, Wyoming State Geological Survey

The Geographic Information Systems (GIS)/Cartographic unit of the Wyoming State Geological Survey (WSGS) has been increasingly busy in the first part of 2002. The Publications Section received additional personnel and positions, along with needed equipment. Since the beginning of the year, the GIS/Cartographic personnel have been and are involved in at least eight projects including simple digitization of data, construction of GIS databases, full cartographic layouts, and new developments with internet map serving (IMS).

Personnel and positions

The WSGS welcomed Justin Carreno as the first research assistant (RA) for the agency in cooperation with the Department of Geography and Recreation, University of Wyoming (UW). After working with the WSGS on STATEMAP 2001 in the spring and summer, he accepted the new RA position with UW and the WSGS at the start of the school year. The RA is a thesis-driven position with the goal being compilation of a 1:250,000-scale geologic map of the northeastern quarter of the state. The map will be completely digital using GIS techniques and technology. Justin is a graduate of the University of Connecticut and is planning to finish a M.S. degree in Geography by the end of next summer.

The WSGS added three intern positions this summer under the State of Wyoming's Internship Program. Two of the interns are working in the GIS/Cartographic unit of the Publications Section; the other is working in the Industrial Minerals and Uranium Section. Both interns in the GIS/Cartographic unit are working as GIS technicians as well as attending UW. Justin Mulbay has a B.S. degree in Geography from UW and is now working on a Masters of Business Administration. Robin Lyons is a Laramie Senior High School graduate and is majoring in Graphic Arts. These gentlemen have been in the internship program from the beginning of this summer and will continue through December. They are enthusiastic, driven, have a willingness to learn, and add a great value to the Survey's GIS team. The WSGS has been very pleased with their work and both interns have agreed to continue on with the Survey after December to work on the STATEMAP 2002 project (see below).

STATEMAP 2001

The STATEMAP 2001 (subproject 2) was completed August 1, 2002 with four new 1:100,000-scale quadrangles in Wyoming: two digital bedrock geologic maps and two digital surficial geologic maps (see *Wyoming Geo-notes No. 68*, December, 2000, p. 29-30 and *Wyoming Geo-notes No. 72*, December, 2001, p. 37-39). The project was funded by the U.S. Geological Survey (USGS) with matching funds from the WSGS. Bedrock geologic maps for the Buffalo and Recluse quadrangles were prepared and are to be published as WSGS Digital Maps 02-1 and 02-2. Surficial geologic maps of the Basin and Midwest quadrangles were prepared and will be published as WSGS Digital Maps 02-3 and 02-4. The project was completed by Justin Carreno and the two GIS/Cartographic intern positions along with several WSGS staff.

STATEMAP 2002

STATEMAP 2002 (subproject 2) began this summer with both GIS/Cartographic interns and WSGS staff working on four 1:100,000-scale quadrangle maps. These maps include the Kaycee, Rattlesnake Hills, and Reno Junction bedrock geologic maps, and the Bill surficial geologic map. The Bill and Rattlesnake Hills maps will be completed in early 2003 and the Kaycee and Reno Junction maps in mid-2003.

All STATEMAP projects are produced with ESRI's ArcGIS® 8.x and will be released in both hard copy (color plotted maps) and on CD-ROM. The digital release on CD-ROM will include a MrSid® image of the map (plus MrSid® installable viewer), ESRI's ArcReader® files (plus installable ArcReader®) to allow identification and use of the GIS data without GIS software, ESRI shapefiles and ESRI Personal Geodatabase® in ESRI's ArcGIS® 8.2 format, and complete documentation and metadata.

Basin and statewide oil and gas maps

The oil and gas fields maps of Wyoming are now completed as both hard copy maps and CD-ROM digital maps (see **New Publications Available from the WSGS**). These maps are part of the WSGS Map Series (MS), and include MS-51, Powder River Basin; MS-52, Greater Green River Basin; MS-53, Central and northwestern Wyoming basins; MS-54, Southeastern Wyoming basins; and MS-55, Oil and gas fields of Wyoming.

The four basin maps are compiled at a scale of 1:350,000; the statewide map (MS-55) is compiled at a scale of 1:500,000 and the plotted version measures 42 by 60 inches. The data released on CD-ROM will be delivered as both ESRI shapefiles and ESRI Personal Geodatabase® in ESRI's ArcGIS® 8.2 format. The digital release will also have a MrSid® image of the map (with installable viewer); an ESRI ArcReader® file (with installable reader) to allow identification and use of the GIS data without GIS software; and complete documentation and metadata.

Oil and gas pipeline database

The Oil and Gas pipeline database project, contracted to the WSGS through the Wyoming Energy Commission (a part of the Wyoming Business Alliance), officially concluded on May 31, 2002 (see *Wyoming Geo-notes No. 72*, December, 2001, p. 37-39). Because of the dynamic nature of the data (e.g., changes in pipeline infrastructure, new or modified lines, and other parameters) the WSGS will continue to update this database.

This database has been generalized for use on the oil and gas fields maps of Wyoming and is accessible via the digital releases of the maps on CD-ROM. Additionally, the generalized pipeline routes and other data will be accessible via the internet after the second quarter of next year on the WSGS Geology and Energy Map Server now being constructed.

...a cooperative internet map serving project...will augment the WOGCC's oil and gas well database with an interactive, internet-accessible map.

New geologic map of Wyoming planned

Work is now underway to compile a new 1:250,000-scale state geologic map. With the new RA established between the WSGS and the Department of Geography and Recreation at UW, the first of four maps is being prepared. Justin Carreno, the RA and GIS specialist (see above) is combining the 1:250,000-scale quadrangles of Arminto, Gillette, Newcastle, and Sheridan into a single, digital geologic map of northeastern Wyoming. The maps being compiled are both published WSGS maps and USGS open file reports. The maps are being digitized via varying techniques in a GIS format. ESRI's ArcGIS® software will be used for the final compilation, edits, and for producing both hard copy color maps and digital CD-ROM products.

Compilation of a statewide geologic map at the 1:250,000 scale will supply a higher mapping resolution to augment the existing 1:500,000-scale geologic map. The new map will also serve as an interim geologic map for those areas presently unmapped at the 1:100,000 scale. The WSGS will continue the project with additional RA positions over the next three years, completing maps of the other three quadrants (southwestern, southeastern, and northwestern Wyoming).

Love Map Series

The WSGS has completed a hard copy digital map of J.D. Love's Two Ocean Lake Quadrangle in Teton County. This is the eighth map published in the Love Map Series, which consists of 1:24,000-scale quadrangles in the Jackson Hole/Teton area. The maps are available from the WSGS as plotted color maps.

Additional quadrangles in this series will be published over the next year, including: Jackson, Colter Bay, Davis Hill, Jenny Lake, Moran, and Whetstone Mountain. The USGS is providing funds for scanning, digitizing, and preparation of the GIS data from the original geologic information. The GIS/Cartographic unit at the WSGS, in cooperation with the Editorial unit, will prepare the maps for publication and distribution. An additional four quadrangle maps are presently being scanned and digitized. These include Gravel Peak, Bobcat Ridge, Huckleberry Mountain, and Flagg Ranch. This series will ultimately contain 45 total quadrangle maps and is a continuing project of the WSGS. Maps will be released periodically as they are completed.

Oil and gas well internet map server

The WSGS, the Wyoming Oil and Gas Conservation Commission (WOGCC), and Environmental Systems Research Institute (ESRI) are conducting a cooperative internet map serving project. This will augment the WOGCC's oil and gas well database with an interactive, internet-accessible map. The three groups are conducting various activities, including programming, hardware setup, and software development to create a user-friendly live map (**Figure 35**).

The oil and gas well map server will be accessible from web sites of both the WOGCC and the WSGS (see http://wsgsweb.uwyo.edu/wsgs/mapframe.asp). The IMS allows the users to turn on and off any associated GIS data layers and identify specific wells that are in question. Additionally, those utilizing ESRI's ArcGIS® software will be able to use the information on their computer.

New equipment

The WSGS has expanded its GIS capabilities with a variety of new hardware. New dual processor GIS workstations were

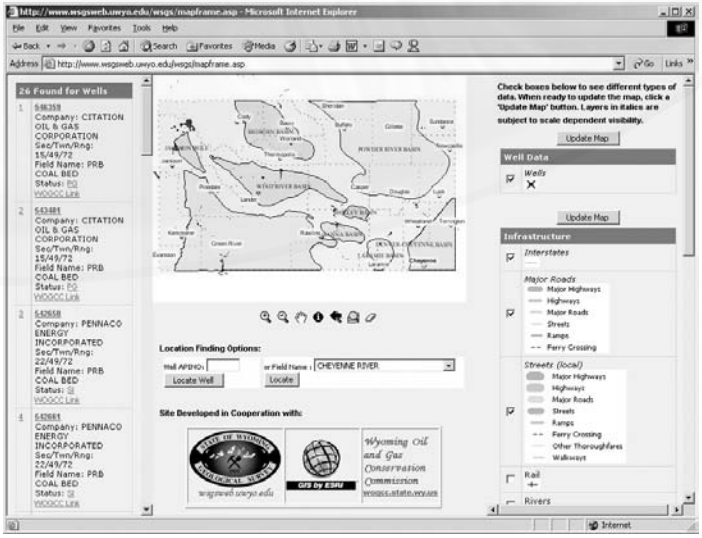

Figure 35. Home page for the newly developed oil and gas well internet map server now available through the WSGS and the WOGCC web sites.

purchased for all personnel working on GIS applications throughout the Agency. These new machines increase our capabilities in processing large, complex geologic data sets as well as increase efficiency and decrease costs, as personnel do not lose time waiting on processing.

A new 42-inch-wide plotter allows the WSGS to produce large 1:500,000-scale statewide map plots. Not only does this greatly increase our map capabilities, it adds efficiency in producing our map products. A new 42-inch-wide scanner (paired with the plotter, above) is also adding new capabilities as older out-of-print maps can be scanned and reproduced along with converting them to digital data. Additionally, open file reports and other unpublished maps can be scanned for archiving, distributing via the internet, and for plotting on demand.

The WSGS has also acquired a large format thermal laminating machine capable of handling most output from both the 42-inch- and the 36-inch-wide plotters that the Survey now has. This will allow us to offer additional map products.

Finally, a new Gigapop® network infrastructure for WSGS computers has been added for enhanced access to data servers and the internet. This high-speed connection saves personnel time and expense by shortening computer access time. With the new IMS technology and related projects occurring at the WSGS, this will also allow faster public access.

All this new equipment can be attributed to excellent use of limited resources, leadership, and teamwork. A hardworking, excellent Information Technology Section has ensured that the WSGS has the ability to efficiently use our new and existing computer and network capabilities.

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☺ We give a discount on large orders of most Wyoming State Geological Survey publications and selected other publications.

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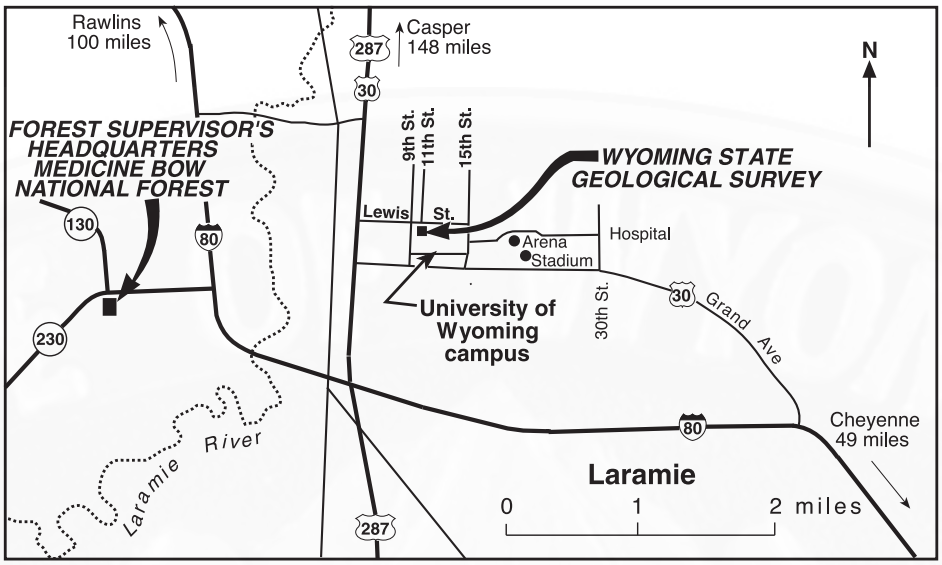
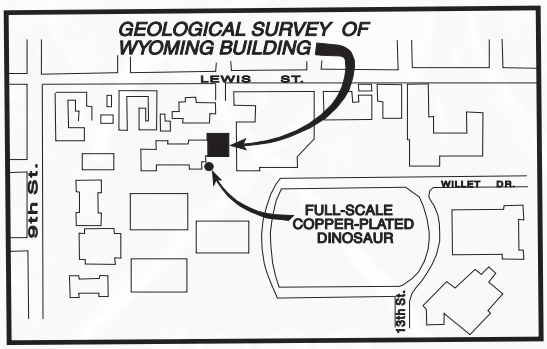
☹ Sorry, we do not accept credit cards for payment at this time.

Many Wyoming State Geological Survey publications are also available for over-the-counter sales at the Wyoming Oil and Gas Conservation Commission office, Basko Building, 777 West First Street, Casper, Wyoming 82601.

Location Maps for the Wyoming State Geological Survey





Improved Telephone System at the Wyoming State Geological Survey

The Wyoming State Geological Survey recently upgraded their telephone system to include voice mail. Those wishing to contact a specific person or section may now do so directly by dialing the Survey's regular phone number (307-766-2286) and then entering the extension of the person to whom they would like to speak. An automated phone directory can also be accessed. Messages can be left for a person in a more convenient way. For persons wishing to place an order, or who have sales-related questions, simply dial "0" for an operator. For your convenience, the following list may help locate staff members or their sections.

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Lance Cook, *State Geologist–*
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Geologic Sections

James C. Case, *Senior Staff Geologist - Geologic Hazards*
Email: jcase@wsgs.uwyo.edu
Rodney H. De Bruin, *Senior Staff Geologist - Oil and Gas*
Email: rdebru@wsgs.uwyo.edu
Ray E. Harris, *Senior Staff Geologist - Industrial Minerals and Uranium*
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Email: dhause@wsgs.uwyo.edu
Robert M. Lyman, *Staff Geologist - Coal*
Email: blyman@wsgs.uwyo.edu
Alan J. Ver Ploeg, *Senior Staff Geologist - Geologic Mapping*
Email: averpl@wsgs.uwyo.edu

Computer Services Unit

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

Publications Section

Richard W. Jones -*Editor*
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Joseph M. Huss -*GIS Specialist*
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Fax: (307) 766-2605
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