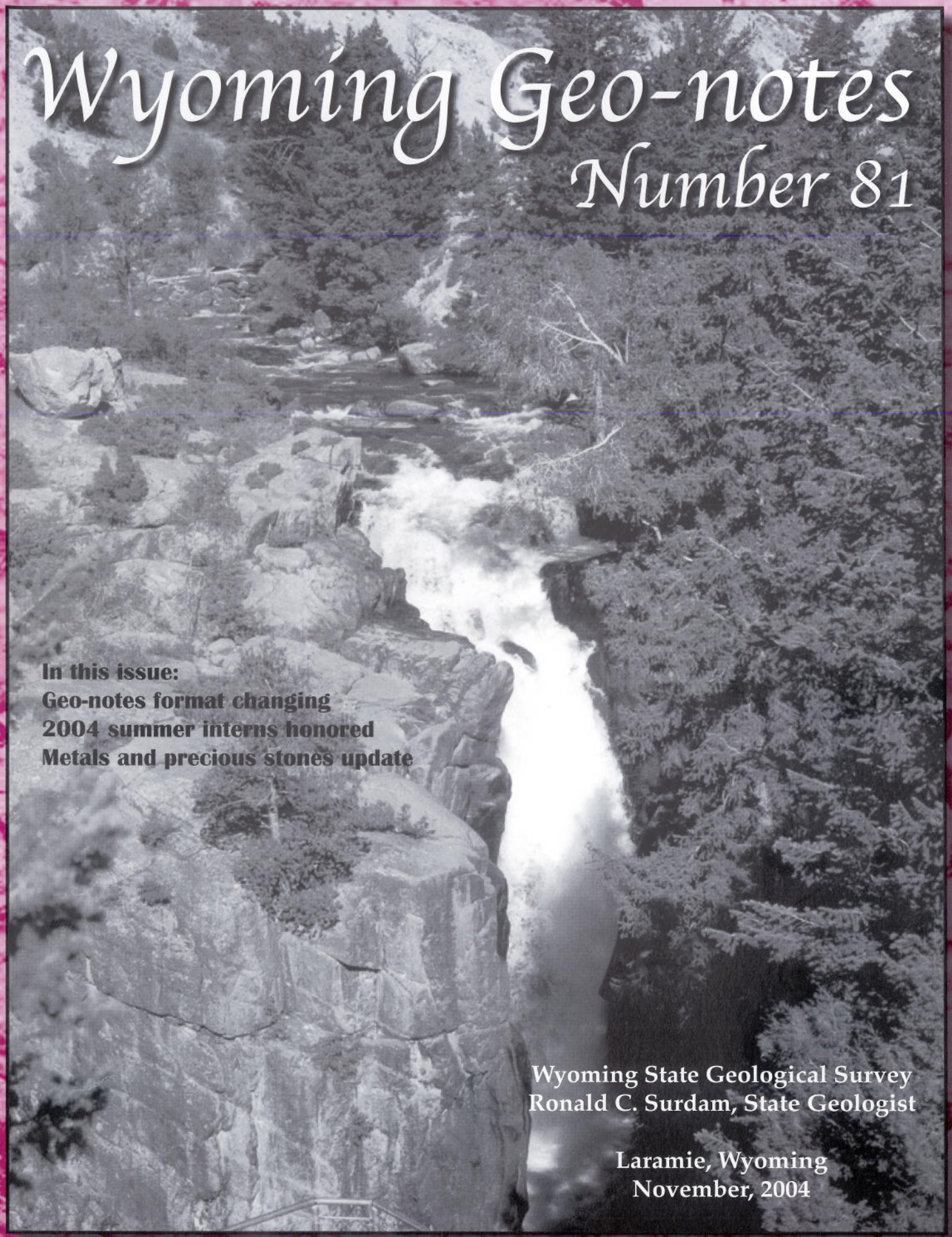
Wyoming Geo-notes
Number 81



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Wyoming State Geological Survey
Ronald C. Surdam, State Geologist

Laramie, Wyoming
November, 2004

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Co-editor, layout, and design

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Front cover: Shell Falls and Shell Creek are located in the Bighorn Mountains east of the town of Shell. U.S. Highway 14 between Shell and Dayton is designated a national scenic byway through Bighorn National Forest. An interpretive center and trail are located at the falls, and most of Highway 14 in this area contains signs identifying the different geologic formations. Photograph by Richard W. Jones, 1978.

MINERALS UPDATE

Overview

Richard W. Jones, Wyoming PG-2972

Editor/Senior Geologist, Wyoming State Geological Survey

The first quarter of 2004 showed a modest increase in Wyoming's coal and natural gas production over the first quarter of last year, and by the first half of 2004, production was ahead of last year's record-setting pace. Trona production also increased in the first quarter with uranium, bentonite, and gypsum production remaining at about the same level as last year. Oil production continued to decline during the first and into the second quarter, as did coalbed methane (CBM). A decrease in CBM production in the Powder River Basin (PRB) was tempered somewhat by increased CBM production elsewhere in Wyoming. The increase in conventional natural gas production in southwestern Wyoming more than offset the decline of CBM in the PRB. The next issue of Wyoming Geo-notes will discuss new production forecasts made by the State of Wyoming's Consensus Revenue Estimating Group (CREG) in late 2004 and early 2005 and will present an updated **Table 1**.

The State of Wyoming and our energy producers benefited from the high prices for coal, natural gas, and oil in the first quarter and going into the second quarter. For example, 8800-Btu spot coal from the PRB was $1.14 per short ton higher in March, 2004 than it was a year ago, average natural gas prices were $0.95 per thousand cubic feet (MCF) higher, and oil prices were $0.57 per barrel higher. Although coal prices peaked in the first quarter, they still remained significantly higher in the second quarter than for the same period last year. Oil prices continued to rise in the second quarter of 2004, and average prices were over $4.00 per barrel higher than last year. The average price of natural gas was $0.82 per MCF higher in the second quarter of 2004 than a year ago. Based on these price increases, CREG will be revising the price forecasts shown in **Table 2** for the next issue of Wyoming Geo-notes. For a detailed analysis of production and prices for the first quarter of 2004, see the individual update articles for each mineral commodity.

Several activities and projects discussed in this issue of *Wyoming Geo-notes* are significant for Wyoming's mineral industry; they give us much optimism for the future and hopefully, they will have a very positive effect on

Table 1. Wyoming mineral production (1987 through 2003) with forecasts to 2008[1].

Calendar Year	Oil[2,3]	Methane[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[7]	*In situ* Uranium[8]
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3
1996	73.9	1023.4	149.0	1.10	278.4	18.6	1.6
1997	70.2	1040.7	151.0	1.10	281.5	19.4	2.2
1998	65.7	1072.6	151.0	1.10	315.0	18.6	2.3
1999	61.3	1133.1	161.0	1.10	336.5	17.8	2.8
2000	60.6	1293.3	161.0	1.10	338.9	17.8	2.1
2001	57.5	1437.6	174.0	1.20	368.8	17.7	1.6
2002	54.7	1572.6	174.0	1.20	373.2	17.2	1.4
2003	52.4	1636.9	196.0	1.20	376.6	17.5	1.2
2004	50.4	1602.8	196.0	1.20	380.6	18.0	1.4
2005	50.4	1652.8	196.0	1.20	384.4	18.5	1.4
2006	52.4	1707.8	196.0	1.20	388.3	18.5	1.4
2007	54.5	1765.5	196.0	1.20	392.1	18.5	1.4
2008	57.7	1824.3	196.0	1.20	396.0	18.5	1.4

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

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1987 through 2003) with forecasts to 2008[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.78	42.29
1998	10.67	1.81	5.41	41.29
1999	16.44	2.06	5.19	38.49
2000	26.87	3.42	5.40	37.28
2001	21.59	3.66	5.75	38.00
2002	22.08	2.09	6.66	38.00
2003	26.63	4.41	6.85	37.40
2004	22.50	3.50	6.00	37.50
2005	20.50	3.25	6.03	37.50
2006	20.50	3.25	6.12	37.50
2007	20.50	3.25	6.24	37.50
2008	20.50	3.25	6.40	37.50

[1]From CREG's Wyoming State Government Revenue Forecast, October, 2003; [2]First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1987-2003; [3]Wellhead price in dollars per thousand cubic feet (MCF), includes coalbed methane. Source: American Association, 1998-2003; Wyoming Office of State Lands and Investments, 1989-2003 (derived from State royalty payments); and Minerals Management Service, 1987-1988 (derived from Federal royalty payments); [4]Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1987-1990 and derived from Department of Revenue, 1991-2003; [5]Dollars per short ton of trona, not soda ash. Source Wyoming Department of Revenue, 1987-2003.

the state. The newly installed carbon dioxide floods in old oil fields such as Salt Creek are proving quite effective in recovering additional oil reserves and by 2006, the oil recovered may be enough to actually reverse Wyoming's declining production curve, at least for a few years. A number of Wyoming oil fields have unrecovered reserves and are good candidates for carbon dioxide floods; there appears to be plenty of carbon dioxide reserves available.

The Wyoming Natural Gas Pipeline Authority is placing some of its bonding authority behind several projects that would benefit Wyoming's natural gas industry. These projects include the Cheyenne Plains pipeline that would expand gas markets to the Midwest, a long-overdue plan to construct a pipeline that would open up natural gas service to Jackson Hole, and loan assistance for developing a business complex in Rock Springs that would serve the natural gas production and service industry.

The **Coal Update** contains a discussion on future uses of Wyoming coal that go above and beyond its use as fuel in electrical power generation. Gasification and liquefaction technologies already exist for coal conversion, and Wyoming's subbituminous coal resources are especially well suited for them. Coal gasification can help reduce U.S. dependence on foreign oil imports by providing alternative fuels for power generation and heating and by providing value-added by-products such as hydrogen and carbon dioxide. Coal liquefaction can provide synfuels that would replace those refined from imported oil. If the current high prices for natural gas and oil continue, these coal conversion processes become economically feasible. With new coal gasification and liquefaction plants in place, our dependence on foreign supplies of oil and gas is lessened and there would be less price volatility with the more stable domestic fuel supply. One such project has already been proposed for southern Wyoming, the Medicine Bow Energy Project, which would include a mine-mouth coal gasification and liquefaction facility in addition to a 1000-megawatt electrical generating plant and a new coal mine to supply the coal.

...a new iolite-kyanite-sapphire-ruby deposit was discovered in the Laramie Mountains...

Uranium prices continued to increase in early 2004, prompting some inquiries to the Industrial Minerals and Uranium Section at the WSGS about reopening closed uranium mines and locations of possible new deposits. Revival of this industry would certainly boost Wyoming's economy.

According to the **Metals and Precious Stones Update**, a new iolite-kyanite-sapphire-ruby deposit was discovered in the Laramie Mountains and a large opal deposit in central Wyoming has been documented through mapping. The former deposit contains some especially large iolite gemstones and is apparently a large-tonnage deposit, which could place Wyoming as a primary source worldwide for this gemstone. The opal deposit contains a wide variety of colors and some massive, unfractured opals over a large zone of mineralization. It may be one of the largest opal deposits in North America.

The **Metals and Precious Stones Update** also reports increased activity in diamonds and gold. More diamonds have been recovered in the Green River Basin and a possible major gold discovery was reported at an undisclosed location.

The WSGS has started releasing digital maps from our latest STATEMAP projects. The **Publications Update** lists these new maps, which include digital versions of several previously published geologic maps and several unpublished surficial geologic maps. A new 1:100,000-scale geologic map of the Saratoga Quadrangle was compiled by the Metals and Precious Stones Section and released as an open file report and newly compiled bedrock geologic maps of the Casper and Torrington 1:100,000-scale quadrangles will be released later this year. The Geologic Mapping Section, in cooperation with the geographic information systems (GIS) unit of the WSGS, has also completed the first two of twelve 1:24,000-scale quadrangle maps in the southern Bighorn Mountains in digital form. This is part of an ongoing project to convert all the 1:24,000 quadrangle maps published by the WSGS to digital coverages. Some of this work is funded (or proposed for funding) through the STATEMAP program.

The WSGS is now using the open file series to release many of the new maps. The open file map presentations have been upgraded to conform with accepted mapping standards and include full-color digital maps that can be plotted on demand. The digital files for all these maps will eventually be available on CD-ROM or possibly for download from the WSGS web site. The WSGS is also converting some of the maps published in the Map Series (MS) to digital format, which allows for easy updating and ensures that the user receives the latest version of the map. The most recent digitized maps are MS-39, *Geologic map of the Nowater Creek 1:100,000 Quadrangle*, and MS-47, *Industrial mineral and construction materials map of Wyoming*. Both these maps have been updated and revised from the earlier published and printed versions.

Finally, this issue of *Wyoming Geo-notes* contains a county-by-county assessment of damages that could occur in Wyoming from earthquakes. The assessment uses the computer program HAZUS-MH. Wyoming is the national test state for developing these assessments and the program at a census-block level of analysis. The program uses real data from a number of geologic and seismic parameters and relates it to actual damage that could occur to buildings and property. The analyses use mapped features, inventories of property and structures, and other site-specific data. Personnel from the Surficial Processes and Geohydrology Section (formerly the Geologic Hazards Section) at the WSGS are currently testing and modifying the program as needed.

Geo-notes Format Changing

We are revising the way we offer *Wyoming Geo-notes*. After issues 81 and 82 are published, the traditional Mineral Update articles in *Wyoming Geo-notes* will be discontinued as part of the printed version, and offered instead via an Email subscription or online over the WSGS web site. The printed publication will be issued twice a year instead of quarterly and will contain only a year-end overview of significant mineral activity.

The mineral updates for oil and gas, coal, coalbed methane, industrial minerals and uranium, and metals and precious stones will continue to be offered every quarter, but only in electronic format. Since these will not be printed, they will be issued in a timelier manner. All the traditional graphs and tables for production and prices will be retained, as will the exploration activity graphs, activity and leasing maps, and other information currently included in the printed version. Some of the tabular data on spreadsheets will be available for download. Readers will have the option of receiving all the mineral updates or just the updates that they specify. There will be no charge for any of these new quarterly update subscriptions.

Wyoming Geo-notes will continue to be published twice a year, but will focus on activities and projects at the WSGS and provide more reports on various aspects of Wyoming geology and mineral resources. The new *Wyoming Geo-notes* will include updates and articles on geologic hazards, geologic mapping, and GIS that appear in our current issues. We hope to publish additional short articles by WSGS authors as well as outside authors, and we invite our readers to submit articles to us for consideration. We anticipate using full color graphics and photographs and hope to make the new *Wyoming Geo-notes* more a newsletter about the WSGS and the state's geology and minerals.

New and renewing subscribers to *Wyoming Geo-notes* will be notified about these new options and will be able to receive the free quarterly updates. The new semi-annual *Wyoming Geo-notes* will be available by subscription for a minimal fee. Those subscribers who have paid past *Wyoming Geo-notes No. 82* will continue to receive the printed version through the final issue that has been paid. Please fill out the order form below. The entire page can then be cut out, folded, and sent to us. Please do not include payment for *Wyoming Geo-notes* at this time, as we have not determined what the new subscription price will be.

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2004 Summer Interns Honored

Jaime R. Moulton

Assistant Editor–Publications, Wyoming State Geological Survey

The Wyoming State Geological Survey (WSGS) again employed four students under the State of Wyoming's Summer Intern Program for 2004 (**Figure 1**). The internship program is in its third year, and the WSGS has employed interns each year with great success. This program was established to help students gain practical work experience in a state government setting. Each intern is allowed to work a maximum of 520 hours, which equals approximately 3 months of full-time work. The internship ends when the total hours are completed or on December 31, 2004 if all hours are not worked.

Brooke Culver interned for the Publications Section. She is from Cheyenne and is currently a Junior at the University of Wyoming (UW) majoring in Journalism with an emphasis in Public Relations and Advertising as well as a minor in Marketing. Brooke assisted with several publications and completed two new Information Pamphlets, one on rock hounding and one on placer diamonds, from start to finish. She gained knowledge of several complex computer programs and has a couple of publications to begin her portfolio. Brooke is a good worker and her efforts will be missed. Brooke would like to work in either a public relations or advertising field upon graduation from UW.

Shawn Lanning, from Pinedale, was the intern for the geographic information systems (GIS) Section. He is a second-year graduate student at UW working on his Masters in Geography. Shawn produced a digital version of the Topographic Map Index for Wyoming. He then created hunting maps using this index and superimposing hunting areas for all big game animals. These maps have been helpful for hunters locating maps for their respective hunting areas. Shawn completed his internship early, and is now a Teaching Assistant for GIS classes at UW.

Sonja Parson, from Delta, Utah, graduated from UW in May and is now working on her Masters in computer science. She interned with the Information Technology (IT) Section. During her internship, she worked on updating the WSGS web site. Her ideas, combined with other people's efforts, have helped improve the visual appeal of the web site. She has also assisted the IT Section with upgrading all computer systems in the building to Windows XP operating system.

Cambia Talbot calls Worland home. She graduated from UW in May with a Bachelors degree in Geography. She is interning for the Industrial Minerals and Uranium Section. Cambia's efforts have been compiling data for a statewide uranium map. This data is an expansion of the work the previous intern for this Section completed. Upon completing her internship she hopes to find a permanent position in a GIS-related field.

Each summer, the State of Wyoming holds a recognition ceremony to honor all summer interns employed by every state agency. The interns each received a Certificate of Recognition in addition to a beautiful desk clock. Each intern at the WSGS made a valuable contribution to the agency, and their professional attitude and enthusiasm will be missed.

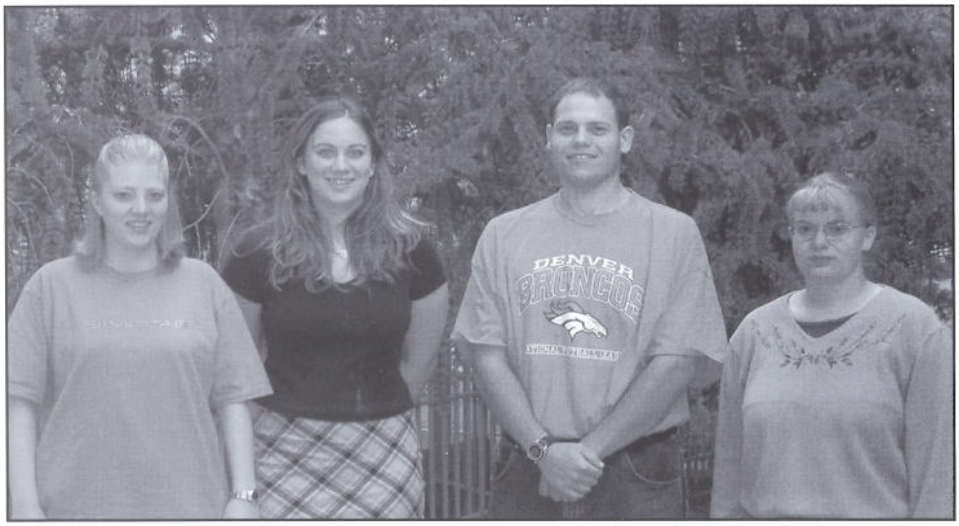

Figure 1. Participants in the 2004 Summer Internship Program at the Wyoming State Geological Survey. From left to right: Sonja Parson, Brooke Culver, Shawn Lanning, and Cambia Talbot.

Oil and Gas Update

Rodney H. De Bruin, Wyoming PG-3045

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

Wyoming oil and gas producers received higher prices in the first quarter of 2004 for their oil and natural gas than they received during the corresponding period in 2003. Average oil prices for the first quarter of 2004 were up $0.57 per barrel from the first quarter of 2003, while average natural gas prices were up $0.95 per thousand cubic feet (MCF). Oil production declined nearly 4% from the first quarter of 2003 to the first quarter of 2004, while natural gas production increased 1.9%. Coalbed methane (CBM) production from the Powder River Basin (PRB) for the first quarter of 2004 accounted for 81.8 billion cubic feet (BCF) or 17.2% of Wyoming's total natural gas production. Increased gas production from Jonah Field and from wells on the Pinedale anticline for the first quarter accounted for 86.3 BCF or 18.2% of the total 474.7 BCF produced in Wyoming.

The February, 2004 federal lease sale brought in over $7 million. The highest per-acre bid was $2012 for a 40.2-acre lease and the second highest per-acre bid was $1675 for an 80-acre tract. The sale's average per-acre bid of $93.67 was the highest in a U.S. Bureau of Land Management (BLM) oil and gas sale in Wyoming over the last five years. Thirty-three parcels at this sale received a bid of $50 or more per acre.

The number of applications for permit to drill in the first quarter of 2004 remained healthy with 2087 approvals. Ten seismic projects were approved in the first quarter and the average daily rig count was 65. This average is the highest for a first quarter in over 14 years; if the trend continues, the average rig count for 2004 will be the highest since 1985.

Prices and production

Prices paid to Wyoming oil producers during the first quarter of 2004 averaged $29.88 per barrel (**Table 3**). This price was $0.57 higher than the average price in the first quarter of 2003. The average monthly price for a barrel of Wyoming crude oil has been over $20 for the last 29 months (**Table 3**), and we are predicting that the average yearly price will be over $20 per barrel for the fifth year in a row at the end of 2004 (**Figure 2**). By mid-year, 2004, the posted sweet and sour crude prices and first purchase price for Wyoming oil averaged by month were around $35.00 per barrel or more (**Figure 3**).

Oil production reported by the Wyoming Oil and Gas Conservation Commission (WOGCC) for the first quarter of 2004 was 12.7 million barrels (**Table 4**). This production was only 500,000 barrels less than production in the first quarter of 2003; but still amounted to a 3.8% decline. With several carbon dioxide floods coming on line in the next few years, we are expecting yearly oil production declines to end after 2004 (**Figure 4**).

Spot prices for natural gas at Opal, Wyoming averaged $5.04 per MCF during the first three months of 2004. This is $0.95 per MCF higher than the average price for the corre-

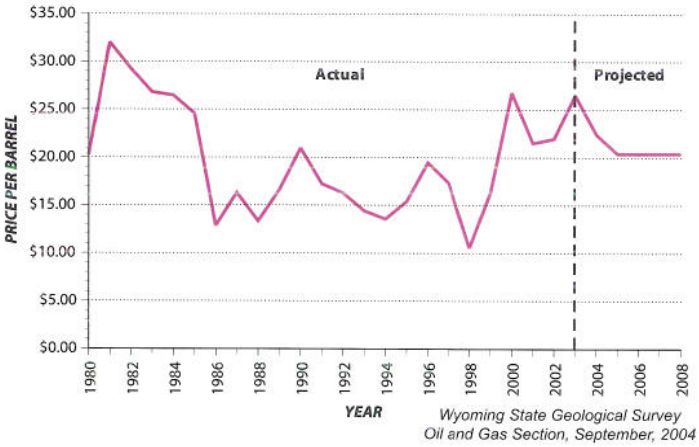

Figure 2. Average prices paid for Wyoming crude oil (1980 through 2003) with forecasts to 2008.

Table 3. Monthly average price of a barrel of oil produced in Wyoming (2000 through July, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$24.01	$24.01	$24.62	$24.62	$15.70	$15.70	$28.02	$28.02	$28.88	$28.88
February	$26.48	$25.25	$24.82	$24.72	$16.63	$16.17	$31.00	$29.51	$29.40	$29.14
March	$27.24	$25.91	$22.71	$24.05	$20.64	$17.66	$28.92	$29.31	$31.36	$29.88
April	$22.92	$25.16	$22.85	$23.75	$22.63	$18.90	$24.50	$28.11	$31.22	$30.22
May	$26.06	$25.34	$23.68	$23.74	$22.86	$19.69	$24.51	$27.39	$34.31	$31.03
June	$28.31	$25.84	$22.99	$23.61	$21.71	$20.03	$26.55	$27.25	**$33.00**	**$31.36**
July	$27.12	$26.02	$22.55	$23.46	$23.29	$20.49	$26.37	$27.12	**$35.50**	**$31.95**
August	$28.18	$26.29	$23.67	$23.49	$24.27	$20.97	$27.20	$27.13		
September	$30.22	$26.73	$22.02	$23.32	$25.47	$21.47	$24.16	$26.80		
October	$28.75	$26.93	$17.71	$22.76	$24.27	$21.75	$25.71	$26.69		
November	$29.63	$27.17	$16.44	$22.19	$22.66	$21.83	$25.63	$26.60		
December	$23.60	$26.88	$14.86	$21.58	$24.85	$22.08	$26.98	$26.63		
Average yearly price		**$26.88**		**$21.58**		**$22.08**		**$26.63**		

All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 2004 are estimated from various unpublished bulletins listing posted prices. *Wyoming State Geological Survey, Oil and Gas Section, August, 2004.*

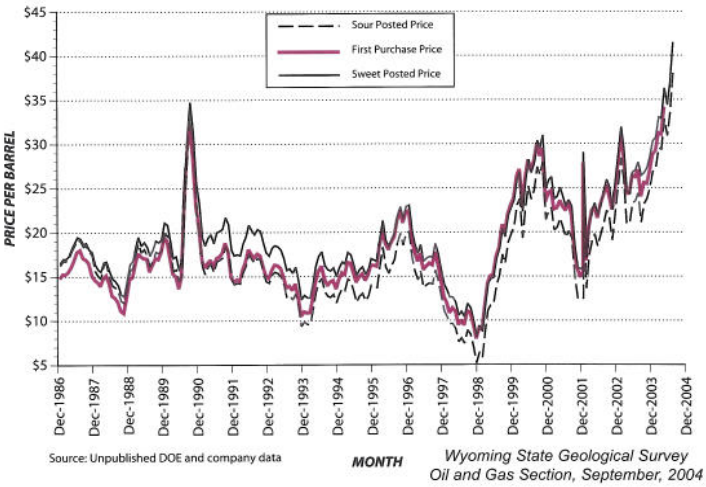

Figure 3. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through April, 2004).

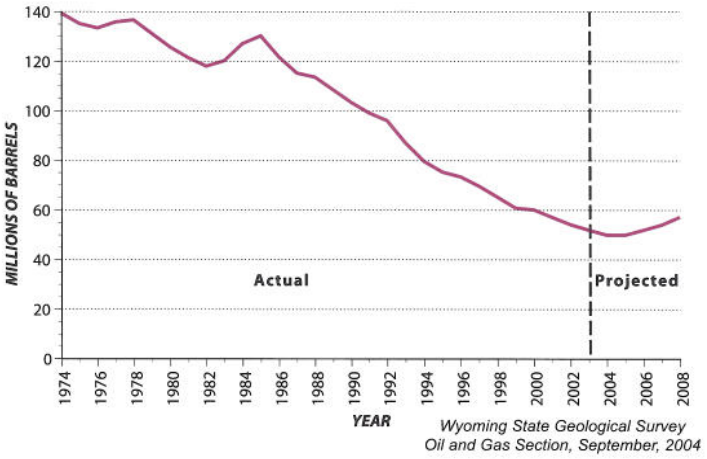

Figure 4. Annual crude oil production from Wyoming (1974 through 2003) with forecasts to 2008.

sponding period in 2003 (**Table 5**). Spot prices for natural gas have been over $4.00 per MCF for 16 straight months (**Table 5** and **Figure 5**). Based on prices for natural gas through August, it appears that our forecast decrease in prices for 2004 (**Figure 6**) will not occur. Our production and price forecasts will be revised in late 2004.

According to production figures from the WOGCC, total natural gas production in Wyoming for the first quarter of 2004 was 474.7 BCF, up 8.8 BCF or 1.9% from the first three months of 2003 (**Table 6**). CBM production from the PRB accounted for 81.8 BCF or 17.2% and increased gas production from Jonah Field and from wells on the Pinedale anticline accounted for 86.3 BCF or 18.2% of that total. By 2006, we are expecting Wyoming's natural gas production to exceed 2 trillion cubic feet (TCF) per year (**Figure 7**).

Projects

The BLM recently approved several projects that will allow increased development in a number of different areas

Table 4. Monthly oil production from Wyoming in barrels (2000 through May, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	5,187,557	5,187,557	5,003,766	5,003,766	4,711,532	4,711,532	4,617,857	4,617,857	4,321,184	4,321,184
February	4,873,042	10,060,599	4,495,136	9,498,902	4,238,372	8,949,904	4,130,199	8,748,056	4,040,747	8,361,931
March	5,213,721	15,274,320	4,972,168	14,471,070	4,629,468	13,579,372	4,473,585	13,221,641	4,360,964	12,722,895
April	5,014,266	20,288,586	4,804,531	19,275,601	4,565,445	18,144,817	4,345,365	17,567,006	4,180,936	16,903,831
May	5,205,848	25,494,434	4,933,201	24,208,802	4,687,127	22,831,944	4,469,085	22,036,091	4,292,077	21,195,908
June	5,005,008	30,499,442	4,678,672	28,887,474	4,495,524	27,327,468	4,246,526	26,282,617		
July	5,083,393	35,582,835	4,854,173	33,741,647	4,595,080	31,922,548	4,413,901	30,696,518		
August	5,108,431	40,691,266	4,768,811	38,510,458	4,626,308	36,548,856	4,368,236	35,064,754		
September	4,990,825	45,682,091	4,726,876	43,237,334	4,492,324	41,041,180	4,334,149	39,398,903		
October	5,165,311	50,847,402	4,834,294	48,071,628	4,623,348	45,664,528	4,436,608	43,835,511		
November	4,884,659	55,732,061	4,655,985	52,727,613	4,456,006	50,120,534	4,200,472	48,035,983		
December	4,987,669	60,719,730	4,763,863	57,491,476	4,596,150	54,716,684	4,373,237	52,409,220		
Total Barrels Reported [1]	**60,719,730**		**57,491,476**		**54,716,684**		**52,409,220**			

[1]Monthly production reports are from Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, August, 2004.*

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (2000 through August, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$2.20	$2.20	$8.75	$8.75	$2.35	$2.35	$3.20	$3.20	$5.57	$5.57
February	$2.40	$2.30	$6.60	$7.68	$1.75	$2.05	$4.73	$3.97	$4.77	$5.17
March	$2.35	$2.32	$4.90	$6.75	$2.00	$2.03	$4.34	$4.09	$4.78	$5.04
April	$2.70	$2.41	$4.55	$6.20	$2.85	$2.24	$3.76	$4.01	$5.04	$5.04
May	$2.70	$2.47	$4.10	$5.78	$2.30	$2.25	$4.81	$4.17	$5.44	$5.12
June	$3.65	$2.67	$2.60	$5.25	$1.60	$2.14	$4.96	$4.30	$5.14	$5.12
July	$3.90	$2.84	$2.05	$4.79	$1.25	$2.01	$4.52	$4.33	$5.32	$5.15
August	$3.10	$2.88	$2.25	$4.48	$1.60	$1.96	$4.65	$4.37	$4.89	$5.12
September	$3.40	$2.93	$2.10	$4.21	$1.20	$1.88	$4.29	$4.36		
October	$4.30	$3.07	$1.25	$3.92	$2.04	$1.89	$4.23	$4.35		
November	$4.35	$3.19	$2.60	$3.80	$3.04	$2.00	$4.18	$4.33		
December	$6.00	$3.42	$2.15	$3.66	$3.08	$2.09	$5.27	$4.41		
Average Yearly Price	**$3.42**		**$3.66**		**$2.09**		**$4.41**			

Source: American Gas Association's monthly reports. Starting in October, 2002, averages calculated from weekly prices posted on Enerfax website. *Wyoming State Geological Survey, Oil and Gas Section, September, 2004.*

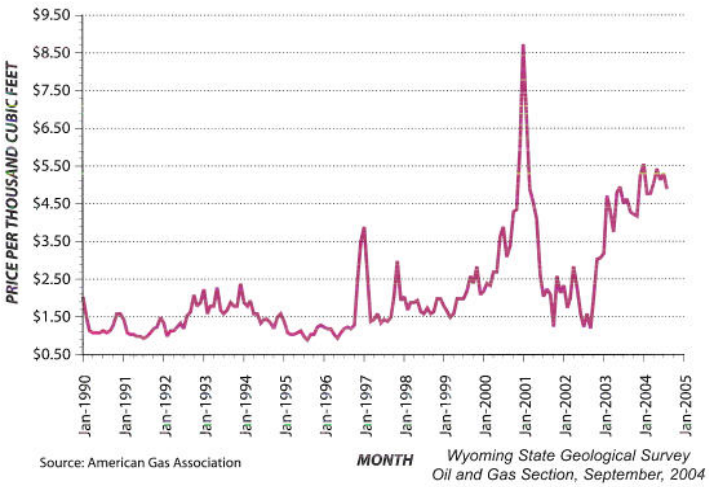

Figure 5. Spot sales prices for methane at Opal, Wyoming, averaged by month (January, 1990 through April, 2004).

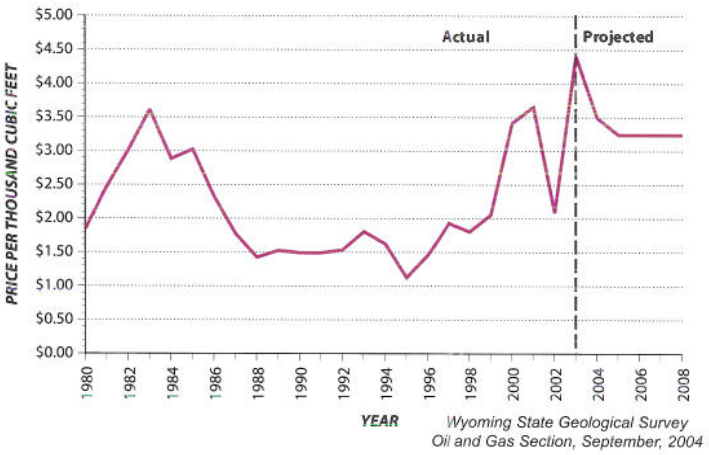

Figure 6. Average prices paid for Wyoming natural gas (1980 through 2003) with forecasts to 2008.

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (2000 through May, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	122,320,888	122,078,095	135,998,574	135,998,574	143,510,891	143,510,891	161,162,853	161,162,853	160,806,025	160,806,025
February	112,851,735	235,172,623	123,506,503	259,505,077	132,981,761	276,492,652	145,026,305	306,189,158	151,330,974	312,136,999
March	121,287,580	356,460,203	139,126,687	398,631,764	143,707,799	420,200,451	159,734,697	465,923,855	162,537,080	474,674,079
April	118,886,204	475,346,407	132,684,058	531,315,822	141,016,463	561,216,914	151,047,796	616,971,651	157,022,727	631,696,806
May	118,631,057	593,977,464	138,214,926	669,530,748	146,950,768	708,167,682	143,493,146	760,464,797	162,080,531	793,777,337
June	117,033,775	711,011,239	128,145,994	797,676,742	141,386,350	849,554,032	146,507,531	906,972,328		
July	120,838,202	831,849,441	131,752,355	929,429,097	145,796,954	995,350,986	149,789,416	1,056,761,744		
August	122,698,001	954,547,442	132,847,188	1,062,276,285	139,407,056	1,134,758,042	149,206,628	1,205,968,372		
September	120,166,494	1,074,713,936	131,334,584	1,193,610,869	142,448,905	1,277,206,947	150,567,184	1,356,535,556		
October	127,682,448	1,202,396,384	137,507,181	1,331,118,050	151,247,991	1,428,454,938	159,308,221	1,515,843,777		
November	123,108,333	1,325,504,717	136,878,261	1,467,996,311	155,751,286	1,584,206,224	155,178,164	1,671,021,941		
December	131,474,722	1,456,979,439	144,790,631	1,612,786,942	162,039,833	1,746,246,057	163,090,284	1,834,112,225		
Total MCF Reported [1]		**1,456,979,439**		**1,612,786,942**		**1,746,246,057**		**1,834,112,225**		

[1] Monthly production reports are from Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, August, 2004.*

in the state. The Desolation Flats Project was proposed by Marathon Oil, Yates Petroleum, EnCana, EOG Resources, Tom Brown, Basin Exploration, Questar Exploration & Production, Merit Energy, and Devon SFS Operating. The project area has the potential to produce 1.1 TCF of gas over the 40-year production period and will involve drilling and completing up to 385 wells in a 233,000-acre area in southeastern Sweetwater County and southwestern Carbon County. The BLM's Rawlins office estimated that economic benefits to the region could be as much as $1.1 billion over the 20-year development period and could generate $154 million in wages by adding as many as 246 drilling and field development jobs and about 156 production-related jobs. If natural gas prices remain in the $4.00 per MCF range for the life of the project, production could generate approximately $264 million in ad valorem taxes, $264 million in state severance taxes, and $550 million in federal royalties (of which half go to the State of Wyoming). The project is controversial mainly because the Adobe Town Wilderness Study Area borders it on the western side.

...production could generate approximately $264 million in ad valorem taxes, $264 million in state severance taxes, and $550 million in federal royalties...

The BLM's Rock Springs office approved a project proposed by Burlington Resources to increase the drilling density in the Little Monument Project Area on the La Barge Platform. Burlington will drill up to 31 additional wells at a density of eight or more wells per section in an area of approximately 3757 acres, all on BLM-managed land. Drilling is expected to take up to three years, depending on the success of the wells.

The BLM's Rawlins office approved a proposal by Cabot Oil & Gas and GMT Energy to drill an additional 12 wells, in addition to the five existing wells, in the Great Divide Basin located on 6400 acres within T24N, R96W. Last year, Cabot's 10-28 Wind Dancer Unit discovery well flowed 3.5 million cubic feet (MMCF) of gas and 22 barrels of condensate per day from the Lewis and Almond formations.

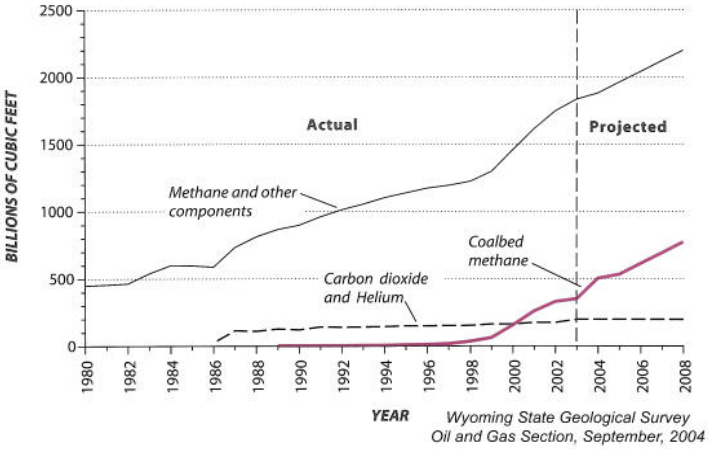

Figure 7. Annual natural gas production from Wyoming (1980 through 2003) with forecasts to 2008.

The BLM's Casper office approved a proposal by Bill Barrett Corp. to drill 10 wells targeting a sandstone in the Cody Shale in and adjacent to Wallace Creek Field in the Wind River Basin. The wells will be drilled in T34N, R87W.

Windsor Wyoming LLC. submitted a notice of intent (NOI) to complete a 3-D seismic survey in the Bighorn Basin in the area of the Clarks Fork River generally west and southwest of Badger Basin Field. The project will target a 47-square-mile area in Ts56 to 57N, Rs102 to 103W. The BLM's Cody office and the U.S. Forest Service's Wapiti Ranger District began an analysis of the proposal in June.

The BLM's Pinedale office approved the NOI for Veritas DGC Land to conduct the La Barge 3-D seismic project covering 127 square miles between Big Piney and La Barge in west-central Sublette County. Veritas also filed a NOI with the Pinedale office to conduct a 3-D seismic survey covering about 8.6 square miles adjacent to the La Barge project. This new project is named the Lake Mountain 3-D project and is completely within the boundary of the Lake Mountain Wilderness Study Area.

Lower Valley Energy has plans to construct a $15 million pipeline to serve customers in the Jackson area. Currently Jackson is served by liquified natural gas which is hauled by tanker trucks...

Veritas received approval to conduct its Simpson Gulch 107-square-mile 3-D Vibroseis seismic survey in northwestern Sweetwater County in Ts23 to 25N, Rs107 to 109W just north of Stagecoach Draw Field. The area has had very few oil or gas tests.

The BLM also approved a proposal by Veritas to conduct a 279-square-mile 3-D seismic survey in the area of Hay Reservoir Field in Ts22 to 25N, Rs95 to 99W. About 70% of the project is within jurisdiction of BLM's Rawlins office and the other 30% is within juristiction of the Rock Springs office.

Anadarko and Veritas plan to conduct the West Flank 3D Geophysical Project that will encompass about 81 square miles of federal land, 4 square miles of state land, and 139 square miles of private land over the west flank of the Rock Springs uplift within Ts18 to 21N, Rs104 to 106W. The Rock Springs office of the BLM has determined that an environmental analysis is required for the project.

The Wyoming Natural Gas Pipeline Authority has indicated a willingness to place some of its $1 billion in bonding authority behind projects that would help to elevate the State's revenues from natural gas. There are presently three projects that may receive some of that bonding: 1) the $430 million, 36-inch diameter, Cheyenne Plains pipeline would give Wyoming gas access to increasing markets in the Midwest. The pipeline was scheduled to begin construction in July and to begin service around the beginning of 2005; its original installed capacity of 560 MMCF per day could be expanded to 1.7 BCF per day; 2) Lower Valley Energy has plans to construct a $15 million pipeline to serve customers in the Jackson area. Currently Jackson is served by liquified natural gas (LNG) which is hauled by tanker trucks that make about 500 trips per year through Hoback Canyon; and 3) the Authority will issue its first bond to raise loan money for a $33 million office complex on 36 acres south of Rock Springs. Halliburton has committed to occupy the new business complex that will serve a rapidly-expanding natural gas production and service industry in the area. The State Land and Investment Board authorized the State Treasurer to buy up to $22.5 million of the pipeline authority's bond issue.

The BLM's Pinedale office received a proposal from Questar Exploration & Production to conduct a limited year-round drilling program, to construct a 110-mile pipeline to transport condensate, and to construct a separate pipeline to remove produced water. Questar and its partner Wexpro plan to drill from 225 to 430 new wells on the Pinedale anticline over the next ten years. The company is seeking exceptions to the BLM's winter drilling restrictions, which prohibit drilling in deer, elk, moose, and antelope winter range from November 15 through April 30 to protect wildlife and habitat. The company seeks BLM's permission to occupy three well pads each winter for the next nine years and to operate two drilling rigs from each of the three pads. Each pad would include from eight to 16 directionally-drilled wells. Questar estimates that the condensate and water pipelines would eliminate more than 25,500 tanker truck trips annually within the company's leases. Questar would also facilitate habitat enhancement on its leases adjoining, but outside, the development area in cooperation with the BLM and the Wyoming Game and Fish Department. In a related item, Questar recently received approval from the WOGCC for 20-acre spacing on its Pinedale anticline acreage.

Lease sales

Leasing activity at the February BLM sale was concentrated in the Wind River Basin (WRB) (**Figure 8**). The high per-acre bid of $2012 was made by Ann Trujillo for a 40.2-acre lease that covers part of section 6, T47N, R77W (**location A, Figure 8**). The lease is in the Fort Union Formation coalbed methane play about a mile east of CBM production in the Whiskey Draw Unit. The second high per-acre bid of $1675 was made by Merrion Oil and Gas for an 80-acre tract in the WRB that covers the E/2 NE section 29, T37N, R93W (**location B, Figure 8**). The lease is about a mile north of a well completed in 1961 that opened Poison Creek Field. The sale generated over $7 million and the average per-acre bid was $93.67, the highest per-acre average bid in a BLM sale in Wyoming in at least the last five years (**Table 7**). There were 33 parcels at this sale that received a bid of $50 or more per acre; 29 of the 33 bids were for $100 or more per acre.

Permitting and drilling

The WOGCC approved 2087 Applications for Permit to Drill (APDs) in the first quarter of 2004 (**Table 8**). Campbell County again led with 33.1% of the total APDs; Sheridan and Johnson counties combined for another 46.0% of the total APDs that were approved. Nearly all of the approved APDs in these three counties were for CBM tests. Approved APDs in Sweetwater, Sublette, and Carbon counties increased due to companies emphasizing the development and exploration for natural gas reserves in southwestern Wyoming. The increased number of approved APDs in Fremont County was due to accelerated drilling for natural gas in the WRB.

The WOGCC permitted 10 seismic projects in the first quarter of 2004. The number of permitted conventional miles has already exceeded the total for all of 2003, but the amount of 3-D seismic is lagging (**Table 9**). Geophysical activity is a good indicator of future exploration and production drilling.

The average daily rig count for the first quarter of 2004 was 65. This average is the highest for a first quarter in over 14 years (**Figure 9**); if the trend continues, the average rig count for 2004 will be the highest since 1985. The rig count does not include rigs drilling for CBM. The higher prices for natural gas, and to lesser extent higher prices for crude oil, are responsible for the improved rig count.

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 successful activities exclusive of CBM (see the **Coalbed Methane Update** for development in that industry) during the first quarter of 2004. The numbers correspond to locations on **Figure 10**.

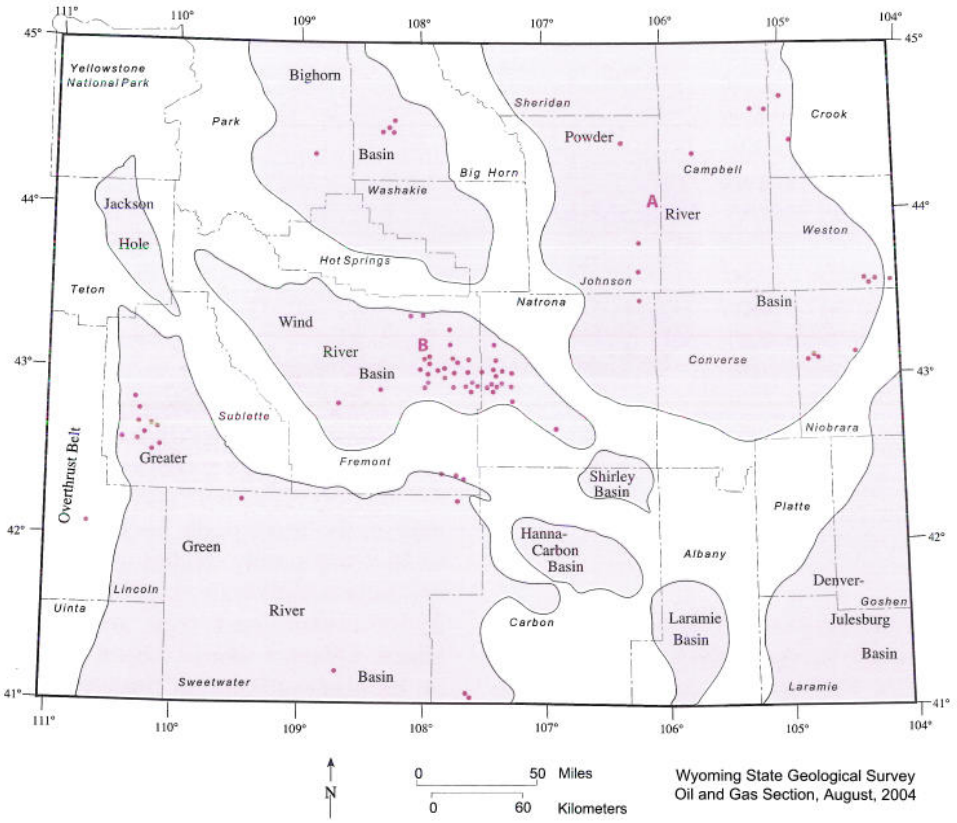

Figure 8. Locations of federal oil and gas tracts leased by the U. S. Bureau of Land Management at its February, 2004 sale. Locations are approximate and may represent more than one tract.

Table 7. Federal and state competitive oil and gas lease sales in Wyoming (2000 through February, 2004).

Federal Sales (U.S. 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
			2000								2000				
February	$5,497,834	192	180	130,289	120,219	$45.73	$525.00								
April	$3,057,278	189	161	160,712	128,063	$23.87	$440.00	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**	**1,183**	**1,055**	**1,058,204**	**898,612**	**$35.10**	**$725.00**	**Total**	**$6,495,616**	**1,199**	**796**	**475,090**	**295,915**	**$21.95**	**$775.00**
			2001								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	April	$2,250,353	300	212	112,379	82,834	$27.16	$450.00
August	$7,626,362	204	190	260,409	245,116	$31.11	$525.00	June	$1,754,320	300	192	111,507	66,829	$26.25	$650.00
October	$998,308	119	105	127,396	107,880	$9.25	$160.00	October	$679,343	300	129	112,255	53,396	$12.72	$120.00
December	$2,162,599	155	146	125,830	112,159	$9.28	$550.00								
Total	**$33,991,566**	**1,023**	**933**	**1,103,745**	**973,282**	**$34.92**	**$1,475.00**	**Total**	**$4,684,016**	**900**	**533**	**336,141**	**203,059**	**$23.07**	**$650.00**
			2002								2002				
February	$5,137,024	219	164	271,248	177,117	$29.00	$345.00								
April	$2,969,094	142	127	136,864	117,852	$25.19	$375.00								
June	$1,183,222	91	63	82,958	55,808	$21.20	$185.00	April	$465,104	200	90	74,321	35,084	$13.26	$105.00
August	$858,686	124	89	111,462	88,719	$9.68	$205.00	June	$517,143	200	124	74,608	46,481	$11.04	$525.00
October	$578,597	117	86	122,962	72,039	$8.03	$46.00	October	$1,222,823	198	133	70,800	47,436	$25.77	$480.00
December	$866,561	111	95	86,139	73,237	$11.83	$165.00								
Total	**$11,593,184**	**804**	**624**	**811,633**	**584,772**	**$19.83**	**$375.00**	**Total**	**$2,205,070**	**598**	**347**	**219,729**	**129,001**	**$17.09**	**$525.00**
			2003								2003				
February	$170,647	37	27	28,836	19,746	$8.64	$56.00								
April	$1,455,295	98	71	49,521	33,304	$43.70	$310.00								
June	$1,729,660	63	54	46,412	40,177	$43.05	$360.00	April	$812,916	200	92	79,290	30,152	$26.96	$350.00
August	$3,357,650	177	104	233,189	121,515	$27.63	$675.00	June	$583,950	200	121	76,433	43,966	$13.28	$575.00
October	$4,173,493	94	82	70,892	64,072	$65.14	$990.00	October	$1,978,075	199	113	75,614	37,205	$53.16	$2025.00
December	$5,698,724	149	136	117,076	100,188	$56.88	$1110.00								
Total	**$16,585,469**	**618**	**474**	**545,926**	**379,002**	**$43.76**	**$1110.00**	**Total**	**$3,374,941**	**599**	**326**	**231,337**	**111,323**	**$30.32**	**$2025.00**
			2004								2004				
February	$7,063,343	96	85	84,593	75,406	$93.67	$2012.00								

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, August, 2004.

Table 8. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1998 through March, 2004).

County	1998 APDs	1999 APDs	2000 APDs	2001 APDs	2002 APDs	2003 APDs	2004 APDs
Albany	0	0	0	1	1	1	0
Big Horn	13	6	11	23	8	5	2
Campbell	1586	4461	5580	6204	2793	2747	690
Carbon	96	127	174	261	198	278	46
Converse	6	19	70	25	43	86	9
Crook	29	30	47	20	13	52	1
Fremont	76	67	136	149	62	133	48
Goshen	0	0	0	0	1	0	0
Hot Springs	1	8	6	2	9	8	3
Johnson	49	304	769	805	799	1155	568
Laramie	2	0	2	3	3	1	2
Lincoln	105	51	70	87	51	72	30
Natrona	36	51	53	45	49	146	19
Niobrara	8	5	18	15	10	14	1
Park	11	12	18	45	23	56	4
Platte	0	0	0	0	0	0	0
Sheridan	35	416	891	1811	1531	1421	392
Sublette	230	189	338	435	428	486	134
Sweetwater	181	124	335	534	379	591	133
Teton	0	0	0	0	0	0	0
Uinta	26	26	53	35	16	17	4
Washakie	9	0	7	10	1	0	1
Weston	6	4	20	7	2	14	0
Totals	**2505**	**5900**	**8598**	**10,517**	**6420**	**7283**	**2087**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, August, 2004.*

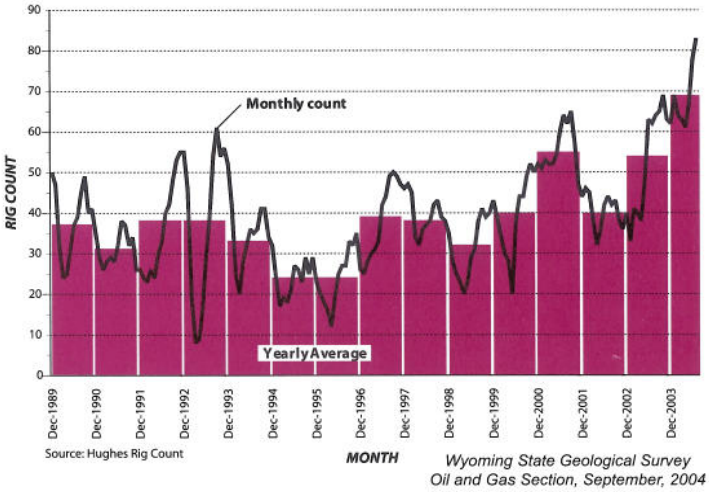

Figure 9. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month and year (December, 1989 through July, 2004).

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (2001 through March, 2004).

	2001			2002			2003			2004		
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
Albany	0	0	0	1	6	0	0	0	0	0	0	0
Big Horn	1	0	4	0	0	0	0	0	0	0	0	0
Campbell	5	38	3	10	49	3	4	8	3	0	0	0
Carbon	1	500	0	4	419	3	1	0	55	0	0	0
Converse	0	0	0	2	6	47	1	0	75	0	0	0
Crook	4	32	0	1	0	2	3	46	0	3	24	0
Fremont	2	70	15	1	160	0	4	12	717	2	1	39
Goshen	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	0	0	0	0	0	0	0	0	0	0	0	0
Johnson	2	4	4	1	16	0	1	25	0	1	7	0
Laramie	0	0	0	1	0	18	0	0	0	0	0	0
Lincoln	1	0	25	0	0	0	0	0	0	0	0	0
Natrona	2	19	63	4	11	72	0	0	0	0	0	0
Niobrara	1	0	16	3	3	52	2	0	42	0	0	0
Park	4	21	20	0	0	0	1	0	6	0	0	0
Platte	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	2	0	81	0	0	0	0	0	0	1	37	0
Sublette	10	261	374	1	464	0	2	0	238	2	35	5
Sweetwater	11	129	802	7	348	485	5	1	246	0	0	0
Teton	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	1	259	0	2	196	0	1	0	47	0	0	0
Washakie	0	0	0	1	21	0	1	4	0	0	0	0
Weston	0	0	0	0	0	0	0	0	0	1	0	4
Totals	**47**	**1333**	**1407**	**39**	**1699**	**682**	**26**	**96**	**1429**	**10**	**104**	**48**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, August, 2004.*

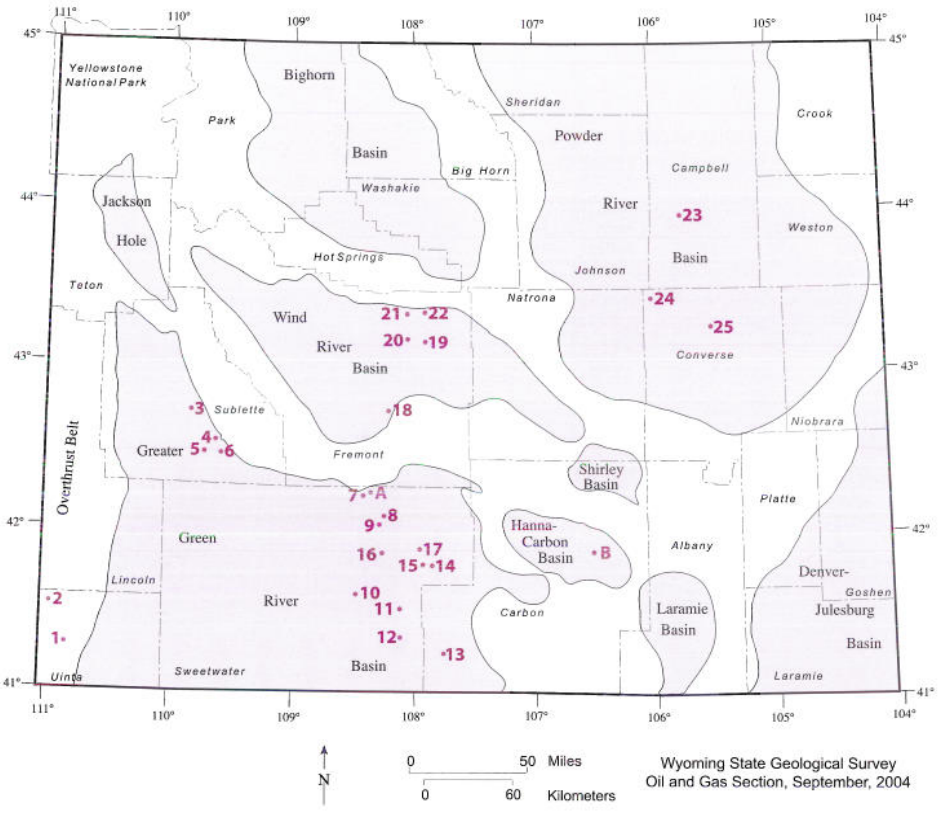

Figure 10. Oil and gas exploration and development activities in Wyoming during the first quarter of 2004. Numbers are those used in Table 10. Letters indicate coalbed methane developments described in the Coalbed Methane Update. Locations are approximate and may represent more than one well location or project.

Table 10. Significant exploration and development wells in Wyoming, first quarter of 2004. 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	Chevron Production USA	23-7AH Painter Reservoir Unit	NW SW sec 7, T15N, R119W	Nugget Ss.	13,678-16,644 horizontal interval	8.8 MMCF 1030 BBL cond	New horizontal production well in Painter Reservoir Field
2	Chevron Production USA	2-36 ST Ray-State	NW NE sec 36, T18N, R120W	Mission Canyon Ls.	13,492-13,900	2.9 MMCF	Reentered a well and recompleted it in a sidetracked hole
3	Shell Rocky Mountain Production	6-33D Mesa	SE NW sec 33, T32N, R109W	Lance Fm. Mesaverde Fm.	8675-12,606 27 intervals	13.2 MMCF 87 BBL cond 390 BBL H_2O	New producer on Pinedale anticline
	Shell Rocky Mountain Production	13-35D Mesa	SW SW sec 35, T32N, R109W	Lance Fm. Mesaverde Fm.	10,435-13,327 12 intervals	12.2 MMCF 58 BBL cond 134 BBL H_2O	New producer on Pinedale anticline
	Shell Rocky Mountain Production	13-28D Mesa	SW SW sec 28, T32N, R109W	Lance Fm. Mesaverde Fm.	9786-13,297 13 intervals	10.6 MMCF 50 BBL cond 452 BBL H_2O	New producer on Pinedale anticline
	Shell Rocky Mountain Production	9-29D Mesa	NW SW sec 29, T32N, R109W	Lance Fm. Mesaverde Fm.	11,073-13,262 eight intervals	8.0 MMCF 58 BBL cond 324 BBL H_2O	New producer on Pinedale anticline
4	BP America Production	10-32 Rainbow	NW SE sec 32, T30N, R107W	Lance Fm.	10,825-13,585 seven intervals	8.3 MMCF 44 BBL cond 236 BBL H_2O	New producer on southern end of Pinedale anticline
5	Yates Petroleum	1 Gobblers Knob-Federal	SW SW sec 8, T29N, R108W	Lance Fm.	9204-12,493 eight intervals	967 MCF 6 BBL cond 44 BBL H_2O	New discovery, reentered dry hole
6	Yates Petroleum	7 Highway-Federal	SW NW sec 9, T29N, R107W	Lance Fm.	10,880-13,463 four intervals	1.8 MMCF 36 BBL cond 96 BBL H_2O	New discovery about three miles northeast of Jonah Field production
7	Cabot Oil & Gas	32-14 Osbourne Spring Unit	SE SW sec 32, T26N, R97W	Lance Fm. Lewis Sh. Almond Fm. Ericson Ss.	unknown intervals		150 feet of potential pay in four formations, five miles southwest of Lewis production at Picket Lake Field
8	Cabot Oil & Gas	20-29 Wind Dancer Unit	NW NE sec 29, T24N, R96W	Lewis Sh. Almond Fm.	10,401-10,453	1.0 MMCF	Confirmation well for Wind Dancer Unit discovery
9	Tom Brown, Inc	82 Hay Reservoir Unit	SW SW sec 31, T24N, R96W	Lewis Sh.	10,030-10,118	1.9 MMCF 50 BBL cond 37 BBL H_2O	New producer on the eastern flank of Hay Reservoir Field
10	Anadarko Exploration & Production	19 Higgins Unit	NE SE sec 15, T18N, R98W	Weber Ss.	17,474-17,660 17,848-17,858	2.5 MMCF 24 BBL H_2O	New Weber producer in Table Rock Field
	Chevron Production USA	125 Table Rock Unit	NW SE sec 36, T19N, R98W	Weber Ss.	17,448-17,832 eight intervals	16.9 MMCF 96 BBL H_2O	New Weber producer in Table Rock Field
11	BP America Production	27-1 Delaney Rim	NE NE sec 27, T18N, R95W	Mesaverde Gp.	10,755-11,088 three intervals	1.9 MMCF 13 BBL cond 78 BBL H_2O	Wildcat discovery
	BP America Production	9-1 Two Rim Unit	SW NE sec 9, T18N, R95W	Mesaverde Gp.	10,567-10,578 10,714-10,853	1.5 MMCF 50 BBL cond 143 BBL H_2O	New discovery
12	Questar Exploration & Production	14 Wedge Unit	SE SW sec 23, T16N, R95W	Almond Fm.	12,198-12,222	5.0 MMCF 18 BBL cond 4 BBL H_2O	New discovery
13	Yates Petroleum	2 Peach Flat-State	SE NW sec 36, T15N, R92W	Mesaverde Gp.	6934-6943 7348-7430	2.3 MMCF 3 BBL cond 10 BBL H_2O	New producer in Blue Gap Field
14	BP America Production	13-1 Fivemile-Fee	NW SW sec 13, T21N, R93W	Mesaverde Gp.	10,893-10,898 10,992-11,172	565 MCF 2 BBL cond 28 BBL H_2O	Wildcat discovery
15	BP America Production	21-1 Fivemile	C SW sec 21, T21N, R93W	Lewis Sh. Mesaverde Gp.	10,079-10,084 10,711-10,972	541 MCF 1 BBL cond	Wildcat discovery
16	BP America Production	13-2 Red Lake-Fee	SW NW sec 13, T22N, R96W	Lewis Sh. Mesaverde Gp.	9685-9739 10,040-10,184	534 MCF 19 BBL cond 433 BBL H_2O	Wildcat discovery
17	Yates Petroleum	1 Monument Lake-Federal	SE SW sec 20, T22N, R93W	Almond Fm.	11,380-11,866 three intervals	2.3 MMCF 27 BBL cond 34 BBL H_2O	New discovery
18	Wold Oil Properties	40 Big Sand Draw Unit	SE NW sec 10, T32N, R95W	Tensleep Ss.	7144-7166	357 BBL oil 276 BBL H_2O	New producer in Big Sand Draw Field
19	Tom Brown Inc.	10-22 Curly	SE NW sec 10, T37N, R92W	Fort Union Fm.	9630-9694	1.0 MMCF 140 BBL H_2O	New producer in Wickersham Draw Field area
20	Tom Brown Inc.	33-24 Lili	SE SW sec 33, T37N, R93W	Fort Union Fm.	undisclosed	1.3 MMCF	New discovery
21	Stone Energy	1-18 Owl Creek-Federal	NW NE sec 18, T39N, R93W	Fort Union Fm. Lance Fm.	6840-6864 10,572-12,074 five intervals	3.8 MMCF 70 BBL cond 132 BBL H_2O	Wildcat discovery[1]
22	Stone Energy	5-20 Tough Creek-Federal	SW NW sec 20, T39N, R92W	Lance Fm.	8924-10,376 five intervals	4.5 MMCF 48 BBL cond 85 BBL H_2O	Wildcat discovery
23	Medicine Bow Operating	12-8 HCNU	SW NW sec 8, T46N, R74W	Sussex Ss.	8176-8196	275 BBL oil 77 MCF 326 BBL H_2O	Development well in House Creek Field
	Medicine Bow Operating	13-16 HCNU	NW SW sec 16, T46N, R74W	Sussex Ss.	8242-8262	244 BBL oil 44 MCF 216 BBL H_2O	Development well in House Creek Field
	Medicine Bow Operating	43-21 HCNU	NE SE sec 21, T46N, R74W	Sussex Ss.	8242-8262	160 BBL oil 27 MCF 54 BBL H_2O	Development well in House Creek Field

Table 10. Significant exploration and development wells in Wyoming, first quarter of 2004. 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
24	EOG Resources	1-7 Copperhead	SE NE sec 7, T40N, R76W	Frontier Fm.	12,475-12,505	504 BBL oil 627 MCF 4 BBL H_2O	Wildcat discovery about three miles west of Finley Draw Field and about three miles east of Sherwood Field
25	Yates Petroleum	1 Ggoemmer	NW SE sec 31, T38N, R72W	Sussex Ss.	9583-9589	24 BBL oil 8 BBL H_2O	Deeper pool discovery in Brush Creek Field

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; Gp.=Group. [1]This is the obligation well for the Owl Creek Exploratory Unit, which comprises 3649 acres. *Wyoming State Geological Survey, August, 2004.*

Coal Update

Robert M. Lyman, Wyoming PG-656

Staff Geologist—Coal, Wyoming State Geological Survey

In 2004, Wyoming's coal production appears to be on track for yet another record year. Production increases are being seen at most of the state's Powder River Basin (PRB) mines, the result due in part to completing several capital improvement projects early this year. Even though railroads have faced complications in 2004, coal movements out of Wyoming are now expected to show an annual increase of the state's coal production by 2.6% over the 2003 figure.

Arch successfully concluded their lengthy battle with the Federal Trade Commission (FTC) and acquired Triton's North Rochelle mine. As a result, Buckskin is now owned by Peter Kiewit & Sons'. RAG has left the basin, and a new player, known as Foundation Coal Corp., is at the helm of the Eagle Butte and Belle Ayr mines.

Peabody Energy won the first 2004 Lease by Application (LBA) tract at auction with an accepted bid of $274.08 million, which equates to a record high price of $0.92 per short ton of coal. This bid raised the bar for the bonus bid value of Wyoming PRB coal reserves. This tract was the first of six LBA tracts promised in 2004.

In the future, Wyoming is positioned via its coal resources, to lead the nation in coal gasification and liquefaction plants.

The future of Wyoming coal

Wyoming coal fields contain a large resource of easily accessible, low-sulfur, subbituminous rank coals. These coals supply the U.S. with over a third of the coal utilized to generate the nation's electrical power. Annual growth in the production and use of Wyoming coal is currently projected at a modest 2.6 to 3%. Long-term, additional growth and stability in the state's coal industry will depend on converting raw coal resources to environmentally clean, alternate fuel forms for electrical generation, transportation, and industrial use. The highly reactive, high-moisture, low-sulfur, noncaking (for the most part) subbituminous coals are particularly suited to these energy applications.

Between 1992 and 2002, natural gas demand in the power sector has risen by over 60%, while natural gas production has only increased by 11%. Electric utilities can use different energy sources to produce power, but industrial consumers, farmers, ranchers, and homeowners often cannot. Natural gas in these latter sectors is used both as a raw material (to produce everything from fertilizer to plastics) and as fuel (to heat homes and water). To solve this problem, we must increase the supply or decrease the demand for natural gas.

Both sides of the supply / demand equation are not equal. Limiting demand often means loss of jobs and little economic growth for the nation. In a recent letter to the Environmental Protection Agency (EPA), Administrator Mike Leavitt from the Industrial Energy Consumers of America pointed out that the high price of natural gas over the last 46 months has cost U.S. manufacturers, farmers, ranchers, and business owners roughly $130 billion. The nation's fertilizer industry is a good example of an industry that as been hard hit by natural gas price hikes. According to The Fertilizer Institute, the costs of natural gas account for roughly 70 to 90% of the costs of producing nitrogen fertilizer. Since mid-2000, 11 ammonia fertilizer plants (21% of the U.S. fertilizer market) have permanently closed; until June, 2003 only half the industry was operating at full capacity.

What does the above discussion about fertilizer mean? It points out that the supply side of the equation needs major attention in this country, and Wyoming should be a leader in helping solve this important problem. In the future, Wyoming is positioned via its coal resources, to lead the nation

in coal gasification and liquefaction plants. Technologies for these plants are not new; in fact they have been around for over 60 years. Recently these technologies have experienced a revival of interest due to the country's need to reduce its dependence on foreign oil imports. Coal-fired power plants utilize only a third of the energy produced from burning coal. Coal gasification plants can raise that amount to nearly 50%. Coal gasification can also generate saleable hydrogen and simplifies and lowers the cost of carbon dioxide capture. Hydrogen and carbon dioxide are valued products in a wide range of markets. If this country moves toward a hydrogen economy, gasification plants will become an integral component of that economy.

Coal liquefaction is another technology that could be central to Wyoming's future economy. Coal liquefaction is the conversion of coal to liquid fuel (mostly methanol), and recent studies indicate that a single ton of coal can be converted into roughly 3 barrels of fuel. Synthetic liquid fuels (synfuels) can be produced either by gasifying the coal and then synthesizing higher hydrocarbons from the carbon monoxide and hydrogen produced, which is known as indirect liquefaction, or by direct reaction of hydrogen with coal in a process-derived solvent, termed direct liquefaction. Both types of processes are applicable to Wyoming's subbituminous coals.

...challenges faced by the primary railroads out of the PRB should slow some of the anticipated growth in production until 2005.

Fuel prices are currently at or near the necessary price levels to make these gasification and liquefaction technologies competitive. Gasification of coal is believed to be competitive with natural gas prices of $4 to $5 per thousand cubic feet (MCF). Liquid fuels from coal are competitive when crude oil prices reach the low- to mid-$30 per barrel range. Even oil shale projects are competitive when crude oil reaches prices in the low-$40 per barrel range.

These benchmark prices for crude oil and natural gas must be sustainable before investors will commit to the unconventional fuel technologies described above. Building synfuel and gasification plants is a capital-intensive undertaking. Unlike traditional oil and gas wells (which can be produced or shut in easily and the resource is easily accessible, provided the infrastructure is in place), coal conversion energy product plants must operate continuously to realize their economic goals. Coal gasification and liquefaction projects in this country will not make significant strides until an energy bill with enticing incentives is introduced and fuel prices are not kept artificially low.

Production and prices

After setting a record pace in 2003, Wyoming's coal mines continued producing coal in record-breaking fashion in the first two quarters of 2004. By the end of June, production figures showed Wyoming's mines had produced over 187.3 million short tons of coal. This represents an increase of 4.4 million short tons, or 2.4% over the same period of 2003.

Because of this increase, we have adjusted our projection for 2004 coal production. We now expect a 2.6% increase in 2004 with another 2% increase coming in 2005 (**Table 11**). While some analysts are still predicting close to a 6.5% growth in 2004, challenges faced by the primary railroads out of the PRB should slow some of the anticipated growth in production until 2005.

Figure 11 shows the monthly shipments of Wyoming coal for the first half of 2004 compared to the three previous years.

Figure 12 shows the amount of monthly spot and contract coal shipped in the first six months of 2004. Of interest in this figure is the chart of spot coal deliveries. The chart indicates that the portion of Wyoming coal sold on the spot market is becoming smaller, signifying that the mines are front loading

Table 11. Wyoming coal production by county[1,2] (in millions of short tons), from 1999 to 2003 with forecasts to 2010.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Powder River Basin												
Campbell County	294.3	299.5	329.5	332.8	334.1	343.5	350.2	353.9	357.4	360.4	364.5	368.6
Converse County	25.6	23.6	24.6	26.8	29.5	29.0	30.0	30.0	30.0	30.0	30.0	30.0
Sheridan County	M	M	0.0	0.0	0.0	M	M	M	M	M	M	M
Subtotal	319.9	323.1	354.1	359.6	363.6	372.5	380.2	383.9	387.4	390.4	394.5	398.6
Southern Wyoming												
Carbon County	2.7	2.0	0.5	0.7	0.3	0.3	0.3	0.5	1.0	2.0	2.0	2.0
Sweetwater County	9.4	10.0	9.5	8.6	8.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Lincoln County	4.3	3.7	4.5	4.2	4.1	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Subtotal	16.4	15.7	14.5	13.5	12.9	13.8	13.8	14.0	14.5	15.5	15.5	15.5
Total Wyoming[3]	**336.5**	**338.9**	**368.6**	**373.1**	**376.5**	**386.3**	**394.0**	**397.9**	**401.9**	**405.9**	**410.0**	**414.1**
Annual change	**6.9%**	**0.7%**	**8.8%**	**1.2%**	**0.9%**	**2.6%**	**2.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**

[1]Reported tonnage from the Wyoming State Inspector of Mines (1999 through 2003). [2]County estimates by the Wyoming State Geological Survey, May, 2004 for 2004 through 2010. Totals may not agree because of independent rounding. [3]Estimate from CREG's Wyoming State Government Revenue Forecast, October, 2003. M=minor tonnage (less than a million short tons). *Wyoming State Geological Survey, Coal Section, September, 2004.*

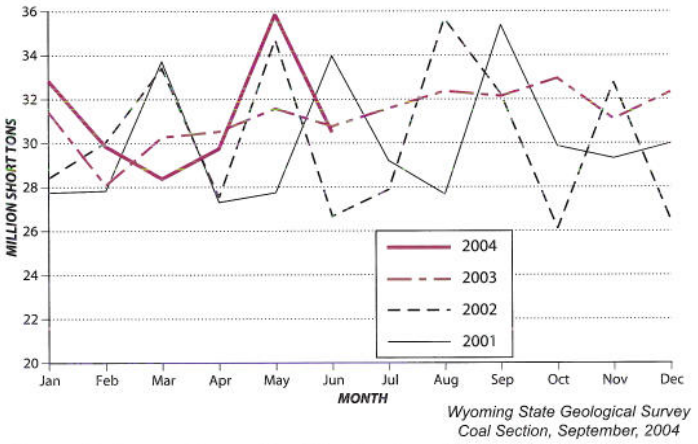

Figure 11. Reported monthly deliveries from Wyoming coal mines (2001 through June, 2004). From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the Wyoming State Geological Survey.

their term coal at a higher rate than in the past. Estimated deliveries from Wyoming's mines in the first half of 2004 are 4.4 million short tons higher than from the same time in 2003 (**Table 12**).

Spot market prices for PRB coal in 2004 remained steady, although moderately higher than during the same period of 2003 (**Figure 13**). 8400-Btu spot coal prices began 2004 at $5.45 per short ton, up $0.40 per short ton from the start of 2003. At the end of March, 2004, the lower Btu spot coal was moving at $5.53 per short ton, up from $5.16 at the same time in 2003. Over the first eight months of 2004, spot price for this coal remained relatively steady, closing at $5.42 per short ton in August. Average spot prices for 8800-Btu PRB coal began 2004 at $6.53 per short ton; by the end of March, the higher Btu coal was being quoted at nearly $7.32 per short ton compared to $6.18 a year earlier. By the end of August, the 8800-Btu coal was averaging an estimated $6.76 per short ton, after dropping from the March high (**Figure 13**).

Developments in the Powder River Basin

Arch Coal completed its $364 million purchase of Triton Coal shortly after the U.S. Court of Appeals for the District of Columbia declined to issue an emergency stay that would have halted the acquisition. The action was sought by the FTC. With completion of the Triton purchase, Arch immediately sold Triton's Buckskin mine to Peter Kiewit & Sons for a net sales price of $72.9 million (COAL Daily, 8/20/04).

In August, Arch announced that it would merge its Black Thunder mine with its newly acquired North Rochelle operation, which share a 5.5-mile property line. The company hopes to realize operational savings by combining the mines into a super mine complex, which will carry on the Black Thunder name. Beginning in 2005, the company anticipates capturing annual synergies totaling around $15 to $20 million per year. The new mine complex could potentially produce over 100 million short tons per year. In 2003, the two mines

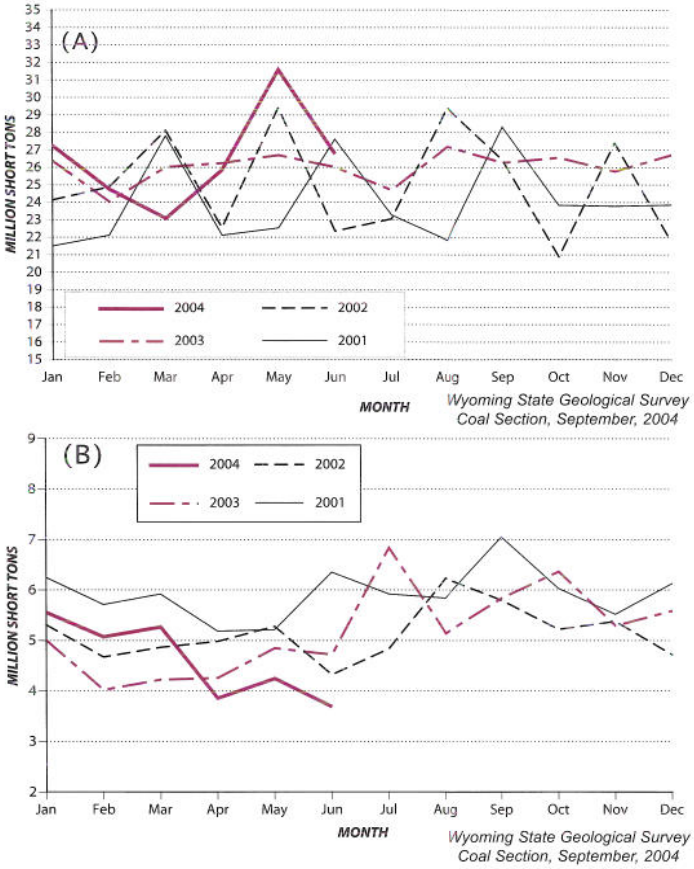

Figure 12. Monthly coal deliveries from Wyoming (2001 through June, 2004). (A) Coal sold on contract and (B) coal sold on the spot market. From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the Wyoming State Geological Survey.

produced a combined 88 million short tons (COAL Daily, 8/24/04).

A group of private investors purchased RAG Coal International's remaining U.S. coal mining operations for just under $1 billion. The Belle Ayr and Eagle Butte mines in Wyoming as well as other operations located in Central Appalachia, Pittsburgh Seam, and the Illinois Basin were included in the acquisition. At the end of May, 2004, The Blackstone Group, First Reserve, and American Metals & Coal International agreed to buy RAG American Coal Holdings, the fourth largest coal producer in the U.S. The deal closed on July 30, 2004 and RAG American Coal Holdings is now operating under the name of Foundation Coal. Terms of the final transaction were not disclosed (COAL Daily, 4/4/04).

Foundation is currently one of the nation's largest privately held coal companies; however, it appears the company is moving towards becoming publicly owned. The company filed an S-1 with the Securities and Exchange Commission in August; this is the first regulatory step in making an initial stock offering. The filing did not provide details about the amount of stock to be offered or the price expected. However, it did specify that proceeds from the sale will be used to buy back shares from the three owners, repay certain debts, and provide general corporate funds (COAL Daily, 8/23/04).

Table 12. Estimated monthly coal deliveries from Wyoming's mines in short tons (January, 2000 through June, 2004).

	2000		2001		2002		2003		2004	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
January	27,773,610	27,773,610	27,743,000	27,743,000	28,406,666	28,406,666	31,450,642	31,450,642	32,870,561	32,870,561
February	25,594,109	53,367,719	27,827,000	55,570,000	30,041,748	58,448,414	28,113,877	59,564,519	29,881,411	62,751,972
March	28,262,696	81,630,415	33,739,000	89,309,000	33,409,797	91,858,211	30,310,040	89,874,559	28,411,135	91,163,107
April	25,549,039	107,179,454	27,302,000	116,611,000	27,534,057	119,392,268	30,656,600	120,531,159	29,773,501	120,936,608
May	26,222,515	133,401,969	27,752,000	144,363,000	34,704,299	154,096,567	31,631,441	152,144,600	35,899,223	156,835,831
June	25,085,516	158,487,485	33,968,000	178,331,000	26,674,488	180,771,055	30,797,925	182,942,525	30,523,471	187,359,302
July	28,881,862	187,369,348	29,200,000	207,531,000	27,885,210	208,656,265	31,608,733	214,551,258		
August	29,075,295	216,444,642	27,662,000	235,193,000	35,670,535	244,326,800	32,402,820	246,954,078		
September	25,865,389	242,310,032	35,369,000	270,562,000	32,234,471	276,561,271	32,169,561	279,123,639		
October	26,441,615	268,751,646	29,869,000	300,431,000	26,101,957	302,663,228	32,983,610	312,107,249		
November	27,400,246	296,151,892	29,308,000	329,739,000	32,767,619	335,430,847	31,132,084	343,239,333		
December	28,300,773	324,452,665	29,984,000	359,723,000	26,476,240	361,907,087	32,362,439	375,601,772		
Total Utility Tonnage[1]		**324,452,665**		**359,723,000**		**361,907,087**		**375,601,772**		
Total Tonnage Other[2]		**14,399,483**		**8,955,135**		**11,288,344**		**963,475**		
Total Tonnage Produced[3]		**338,852,148**		**368,678,135**		**373,195,431**		**376,565,247**		

[1]From Federal Energy Regulatory Commission (FERC) Form 423 for 1998; FERC Form 423 as modified by WSGS for 2000 through June, 2004. [2]Includes estimates of a residential, industrial, and exported coal. [3]Wyoming State Mine Inspector's Annual Reports. *Wyoming State Geological Survey, Coal Section, September, 2004.*

Foundation Coal was rumored to be planning production expansion at its newly acquired Wyoming mines. Supposedly the Belle Ayr and Eagle Butte mines would ramp up to an annual production rate of 30 million short tons each. In 2003, Belle Ayr produced 17.85 million short tons of coal. Eagle Butte's 2003 production was reported at 24.55 million short tons. Current air permits in place (25 million short tons per year at Belle Ayr and 35 million short tons per year at Eagle Butte) would have to be balanced to cover the expansion plans. The company would need to submit a new mine plan to Wyoming environmental officials in order to increase production. Finally, the company would have to scrutinize the mines' load out and coal handling facilities for upgrades to handle the increased coal production. In their response, the company said there are no such plans for a rapid or drastic shift in production at the mines, and such a major shift to that production level without some serious investments is "ludicrous" (U.S. Coal Review, 8/23/04).

In early May, Kfx announced plans to develop a 750,000-short ton-per-year K-Fuel plant at Kennecott Energy's Fort Union mine. Originally, the plant was to be built at the Buckskin mine but delays in Arch Coal's acquisition of the North Rochelle mine provoked Arch to smooth the waters in their acquisition by selling Buckskin to Peter Kiewit & Sons. Kfx plans to purchase raw coal from surrounding mines near the Fort Union site north of Gillette. Roughly 500,000 short tons of Kfx's initial production is already under contract and the company will use the rest to fuel test burns. Kfx completed its acquisition of the Fort Union mine site from Black Hills in late May. The transaction included approximately 1000 acres, a rail loop with load-out facilities, a coal crusher, related buildings, water disposal wells, and approximately 500,000 tons of coal reserves (COAL Daily, 5/24/04).

In June, Kfx was reported to be exploring possible ventures in South Dakota and Alaska. The company talked with South Dakota officials about building a $250 million processing plant in Edgemont. Reportedly, the company was also looking to build a facility at or near a mine in the Beluga coal field in Alaska (COAL Daily, 6/2/04).

Kfx signed an agreement with Arch Coal that further explores the possibility of a K-Fuel plant in Campbell County. Arch reportedly has invested $2 million in Kfx shares and has agreed to evaluate the potential for jointly developing the proposed 8-million-short ton-per-year K-Fuel plant at Arch's idle Coal Creek mine.

Originally planned for completion in 1999, North American Power Group (NAPG) now hopes to bring their Two Elk power plant on line in 2008. The coal-fired power plant project is designed to burn waste coal from PRB mines in pulverized coal boilers. Permitting delays and market changes have slowed the project. The project's air permit expired and had to be renewed; Wyoming again awarded Two Elk an air permit in June, 2003, but since that time the company has focused its efforts on marketing the project. In early July, 2004, Wyoming Governor Dave Freudenthal rejected NAPG's application for an additional $213.5 million in tax-exempt revenue bonds to support the development.

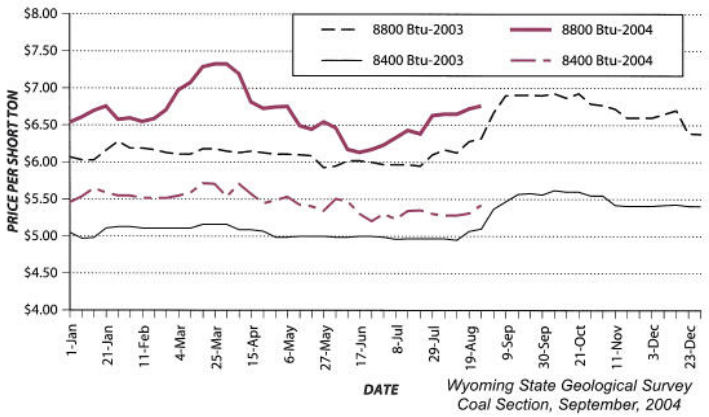

Figure 13. Wyoming Powder River Basin coal spot price watch (January 1, 2003 through August 30, 2004). Modified from COAL Daily's spot market index and U.S. Coal Review spot market price index.

Reportedly, the company has already converted one-third of its bond authority into tax-exempt bonds and notes (COAL Daily, 7/27/04).

The U.S. Bureau of Land Management (BLM) released valuations on three tracts of land that Pittsburg & Midway Coal Mining Company (P&M) wants to swap for 1234 acres of federal land in Sheridan County. The deal would give BLM control over 5859 acres in various places in Wyoming, including 2448 acres which would become part of the Bridger-Teton National Park. The three P&M tracts are known as the Bridger land, valued at $4.17 million; the JO Ranch land, worth $388,000; and the Welch Ranch land, appraised at $890,000. The three properties cover an estimated 84.2 million short tons of recoverable coal reserves. The BLM land in Sheridan County has been valued at approximately $5.36 million or about $88,000 less than the coal company's properties. If the deal is finalized the BLM or U.S. Forest Service would make a cash payment to the coal company to cover the difference in values (COAL Daily, 5/18/04).

The BLM held an auction on the NARO South LBA on June 28, 2004. The tract consists of 2957 acres with an estimated 297 million short tons of coal in the Wyodak coal zone. Nominated by Peabody Energy, the tract is adjacent to the company's North Antelope/Rochelle mine complex and Kennecott Energy's Antelope mine. The coal is considered prime compliance quality with an overall average quality (as-received) of 8929 Btu per pound, 0.2 % sulfur, and 2% sodium in the ash. Peabody won the tract at auction with an accepted bid of $274.08 million, or a record high price of $0.92 per short ton. The State of Wyoming will receive half of the bonus bid price spread over the next five years, or $27.4 million per year starting in 2004.

Peabody Energy made a bid on the NARO North LBA on August 31. The tract consists of 2368 acres with an estimated 306.9 million short tons of recoverable coal and is located adjacent to the northern boundary of the company's North Antelope-Rochelle mine. The company's bid of just under $237.5 million for the tract was rejected by the BLM as insufficient according to the agency's estimate of the property's current fair market value. The bid from the coal company translated into $0.73 per short ton. A Peabody spokesman said, "Our subsidiary certainly believes it had made a fair and highly competitive bid for the reserve. We intend to rebid for that reserve block. It is another sign of the high value that is being placed on PRB reserves by all parties" (COAL Daily, 9/1/04). The value of coal reserves in the PRB has appreciated since the LBA process began (**Table 13**).

The Little Thunder Tract is the next LBA scheduled for bids. The auction for this tract is on September 22. The tract consists of 5084 acres estimated to contain 718.72 million short tons of mineable coal. The tract is located adjacent to Arch's Black Thunder mine and is close to Kennecott Energy's Jacobs Ranch operation. All the acreage offered is deemed suitable for mining with the exception of land within 100 feet of the joint railroad line right-of-way. Numerous oil and gas wells have been drilled on the tract. The estimated bonus value of the coal lease will include consideration of the future production from these wells. This new aspect will make this an interesting auction to watch (COAL Daily, 8/20/04).

Table 13. Historical price per ton paid for Powder River Basin LBA tracts.

LBA	Date sold	$ per ton
NARO North	6/29/04	0.920
North Jacobs Ranch	1/16/02	0.706
Horse Creek	9/7/00	0.330
Thundercloud	10/1/98	0.384
Powder River	6/30/98	0.206
North Rochelle	9/25/97	0.194
Antelope	12/4/96	0.150
Eagle Butte	4/5/95	0.111
West Rocky Butte	1/7/93	0.291
North Antelope/Rochelle	9/28/92	0.216
West Black Thunder	8/12/92	0.168
Jacobs Ranch	9/26/91	0.136

Source: U.S. Bureau of Land Management. *Wyoming State Geological Survey, Coal Section, August, 2004.*

The Final Environmental Impact Statement on the West Hay Creek LBA was published in June. Triton Coal filed the LBA in August, 2000 to add reserves to the Buckskin mine. Under the proposed action, the tract consists of 832.8 acres and contains estimated recoverable coal reserves of nearly 130 million short tons. Projected coal quality of the reserves is 8140 Btu per pound, 0.41% sulfur, 5.32% ash, and 32.1% moisture, all on an as-received basis. The lease sale is expected in the forth quarter of 2004 (U.S. Coal Review, 6/21/04).

The Dave Johnston mine, which began its final reclamation in 1999, has placed its Page 752 dragline and the machine's spare parts up for sale. The mine located near Glenrock, produced coal for PacifiCorp's Dave Johnston power plant for 40 years. With dragline reclamation work now concluded, the remaining grading and topsoil work will be done by mobile equipment (U.S. Coal Review, 5/10/04).

An April test burn of PRB coal went well at Progress Fuels' Crystal River, Florida plant. The company said it was pleased with the performance of its boilers with a reasonable blend of PRB coal. The company was also pleased that the PRB coal achieved better NOx reduction in comparison to Central Appalachian coal. However, neither PRB nor Central Appalachian coal helped to reduce NOx as much as South American coal. The combination of the import coal and PRB coal will enable the power plant to achieve its NOx targets on an annual basis. This could indicate that Crystal River could burn up to 500,000 short tons of PRB coal annually. PRB coal for the test came from Peabody Energy's North Antelope/Rochelle mine complex (U.S. Coal Review, 5/17/04).

Kennecott Energy's Cordero Rojo mine had to temporarily idle one of its draglines as a result of the operation becoming coal-bound. Because the mine had not received enough empty trains to haul all the coal being produced, the mine ran out of room to keep removing overburden. While the idle dragline was out of service for only a few days, each day it was idled cost the mine about 40,000 short tons per day in lost sales potential (U.S. Coal Review, 6/28/04).

The Wyoming Wildlife Federation bestowed their Corporation of the Year Award upon Peabody Energy. Work done to protect sage grouse habitat within the Powder River coal mining fairway during the past three years by North Antelope/Rochelle mine complex's environmental team earned the award. As part of the winning project, the team identified the bird's favorite vegetation and cover, and tracked bird movements by radio-collar transmitters to define prime areas for sage grouse-specific reclamation (Casper Star Tribune, 8/22/04).

Developments in southern Wyoming

Tri-State Generation & Transmission reportedly is revisiting an earlier proposal to build a coal-fired power plant in Colorado. In 2001 and 2002, the company considered construction of a new 1200-megawatt (MW) generating plant, but several demand studies and cheap wholesale power prices put the project on hold. Electricity demand from their 44-member system is now averaging a 4% annual growth. To meet that demand, Tri-State must buy power on the open market or look at the option of building a new coal-fired power plant. The company has hired a consulting firm to study the power plant development issue. One option for the power plant's possible location is believed to be a new captive plant in the southeastern portion of Wyoming's Green River Basin. If that becomes a reality, it could mean about a 10-million-short ton-per-year increase in the use of southern Wyoming coal. The consultant's studies are due at the end of 2004. More should be known early in 2005 about this possible project's location.

Much needed competition from the proposed DM&E build-in project remains on hold by additional court imposed environmental studies...

The U.S. Department of Energy (DOE) received proposals for new clean coal projects valued at nearly $6 billion in the latest phase of the Presidents Clean Coal Power Initiative. Secretary of Energy Spencer Abraham said, "We are pleased these latest proposals encompass an advance generation of technologies that will help us meet national priorities set forth by the President in his Clear Skies and Global Climate Change objectives" (Casper Star Tribune, 8/6/04).

Among the proposals is one from Medicine Bow Fuel and Power. In their proposal, they seek to develop and operate the Medicine Bow Energy Project, a mine-mouth coal gasification and liquefaction facility that would demonstrate integration of technologies for producing 1000 MW of electric power and 26,200 barrels of ultraclean diesel fuel per day while consuming about 6 million short tons of coal per year. Proposed by Texas-based DKRW Energy, the company is hoping to build the facility by 2008 on the Medicine Bow River Ranch, approximately 13 miles south of Medicine Bow, Wyoming. The proposed Medicine Bow Fuel and Power Plant would bring nearly 500 new jobs into the area, employing them in a new underground coal mine and liquefaction facility. Most likely, the plant would be supplied with coal from the proposed Elk Mountain mine, which already received its Draft Environmental Impact Statement from the BLM (Casper Star Tribune, 8/6/04).

The BLM released its final environmental assessment for Bridger Coal's LBA for the Ten Mile Run tract, which is adjacent to the Bridger coal mine in Sweetwater County. The document discusses direct, indirect, and cumulative environmental impacts of issuing the coal lease. The lease covers approximately 2242 acres of federal land estimated to contain 44 million short tons of coal reserves. The document can be viewed at: http://www.wy.blm.gov/rsfo.

The Jim Bridger Power Plant and its adjacent Bridger coal mine celebrated their 30th anniversary in August. The public was invited to visit both sites to get a better understanding of how electricity is produced. The power station generates electricity for customers in six western states. The coal mine has served as the plant's primary source of fuel since it opened in 1974. Currently, the combined annual payroll of the two operations is $39 million. The mine employs 325 workers and the power plant employs an additional 350 employees. Construction on the Jim Bridger Power Plant began in 1969. Today the plant is a four-unit complex, with each unit rated at 530 MW (Casper Star Tribune/8/21/04).

Transportation developments

Much of the trade press has been full of news about the railroads' struggle to meet increased demand out of the PRB while keeping their other services running smoothly and trying to boost profits. The continuing surge in demand for rail service, coupled with continued production growth in the West, has raised questions about the major railroads' ability to keep up (Coal Weekly, 8/6/04).

In early 2004, up to 31 states were burning PRB coal. At times, the coal carriers out of Wyoming, in particular the Union Pacific Railroad (UP), seemed desperate to find available cars, locomotives, and crews to meet the rising demand for the area's cheaper, low-sulfur coal.

The threat of further competition is still far off for the UP and Burlington Northern Santa Fe (BNSF) railroads. Much needed competition from the proposed DM&E build-in project remains on hold by additional court imposed environmental studies, allowing these joint line carriers time to apply some new pricing power.

In addition to a surge in hiring and track maintenance projects, rising fuel costs have made their own impact on the rail transportation picture. A fuel cost increase reportedly near 9% in the second quarter was followed by a forecast 14% jump for the third quarter as crude oil traded over the $44-per-barrel level. Some observers sense that the rising

cost of transportation for PRB coal has tempered some of the demand earlier than expected for the product.

On August 2 and 3,2004, the Surface Transportation Board toured the PRB, giving the agency its first direct contact with the area that makes up a majority of its workload. Board members Rodger Nober, Francis Mulvey, and Douglas Buttrey toured Peabody Energy's Caballo mine. At the mine, they got to see a coal shot that released approximately 300,000 short tons of coal (enough to fill 30 unit trains). They also rode some of the trains to see the triple tracking of the joint line. A spokesman for the group commented, "not a single person from our agency had ever been to the Powder River Basin. So here we are, essentially evaluating cases involving movement of coal out of there, and no one from our agency has been on site to see what the practical reality of doing business there is" (COAL Daily, 8/6/04).

On July 30, 2004, the rear locomotive and five coal cars of an eastbound UP coal train derailed at Willow Island, Nebraska. The derailment blocked one of the three main tracks along that portion of the rail line for 24 hours. The derailment was the third for the UP since June 24, 2004 (COAL Daily, 8/2/04). On August 5, 2004, another UP coal train moving from Wyoming to Illinois derailed in southeastern Nebraska and an oncoming freight train hit the derailed UP train (COAL Daily, 8/6/04).

Regulatory developments

In April, the DOE and We Energies signed a $52.9 million agreement to initiate a new mercury control technology labeled the TOXECON project. The new technology is expected to reduce mercury emissions from coal-fired power plants by up to 90%. The project calls for the technology to be installed at the company's Presque Isle power plant in Michigan by 2009. TOXECON is also expected to reduce SO_2 emissions by 30% and NOx emissions by 70%. If successful, TOXECON may be the primary mercury control choice for users of Western coals (COAL Daily, 4/22/04).

The House Appropriations Committee voted to cut $219 million in funding for FutureGen, a federal project for developing a zero-pollution coal-fired generating plant. FutureGen is a $1 billion integrated sequestration and hydrogen research initiative, involving a government/industry partnership to design, build, and operate a nearly emission-free, coal-fired electric and hydrogen production plant. The 275-MW prototype plant will serve as a large scale engineering laboratory for testing new clean power, carbon capture, and coal-to-hydrogen technologies (U.S. Coal Review, 6/7/04).

The Bush administration abandoned its attempt to uphold a nationwide ban on new road building on millions of acres of federal land, and presented a new final rule that will leave states and Native American tribes to largely make their own decisions on new road construction. The change in rules was in response to the June, 2003 ruling from a district court in Wyoming declaring the roadless rule illegal and unconstitutional. The new set of proposed rules would allow states a maximum of latitude in deciding when and where new roads can be built (COAL Daily, 7/13/04).

Market developments and opportunities

Rentech has signed a contract with the Wyoming Business Council to conduct engineering and economic studies for a Fischer-Tropsch (FT) gas-to-liquids plant using Wyoming coal as feedstock. The company will consider the economic feasibility of constructing a mine-mouth plant capable of producing 10,000 barrels per day of ultra-low-sulfur FT diesel for distribution in various Western states. The plant would consume approximately 3 million short tons of subbituminous coal per year for each 10,000-barrel-per-day unit built. The project is funded by a $500,000 award from the State of Wyoming under funding from the DOE.

Wisconsin Power & Light and Wisconsin Public Service are set to conduct feasibility and location studies on power plant options based on expected increases in energy demands through 2010. The result of the studies most likely would result in a new 500-MW plant, which may be fueled by PRB coal. Plans call for completion of the feasibility study by the end of 2004, with permitting taking until 2006. Actual construction is not expected to begin until 2007 (COAL Daily, 5/26/04).

If the railroads can deliver the coal, many test burns appear to be on the horizon in the eastern U.S. Cinergy is preparing to conduct a test burn of PRB coal at two of its plants. FirstEnergy said it is looking at shifting its Burger plant in Ohio from a 70% blend to a 100% burn. Dynegy Midwest is also considering going from a 70% to 100% PRB coal burn at its Havana station. NRG's Dunkirk and Huntley plants in New York switched to PRB coal in January. Now the company is studying the possibility of switching its Indian River station, the largest coal-fired power plant in Delaware, over to PRB coal. Conectiv's Edgemoor plant, also in Delaware, is looking at PRB coal (Coal Weekly, 8/20/04).

Table 14 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal, announced during the first eight months of 2004.

References cited

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

Stauffenberg, D.G., 2003, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 2003: Office of the State Inspector of Mines, Rock Springs, 88 p.

Table 14. Marketing activities for Wyoming coal producers through August, 2004*.

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
City Public Service of San Antonio	System	Kennecott Energy/ PRB	Sp	3 trains/month	Second half of 2004
Consumers Energy	System	PRB	Sp	200,000 t	Delivery in 4th quarter 2004
Electroandina of Chile	Export	PRB	Sp	600,000 t	Shipped through Port of Vancouver
FirstEnergy Generation	System	PRB	So	Between 500,000 to 2 mt/y for six years	Delivery in 2005-2010
Guacolda (Chile)	Export	PRB	Sp	100,000 t	Shipped through Port of Vancouver
Kentucky Utilities	Ghent Station	PRB	So	Not specified	One to up to five years. Spot and Term
Lower Colorado River Authority	System	PRB	So	3 trains/month	Delivery in 2005
MidAmerican Energy	System	PRB	Sp	100,000 to 250,000 t	Delivery in last half of 2004
MidAmerican Energy	System	PRB	So	Up to 1 mt	Delivery in 2005
Omaha Public Power District	North Omaha & Nebraska City	PRB	So	1.6 to 1.8 mt	Delivery in 2005
Progress Fuels	Crystal River	North Antelope-Rochelle/PRB	T	2 unit trains	Test coal
City Utilities of Springfield	Deely/Spruce	PRB	Sp	Up to 100,000 t	Delivery in second half of 2004
City Utilities of Springfield	Deely/Spruce	PRB	So	1 mt/y for up to three years	Term coal for delivery starting in 2005
Tennessee Valley Authority	System	PRB	So	Up to 2 mt/y for one, six, or 10 years	Delivery beginning in 2005
Texas Genco	Limestone	PRB	So	Up to 2.3 mt/y fot up to three years	Delivery beginning in 2005
Texas Genco	Parish	PRB	So	Up to 2.7 mt/y for one year	Delivery in 2005

*Data obtained from: Coal Outlook, COAL Daily, U.S. Coal Review, FERC database, and personal contacts. Note: mt = million short tons; mt/y = million short tons per year; PRB = Powder River Basin; So = solicitation; t = short tons; t/y = short tons per year. *Wyoming State Geological Survey, Coal Section, September, 2004.*

Coalbed Methane Update

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At the end of the first quarter, 2004, Wyoming's coalbed methane (CBM) production was just over 82.5 billion cubic feet (BCF), 3.25% less than for the same period in 2003. Development in the Powder River Basin (PRB) was stalled slightly by a restructuring of the U.S. Bureau of Land Management's (BLM's) permitting process, but under orders from headquarters, the agency is now looking at a 46-day turnaround on processing Applications for Permit to Drill (APDs). The BLM has also instituted a new plan intended to help resolve the conflicts in areas of potential CBM recovery adjacent to active mines within the PRB.

One of the PRB's largest CBM producers, Marathon, has placed their subsidiary, Pennaco Energy, for sale. Petro-Canada has agreed to purchase Prima Energy Corp's holdings in the PRB and Denver-Julesburg Basin. Galaxy Energy is trying to acquire an additional 4400 acres and enhance their foothold in the PRB. Anadarko is continuing to develop CBM in the Atlantic Rim area and has proposed another CBM project for the Hanna Basin, which includes a pilot project for horizontal drilling techniques. The Hudson Group LLC., is proposing a project in the northern Great Divide Basin for deep coal beds in the Fort Union Formation.

The first annual Coalbed Natural Gas Research, Monitoring, and Applications Conference took place on the University of Wyoming campus in August. Another forum on produced water from CBM operations was held in Denver.

Production

Wyoming's CBM play within the PRB showed little change in the number of producing versus shut-in wells between the last quarter of 2003 and the first quarter of 2004. Just over 81.75 BCF of gas was produced (**Table 15**) from 12,427 wells while 4072 shut-in wells were waiting to go online in the first quarter. During this same time, there were roughly 3600 APDs still on file. CBM production in the PRB for the first quarter of 2004 was 3.51% less than the first quarter of 2003.

CBM development and production outside of the PRB has picked up in the first quarter (**Table 16**) but was unable to offset the PRB's decline. Statewide CBM production in the first quarter was just over 82.54 BCF, down 3.05% over the same period in 2003 (**Tables 15** and **16**). Currently CBM development and production outside of the PRB is occurring in the northeastern Wind River Basin, Hanna Basin, along the Atlantic Rim (eastern Washakie Basin), and in the northern Greater Green River Basin. As of the end of March, 2004 there were 70 producing and 72 shut-in wells outside of the PRB.

Acquisitions

Rocky Mountain Gas closed a purchase and sale agreement to acquire CBM properties in Wyoming's PRB. The $6.8 million investment was for 247 completed wells, of which 138 are currently producing nearly 600 thousand cubic feet (MCF) per day, and 40,120 undeveloped fee acres (PI/Dwights Drilling Wire, 02/10/04).

In June of 2004, Marathon Oil Corp. announced its plan to sell a large slice of their CBM holdings within the PRB. Although Marathon is planning on selling its wholly owned subsidiary, Pennaco Energy, it still plans to pursue an aggressive plan to drill 500 new wells by the end of the year. Pennaco's production in the PRB only represents about 10% of Marathon's national gas production. The deal will include 650,000 net acres of mineral lease and assets and 388 BCF of proven recoverable CBM (PI/Dwights Drilling Wire, 6/9/04).

Canadian-based Petro-Canada has entered into an agreement to acquire Prima Energy Corp. at $39.50 a share, totaling $534 million. The transaction will be implemented through a wholly owned subsidiary by Petro-Canada. The acquisition was called an "excellent fit" for the company's long-term strategy to expand its North American natural gas business. Prima Energy has increased its production 11% each year to its current 55 million cubic feet (MMCF) per day. Prima's production comes largely from the Powder River and Denver-Julesburg basins and 40% of the gas is CBM. In the deal, Petro-Canada would acquire 1600 drillable locations and 360,000 undeveloped acres in the Green River and Wind River basins (PI/Dwights Drilling Wire, 6/10/04).

Galaxy Energy Corp. has entered into an agreement to acquire 4400 net acres of prospective CBM properties in Campbell and Converse counties. Under the agreement, Galaxy is committed to drilling 12 new wells on the property to earn 50% of the working interest in nine existing wells, of which seven have already been completed. The company will pay about $1.2 million for drilling the 12 new wells and developing the necessary infrastructure. Galaxy has the right to acquire up to 90% of the working interest in the 4400 acres for an additional $1.9 million. The properties are located in the eastern PRB and include the West Recluse and Glasgow

Table 15. Monthly Powder River Basin coalbed methane production in million cubic feet (MCF) (2000 through June, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	8,465,248	8,465,248	18,216,791	18,216,791	25,814,734	25,814,734	29,491,004	29,491,004	27,961,549	27,961,549
February	8,706,458	17,171,706	16,918,619	35,135,410	23,380,195	49,194,929	26,450,759	55,941,763	26,149,187	54,110,736
March	9,864,450	27,036,156	19,824,513	54,959,923	26,045,128	75,240,057	28,972,661	84,914,424	27,646,636	81,757,372
April	10,549,945	37,586,101	19,699,644	74,659,567	25,383,973	100,624,030	27,992,881	112,907,305	27,101,673	108,859,045
May	11,824,542	49,410,643	20,714,721	95,374,288	27,268,027	127,892,057	28,819,962	141,727,267	27,937,512	136,796,557
June	12,196,467	61,607,110	20,516,641	115,890,929	26,372,024	154,264,081	28,218,733	169,946,000	26,985,252	163,781,809
July	13,031,976	74,639,086	21,843,289	137,734,218	27,919,362	182,183,443	29,028,155	198,974,155		
August	14,185,648	88,824,734	22,402,964	160,137,182	28,666,892	210,850,335	29,862,075	228,836,230		
September	14,403,249	103,227,983	21,652,656	181,789,838	28,208,254	239,058,589	29,290,319	258,126,549		
October	15,396,043	118,624,026	24,103,492	205,893,330	29,244,072	268,302,661	30,287,206	288,413,755		
November	15,233,376	133,857,402	24,092,741	229,986,071	28,980,587	297,283,248	28,358,292	316,722,047		
December	16,903,406	150,760,808	25,697,131	255,683,202	29,707,016	326,990,264	29,225,939	345,997,986		
Total		**150,760,808**		**255,683,202**		**326,990,264**		**345,997,986**		

Data from the Wyoming Oil and Gas Conservation Commission. MCF = thousands of cubic feet. *Wyoming State Geological Survey, September, 2004.*

Table 16. Other Wyoming coalbed methane production in million cubic feet (MCF) (2000 through June, 2004).

	2000		2001		2002		2003		2004	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	31	31	1,594	1,594	21,118	21,118	123,681	123,681	218,715	218,715
February	119	150	1,982	3,576	12,069	33,187	115,247	238,928	215,554	434,269
March	167	317	2,486	6,062	6,737	39,924	162,466	401,394	349,658	783,927
April	366	683	2,738	8,800	6,713	46,637	157,434	558,828	313,123	1,097,050
May	637	1,320	4,255	13,055	8,640	55,277	179,883	738,711	376,863	1,473,913
Jun	1,494	2,814	5,149	18,204	32,691	87,968	177,829	916,540	387,383	1,861,296
July	992	3,806	5,453	23,657	39,716	127,684	213,937	1,130,477		
August	1,417	5,223	3,329	26,986	52,391	180,075	214,106	1,344,583		
September	1,459	6,682	2,993	29,979	69,082	249,157	220,629	1,565,212		
October	1,165	7,847	2,667	32,646	71,672	320,829	221,578	1,786,790		
November	1,335	9,182	4,434	37,080	77,640	398,469	186,793	1,973,583		
December	1,317	10,499	39,232	76,312	99,629	498,098	203,161	2,176,744		
Total		**10,499**		**76,312**		**498,098**		**2,176,744**		

Data from the Wyoming Oil and Gas Conservation Commission. MCF = thousands of cubic feet. *Wyoming State Geological Survey, September, 2004.*

projects. The areas already possesses significant infrastructure; the targeted depths of production are between 500 and 800 feet. The deal is expected to be closed after the necessary due diligence the first of November. Galaxy currently controls 54,000 acres in Wyoming (PI/Dwights Drilling Wire, 7/9/04).

Activities

Over the next two to three years, Anadarko Petroleum plans to increase employment and spending for its properties and leases in the Atlantic Rim area, Carbon County. Although the BLM's Environmental Impact Statement (EIS) for the area won't be finalized for some time, Anadarko plans to hire up to 70 new employees. The company has already drilled pilot wells southwest of Rawlins and north of Baggs. The Atlantic Rim Project encompasses 211,000 acres and will eventually have as many as 950 CBM wells, most of which will be developed on Anadarko's property. Anadarko expects that full field development will cost around $500 million. In addition to drilling and completing the wells, necessary infrastructure such as power lines, gas pipelines, and water pipelines will have to be built. Anadarko's acquisition of land in the Atlantic Rim area came from purchasing holdings from Union Pacific Resources in 2000 (Casper Star Tribune, 4/29/04).

The Wyoming State Geological Survey will publish the papers that were presented at this conference in their Public Information Circular series.

In an effort to reduce surface impacts from CBM drilling, Anadarko is seeking permission to apply horizontal drilling techniques used in traditional oil and gas wells to CBM development. The company wants to drill two wells in the Hanna Draw area of Carbon County to test the feasibility of horizontal drilling and CBM production. The BLM's Rawlins Field Office began work on an Environmental Assessment (EA) of the proposal that was due in June. If accepted, drilling will occur 10 miles northwest of the town of Hanna in section 2, T22N, R81W (**Figure 10**). Fourteen additional conventional wells were included in the analysis. The analysis area for the proposed project covers roughly 5682 acres, of which nearly half is BLM-administered federal surface and mineral estate. Water produced from the wells would be discharged into the Medicine Bow River above Seminoe Reservoir. If the project proves economically feasible, a gas pipeline would be constructed as well as the necessary infrastructure such as roads, water collection and disposal pipelines, and power lines. Each well would be production-tested for a period of six to 12 months in order to determine economic feasibility (PI/Dwights Drilling Wire, 5/25/04).

In late July, 2004, The Wyoming Outdoor Council and Biodiversity Conservation Alliance dropped their legal suit against Bill Barrett Corp. over CBM development in the Thunder Basin National Grassland. The suit was dropped in exchange for voluntary conservation measures on the part of Bill Barrett. The company made assurances that the drilling activity would not adversely affect prairie dogs, sage grouse, and other wildlife, or recreational uses of the national grassland during the life of the project (Casper Star Tribune, 7/30/04).

If approved, up to 18 exploratory CBM wells could be drilled within the Scotty Lake Project Area located in the Great Divide Basin in southwestern Wyoming, approximately 45 miles northwest of Wamsutter in eastern Sweetwater County, T26N, Rs96-97W (**location A, Figure 10**). The Casper-based company, Hudson Group LCC, wants to determine from drilling if further development will be economically favorable. The drilling will occur in three phases over the course of three years, wrapping up in 2006. The area encompasses some 2880 acres of federal surface and will target coal beds within the Tertiary Fort Union Formation at depths of up to 5000 feet on 160-acre spacing. The proposal also listed the construction of 5 miles of new access roads and 13 miles of gas collection pipelines. The expected life of the project, if approved, is between 15 and 25 years. Produced water (if it is of acceptable quality) from the wells will be discharged on the surface into nearby drainages (PI/Dwights Drilling Wire, 8/9/04).

Devon Energy has agreed to share in the cost of a 7-acre drip irrigation system on the Malli Ranch in the PRB between Gillette and Sheridan on U.S. Highway 14/16. The drip system will utilize produced CBM water to irrigate trees and will potentially prove itself as an application that benefits agriculture in the area. Don Malli, owner of the ranch, has high hopes for CBM water on his property for both recreational and drought-relief purposes. However, both regulatory and permitting issues have slowed Malli's plans for large-scale drip systems, stocked fishing ponds, and hunting habitat. So far, Devon has only drilled half of its intended number of wells on the ranch, due in part to the delays in the permitting process (Casper Star Tribune, 8/1/04).

The first annual "Coalbed Natural Gas Research, Monitoring, and Applications Conference" was held in August at the University of Wyoming (UW) in Laramie. The three-day conference brought together researchers, consultants, state and federal agencies, and industry officials. Among those things discussed were: current CBM development, water monitoring and treatment methods, legal issues, and the future impact and development of CBM within the state. The conference was sponsored by the Ruckleshaus Institute at UW. The event was open to the public with oral presentations on CBM and poster sessions displaying research. The emphasis of the conference was to open doors between different research projects and to develop an open forum for the exchange of information and collaboration between various researchers and regulators. The Wyoming State Geological Survey will publish the papers that were presented at this conference in their Public Information Circular series.

Regulatory issues

In lieu of the conflicts between CBM lease holders and coal producers, the BLM has devised a plan that would help to diffuse the conflicts by creating a Conflict Administration Zone (CAZ) around each of 14 coal mines in the PRB. Notices of the plan were sent out early last July to CBM lease holders advising them of what the plan would involve. A zone around the mines would allow the coal seams to be degassed by CBM producers prior to mining. This would prevent gas leases from becoming worthless and help to insure proper utilization of the CBM resources. The BLM's plan designates roughly 69,000 acres around mines where potential conflicts between methane production and expanding coal mining operations would hinder gas recovery. Incentives to CBM developers by the BLM could include a 50% royalty reduction. The BLM is hoping to encourage CBM producers to accelerate methane production in areas of potential conflict ahead of coal mining operations. Other options in the notice included allowing the CBM lease holders to suspend operations and production until a later date, to relinquish all or part of an affected lease area, and to indicate that a lease is uneconomic to develop. The burden of information rests with the affected CBM lease holders—they must provide adequate information to the BLM outlining the situation in order to abandon or modify their lease (Coal Daily, 7/13/04).

With regard to well permitting, BLM's Wyoming offices were instructed to meet a 46-day turnaround time on issuing CBM well permits, and is expected to issue 3000 permits per year; a recent EIS will allow up to 3500 new wells to be drilled each year for the next nine years within the PRB. The recent restructuring of the Buffalo Field Office did slow the pace of the agency's rate of issuing permits. During the restructuring, the BLM created a backlog of nearly 1400 APDs, but by the end of April, the agency eliminated the backlog and processed those APDs. (Casper Star Tribune, 3/22/04)

On the forefront of the Bush Administration's policy of exploiting the nation's own gas resources is the issue of water treatment for CBM producers here in Wyoming. In Denver, Colorado at the "American Petroleum Institute's Rocky Mountain Coalbed Natural Gas Forum: Produced Water," 90 people from all venues of industry gathered to discuss mitigation for the costs of produced water. The reason for the concern is that in some instances the cost of treating produced water makes production of CBM uneconomical. The treatment of produced water ranges between 13 and 17 cents per barrel, and one CBM field with 100 to 200 wells can produce over a million barrels of water per year. Ideas that surfaced during the two-day forum were tax breaks for producers in areas where water treatment was cost-prohibitive, passing the expense of treating produced water on to consumers, and other types of tax incentives. But the issue still stands: the public owns the largest share of natural gas resources and the cost of water treatment counters the national push to exploit all possible domestic natural gas resources at an economically favorable rate (Casper Star Tribune, 4/30/04).

Fidelity Exploration and Production Co. was recently presented with the BLM's Fluid Mineral Award for outreach and community education work. Fidelity was chosen to receive the award based on its three-year soil monitoring program for farmers and ranchers along the Tongue River in Montana. The program was instituted to monitor soil and water conditions based on discharge of CBM-produced water. For more information on the soil and monitoring program visit the following web site: http://www.tongueriverampp.com (Casper Star Tribune, 8/22/04).

Industrial Minerals and Uranium Update

Ray E. Harris, Wyoming PG-46

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

The production of the major industrial minerals in Wyoming remained mostly steady in early 2004. Production of trona, the most valuable industrial mineral commodity, increased slightly. Uranium continued to be produced at two in-situ localities in Wyoming. The price of yellowcake increased from $14.50 per pound at the end of 2003 to $19.50 at the end of the first quarter of 2004; the number of inquiries to the Industrial Minerals and Uranium (IM&U) Section regarding reopening closed uranium mines or locating new deposits continued to increase during 2004.

The IM&U Section is constructing a new uranium database and locations map in the summer of 2004. Included in this project is a digital data sheet listing and locating uranium well logs archived at the Wyoming State Geological Survey (WSGS). Under a grant from the U.S. Geological Survey's (USGS) STATEMAP program, the Section compiled a bedrock geologic map of the Torrington 1:100,000-scale Quadrangle. A digital version of the *Industrial minerals and construction materials map of Wyoming*, WSGS Map Series (MS) 47, is also being completed.

Bentonite

Seven companies operate thirteen plants in Wyoming (**Figure 14**). The major bentonite mining areas are in the Bighorn Basin, the flanks of the Black Hills uplift, and the western Powder River Basin (**Figure 14**). The mills for the last area are located in Casper. At each operation, bentonite of different properties is mined from separate pits and hauled to a mill, where it is blended into products of consistent quality.

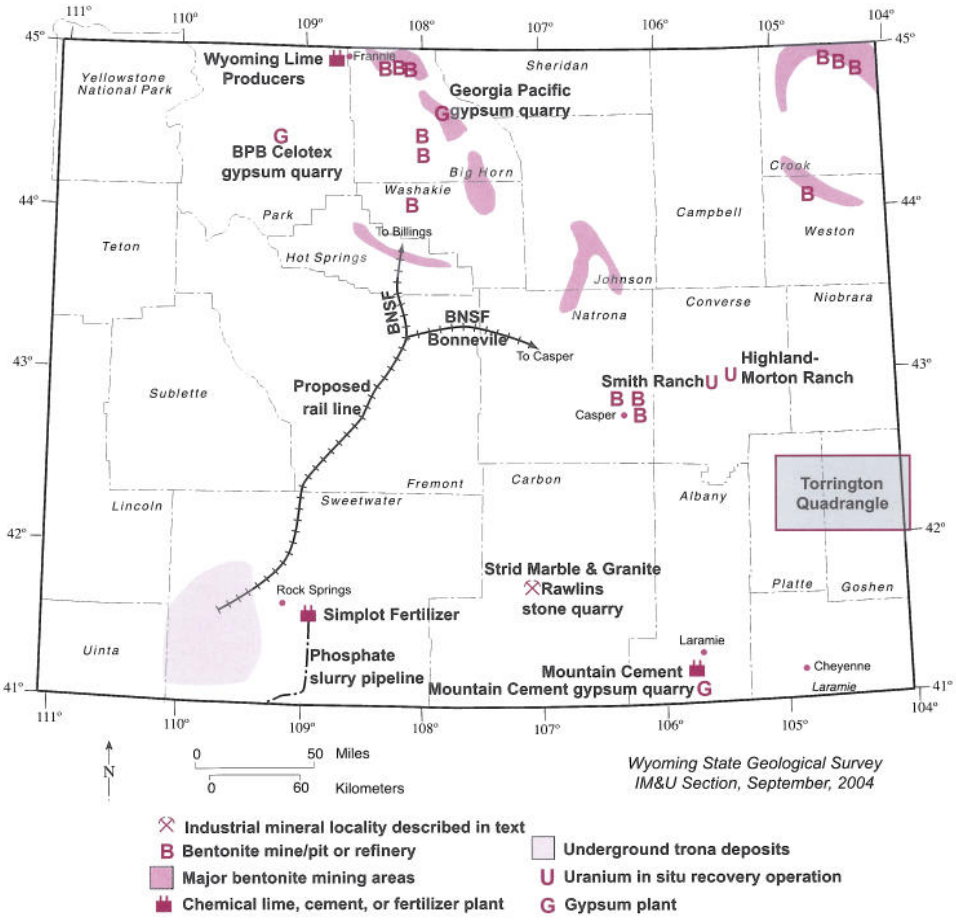

Figure 14. Index map of Wyoming showing the location of industrial mineral and uranium sites, selected mining areas, mapping areas, and proposed rail lines mentioned in the text. Locations are approximate and may represent more than one site.

Bentonite is high-sodium clay that formed from the diagenesis of volcanic ash in submarine environments. Wyoming mineable bentonites are Late Cretaceous in age. There are, however, thinner layers of bentonite in other units, particularly Eocene to Pliocene volcanogenic rocks. A high-calcium clay mined in one locality in Mississippi is also called bentonite, but the two have been informally distinguished into Wyoming bentonite and southern bentonite. Sodium bentonite is used for its cation exchange and absorptive capabilities and its property of swelling to many times its dry volume when wet.

According to the U.S. Geological Survey, bentonite is primarily used for pet waste absorbents (25%), drilling mud (21%), foundry sand bonding agent (21%), and iron ore pelletizing (15%), with the remaining 18% going to numerous other uses.

Construction aggregate

Construction aggregate production in Wyoming declined slightly in 2003 compared with 2002: from 17.2 million tons to 15.1 million tons. Production for 2004 will be about the same as the previous two years, considering stockpiling provisions.

Decorative and dimensional stone

Strid Marble and Granite of Cheyenne continues to operate a dimensional sandstone quarry southeast of Rawlins (**Figure 14**). This is the quarry from which the stone that faces the Wyoming State Capitol Building, the Union Pacific Railroad Depot in Ogden, Utah, the old Wyoming State Penitentiary, some buildings on the University of Wyoming campus, and probably others. The rock is a sandstone from a unit in the Upper Cretaceous Mesaverde Formation. In 2004, some of this stone was used on an extension of the Albany County Courthouse in Laramie. Although not the same stone as the rest of the courthouse, it is similar in texture to the Pennsylvanian sandstone from the Casper Formation, but slightly grayer in color.

Moss rock, flagstone, and fieldstone are sold regionally to markets in the Wasatch front of Utah and the Front Range and developing ski towns of Colorado. Some stone has been sold to customers as far away as California and Chicago.

Gypsum

Gypsum is produced at three localities in Wyoming (**Figure 14**); two are associated with wallboard manufactur-

ing plants in the Bighorn Basin, and at the third locality, gypsum is quarried south of Laramie for use nearby as a retardant in cement manufacture at the Mountain Cement plant. Gypsum production decreased from 0.43 million tons in 2002 to 0.42 million tons in 2003. However, 2004 production is expected to equal the last few years' production because each wallboard plant is operating at capacity.

Limestone

Limestone is produced for two purposes—construction aggregate and as a source of lime. Lime is used in cement manufacture and other industrial applications. Chemical grade limestone production decreased from 0.93 million tons in 2002 to 0.74 million tons in 2003 but will probably increase again in 2004. Chemical grade limestone is another commodity that is quarried and stockpiled. Most chemical grade limestone quarried in Wyoming is used at Mountain Cement's plant in Laramie, while small quantities are quarried near Hartville for use in sugar beet refining. Lime from Wyoming Lime Producers in Frannie, Wyoming (**Figure 14**), uses limestone quarried in Montana.

Phosphate

Farmland Industries sold its interest in SF Phosphate's fertilizer plant near Rock Springs (**Figure 14**) to Simplot, the other partner, so the plant is now owned by Simplot Fertilizer. The plant's operations have not changed; phosphate is mined north of Vernal, Utah and transported to the plant by slurry pipeline. The plant also uses sulfur from natural gas. Some natural gas contains hydrogen sulfide (H_2S), which is extracted at a gas plant and converted to elemental sulfur. Elemental sulfur is manufactured into sulfuric acid, which is then used in the fertilizer industry.

Trona

Trona is mined in southwestern Wyoming at four underground mines and refined into soda ash and other sodium compounds at mine-mouth plants. FMC, General Chemical Soda Ash Partners, OCi, and Solvay Minerals operate the mines and refining plants. FMC also recovers trona from mine water. Mined trona production in Wyoming increased from 17.2 million tons in 2002 to 17.5 million tons in 2003 (**Table 1**) and should increase another million short tons in 2004 due to closure of one of the two *in situ* (solution) mines in Colorado.

Efforts are underway in the Wyoming Legislature to reduce the severance tax rate on mined trona from 6% to 2% to ease the tax burden on Wyoming producers. This will help our producers who are struggling with profitability with rising costs of operation, particularly employee health care and insurance, and foreign competition, especially from China.

One bright spot in the trona industry recently was the lowering of tariffs on imported soda ash by Australia. This will enable more exports to Australia.

In late 2003, a proposal was announced to try to obtain funding to construct a railroad from the trona mining area northeast to connect with the Burlington Northern Santa Fe Railroad at Bonneville (**Figure 14**). However, by mid-2004, the promoters announced that funding was not available and abandoned the effort. Unfortunately, the rail line that once existed from north of Rock Springs to the now abandoned iron ore mine and mill at Atlantic City was dismantled prematurely in the late 1980s, as was the rail line between Riverton and Bonneville.

The U. S. Bureau of Land Management (BLM) announced a proposal that will ban oil and gas drilling in areas of present and future underground trona mining (**Figure 14**). Committees consisting of officials and technical experts from the industry, Wyoming state government, the BLM, oil and gas producers, and Union Pacific and Anadarko Petroleum (major surface and mineral rights owners in the area) have been working on this proposal for over 11 years. If an oil or gas well ruptured some lethal gas could get into mine workings, resulting in the death of underground workers. The oil and gas resources situated below the trona resource would remain undisturbed until mining was completed, or other methods of extracting trona were developed.

Uranium

The spot market price of yellowcake (oxidized uranium -- the product of Wyoming's uranium mills) jumped from $14.50 per pound at the end of 2003 to $19.50 per pound in March, 2004, according to the Ux Consulting Company, LLC. The Uranium Exchange Company: (http://www.uxc.com/review/uxc_prices.html) and the Rocky Mountain Minerals Scout. Yellowcake is uranium oxide with a varying amount of other elements, having no definite chemical formula. The price increase is probably due to an anticipated decrease in the amount of uranium from Russia, which had been manufactured from weapons-grade uranium diluted to power plant fuel.

Uranium is produced in Wyoming at two *in situ* recovery sites, Smith Ranch and Highland/Morton Ranch by Power Resources, a subsidiary of CAMECO (**Figure 14**). CAMECO, of Saskatoon, Saskatchewan, also owns the only other current uranium production in the U.S. at Crow Butte, Nebraska. Uranium production from the two Wyoming mines decreased slightly from 1.4 million pounds of yellowcake in 2002 to 1.2 million pounds of yellowcake in 2003 and is expected to remain at about 1.2 million pounds in 2004.

Digital mapping projects

The IM&U Section has completed two projects involving digital mapping. The first is a geologic map of the Torrington 1:100,000-scale Quadrangle in southeastern Wyoming (**Figure**

14). This area contains the southern Hartville uplift and some of the Tertiary rocks of the High Plains as well as Pleistocene gravel, boulder conglomerate, sand, alluvium, and loess. Compilation of this map was done using funds from the 2003 STATMAP program, a cooperative mapping effort with the WSGS and the USGS. The full-color map entitled *Preliminary geologic map of the Torrington 1:100,000-scale Quadrangle, Platte and Goshen Counties, Wyoming and western Nebraska*, by J. Fred McLaughlin and Ray E. Harris, is WSGS Open File Report 04-11 (see the **Publications Update** for prices and ordering information). The map was prepared digitally using geographic information systems (GIS) technology.

The second new map is a revised *Industrial minerals and construction materials map of Wyoming*, by R.E. Harris, WSGS MS-47. Originally published in 1996, the map is now in digital form and contains updated and revised information on the state's industrial minerals. The large, full-color map is at the scale of 1:500,000 and is available as a plotted map. The digital data on CD-ROM will be available soon. See the **Publications Update** for prices and ordering information.

Metals and Precious Stones Update

W. Dan Hausel, Wyoming PG-1025

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

Two new gemstone deposits were identified in Wyoming over the summer, an iolite-kyanite-sapphire-ruby deposit and an opal deposit. Limited exploration for diamonds occurred in Wyoming; however, diamonds were recovered from a breccia pipe in the Greater Green River Basin. Exploration activities continued for gold in the state; a discovery was reported at an undisclosed location. The Metals and Precious Stones Section at the Wyoming State Geological Survey (WSGS) led some educational field trips throughout the year, ending the year with a trip to South Pass.

Iolite

During this past summer, the Metals and Precious Stones Section identified two significant gemstone deposits, adding to other discoveries made in recent years. A significant iolite-kyanite-sapphire-ruby deposit was identified at Grizzly Creek, south of Palmer Canyon in the central Laramie Mountains and a major opal deposit was identified in central Wyoming.

The iolite-kyanite-sapphire-ruby deposit has a very similar geological setting to Palmer Canyon. The Grizzly Creek discovery contains some extraordinary sky-blue, transparent to translucent kyanite specimens that are 3 to 4 inches in length. These minerals will undoubtedly produce some very nice semi-precious stones. The ruby and sapphire at this site is not as common as at Palmer Canyon and therefore, does not appear to be much of a significant resource. However, the iolite is as good as that found at Palmer Canyon, appearing to have more tonnage and some very large gemstones. For example, one of the largest gemstones found at Palmer Canyon weighed over 1500 carats. The largest stone found at Grizzly Creek has not been weighed as it contains some rock material mixed in with the gem material. Even so, this highly fractured gem mass is the size of a football and could potentially contain as much as 5000 carats of gem material.

Few people know that the primary source for the iolite gemstone is Sri Lanka, where it is produced as a placer mineral. Generally, the size of the material from Sri Lanka is less than 10 carats. Based on the Palmer Canyon and Grizzly Creek deposits, as well as some other iolite found in the anorthosite complex east of Laramie by the WSGS last winter, Wyoming could become the primary source for this extraordinary gemstone with some proper marketing strategies. The WSGS released Open File Report 04-14, entitled *Geological reconnaissance of the Grizzly Creek gemstone deposit, Laramie Mountains, Wyoming—Potential source for iolite, sapphire, ruby, and kyanite*, in November. This report can be ordered through the WSGS sales office, see **New Publications Available from the WSGS**.

Opal

A prospector from Riverton led the WSGS to an opal deposit in central Wyoming. Since the initial field examination, the WSGS has mapped the opals over a large area covering parts of eleven sections, making this one of the largest opal deposits in North America. The mineralized zone occurs in the White River Formation and ranges in thickness from a few feet to upwards of 100 feet thick. A variety of opal has been recovered including milky white, transparent, yellow, green, brown, and gray, with several of the specimens exhibiting color play. The material also includes many massive unfractured opals weighing hundreds of carats each. Further investigations are scheduled for this location.

Diamonds

During the past field season, several companies contacted the WSGS, showing interest in searching for diamonds in Wyoming. However, only limited exploration occurred. Diamonds were recovered by one company exploring the Greater Green River Basin. The diamonds were extracted

from two different bulk samples on a Tertiary-age breccia pipe south of Green River. So far, diamonds have been extracted in Wyoming from Precambrian metaconglomerates in the Medicine Bow Mountains, from Early Cambrian and Early Devonian kimberlites, from a Tertiary breccia pipe, and from some placers. Very recently, a major Canadian diamond company recognized a prominent structure that appears to control many of the kimberlites and anomalies. They tentatively announced intentions to initiate exploration in Wyoming.

Gold

Gold continued to attract attention in the state with several exploration projects reported by various companies. One potentially major gold discovery was reported at an undisclosed location. In addition, there are serious concerns over withdrawing the Jack Morrow Hills study area south of South Pass, as this area includes portions of the Oregon Buttes-Continental Peak auriferous conglomerate. Based on past resource estimates by the U.S. Geological Survey, this deposit may represent one of the largest (if not the largest) undeveloped gold deposits in North America. If this study area is withdrawn, it will prevent anyone from searching for potential deposits of any mineral.

Field trips

The Section led some educational field trips during the summer—the final field trip for the season was to South Pass. More than 100 people attended the field trip to learn about mining history, geology, and gold prospecting (**Figures 15** and **16**). Some of the stop highlights included the Duncan gold mine where the attendees were able to view a gold-bearing ore shoot first hand (**Figure 17**). The group also visited the Carissa gold mine, historically the state's largest gold producer. This mine still contains a large gold deposit with potentially tens of millions of dollars in gold surrounding the historic mine workings (**Figure 18**). The property was recently incorporated into the Wyoming State Park system, limiting possible development in the future. The group also had a chance to view the historic Oregon Buttes gold paleoplacer (**Figure 19**). The source of the gold in the paleoplacer has never been found, but geological evidence suggests that the source could lie at depth in front (north) of the buttes.

Figure 15 (above). A large group of attendees, rivaling this year's caravan, listen to a geology lecture by W. Dan Hausel at the South Pass field trip in 2003 (photograph by Sharon Hall).
Figure 16 (right). Caravan of vehicles line up at the 2004 field trip sponsored by the Rocky Mountain Prospectors and Treasure Hunters Club and the Wyoming State Geological Survey (photograph by Shawn Hart).

Figure 17 (above). Propectors get a first hand look at a ore shoot developed at the Duncan gold mine (photograph by Shawn Hart).
Figure 18 (lower left). View of the imprisoned Carissa gold mine (photograph by Shawn Hart).
Figure 19 (lower right). Overlook of Oregon Buttes, site of possibly the largest undeveloped gold occurrence in North America.

Rock Hound's Corner: Garnet

W. Dan Hausel, Wyoming PG-1025

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

Garnet is a relatively common mineral found in many of Wyoming's mountains, as well as in kimberlitic intrusives scattered in the mountains and basins. It is also found in black sand concentrates in many streams. However, many people do not realize that this particular mineral can produce some extraordinary gemstones and Wyoming has one of the better gem-pyrope deposits in the world (see http://www.wsgs.uwyo.edu/metals/gemstones.aspx).

Garnet includes six end-members known as pyrope [$Mg_3Al_2(SiO_4)_3$], almandine [$Fe_3Al_2(SiO_4)_3$], spessartine [$Mn_3Al_2(SiO_4)_3$], grossularite [$Ca_3Al_2(SiO_4)_3$], andradite [$Ca_3Fe_2(SiO_4)_3$], and uvarovite [$Ca_3Cr_2(SiO_4)_3$]. Pyrope and almandine end-members are common in Wyoming. They produce durable gemstones because they have a relatively high hardness (6.5 to 7.5). They are relatively easy to recover in stream concentrates because of their high specific gravity (3.58 to 4.31).

The typical crystal habit for garnet is a well-crystallized dodecahedral and trapezoidal crystal. However, pyrope is nearly always found as equal dimensional rounded grains and rarely has preserved crystal faces (**Figure 20**).

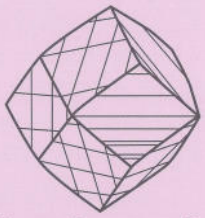

Figure 20. Characteristic dodecahedral crystal habit seen in many well-crystallized garnets.

Garnets have been known to range is size from tiny microscopic grains to giant crystals up to several feet in diameter. However, gem-quality garnet is typically restricted to small crystals less than a centimeter (.39 inch) in diameter.

Almandine garnet is an iron aluminum silicate that may contain variable amounts of the pyrope and spessartine garnet. Almandine is typically found in many aluminum-rich metamorphic rocks including mica schist and gneiss. Pyrope and a solid solution mixture of pyrope and almandine referred to as pyrope-almandine is found in some ultramafic (magnesium-rich, silica poor) rock such as peridotite, serpentinite, some lamprophyres, kimberlite, and in rare schists and gneisses. Some rare, fist-sized, highly-fractured pyrope-almandine garnets were found several years ago in some kimberlites in the Colorado-Wyoming State Line district south of Laramie (**Figure 21**).

Garnet is usually considered an important gemstone because of its brilliance, fire, and color varieties, but the value of garnet gemstones is generally low because of the abundance of the mineral worldwide. Garnets have a wide range

Figure 21. Large pyrope-almandine garnet (left) from the State Line district sits adjacent to chlorite pseudomorph after almandine (right) from the Sierra Madre, with a well-formed almandine garnet from the Teton Range (bottom).

in color from red, reddish-purple, yellow-orange, green, brown, reddish-brown, yellow, white, and black. Nearly every color except blue has been observed in garnet. Reddish garnets are generally a lower value gemstone because of abundance, the more valuable garnets are rare, bright-green varieties that have trade names such as demantoid (chromian andradite) and tsavorite (vanadian grossular)—neither of which have been identified in Wyoming.

Pyrope

Deep-red to purplish-red gem pyropes are sometimes referred to as *Kimberley rubies* or *Cape rubies* that are found in kimberlites. The main chromophore in pyrope is chromium, and iron substitution in the tetrahedral position of the crystal structure will amplify the ruby red color of the garnet whose standard is the famous Bohemian pyropes of the Czech Republic. A uvarovite component in solid solution with pyrope will result in an *alexandrite effect* that gives the garnet a bluish-green appearance in sunlight and pinkish-crimson color in incandescent light. Some pyropes with up to 30% almandine in solid solution are light-pink to light-pale crimson—these ferruginous pyropes are referred to as *rhodolite*. Some reddish-orange and orange pyropes contain only a trace of chromium, they are colored by the presence of Fe^{2+} and Ti^{4+} in the crystal lattice instead. Gem-quality pyropes vary from 2 to 6 mm (0.079 to 0.24 inch) in size with rare stones up to 3 cm (~1 inch).

Almandine

Substitution of Mn for Fe imparts an orange tint to this gemstone; high iron results in a less desirable opaque to translucent, dark-reddish color, and such stones are primarily cut as cabochons. With increasing amounts of pyrope and spessartine, the almandine garnet will exhibit greater transparency and some of these are faceted rather than cabbed. Transparent almandine gemstones are typically less than 7 mm (0.28 inch) in diameter.

Almandine found in metamorphic schists and gneisses may be well crystallized and exhibit distinct crystal faces, whereas almandine from kimberlites is typically rounded. Some very large pyrope-almandine metacrysts up to 10 cm (~4 inches) across have been found in kimberlites in Wyoming. Oriented needle-like mineral inclusions of augite or hornblende in rare almandines may produce 4-rayed stars in polished gemstones.

Wyoming

Gem-quality pyrope and almandine have been found in Wyoming (**Figure 22**). The Wyoming pyrope rivals the best quality pyrope gems in the world and often produces better gemstones than the well-known and popular Bohemian garnet jewelry. Only pyropes from the four-corner region (in particular Arizona) come close to matching the quality of the Wyoming gems.

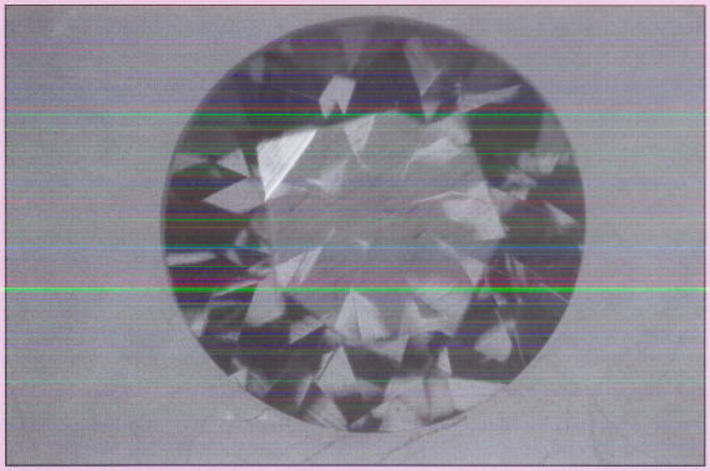

Figure 22. Fancy cut pyrope garnet gem from the Green River Basin.

The two largest kimberlite districts in the U.S. are located in Wyoming. These include the Iron Mountain district north of Cheyenne and the Colorado-Wyoming State Line district south of Laramie. Both districts include diamondiferous kimberlites that intrude the Proterozoic basement complex along the margin of the Wyoming craton. Although pyropes are found in both districts, some of the kimberlites in the State Line district contain appreciable pyrope. A variety of pyropes can be found within the district including red, reddish-brown, yellow-orange, and burgundy stones. Very few of the stones have been cut as gems even though a very large number are gem quality.

The better gems are found in the Green River Basin in southwestern Wyoming; a large kimberlitic indicator mineral anomaly was outlined within this area. The anomaly includes pyropes, almandines, chromian diopsides, and chromian enstatites found in anthills, the Bishop Conglomerate (Oligiocene), stream alluvium, and a small group of diamondiferous breccia pipes along the edge of Cedar Mountain. Many of the pyropes in anthills range in size from 1 to 8 mm (0.039 to 0.315 inch) across with some recovered from the breccia pipes that are as large as 12 mm (0.47 inch). Most are transparent, red, purplish-red, and yellow-orange and can be faceted. Several very attractive gemstones have been cut from these garnets.

A source for similar high-quality gem pyrope and almandine has recently been identified in anthills both east and west of Worland in the Bighorn Basin. These gemstones will undoubtedly lead to undiscovered kimberlitic or lamprophyre pipes, and possibly to a whole new diamond district in that region. Some of these gemstones exhibit good sizes (1 to 6 mm or 0.039 to .024 inch) and all have been excellent transparent pink, red, and burgundy stones.

Some extraordinary euhedral garnet pseudomorphs are found near Encampment in the Sierra Madre of southeastern Wyoming. These garnets have no value as gems, but are attractive to collectors. The garnets occur in chlorite schist near Encampment and form excellent dodecahedrons ranging in size from about 6.4 mm to 10 cm (0.25 to 4 inches) across. These Oldman garnets form near perfect chlorite pseudomorphs after almandine. Most specimens have an almandine core surrounded by chlorite, which has taken on the almandine crystal habit.

GEOLOGIC MAPPING AND HAZARDS UPDATE

Geologic Mapping, Paleontology, and Stratigraphy Update

Alan J. Ver Ploeg, Wyoming PG-1587

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The Geologic Mapping Section recently revised and digitized two preliminary geologic maps of the Poker Butte and Hole-in-the-Wall 1:24,000-scale quadrangles. These quadrangles are the first out of twelve maps of the southern Bighorn Mountains (that were mapped during a project that began in 1985), to be completed and released as digital products.

The Mapping Section at the Wyoming State Geological Survey (WSGS), with funding from STATEMAP 2003, mapped and compiled the geology for the Casper 1:100,000-scale Quadrangle and submitted it as a contract deliverable to the U.S. Geological Survey (USGS) in early August. The completion of this map was prompted by the southward expansion of the Northern Powder River Basin geologic, hydrologic, and water quality database project; it also satisfied the WSGS Mapping Program priority of mapping the more populated areas in Wyoming.

Three new articles relating to Wyoming geology and stratigraphy were released recently. The articles discuss 1) the burial history, thermal maturity, and timing of petroleum generation for eight key source rock horizons at seven localities within the Southwestern Wyoming Province; 2) the structural mechanisms responsible for multi-stage migration and formation of vertically segregated Paleozoic oil pools in Torchlight Field on the east flank of the Bighorn Basin; and 3) the Fivemile fault-related fold trend in the central Bighorn Basin.

New digital geologic quadrangle maps

The WSGS recently completed revising and digitizing two preliminary geologic maps covering the Poker Butte and the Hole-in-the-Wall 1:24,000-scale quadrangles. Preliminary versions of these geologic maps were released in 1998 as PGM 98-1 and 98-2, respectively, as part of a project that began in 1985 to map the southern Bighorn Mountains. They are the first of twelve quadrangles (**Figure 23**) to be completed and released as digital products.

The maps are titled *Geologic map of the Hole-in-the-Wall Quadrangle, Johnson County, Wyoming* and *Geologic map of the Poker Butte Quadrangle, Johnson County, Wyoming*, and are numbered OFR 04-12 and OFR 04-13, respectively. They are 1:24,000-scale, digital color geologic maps that include cross-sections to illustrate the structure of each area. For information on these maps and any others available from the WSGS, contact Alan Ver Ploeg at 307/766-2286, extension 230.

Bedrock ranging from the Cretaceous Frontier Formation on the east end of the mapped area to the Cambrian Gros Ventre Formation on the west, dips relatively uniformly off the east flanks of the southern Bighorn Mountains into the Powder River Basin. Conglomerates of the Tertiary Wasatch and White River formations have been tentatively identified on the Poker Butte Quadrangle. Numerous Quaternary terrace deposits occur along the Middle Fork of the Powder River and Buffalo Creek. Structure on the two quadrangles is limited to some isolated low amplitude folds and minor offset normal and reverse faults. These features are related to the northeast-southwest oriented Laramide compressional forces that created the Bighorn Mountains.

As an interesting historical sidelight, the east-west oriented fold mapped near the southeast corner of the Poker Butte Quadrangle deflected the northerly flow of Buffalo Creek toward the east. Buffalo Creek then made another right angle bend back to the north around the plunging nose of the fold creating the feature known as the Hole-in-the-Wall (**Figure 24**). The Hole-in-the-Wall is a narrow notch eroded in a nearly continuous, vertical cliff of Triassic Chugwater Formation, locally referred to as the "Red Wall." This sig-

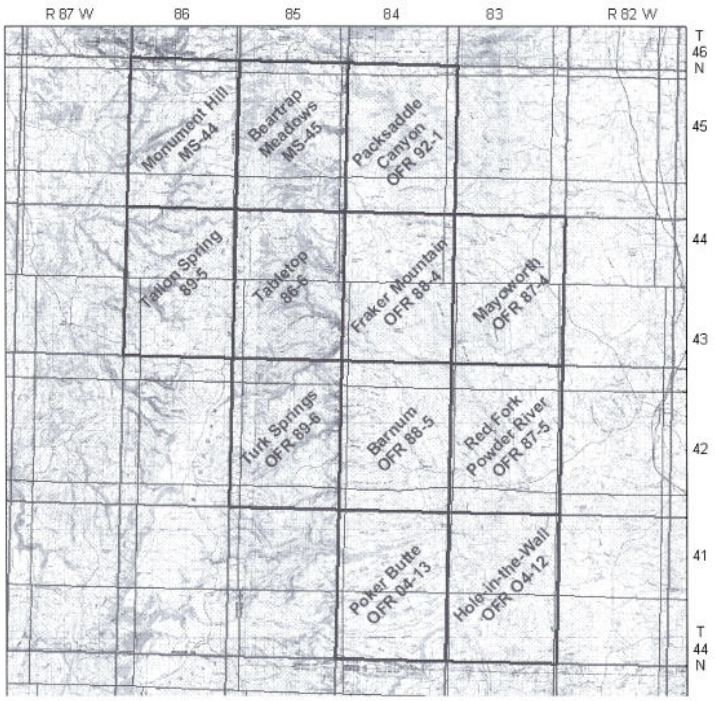

Figure 23. Index to 1:24,000-scale geologic maps completed as part of the southern Bighorn Mountains mapping project.

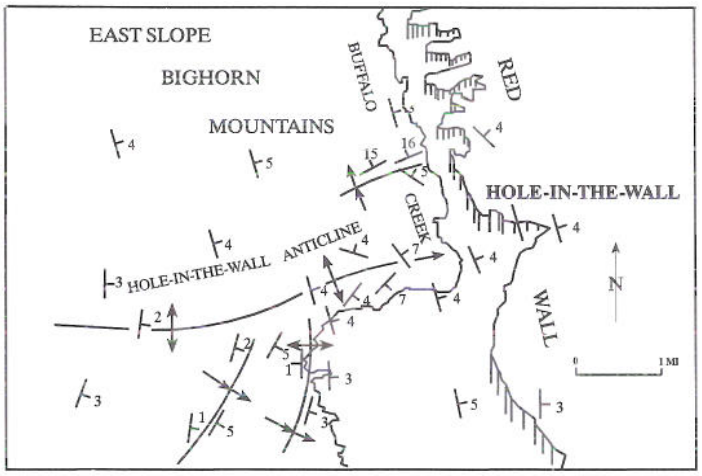

Figure 24. Diagram illustrating the Hole-in-the-Wall anticline and its relationship to the famous Hole-in-the-Wall topographic feature.

nificant topographic feature runs for almost 25 miles from north to south along the east slope of the southern Bighorn Mountains. The Hole-in-the-Wall and the area around it was made famous by various groups of outlaws, rustlers, and army deserters who used this erosional feature as a hidden route in and out of the rugged surrounding area that served as a hideout for many years. Probably the most notable of the outlaws were Butch Cassidy and the Sundance Kid, and their famous Hole-in-the-Wall gang.

...Tensleep Sandstone dip slope on the eastern flank of the southern Bighorn Mountains represents a major recharge area for many of the aquifers in the area.

Interest in the hydrogeology and minerals in the area prompted the completion of these maps. On the Poker Butte Quadrangle, the Tensleep Sandstone dip slope on the eastern flank of the southern Bighorn Mountains represents a major recharge area for many of the aquifers in the area. Over the past several years, the Geologic Mapping Section has received requests for information on the general geology and structure of the area to aid in siting water wells in the vicinity of local ranches. Bentonite is mined from the Frontier Formation cropping out in the northeastern corner of the Hole-in-the-Wall Quadrangle. There is potential to extend these mines to the west and south based on the southerly trend of the Frontier, as illustrated by the map. In addition, numerous terrace deposits mapped on both quadrangles could serve as a local source for sand and gravel.

Casper Quadrangle

The Mapping Section, with funding from STATEMAP 2003, completed mapping and compiling the geology for the Casper 1:100,000-scale Quadrangle in early August and submitted a contract deliverable to the USGS. The completion of this map was prompted by the southern expansion of the Northern Powder River Basin geologic, hydrologic, and water quality database project. It also satisfied the Mapping Program's priority of mapping the more populated areas in the state. The completion of the Casper geologic map was initiated in 1996 by John Hunter, a mapping volunteer then employed by Power Resources in Casper. John compiled about 60% of the map before returning to England with his family. The map was turned over to the Mapping Section and it was proposed for completion as subproject 1 of STATEMAP 2003. The Mapping Section completed the unfinished work on the northeastern corner of the map and the southwestern segment of the map in the Shirley Basin area. Additional work was required to eliminate edge-matching problems with the various map sources used in the compilation.

The Casper Quadrangle is located in central Wyoming (**Figure 25**) and includes bedrock ranging in age from Precambrian to Oligocene. The dominant structural features included in the map area are the Casper Arch and the Casper Mountain uplift, with their associated structures. The Casper uplift includes Precambrian, Paleozoic, and Mesozoic outcrops. This feature and associated structures cover the southern half of the map. Much of the remaining quadrangle includes Cretaceous outcrops dipping toward the east-northeast, capped by Tertiary rocks in the southwestern and southeastern corners. The axis of the Powder River Basin runs northwest to southeast, approximately 25 miles northeast of the quadrangle.

The petroleum and mineral industry have traditionally driven the growth of the Casper area. Oil production has historically occurred from the smaller structural traps which rim the edge of the southeastern corner of the Wind River Basin on the western side of the map and from stratigraphic traps on the southwestern flank of the Powder River Basin on the eastern side of the map. Two active bentonite mills located in Casper process bentonite transported from mines in the Kaycee area on the southeastern flank of the Bighorn Mountains, north of the quadrangle. Decorative stone is mined from various localities around Casper Mountain. Sand, gravel, and other types of aggregate are quarried from the numerous terrace deposits flanking the North Platte River and support the construction industry in Wyoming's largest population center.

The WSGS will release this map as an Open File Report in December and we encourage users to review and submit any comments or corrections concerning the map to the WSGS at that time. This will allow us to publish the final version of the map with up-to-date and accurate geologic information.

New publications on Wyoming geology

In a recently published article, Roberts and others (2004) modeled the burial history, thermal maturity, and timing of petroleum generation for eight key source rock horizons at seven localities within the Southwestern Wyoming Province. The bases of the Phosphoria Formation, Mowry Shale, Niobrara Formation, Baxter Shale, upper Mesaverde Group,

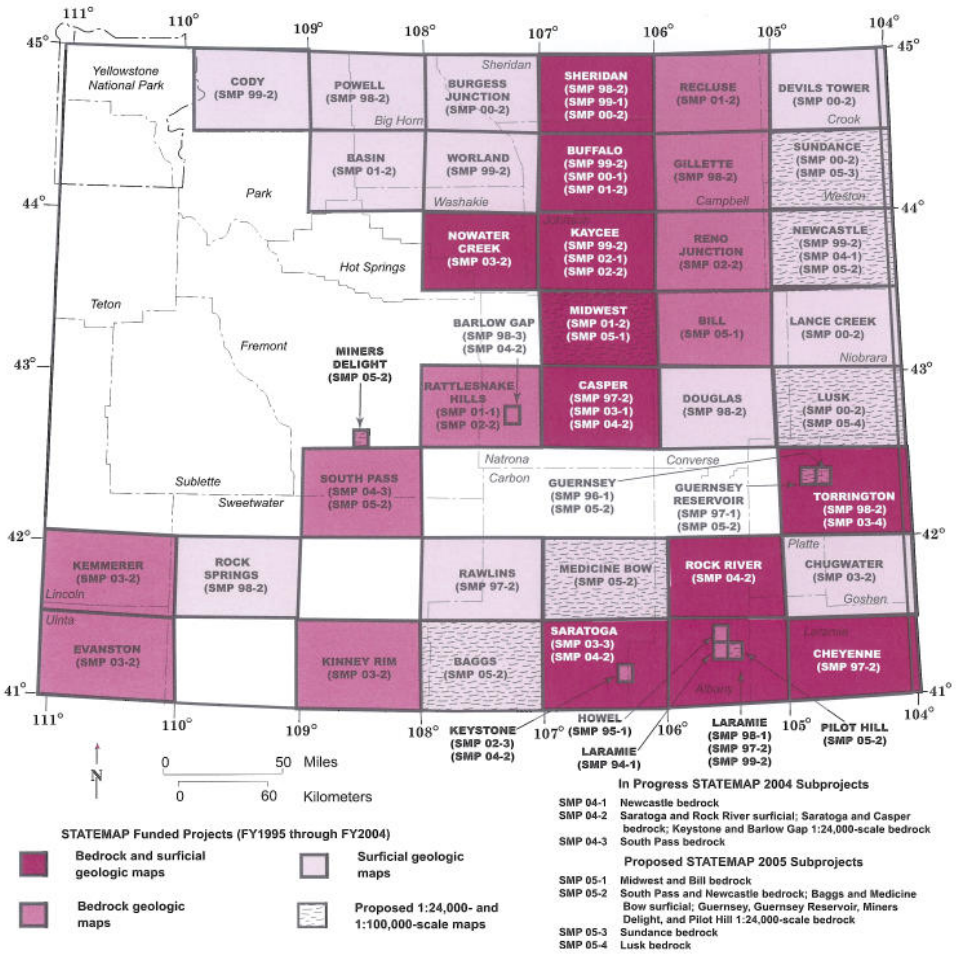

Figure 25. Index to funded, in-progress, and completed STATEMAP projects in Wyoming.

Lewis Shale, Lance Formation, and Fort Union Formation make up the horizons modeled. Burial history locations were chosen in areas of deep burial, intermediate burial, and shallow burial. The results of the modeling indicate that burial history, thermal maturity, and timing of petroleum generation can vary widely depending on location within the province and on source-rock type. The authors detailed these results specific to the locations and depths for each selected horizon in the paper, providing information essential to delineating areas of petroleum generation and for assessing the petroleum resources for the province.

Stone (2004a) detailed the structural mechanisms responsible for multi-stage migration and formation of vertically segregated Paleozoic oil pools in Torchlight Field on the eastern flank of the Bighorn Basin, south of Greybull. Torchlight Field is located in the hanging wall of the west verging Rio thrust, which separates the deeper Bighorn Basin from the uplifted hanging wall Greybull monocline and platform. The proposed explanation for the vertical segregation of oil pools in Torchlight and adjacent Lamb fields centers around the spilling of earliest migrated Phosphoria oil out of the original Paleozoic common pool structural trap, and adjusting to reduced closure brought on by late Laramide tilting basinward of the Greybull platform. Inter-reservoir plugging of fractures and fine pores by cementation, clay, or asphalt along with reduced permeability to oil in a lower temperature and pressure environment prompted this oil pool segregation. The author suggested that this style of trapping mechanism should be considered in future exploration for Paleozoic objectives elsewhere in the Greybull platform.

The first article in a series on structures in the Rocky Mountain Foreland described the Fivemile fault-related fold trend in the central Bighorn Basin. Stone (2004b) prepared a short review of the fold trend with the aid of an interpreted, time-migrated, reflection seismic profile across the trend. The author felt there are some interesting questions that surface from this review. First, what is the possible relationship of the unusual 50-mile length of the Fivemile and Tatman fold trends and the rejuvenated Precambrian zones of weakness? Second, what is the significance of the difference in strike between these northwest-trending structures and the more northerly trending Rio and Oregon Basin thrusts and what is the possible relationship to the proposed left lateral couple on the Tensleep fault? Finally, how is the development of these structures related to movements on the east-west trending Tensleep fault, against which these structures appear to terminate on the southeast?

References cited

Roberts, L.N.R., Lewan, M.D., and Finn, T.M., 2004, Timing of oil and gas generation of petroleum systems in the southwestern Wyoming province: The Mountain Geologist, v. 41, no. 3, p. 87-118.

Stone, D.S., 2004a, Rio Thrusting, multi-stage migration, and formation of vertically segregated Paleozoic oil pools at Torchlight field on the Greybull platform (eastern Bighorn Basin): Implications for exploration: The Mountain Geologist, v. 41, no. 3, p. 119-138.

Stone, D.S., 2004b, Structures of the Rocky Mountain foreland: Fivemile fault-related fold trend, central Bighorn Basin: The Mountain Geologist, v. 41, no. 3, p. 140-142.

HAZUS-MH Assessments of Potential Earthquake Damage for Wyoming Counties

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Potential earthquake damage estimates have been generated for all Wyoming Counties using the Federal Emergency Management Agency's (FEMA) HAZUS-MH, which was described in *Wyoming Geo-notes No. 80*. Wyoming is the national test state for using HAZUS-MH at the census-block level of analysis. The program is currently being tested, and modifications are still being made. As a result, some of the figures presented below may change slightly, but probably not more than one or two percent.

For the first time, possible earthquake damage estimates have been generated for all Wyoming counties. The estimates indicate that western Wyoming counties have the greatest potential impact from earthquakes...

The results of the HAZUS-MH analysis for each county are presented in **Table 17**. The analyses are based upon 2,500-year probabilistic ground accelerations with user-defined data as described in *Wyoming Geo-notes No. 80*. There are two methods to rank the counties to determine where earthquake impacts may be the greatest. Either the loss ratios (**Table 18**) or total damage (**Table 19**) figures can be used. The loss ratio is determined by dividing the sum of the structural and non-structural damage by the total building value for the county. The loss ratio is a better measure of impact for a county as it gives an indication of the percent of damage to buildings. The total damage figure by itself does not reflect the percentage of building damage. If a county has a number of valuable buildings, such as Laramie County, small damage to a number of valuable buildings may result in a higher total damage figure that may be found in a county with fewer, less expensive buildings with a higher percentage of damage.

Regional impacts of earthquakes

Using the loss ratios in **Table 18**, Lincoln, Teton, Uinta, and Sublette counties would have the most significant impact from earthquakes. This is consistent with probabilistic acceleration maps (*Wyoming Geo-notes No. 67*), and projected damage potential from exposed active fault models. Total dollar loss in those counties is projected to be $1,373,332,000. That dollar amount, however, reflects damage that could occur from the largest expected earthquakes in each county. As a result, the figure is best used only to set priorities for future research and to rank regions of the State.

The second most impacted areas would be Hot Springs, Converse, Natrona, Fremont, Washakie, Johnson, Carbon, Park, and Sweetwater counties. Total dollar loss in those counties is projected to be $729,054,000. As above, the figure represents damage from multiple earthquakes, not a single event.

The third most impacted areas would be Big Horn, Albany, Sheridan, Platte, and Campbell counties. Total dollar loss in those counties is projected to be $$203,153,000. As above, the figure represents damage from multiple earthquakes, not a single event.

The counties with the least impact would be Laramie, Niobrara, Goshen, Crook, and Weston counties. Total dollar loss in those counties is projected to be $119,889,000. This is consistent with probabilistic acceleration maps, and projected damage potential from exposed active fault models. As above, the figure represents damage from multiple earthquakes, not a single event.

Summary

Earthquakes have occurred in all counties in Wyoming. For the first time, possible earthquake damage estimates have been generated for all Wyoming counties. The estimates indicate that western Wyoming counties have the greatest potential impact from earthquakes in terms of building loss ratios, which are determined by dividing the sum of the structural and non-structural damage by the total building value for the county. Lincoln County has the highest building loss ratio, followed by Teton County.

The Wyoming State Geological Survey is continuing to work with FEMA on refining HAZUS-MH, which was used to generate the loss estimates. In addition, site-specific data are now being analyzed.

Table 17. HAZUS-MH damage estimates for Wyoming counties.

County	Capital stock losses (thousands of dollars)				Loss Ratio	Income losses (thousands of dollars)				Total loss (thousands of dollars)
	Structural	Non-structural	Contents	Inventory		Relocation	Capital	Wages	Rental	
Albany	9,714	36,865	13,946	151	2.32%	276	2,717	3,198	4,210	71,077
Big Horn	3,470	12,203	4,647	65	2.43%	84	533	694	963	22,659
Campbell	5,116	20,093	9,419	282	1.37%	144	1,484	2,013	1,592	40,143
Carbon	7,145	26,325	10,472	169	3.08%	186	2,117	2,700	2,454	51,568
Converse	6,054	24,172	9,787	185	4.15%	152	984	1,303	1,845	44,482
Crook	836	2,640	896	17	1.04%	21	107	139	211	4,867
Fremont	14,897	61,035	24,638	463	3.75%	380	2,917	3,939	4,425	112,694
Goshen	2,168	6,982	2,543	69	1.13%	57	392	528	623	13,362
Hot Springs	3,038	10,871	4,176	52	4.20%	82	799	1,149	969	21,136
Johnson	3,293	13,062	5,514	94	3.40%	86	557	648	1,066	24,320
Laramie	13,605	47,839	17,577	233	1.25%	406	3,926	4,402	4,976	92,964
Lincoln	65,670	225,594	62,429	2,538	31.08%	1,211	8,579	10,359	15,347	391,727
Natrona	36,964	137,379	57,269	1,149	3.99%	981	9,890	13,033	12,245	268,910
Niobrara	423	1,585	617	12	1.20%	12	72	83	132	2,936
Park	11,430	42,694	15,289	429	2.98%	285	5,173	6,217	4,487	86,004
Platte	1,875	6,894	2,697	36	1.60%	51	326	418	554	12,851
Sheridan	7,830	29,154	12,057	233	2.09%	213	1,898	2,402	2,636	56,423
Sublette	9,654	30,667	9,436	222	8.24%	206	2,438	3,052	2,665	58,340
Sweetwater	12,782	50,213	20,753	542	2.84%	313	2,180	2,514	3,719	93,016
Teton	92,477	359,169	110,323	2,402	24.72%	1,821	37,784	43,975	34,030	681,981
Uinta	39,912	135,111	38,841	1,007	15.84%	782	5,888	8,741	11,004	241,286
Washakie	4,115	13,761	5,656	134	3.54%	99	904	1,019	1,236	26,924
Weston	897	3,016	1,085	21	0.96%	26	147	266	302	5,760

Table 18. County impacts rated by loss ratio.

County	Loss ratio	Total loss (thousands of dollars)
Lincoln	31.08	391,727
Teton	24.72	681,981
Uinta	15.84	241,284
Sublette	8.24	58,340
Hot Springs	4.20	21,136
Converse	4.15	44,482
Natrona	3.99	268,910
Fremont	3.75	112,694
Washakie	3.54	26,924
Johnson	3.40	24,320
Carbon	3.08	51,568
Park	2.98	86,004
Sweetwater	2.84	93,016
Big Horn	2.43	22,659
Albany	2.32	71,077
Sheridan	2.09	56,423
Platte	1.60	12,851
Campbell	1.37	40,143
Laramie	1.25	92,964
Niobrara	1.20	2936
Goshen	1.13	13,362
Crook	1.04	4867
Weston	0.96	5760

Table 19. County impacts rated by dollar loss.

County	Total loss (thousands of dollars)	Loss ratio
Teton	681,981	24.72
Lincoln	391,727	31.08
Natrona	268,910	3.99
Uinta	241,286	15.84
Fremont	112,694	3.75
Sweetwater	93,016	2.84
Laramie	92,964	1.25
Park	86,004	2.98
Albany	71,077	2.32
Sublette	58,340	8.24
Sheridan	56,423	2.09
Carbon	51,568	3.08
Converse	44,482	4.15
Campbell	40,143	1.37
Washakie	26,924	3.54
Johnson	24,320	3.40
Big Horn	22,659	2.43
Hot Springs	21,136	4.20
Goshen	13,362	1.13
Platte	12,851	1.60
Weston	5760	0.96
Crook	4867	1.04
Niobrara	2936	1.20

PUBLICATIONS UPDATE

New Publications Available from the Wyoming State Geological Survey

Wyoming State Geological Survey publications

Wyoming State Geological Survey publications catalog, August 2003: Available on CD-ROM or 40 p. printed catalog - FREE.

Fossils of Wyoming, by M.W. Hager, 1970: digital version of Bulletin 54, CD-ROM only - $5.00.

Thermal springs of Wyoming, by R.M. Breckenridge and B.S. Hinckley, 1978: digital version of Bulletin 60 (Includes Bulletin 19, The mineral hot springs of Wyoming, by A.B. Bartlett, 1926), CD-ROM only - $5.00.

A geologic tour of Wyoming from Laramie to Lander to Jackson and Rock Springs, by B Mears, Jr. and others, 1986: digital version of Public Information Circular 27, CD-ROM only - $5.00.

*Geologic map of the Nowater Creek 30′ x 60′ Quadrangle, Washakie, Hot Springs, and Johnson Counties, Wyoming, by A.J. Ver Ploeg, 2004: Map Series MS-39, 1:100,000 - $25.00.

*Industrial minerals and construction materials map of Wyoming, by R.E. Harris, 2004: Map Series MS-47, 1:500,000 - $30.00.

*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, 2004: Map Series 56 (updated to September 1, 2004, replaces March, 2004 version), 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, 2004: Map Series 57 (updated to September 1, 2004, replaces March, 2004 version), 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, 2004: Map Series 58 (this is a reduced and combined version of MS-56 and MS-57 at 1:250,000 scale, updated to September 1, 2004, replaces March, 2004 version), on-demand plotted and laminated color map, rolled only - $50.00; on-demand plotted color map, rolled only - $40.00; ESRI® ArcGIS®/ArcReader® format on CD-ROM (including MrSid® viewable files) - $50.00.

Geologic map of the Reno Junction 30′ x 60′ Quadrangle, Campbell and Weston counties, Wyoming, by A.J. Ver Ploeg and C.S. Boyd, 2003: Map Series 62 (scale 1:100,000), plotted color map, rolled only - $25.00.

Geologic map of the Kaycee 30′ x 60′ Quadrangle, Johnson and Campbell counties, Wyoming, and southeastern Montana, by A.J. Ver Ploeg, C.S. Boyd, and J.M. Mulbay, 2004: Map Series 63 (scale 1:100,000), plotted color map, rolled only - $25.00.

Geologic map of the Sheridan 30′ x 60′ Quadrangle, Sheridan, Johnson, and Campbell counties, Wyoming, and southeastern Montana, by A.J. Ver Ploeg and C.S. Boyd, 2003: Map Series 64 (scale 1:100,000), plotted color map, rolled only - $25.00.

Structure contour and isopach maps of the Fox Hills Sandstone, northern Powder River Basin, northeastern Wyoming, by R.H. De Bruin, A.J. Ver Ploeg, R.M. Lyman, N.R. Jones, and J.C. Case, 2003: Open File Report 03-1, plotted color map and text, 1 sheet, rolled only - $10.00.

Structure contour and isopach maps of the Lance Formation, northern Powder River Basin, northeastern Wyoming, by A.J. Ver Ploeg, R.H. De Bruin, R.M. Lyman, N.R. Jones, and J.C. Case, 2003: Open File Report 03-2, plotted color map and text, 1 sheet, rolled only - $10.00.

Structure contour and isopach maps of the Bearpaw/Pierre Shale, northern Powder River Basin, northeastern Wyoming, by R.M. Lyman, R.H. De Bruin, A.J. Ver Ploeg, N.R. Jones, and J.C. Case, 2003: Open File Report 03-3, plotted color map and text, 1 sheet, rolled only - $10.00.

Structure contour and isopach maps of the Fort Union Formation, northern Powder River Basin, northeastern Wyoming, by N.R. Jones, R.M. Lyman, A.J. Ver Ploeg, R.H. De Bruin, and J.C. Case, 2003: Open File Report 03-4, plotted color map and text, 1 sheet, rolled only - $10.00.

Preliminary surficial geologic map of the Midwest 30′ x 60′ Quadrangle, Natrona, Converse, and Johnson counties, Wyoming, by L.L. Hallberg and J.C. Case, 2003: Open File Report 03-5 (scale 1:100,000), plotted color map, rolled only - $25.00.

Preliminary surficial 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, 2003, Open File Report 03-6 (scale 1:100,000), plotted color map, rolled only - $25.00.

Preliminary surficial geologic map of the Bill 30′ x 60′ Quadrangle, Converse, Campbell, and Weston counties, Wyoming, by L.L. Hallberg and J.C. Case, 2003: Open File Report 03-7 (scale 1:100,000), plotted color map, rolled only - $25.00.

Carbon dioxide (CO_2) map of Wyoming, by R.H. De Bruin, C.W. Cook, and J.M. Huss, 2004: Open File Report 04-1 (scale 1:500,000), plotted color map, rolled only - $30.00.

Wyoming multi-hazards flood map modernization state business case plan FY 2004-2008, by J.C. Case and E.A. Dobler, 2004, Open File Report 04-2, 28 pages copied - $4.20.

*Preliminary surficial geologic map of the Nowater Creek 30′ x 60′ Quadrangle, Washakie, Hot Springs, and Johnson Counties, Wyoming, by L.L. Hallberg and J.C. Case, 2004: Open File Report 04-3, 1:100,000 - $25.00.

*Preliminary surficial geologic map of the Chugwater 30′ x 60′ Quadrangle, Wyoming, by J.C. Case and L.L. Hallberg, 2004: Open File Report 04-4, 1:100,000 - $25.00.

*Geologic map of the Kinney Rim 30′ x 60′ Quadrangle, Sweetwater County, Wyoming and Moffat County, Colorado, by H.W. Hoehler, 2004: Open File Report 04-5, 1:100,000 - $25.00.

*Geologic map of the Evanston 30′ x 60′ Quadrangle, Uinta and Sweetwater Counties, Wyoming, by J.H. Dover and J.W. M'Gonigle, 2004: Open File Report 04-6, 1:100,000 - $25.00.

*Geologic map of the Kemmerer 30′ x 60′ Quadrangle, Lincoln, Uinta, and Sweetwater Counties, Wyoming, by J.W. M'Gonigle and J.H. Dover, 2004: Open File Report 04-7, 1:100,000 - $25.00.

*Geologic map of the Saratoga 30′ x 60′ Quadrangle, Wyoming (b&w version), by W.M. Sutherland and W.D. Hausel, 2004: Open File Report 04-10, 1:100,000 - $25.00.

*Geologic map of the Saratoga 30′ x 60′ Quadrangle, Wyoming (color version), by W.M. Sutherland and W.D. Hausel, 2004: Open File Report 04-10, 1:100,000 - $35.00.

Geologic map of the Hole-in-the-Wall 1:24,000-scale Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg, 2004: Open File Report 04-12, plotted color map, rolled only - $10.00.

Geologic map of the Poker Butte 1:24,000-scale Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg, 2004: Open File Report 04-13, plotted color map, rolled only - $10.00.

*Geological reconnaissance of the Grizzly Creek gemstone deposit, Laramie Mountains, Wyoming—Potential source for iolite, sapphire, ruby, and kyanite, by W.D. Hausel and W.M. Sutherland, October, 2004: Open File Report 04-14 - $4.00.

*New releases since *Wyoming Geo-notes No. 80* (June, 2004).

National Geographic maps

The Wyoming State Geological Survey (WSGS) is proud to announce they are now an official dealer of maps and related products published by National Geographic Maps (NGM), a division of the National Geographic Society. The WSGS plans to carry a limited supply of all the National Geographic maps relating specifically to Wyoming as well as some selected regional maps. These products are available by mail or over-the-counter at the WSGS publications sales office in Laramie; add sales tax (where applicable) and shipping and handling (see order form for details). Listed below are the maps and other products that we presently carry.

Reference and wall maps

World Political Classic (multi-color), scale 1:38,931,000, size 43″ x 30″ rolled only - $12.99.

World Political Executive (brown antique style), scale 1:38,931,000, size 43″ x 30″ rolled only - $12.99.

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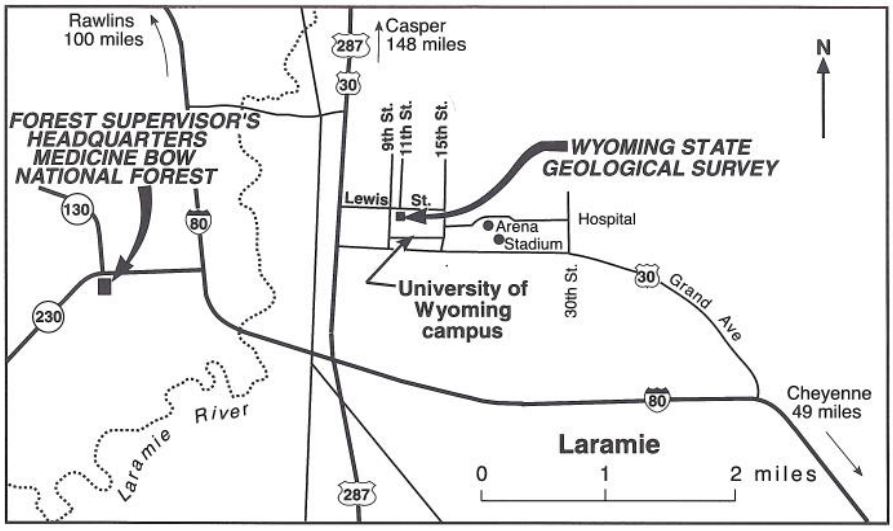

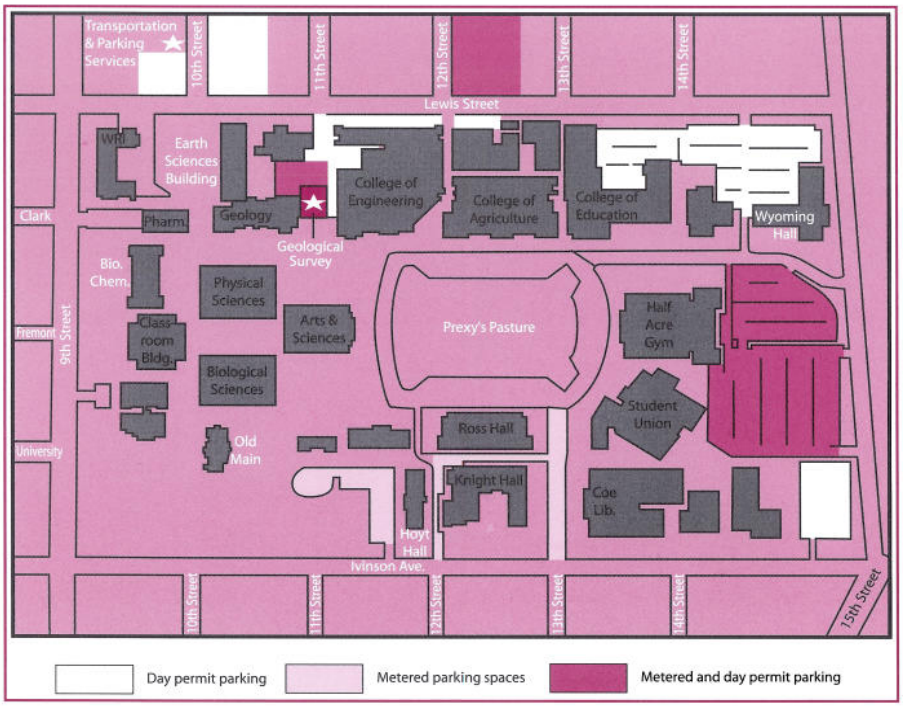

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