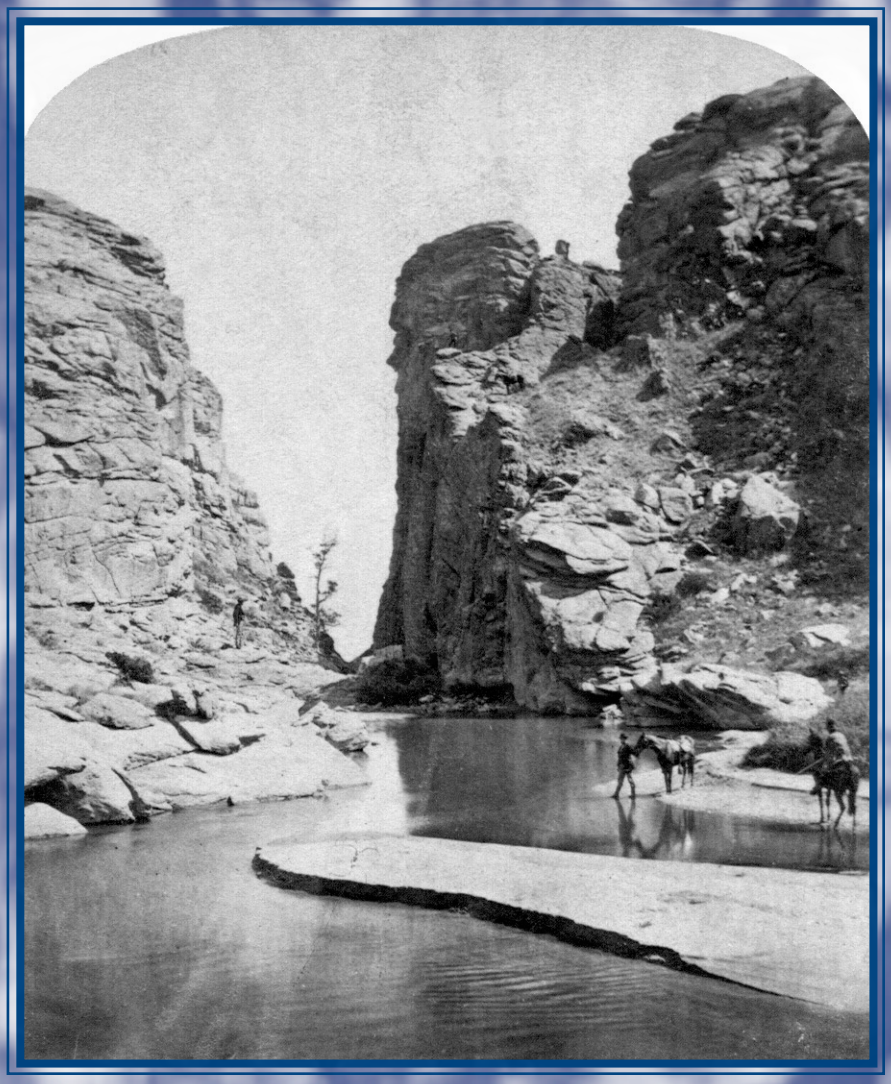
Wyoming Geo-notes

Number 71



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Wyoming State Geological Survey
Lance Cook, State Geologist

Laramie, Wyoming
October, 2001

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

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Front cover: Devil's Gate, which was a prominent landmark along the Oregon Trail as well as a Pony Express station, is about 5 miles southwest of Independance Rock. It is almost exactly halfway between Rawlins and Casper along the present State Highway 220. The east-flowing Sweetwater River, which drains the Granite Mountains of central Wyoming, was superimposed across the Precambrian granitic knobs in the late Tertiary, cutting a 400-foot deep chasm that is only 30 feet wide at river level. "Devil's Gate on the Sweetwater," photograph from a stereoview image by William Henry Jackson, taken during the Hayden Survey of Wyoming and surrounding territories, 1870. Published by E. & H. T. Anthony Co., New York. From the personal collection of Lance Cook.

MINERALS UPDATE

Overview

Lance Cook

State Geologist–Wyoming State Geological Survey

This issue contains mixed news of Wyoming's mineral industry, as price fluctuations in response to market conditions, especially in the energy minerals, continues to make longer term prediction less reliable. Despite the price situation, Wyoming's mineral production continues to climb, as described in the update articles. The Wyoming State Geological Survey (WSGS)-sponsored field trip this summer was well attended (see the **METALS AND PRECIOUS STONES UPDATE**), as the interest in gold prospecting has not waned. Our STATEMAP project is generating some badly needed geologic base maps necessary for some of the state's mineral development and the WSGS coalbed methane project (see the **GEOLOGIC MAPPING, PALEONTOLOGY, AND STRATIGRAPHY UPDATE**). Finally, our ability to detect and monitor seismic events in Jackson Hole may be jeopardized if the Jackson Hole Seismic Network is shut down. Jim Case, head of our Geologic Hazards Section, has addressed State of Wyoming concerns about losing this valuable resource (see **GEOLOGIC HAZARDS UPDATE**).

Second quarter mineral activity

The second quarter of 2001 saw the prices for natural gas, oil, and coal produced in Wyoming continue to fall as they did in the first quarter. Fortunately, production of natural gas and coal continued to increase over last year, as 2001 is expected to be a record year for both commodities (**Table 1**). A modest increase in trona production, a modest decrease in oil production, and nearly the same production of other industrial minerals are expected for the year. Our projections for the production of many minerals may change in the third quarter after the State of Wyoming's Consensus Revenue Estimating Group (CREG) meets and the new estimates are published.

Revised final coal prices for 2000 are now included in this issue (**Table 2**) as is a discussion of the Wyoming coal price indicators for 2001 (see **COAL UPDATE**). The good news is that the average prices for Wyoming coal have increased for the first time since 1992. The continued drop in natural gas prices in the second quarter is cause for concern (see **OIL AND GAS UPDATE**) as our estimated price for 2001 (**Table 2**) is apparently too high. The state's coalbed methane activity continues to boom, as production this year is double that of last year and new pipelines are being completed that will allow delivery of the gas to markets (see **COALBED METHANE UPDATE**). Prices for trona, bentonite, and uranium appear dependent on the national and international economic conditions while construction and related minerals depend more on the regional economy (see **INDUSTRIAL MINERALS AND URANIUM UPDATE**).

Trapping mechanism for natural gas in Jonah Field

During testimony before the Wyoming Oil and Gas Conservation Commission in September, 2001, evidence as to the nature of the trapping mechanism at the Jonah Gas Field was presented by Alberta Energy Company (AEC) Oil & Gas. The issue related to a show cause hearing to determine well spacing on the Pinedale anticline, Docket No. 368-2001. A map (**Figure 1**) was presented into evidence by

Table 1. Wyoming mineral production (1985 through 2000) with forecasts to 2006[1].

Calendar Year	Oil[2,3]	Methane[3,4]	Carbon Dioxide[3,4]	Helium[4,5]	Coal[6]	Trona[7]	*In situ* Uranium[7,8]	Sulfur[3,9]
1985	131.0	597.9			140.4	10.8	N/A	0.80
1986	122.4	563.2	23.8	0.15	135.4	11.9	0.05	0.76
1987	115.9	628.2	114.2	0.86	146.5	12.4	0.00	1.19
1988	114.3	700.8	110.0	0.83	163.6	15.1	0.09	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	1.1	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	1.0	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	1.0	1.18
1992	97.0	871.5	139.2	1.05	189.5	16.4	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	1.2	1.14
1994	80.2	959.2	142.6	1.07	236.9	16.1	1.2	1.10
1995	75.6	987.5	148.8	1.11	263.9	18.4	1.3	1.20
1996	73.9	1023.4	149.0	1.10	278.4	18.6	1.9	1.22
1997	70.2	1040.7	151.0	1.10	281.5	19.4	2.2	1.23
1998	65.7	1072.6	151.0	1.10	315.0	18.6	2.3	1.20
1999	61.3	1133.1	161.0	1.10	336.5	17.8	2.8	1.20
2000	60.5	1292.6	161.0	1.10	338.9	17.7	2.1	1.20
2001	59.8	1370.9	161.0	1.10	354.5	20.0	2.0	1.20
2002	58.0	1460.9	161.0	1.10	358.0	20.0	2.0	1.20
2003	55.1	1541.9	161.0	1.10	361.6	21.0	2.0	1.20
2004	52.4	1625.9	161.0	1.10	365.3	21.0	2.0	1.20
2005	49.8	1710.9	161.0	1.10	368.9	21.0	2.0	1.20
2006	47.3	1796.9	161.0	1.10	372.6	21.0	2.0	1.20

[1]Modified from CREG's Wyoming State Government Revenue Forecast, October, 2000; [2]Millions of barrels; [3]Wyoming Oil & Gas Conservation Commission, 1985 through 2000; [4]Billions of cubic feet, includes coalbed methane; [5]Based on ExxonMobil's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; [6]Millions of short tons (Wyoming State Inspector of Mines, 1985 through 2000); [7]Millions of short tons (Wyoming Department of Revenue, 1985 through 2000; Wyoming State Inspector of Mines, 2000); [8]Millions of pounds of yellowcake (Wyoming Department of Revenue, 1986 through 1999; Wyoming State Inspector of Mines, 2000) (not available [N/A] for 1985 and previous years because it was only reported as taxable value; [9]Millions of short tons.

Table 2. Average prices paid for Wyoming oil, methane, coal, and trona (1985 through 2000) with forecasts to 2006[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]
1985	24.67	3.03	11.36	35.18
1986	12.94	2.33	10.85	34.80
1987	16.42	1.78	9.80	36.56
1988	13.43	1.43	9.16	36.88
1989	16.71	1.58	8.63	40.76
1990	21.08	1.59	8.43	43.70
1991	17.33	1.46	8.06	44.18
1992	16.38	1.49	8.13	43.81
1993	14.50	1.81	7.12	40.08
1994	13.67	1.63	6.62	38.96
1995	15.50	1.13	6.38	40.93
1996	19.56	1.46	6.15	45.86
1997	17.41	1.94	5.68	42.29
1998	10.67	1.81	5.41	41.29
1999	16.44	2.06	5.19	38.49
2000	26.87	3.42	5.45	37.90
2001	20.00	4.50	5.48	37.75
2002	18.00	3.00	5.52	37.75
2003	18.00	2.25	5.59	37.75
2004	18.00	2.25	5.64	37.75
2005	18.00	2.25	5.73	37.75
2006	18.00	2.25	5.80	37.70

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

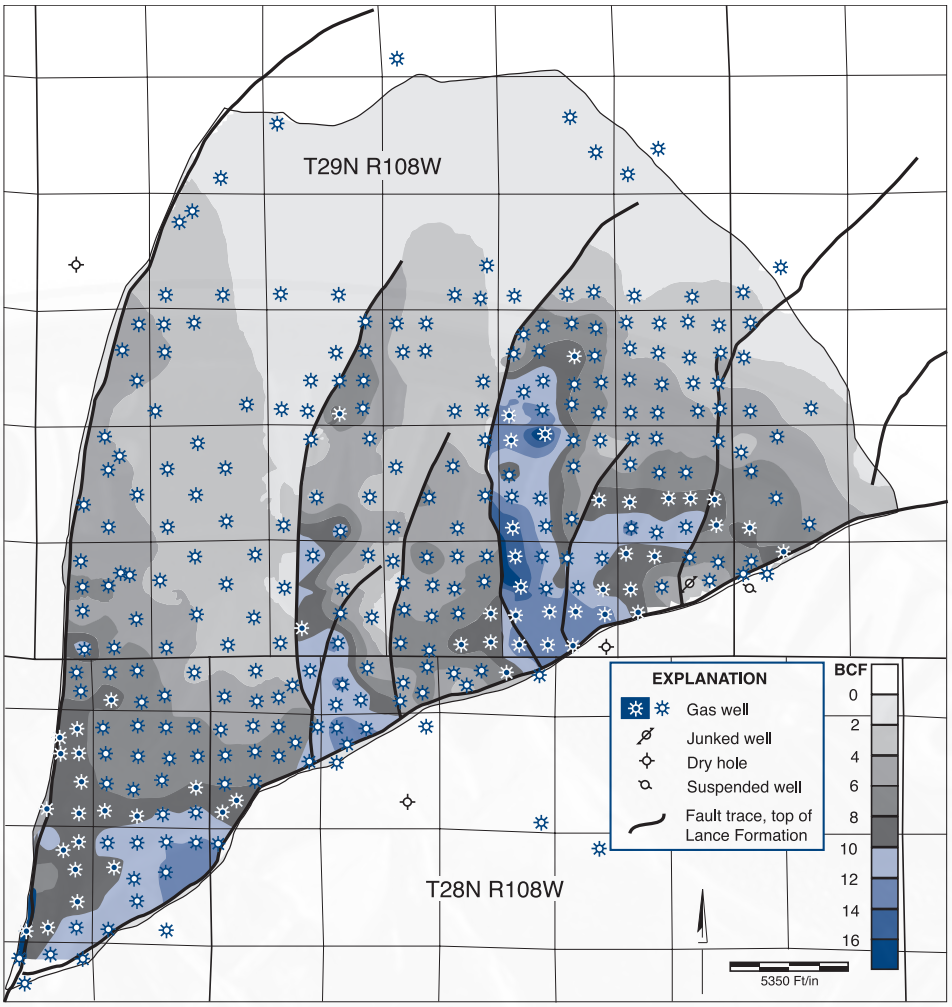

Figure 1. Contour map of estimated ultimate recovery (EUR), in two billion cubic feet (BCF) intervals, for the Jonah Gas Field, Sublette County, Wyoming. Modified from full color map and used with permission of AEC Oil & Gas.

Thomas M. Smagala in support of sworn testimony that compartmentalization and sealing faults were present in the area of Jonah Field and by analogy, the adjacent Pinedale anticline. We believe this is important information and with the generous permission of AEC Oil & Gas, we would like to share it with our readers.

Jonah Field is located in Ts28 and 29N, Rs107 and 108W, Sublette County, Wyoming. The fault traces at the top of the Lance Formation were interpreted using a 3-D seismic survey. As shown on the map, the contours for the various wells represent estimated ultimate recovery (EUR), in billion cubic feet (BCF) per well, based upon decline curve analyses. The fault pattern is very interesting. The west and south bounding faults clearly define the field boundaries, as has been widely documented in the literature. However, the internal fault pattern is now clearly shown as consisting of NNE-SSW trending faults that intersect and terminate into the south bounding fault. These internal faults are described as having a small amount of vertical displacement, in the range of 30 to 100 feet.

Projecting the well production data onto the fault map strongly suggests that these internal faults are sealing and segment the reservoir into pressure compartments. An alternative explanation is that these faults controlled sedimentation and the productivity is simply a function of reservoir quality. However, given the sharp boundaries of the compartments and the large production contrasts across faults, this seems less likely.

The gas reserves in this field are very impressive–over 4 trillion cubic feet, making this field a "giant" by anyone's definition and ranking it one of the largest fields in the Rockies. We appreciate the willingness of AEC Oil & Gas in sharing this data with the geologic community. Any readers who wish to comment on this information or offer alternative interpretations are encouraged to do so.

Oil and Gas Update

Rodney H. De Bruin

Staff Geologist–Oil and Gas, Wyoming State Geological Survey

Wyoming oil and gas producers received decent prices for their commodities during the second quarter of 2001 even though oil prices were slightly lower and gas prices were considerably lower than for the first quarter. However, prices for both commodities were considerably higher than the average for the past several years. Oil production declined 5.7%, while gas production increased 12.2% during the first five months of 2001. Natural gas production was boosted by a large increase in coalbed methane production in the Powder River Basin (PRB), which made up 14% of Wyoming's total gas production in the first five months of 2001. In the second quarter, two federal lease sales brought in over $14 million, and two state sales brought in over $4 million. Geophysical activity, the number of applications for permit to drill, and rig counts also remained healthy.

Prices and production

Prices paid to Wyoming oil producers during the second quarter of 2001 averaged $23.13 per barrel (**Table 3**). The average price for the quarter is $2.63 lower than for the second quarter of 2000, but $8.18 higher than for the second quarter of 1999. The posted sweet and sour crude prices and first purchase price for Wyoming oil averaged by month fell slightly in the second quarter (**Figure 2**) but continued to be higher than our forecast $20.00 per barrel average for the year (**Figure 3**).

Wyoming should produce nearly 1.6 trillion cubic feet (TCF) of natural gas in 2001.

Oil production reported by the Wyoming Oil and Gas Conservation Commission (WOGCC) for the first five months of 2001 was 24.0 million barrels (**Table 4**). This production is a drop of 5.7% from production in the first five months of 2000. This percentage decrease is more than the 1% average decline in oil production we had forecast for the year (**Table 1** and **Figure 4**) and probably reflects the softening of prices during the quarter.

Spot prices for natural gas at Opal, Wyoming averaged $3.75 per thousand cubic feet (MCF) during the second quarter of 2001. This is $0.73 per MCF higher than the average price for the second quarter of 2000, but $3.00 lower than for the first quarter of 2001 (**Table 5** and **Figure 5**). The precipitous drop in natural gas prices early in the year is certainly going to affect our current price forecasts (**Table 2** and **Figure 6**), which will be revised after the State of Wyoming's Consensus Revenue Estimating Group (CREG) meets later this fall.

Natural gas production in Wyoming for the first five months of 2001 was 667.2 billion cubic feet (BCF), according to production figures from the WOGCC. This production is up 12.2% from the first five months of 2000 (**Table 6**). Coalbed methane production from the PRB accounted for 93.4 BCF and 14% of that total. If production stays on its current trend, Wyoming should produce nearly 1.6 trillion cubic feet (TCF) of natural gas in 2001 (**Table 1** and **Figure 7**). About 225 BCF of the total will be coalbed methane from the PRB.

Reports, projects, and transactions

The Potential Gas Committee (2001) estimated Wyoming's most likely resources of traditional natural gas (not including coalbed methane) are 54.8 TCF. These resources are categorized

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1997 through August, 2001).

	1997		1998		1999		2000		2001	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$22.56	$22.56	$12.79	$12.79	$9.30	$9.30	$24.01	$24.01	$24.62	$24.62
February	$19.45	$21.01	$12.16	$12.47	$9.09	$9.20	$26.48	$25.25	$24.82	$24.72
March	$17.99	$20.00	$10.97	$11.97	$11.77	$10.05	$27.24	$25.91	$22.71	$24.05
April	$16.81	$19.20	$11.54	$11.87	$14.34	$11.12	$22.92	$25.16	$22.85	$23.75
May	$17.74	$18.91	$11.19	$11.73	$15.16	$11.93	$26.06	$25.34	$23.68	$23.74
June	$15.90	$18.41	$9.63	$11.38	$15.36	$12.50	$28.31	$25.84	$22.87	$23.59
July	$16.29	$18.11	$10.20	$11.21	$17.39	$13.20	$27.12	$26.02	**$21.50**	**$23.29**
August	$16.61	$17.92	$9.58	$11.01	$18.43	$13.86	$28.18	$26.29	**$22.50**	**$23.19**
September	$16.42	$17.75	$11.19	$11.03	$20.97	$14.65	$30.22	$26.73		
October	$17.89	$17.77	$11.04	$11.03	$20.01	$15.18	$28.75	$26.93		
November	$16.51	$17.65	$9.64	$10.90	$22.20	$15.82	$29.63	$27.17		
December	$14.72	$17.41	$8.05	$10.66	$23.22	$16.44	$23.60	$26.88		
Average yearly price		**$17.41**		**$10.66**		**$16.44**		**$26.88**		

All averages are derived from published monthly reports by the Energy Information Administration, except that averages in bold print in 2001 are estimated from various unpublished bulletins listing posted prices. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

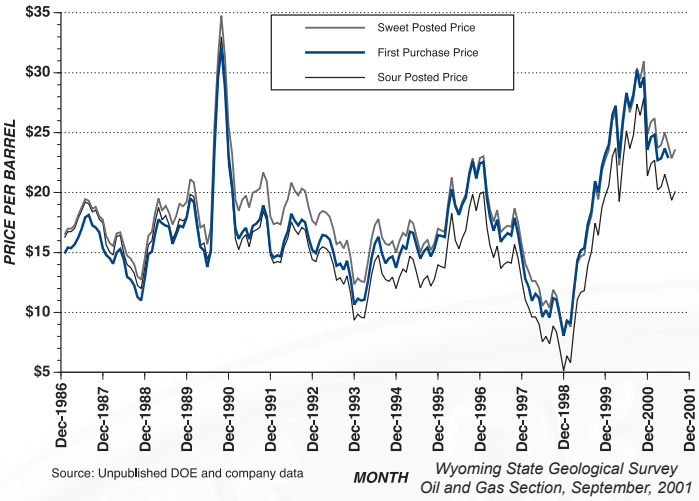

Figure 2. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through June, 2001).

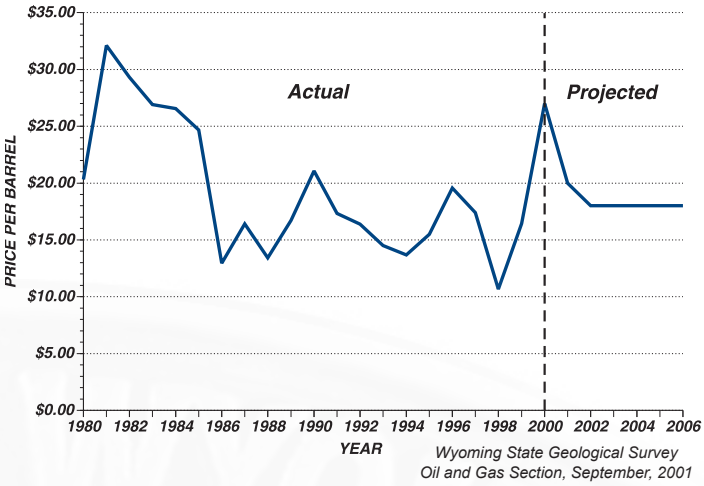

Figure 3. Average prices paid for Wyoming crude oil (1980 through 2000) with forecasts to 2006.

by probable, possible, and speculative resources for reservoirs from 0 to 15,000 feet in depth and for reservoirs between 15,000 and 30,000 feet in depth (**Table 7**). The Greater Green River Basin (GGRB) has the most resources with almost 26.0 TCF followed by the Wind River Basin with 13.2 TCF of resources.

In a related item, the U.S. Department of Energy (DOE) has concluded that access to one of the nation's most promising natural-gas-bearing regions may be much more restricted than previously thought. Working on a tract-by-tract basis, DOE analysts studied federal lands in the GGRB of Wyoming and Colorado and found that nearly 68% of the area's technically recoverable natural gas resource is either closed to development or under significant access restriction.

The analysts found that about 30% of the gas resources are completely off limits; only about 1% underlies lands, such as national parks and wilderness areas, that are closed by statute. The rest of the inaccessible areas have been closed by administrative actions.

An additional 38% of the federal natural gas resource in the GGRB has some type of leasing stipulation that would restrict access, although not prevent it completely. Most restrictions limit the time that access is allowed.

Products of the DOE study will be publicly available digitized maps and other data that will allow users to examine restrictions for each township. DOE contracted with Advanced Resources International to perform the study.

Colorado Interstate Gas (CIG) announced a pipeline project to transport gas from the Cheyenne Hub to Mid-Continent pipeline markets near Greensburg, Kansas. CIG proposes to construct 380 miles of 30-inch diameter pipeline and 17,000 horsepower of compression, designed to transport up to 540 million cubic feet (MMCF) of natural gas per day. The project accesses all of the Rocky Mountain basins via the Cheyenne Hub just south of Cheyenne, Wyoming. The project is scheduled for completion in 2003.

Northwest Pipeline, a unit of the Williams Companies Inc., announced an expansion project that will deliver 276 MMCF of gas per day to new electric generation facilities located in the state of Washington. Northwest Pipeline delivers natural gas from southwestern Wyoming to the Pacific Northwest. The project is scheduled for completion in 2003.

Table 4. Monthly oil production from Wyoming in barrels (1997 through May, 2001).

	1997		1998		1999		2000			
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	5,964,848	5,964,848	5,846,364	5,846,364	5,333,257	5,333,257	5,185,622	5,185,622	4,981,663	4,981,663
February	5,459,518	11,424,366	5,233,502	11,079,866	4,744,527	10,077,784	4,871,978	10,057,600	4,484,121	9,465,784
March	6,014,780	17,439,146	5,759,176	16,839,042	5,297,674	15,375,458	5,200,533	15,258,133	4,953,046	14,418,830
April	5,729,869	23,169,015	5,534,568	22,373,610	5,065,591	20,441,049	5,004,087	20,262,220	4,708,504	19,127,334
May	6,050,971	29,219,986	5,626,125	27,999,735	5,200,031	25,641,080	5,201,814	25,464,034	4,897,628	24,024,962
June	5,761,549	34,981,535	5,335,463	33,335,198	5,000,039	30,641,119	5,001,950	30,465,984		
July	5,964,005	40,945,540	5,464,514	38,799,712	5,164,705	35,805,824	5,077,307	35,543,291		
August	5,868,789	46,814,329	5,287,415	44,087,127	5,190,052	40,995,876	5,093,553	40,636,844		
September	5,710,557	52,524,886	5,109,053	49,196,180	5,081,384	46,077,260	4,983,427	45,620,271		
October	5,949,974	58,474,860	5,274,269	54,470,449	5,163,165	51,240,425	5,157,583	50,777,854		
November	5,800,811	64,275,671	5,232,287	59,702,736	5,010,985	56,251,410	4,877,439	55,655,293		
December	5,900,791	70,176,462	5,078,909	64,781,645	5,090,959	61,342,369	4,969,144	60,624,437		
Total Barrels Reported[1]		**70,176,462**		**64,781,645**		**61,342,369**		**60,624,437**		
Total Barrels not Reported[2]		**52,364**		**897,131**						
Total Barrels Produced[3]		**70,228,826**		**65,678,776**						

[1]Monthly production reports from Petroleum Information/Dwights LLC. Except for 1999 and 2000 which is from Wyoming Oil and Gas Conservation Commission; [2](Total barrels produced) minus (total barrels reported by Petroleum Information/Dwights LLC.); [3]Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

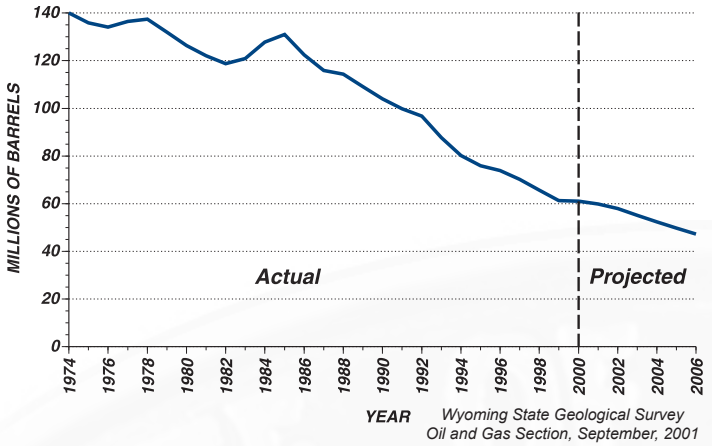

Figure 4. Annual crude oil production from Wyoming (1974 through 2000) with forecasts to 2006.

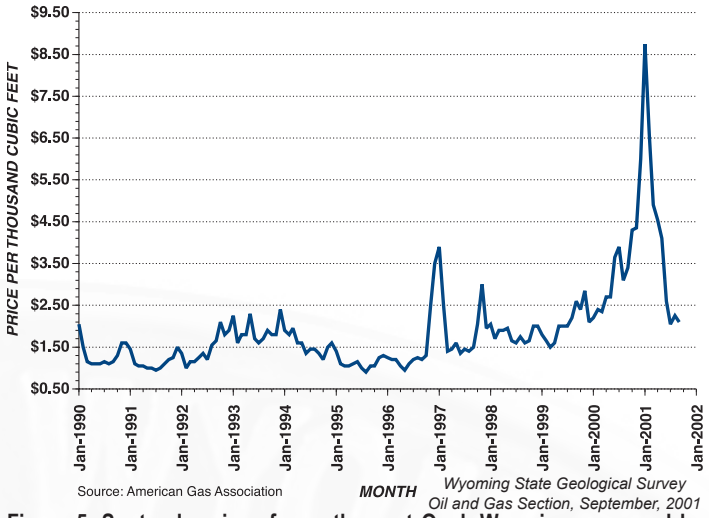

Figure 5. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through September, 2001).

Jonah Gas Gathering proposed building a new 20-inch natural gas pipeline from about 10 miles east of La Barge to Opal, Wyoming. The company also proposed adding 9000 horsepower of compression adjacent to its existing compressor station. The proposed pipeline would parallel the company's existing 20-inch line. The new line would transport 300 to 400 MMCF of gas per day produced from Jonah Field and deliver it to multiple markets.

The Williams Companies purchased producing and undeveloped leasehold interests in two oil and gas properties in Sublette County for $15 million. The purchase includes a small interest that covers a significant portion of Jonah Field and the Pinedale anticline area. The acreage represents more than 300 locations where wells already exist or could be developed.

The [April, 2001 BLM] sale generated revenue of almost $11 million and the average per-acre bid was $49.65.

The Williams Companies also acquired Barrett Resources in a $2.8 billion transaction that more than doubled Williams' natural gas reserves. Barrett had large gas reserves in Waltman Field in the Wind River Basin, and in the coalbed methane play in the PRB.

Lease sales

Leasing activity at the April, 2001 sale held by the Wyoming Office of State Lands and Investments (State Lands) was heaviest in southwestern Wyoming (**Figure 8**). The sale's high per-acre bid of $450 was made by Coleman Oil & Gas for a 320-acre lease that covers the E/2 section 16, T17N, R92W (**location A, Figure 8**). The lease is on the southern flank of Baldy Butte Field which produces from the Almond Formation. James Sullivan made the sale's second and third highest per-acre bids. He paid $270 per acre for a 640-acre tract that covers all of section 16, T15N, R110W, and $260 per acre for a 640-acre lease that covers all of section 36, T15N, R110W (**location B, Figure 8**). These two leases are about 15 miles southeast of production from the Frontier Formation and Dakota Sandstone at Church Buttes Field. A total of 27 tracts at this sale sold for $50 or more per acre. The sale generated revenue of $2.25 million and the average per-acre bid was $27.16 (**Table 8**).

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1997 through September, 2001).

	1997		1998		1999		2000		2001	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	$3.90	$3.90	$2.05	$2.05	$1.80	$1.80	$2.20	$2.20	$8.75	$8.75
February	$2.50	$3.20	$1.70	$1.88	$1.65	$1.73	$2.40	$2.30	$6.60	$7.68
March	$1.40	$2.60	$1.90	$1.88	$1.50	$1.65	$2.35	$2.32	$4.90	$6.75
April	$1.45	$2.31	$1.90	$1.89	$1.60	$1.64	$2.70	$2.41	$4.55	$6.20
May	$1.60	$2.17	$1.95	$1.90	$2.00	$1.71	$2.70	$2.47	$4.10	$5.78
June	$1.35	$2.03	$1.65	$1.86	$2.00	$1.76	$3.65	$2.67	$2.60	$5.25
July	$1.45	$1.95	$1.60	$1.82	$2.00	$1.79	$3.90	$2.84	$2.05	$4.79
August	$1.40	$1.88	$1.75	$1.81	$2.20	$1.84	$3.10	$2.88	$2.25	$4.48
September	$1.50	$1.84	$1.60	$1.79	$2.60	$1.93	$3.40	$2.93	$2.10	$4.21
October	$2.05	$1.86	$1.65	$1.78	$2.40	$1.98	$4.30	$3.07		
November	$3.00	$1.96	$2.00	$1.80	$2.85	$2.05	$4.35	$3.19		
December	$1.95	$1.96	$2.00	$1.81	$2.10	$2.06	$6.00	$3.42		
Average yearly price		**$1.96**		**$1.81**		**$2.06**		**$3.42**		

Source: American Gas Association's monthly reports. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

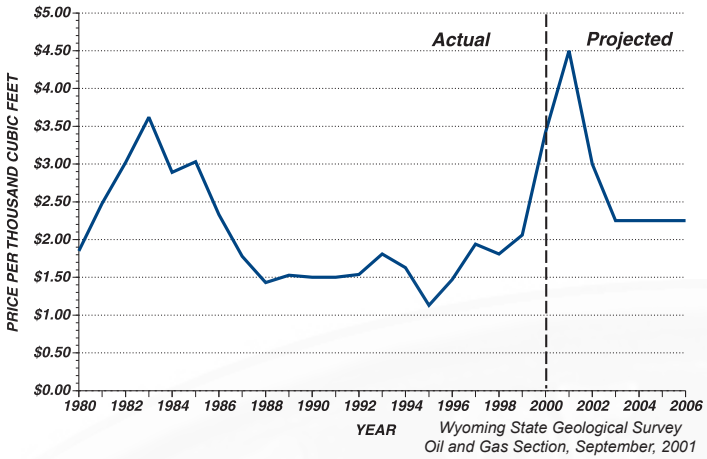

Figure 6. Average prices paid for Wyoming methane (1980 through 2000) with forecasts to 2006.

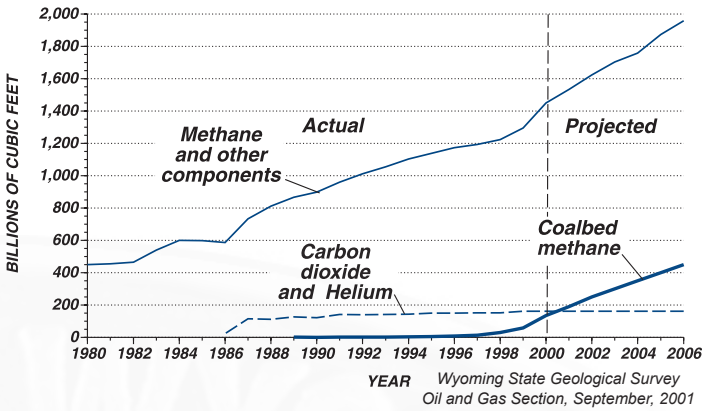

Figure 7. Annual natural gas production from Wyoming (1980 through 2000) with forecasts to 2006.

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1996 through May, 2001).

	1997		1998		1999		2000		2001	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	99,579,818	99,579,818	103,640,214	103,640,214	108,524,793	108,524,793	122,064,217	122,064,217	135,468,877	135,468,877
February	91,766,159	191,345,977	94,501,819	198,142,033	94,288,888	202,813,681	114,229,927	236,294,144	123,283,925	258,752,802
March	104,157,578	295,503,555	103,906,999	302,049,032	111,012,987	313,826,668	121,102,432	357,396,576	139,009,973	397,762,775
April	99,459,039	394,962,594	98,201,007	400,250,039	102,363,550	416,190,218	118,803,903	476,200,479	131,996,713	529,759,488
May	101,070,371	496,032,965	96,741,237	496,991,276	104,746,697	520,936,915	118,229,726	594,430,205	137,470,256	667,229,744
June	91,905,308	587,938,273	98,413,520	595,404,796	102,717,295	623,654,210	116,725,694	711,155,899		
July	100,129,497	688,067,770	102,055,968	697,460,764	106,733,493	730,387,703	120,766,765	831,922,664		
August	97,673,622	785,741,392	105,378,334	802,839,098	107,536,099	837,923,802	122,433,750	954,356,414		
September	100,028,888	885,770,280	98,474,782	901,313,880	108,200,542	946,124,344	119,703,301	1,074,059,715		
October	102,206,875	987,977,155	96,470,624	997,784,504	118,545,893	1,064,670,237	127,504,271	1,201,563,986		
November	100,752,128	1,088,729,283	103,445,859	1,101,230,363	110,904,046	1,175,574,283	122,799,945	1,324,363,931		
December	103,415,430	1,192,144,713	99,339,043	1,200,569,406	119,648,215	1,295,222,498	130,349,355	1,454,713,286		
Total MCF Reported[1]		**1,192,144,713**		**1,200,569,406**		**1,295,222,498**		**1,454,713,286**		
Total MCF not Reported[2]		**683,432**		**22,955,142**						
Total MCF Produced[3]		**1,192,828,145**		**1,223,524,548**						

[1]Monthly production reports from Petroleum Information/Dwights LLC. Except for 1999 and 2000 which is from Wyoming Oil and Gas Conservation Commission; [2](Total MCF produced) minus (total MCF reported by Petroleum Information/Dwights LLC.); [3]Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

Table 7. Wyoming's estimated most likely resources of traditional natural gas in billions of cubic feet as of December 31, 2000. Modified from Potential Gas Committee (2001).

	Depth Categories		All depths
Province	0-15,000 feet	15,000-30,000 feet	subtotal
Powder River Basin			
Probable	1435	0	1435
Possible	2153	0	2153
Speculative	688	1000	1688
Subtotal	4276	1000	5276
Bighorn Basin			
Probable	672	170	842
Possible	530	616	1146
Speculative	1970	2024	3994
Subtotal	3172	2810	5982
Wind River Basin			
Probable	2871	1651	4522
Possible	5211	3304	8515
Speculative	113	64	177
Subtotal	8195	5019	13,214
Greater Green River Basin			
Probable	8997	979	9976
Possible	4851	5696	10,547
Speculative	3747	1683	5430
Subtotal	17,595	8358	25,953
Thrust Belt			
Probable	800	0	800
Possible	1000	0	1000
Speculative	1900	650	2550
Subtotal	3700	650	4350
Grand Total	**36,938**	**17,837**	**54,775**

Wyoming State Geological Survey, Oil and Gas Section, September, 2001.

Leasing activity at the April, 2001 U.S. Bureau of Land Management (BLM) sale was concentrated in the PRB and in southwestern Wyoming (**Figure 9**). Reliance Resources made the high per-acre bid of $530 for a 119.7-acre lease that covers parts of section 11, T46N, R76W (**location A, Figure 9**). The lease is two to three miles west of a shallow coalbed methane project in the Fort Union Formation. John Kennedy made the sale's second high per-acre bid of $330 for a 653.04-acre tract that covers section 35, T23N, R97W (**location B, Figure 9**). The lease is just south of Hay Reservoir Field, which produces gas and condensate from the Lewis Shale. A total of nine leases in T23N, R97W, sold for per-acre bids between $82 and $330. There were a total of 62 parcels at this sale that received bids of $50 or more per acre. The sale generated revenue of almost $11 million and the average per-acre bid was $49.65 (**Table 8**).

Leasing activity at the June, 2001 sale held by State Lands was heaviest in the PRB and in southwestern Wyoming (**Figure 8**). Huntington Walker made the sale's top per-acre bid of $650 for a 40-acre tract that covers SE NE section 12, T45N, R72W (**location C, Figure 8**). The lease is in an area of shallow coalbed methane production from the Fort Union Formation. The sale's second high per-acre bid of $400 was made by Prima Oil & Gas for a 640-acre lease covering all of section 36, T29N, R107W (**location D, Figure 8**). The

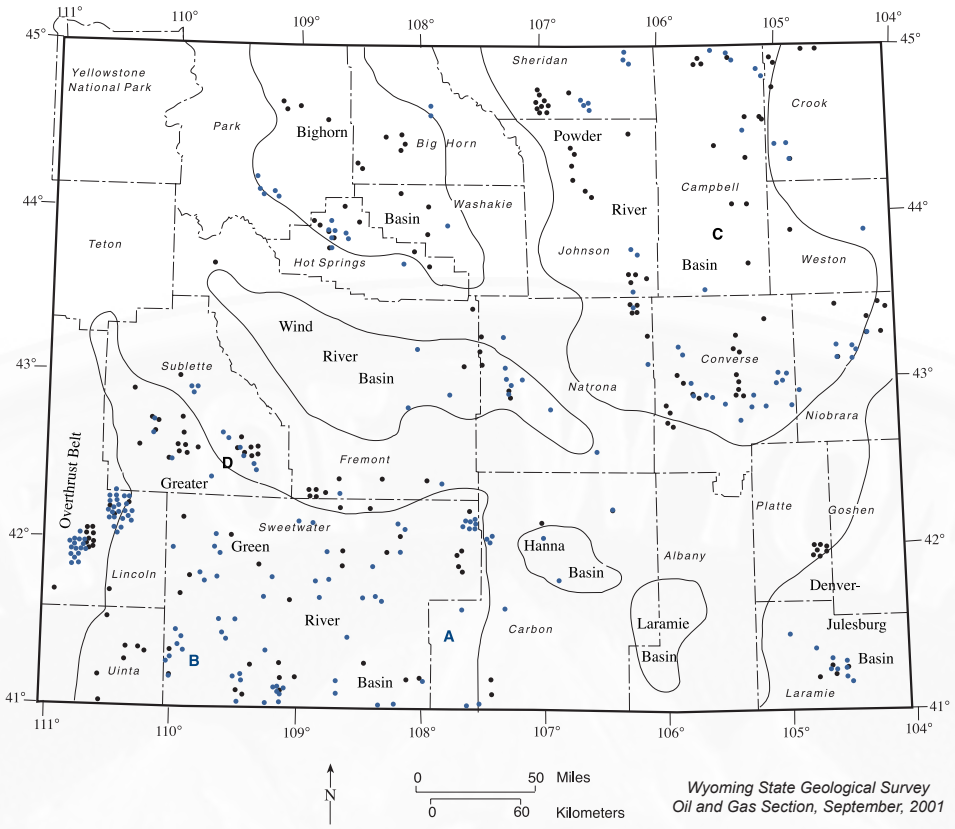

Figure 8. Locations of state oil and gas tracts leased by the Office of State Lands and Investments at its April, 2001 sale (locations in blue) and its June, 2001 sale (locations in black). Locations are approximate and may represent more than one sale.

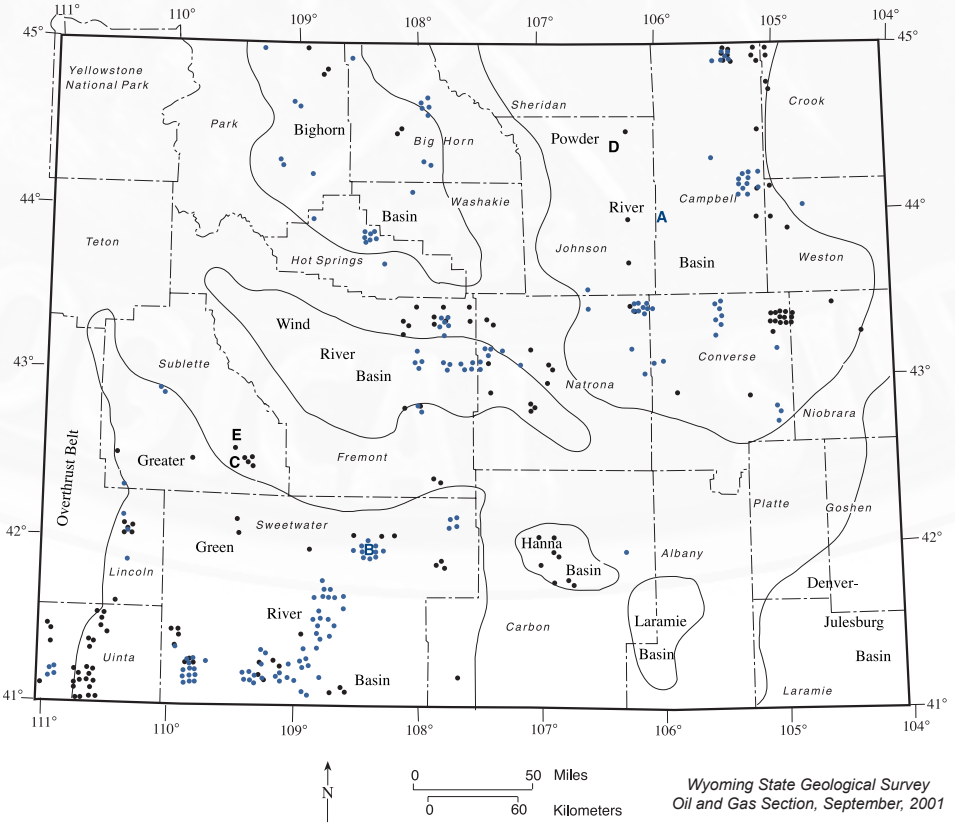

Figure 9. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its April, 2001 sale (locations in blue) and its June, 2001 sale (locations in black). Locations are approximate and may represent more than one sale.

Table 8. Federal and State competitive oil and gas lease sales in Wyoming (1996 through July, 2001).

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)								STATE SALES (OFFICE OF STATE LANDS AND INVESTMENTS)							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1996								**1996**			
TOTAL	$11,487,567	1828	1125	1,403,444	739,505	$15.53	$1,450.00	TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
				1997								**1997**			
TOTAL	$31,976,603	1787	1485	1,578,938	1,206,642	$26.50	$600.00	TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	$340.00
				1998											
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00								
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00					**1998**			
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00	April	$1,203,792	300	161	115,646	63,848	$18.85	$320.00
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00	June	$1,660,438	300	148	108,654	52,501	$31.63	$600.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00	October	$1,313,792	298	178	98,856	65,212	$20.14	$590.00
December	$15,229,257	407	278	388,783	277,538	$54.87	$800.00	December	$1,045,447	300	187	121,551	77,852	$13.43	$215.00
TOTAL	$63,800,496	2247	1710	2,217,975	1,621,637	$39.34	$800.00	TOTAL	$5,223,469	1198	674	444,707	259,413	$20.14	$600.00
				1999											
February	$2,734,442	170	138	157,779	124,880	$21.90	$325.00								
April	$2,121,220	124	116	129,358	121,421	$17.47	$280.00					**1999**			
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00	April	$1,815,526	299	196	123,119	89,194	$20.35	$890.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00	June	$1,002,039	300	190	108,310	69,858	$14.34	$400.00
Octoer	$4,395,288	214	175	195,827	142,525	$30.84	$580.00	October	$2,369,527	300	216	109,140	77,261	$30.67	$475.00
December	$5,598,020	176	164	128,480	124,093	$28.99	$410.00	December	$956,113	291	129	115,502	51,674	$18.50	$500.00
TOTAL	$24,197,991	1,069	945	1,060,674	929,674	$26.03	$32,000.00	TOTAL	$6,143,205	1,190	731	456,071	287,987	$21.33	$890.00
				2000											
February	$5,497,834	192	180	130,289	120,219	$45.73	$525.00								
April	$3,057,278	189	161	160,712	128,063	$23.87	$440.00					**2000**			
June	$6,387,887	230	184	260,294	190,306	$33.57	$410.00	April	$1,475,661	299	191	120,319	71,933	$19.54	$525.00
August	$5,213,595	240	222	174,040	154,920	$33.65	$475.00	June	$2,119,198	300	197	127,798	79,743	$26.58	$775.00
October	$5,028,610	147	129	149,934	124,724	$40.32	$510.00	October	$1,660,315	300	216	117,598	81,603	$20.35	$268.00
December	$6,352,525	185	179	182,935	180,380	$35.22	$725.00	December	$1,240,442	300	192	109,375	62,636	$19.80	$210.00
TOTAL	$31,537,729	1183	1055	1,058,204	898,612	$35.09	$725.00	TOTAL	$6,495,616	1199	796	475,090	295,915	$21.95	$775.00
				2001											
February	$9,138,921	202	159	224,225	148,972	$61.35	$1,475.00								
April	$10,976,580	185	184	221,147	221,067	$49.65	$530.00					**2001**			
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
								June	$1,754,320	300	192	111,507	66,829	$26.25	$650.00

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, September, 2001.*

tract is on the Pinedale anticline about five miles east of Jonah Field. There were 23 leases at this sale that received bids of $50 or more per acre. The sale generated revenue of over $1.75 million and the average per-acre bid was $26.25 (**Table 8**).

Leasing activity at the June, 2001 BLM sale was concentrated in southwestern Wyoming (**Figure 9**). Hanson & Strahn made the high per-acre bid of $360 for an 80-acre lease that covers E/2 SW section 19, T29N, R106W (**location C, Figure 9**). The lease is in a non-producing township about six miles east of Jonah Field. The second highest per-acre bid of $260 was made by Carpenter & Sons for a 728.48-acre tract that covers parts of sections 18, 21, 23, 24, 25, and 27, T52N, R79W (**location D, Figure 9**). The lease is in an area of shallow coalbed methane development in the Fort Union Formation. Marshall & Winston also made a per-acre bid of $260 for a 154.07-acre tract that covers part of section 31, T30N, R106W (**location E, Figure 9**). The lease is about four miles east of named discoveries of gas in the Lance Formation by Amoco Production and in the Mesaverde Formation by McMurry Oil. A total of 20 parcels at this sale received bids of $50 or more per acre. The sale generated revenue of almost $3.1 million and the average per-acre bid was $22.37 (**Table 8**).

Permitting and drilling

The WOGCC approved 3069 Applications for Permit to Drill (APDs) in the second quarter of 2001. The total for that quarter is more than the number of APDs approved in all of 1995, 1996, 1997, or 1998 (**Table 9**). Campbell County again led with 58% of the total APDs; Sheridan and Johnson counties combined for almost 26% of the total. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

The WOGCC permitted 15 seismic projects in the second quarter of 2001 (**Table 10**). The number of permits and square miles permitted is down slightly from the second quarter of 2000. Two less permits were issued in the second quarter of this year than in the second quarter of 2000. The number of permitted conventional miles is substantially lower than the total for the second quarter of 2000, but the square miles of 3-D are nearly the same. Geophysical activity is a good indicator of future exploration and production drilling.

The average daily rig count for the second quarter of 2001 was 55. This average is 23 more than for the second quarter of 2000. The rig count does not include rigs drilling for coalbed methane. **Figure 10** shows the Wyoming daily rig count averaged by month and by year.

Table 9. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1995 through June, 2001).

County	1995 APDs	1996 APDs	1997 APDs	1998 APDs	1999 APDs	2000 APDs	2001 APDs
Albany	1	1	0	0	0	0	0
Big Horn	16	53	59	13	6	11	8
Campbell	151	554	941	1586	4461	5580	2983
Carbon	50	77	84	96	127	174	131
Converse	29	20	16	6	19	70	18
Crook	15	37	26	29	30	47	13
Fremont	30	26	58	76	67	136	84
Goshen	0	0	0	0	0	0	0
Hot Springs	13	24	42	1	8	6	1
Johnson	6	16	6	49	304	769	341
Laramie	10	2	3	2	0	2	3
Lincoln	64	55	122	105	51	70	45
Natrona	80	74	59	36	51	53	21
Niobrara	4	7	8	8	5	18	7
Park	20	30	25	11	12	18	21
Platte	0	0	0	0	0	0	0
Sheridan	0	0	2	35	416	891	797
Sublette	61	118	179	230	189	338	248
Sweetwater	153	136	210	181	124	335	282
Teton	0	0	0	0	0	0	0
Uinta	11	10	27	26	26	53	19
Washakie	31	30	36	9	0	7	10
Weston	10	10	5	6	4	20	4
Totals	**755**	**1280**	**1908**	**2505**	**5900**	**8598**	**5036**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

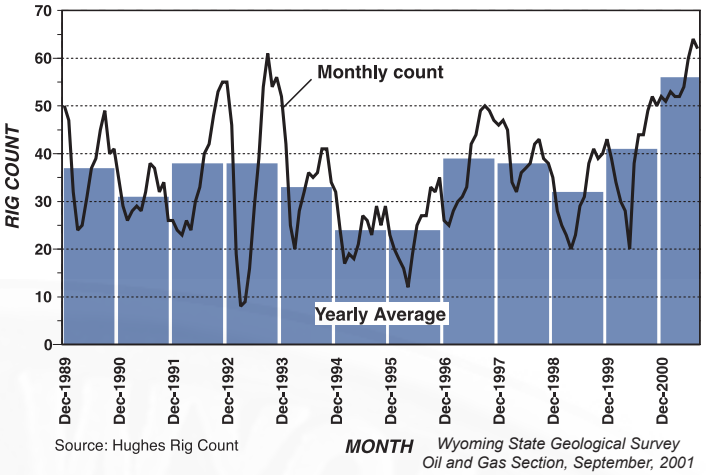

Figure 10. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month and year (December, 1989 through July, 2001).

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 11** reports the most significant activities exclusive of coalbed methane (see the **COALBED METHANE UPDATE** for development in this industry) during the second quarter of 2001. The numbers correspond to locations on **Figure 11**.

Reference cited

Potential Gas Committee, 2001, Potential supply of natural gas in the United States (December 31, 2000): Golden, Colorado, 346 p.

Table 10. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1997 through June, 2001).

	1997			1998			1999			2000			2001		
County	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles	Permits	Conventional Miles	3-D Square Miles
Albany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Horn	2	0	45	1	0	16	0	0	0	1	387	0	1	0	4
Campbell	20	52	79	14	18	182	4	4	10	14	64	132	2	6	0
Carbon	3	7	190	4	0	318	5	77	57	0	0	0	0	0	0
Converse	1	5	0	4	12	239	1	0	50	1	15	0	0	0	0
Crook	7	8	18	2	2	4	1	0	10	7	16	22	1	2	0
Fremont	6	43	126	2	100	0	1	0	88	4	25	116	2	70	15
Goshen	2	227	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Springs	1	8	0	4	19	0	0	0	0	0	0	0	0	0	0
Johnson	2	7	17	1	4	0	0	0	0	4	35	0	1	0	4
Laramie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lincoln	3	7	116	1	10	0	1	0	32	0	0	0	0	0	0
Natrona	5	14	101	6	12	214	2	0	230	5	36	135	0	0	0
Niobrara	0	0	0	0	0	0	5	16	31	1	0	25	0	0	0
Park	4	56	58	3	16	132	3	25	32	1	13	0	3	21	12
Platte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheridan	0	0	0	1	14	0	0	0	0	0	0	0	2	0	81
Sublette	1	0	61	2	1	115	3	0	308	4	77	44	3	6	319
Sweetwater	4	66	296	6	214	66	9	0	530	13	54	1004	7	79	343
Teton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uinta	0	0	0	2	0	147	1	0	26	0	0	0	0	0	0
Washakie	3	36	0	4	41	35	1	0	8	0	0	0	0	0	0
Weston	1	0	17	1	0	35	1	40	0	0	0	0	0	0	0
Totals	**65**	**536**	**1124**	**58**	**463**	**1503**	**38**	**162**	**1412**	**55**	**722**	**1478**	**22**	**184**	**778**

Source: All data are from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, Oil and Gas Section, September, 2001.*

Table 11. Significant exploration and development wells in Wyoming, second quarter of 2001[1]. Number corresponds to location on Figure 11.

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
1	Amoco Production	8 Amoco Chevron Gulf	SE NE sec 18, T17N, R119W	Woodside Sh. Dinwoody Fm. Phosphoria Fm. Weber Ss. Amsden Fm.	9577-11,750	3.3 MMCF	New producer in Whitney Canyon-Carter Creek Field
2	Chevron USA	4-30M Chevron-Federal	SE SW sec 30, T19N, R119W	Mission Canyon Ls.	14,758-15,030	12.3 MMCF 117 BBL cond	New producer in Whitney Canyon-Carter Creek Field
3	Questar Exp. & Production	8 Wedge	SW SE sec 26, T16N, R95W	Almond Fm.	12,314-12,324 12,328-12,348	7.9 MMCF 35 BBL cond 22 BBL H_2O	Infill well in Mulligan Draw Field
4	Devon SFS Operating	16-6-20-95 Red Desert	SE sec 6, T20N, R95W	Fox Hills Ss.	7310-7463	6.2 MMCF 67 BBL cond 41 BBL H_2O	Recompleted well in Wamsutter Field, Fox Hills discovery
	Devon SFS Operating	4X-18-20-95 Red Desert	NW NW sec 18, T20N, R95W	Lewis Sh.	7664-7748	2.3 MMCF 17 BBL cond 3 BBL H_2O	New producer on western flank of Wamsutter Field
5	Yates Petroleum	1 Gandy Dancer-Federal	NE NE sec 2, T20N, R96W	Lewis Sh. Mesaverde Gp.	7789-9982	424 MCF 3 BBL cond 37 BBL H_2O	New discovery, about two miles northwest of nearest production
	Yates Petroleum	1 Trestle-Federal	SW NE sec 14, T20N, R96W	Lewis Sh. Almond Fm. Ericson Ss.	7710-7717 8754-9123	4.6 MMCF 61 BBL cond 38 BBL H_2O	New discovery, extends Lewis/ Mesaverde production a mile to the southwest
	Yates Petroleum	2 Tipton-Federal	NE NW sec 12, T20N, R96W	Lewis Sh. Almond Fm. Ericson Ss.	7753-7759 8996-9094 9165-9289	1.2 MMCF 5 BBL cond 35 BBL H_2O	New discovery
	Yates Petroleum	1 Tipton-Federal	NE SW sec 12, T20N, R96W	Lewis Sh. Almond Fm. Ericson Ss.	7712-8313 8713-8806 9140-9145	2.0 MMCF 30 BBL cond 145 BBL H_2O	New discovery
6	Amoco Production	29-2 Monument	SE NW sec 29, T22N, R93W	Lewis Sh. Almond Fm.	10,793-10,864 11,304-11,600	3.9 MMCF	New producer in Siberia Ridge Field
7	Cabot Oil & Gas	20-14 Blue Forest Unit	NW NE sec 14, T24N, R111W	Frontier Fm.	Not reported	4.7 MMCFe	New producer in Blue Forest Field
	Cabot Oil & Gas	30-14 Blue Forest Unit	NE SE sec 14, T24N, R111W	Frontier Fm.	Not reported	3.6 MMCFe	New producer in Blue Forest Field
8	McMurry Oil	6-13 Yellow Point	SE NW sec 13, T28N, R109W	Lance Fm.	11 intervals 7308-10,113	6.8 MMCF 91 BBL cond 28 BBL H_2O	New producer on the southwestern flank of Jonah Field
	McMurry Oil	14-25 Cabrito	SE SW sec 25, T29N, R108W	Lance Fm.	10 intervals 9237-11,371	8.0 MMCF 113 BBL cond 15 BBL H_2O	New producer on the eastern flank of Jonah Field
	McMurry Oil	8-2 Yellow Point	SE SE sec 2, T28N, R109W	Lance Fm.	12 intervals 7394-10,107	6.2 MMCF 40 BBL cond 22 BBL H_2O	New producer on the southwestern flank of Jonah Field
	McMurry Oil	4-7 Jonah-Federal	NW NW sec 7, T28N, R108W	Lance Fm.	12 intervals 7851-10,048	9.6 MMCF 101 BBL cond 30 BBL H_2O	New producer on the southwestern flank of Jonah Field
	McMurry Oil	2-7 Jonah-Federal	NW NE sec 7, T28N, R108W	Lance Fm.	13 intervals 7984-10,558	6.6 MMCF 87 BBL cond 17 BBL H_2O	New producer on the southwestern flank of Jonah Field
	McMurry Oil	13-20 Stud Horse Butte	SW SW sec 20, T29N, R108W	Lance Fm.	11 intervals 7968-10,929	5.1 MMCF 36 BBL cond 30 BBL H_2O	New producer on the northwestern flank of Jonah Field
	McMurry Oil	9-19 Stud Horse Butte	NE SE sec 19, T29N, R108W	Lance Fm.	11 intervals 8129-11,120	4.1 MMCF 41 BBL cond 27 BBL H_2O	New producer on the northwestern flank of Jonah Field
	McMurry Oil	13-29 Stud Horse Butte	SW SW sec 29, T29N, R108W	Lance Fm.	9 intervals	4.1 MMCF 23 BBL cond 14 BBL H_2O	New producer on the northwestern flank of Jonah Field
	McMurry Oil	10-34 Stud Horse Butte	NW SE sec 34, T29N, R108W	Lance Fm.	11 intervals 8140-11,336	6.7 MMCF 116 BBL cond 50 BBL H_2O	New producer in Jonah Field
	McMurry Oil	14-35 Stud Horse Butte	SE SW sec 35, T29N, R108W	Lance Fm.	11 intervals 8940-11,800	7.2 MMCF 126 BBL cond 58 BBL H_2O	New producer in Jonah Field
	McMurry Oil	8-35 Stud Horse Butte	SE NE sec 35, T29N, R108W	Lance Fm.	13 intervals 8654-10,922	5.3 MMCF 64 BBL cond 29 BBL H_2O	New producer in Jonah Field
	Amoco Production	2-19 Corona Unit	NW NE sec 19, T29N, R108W	Lance Fm. Mesaverde Fm.	13 intervals 7786-11,298	8.6 MMCF 12 BBL cond	New producer on northwestern flank of Jonah Field
	Amoco Production	6-31 Cabrito Unit	SE NW sec 31, T29N, R107W	Lance Fm.	several intervals 8641-11,893	7.4 MMCF	New producer on northwestern flank of Jonah Field
9	Wexpro Co.	11-16 Mesa	NE SW sec 16, T31N, R109W	Lance Fm.	13 intervals 9016-13,110	4.1 MMCF 48 BBL cond 72 BBL H_2O	Pinedale anticline well
	Ultra Petroleum	5-23 Warbonnet	SW NW sec 23, T30N, R108W	Lance Fm.	8 intervals unreported depth	10.5 MMCF 125 BBL cond	Pinedale anticline well
	Wexpro Co.	11-16 Mesa	NE SW sec 16, T32N, R109W	Lance Fm.	13 intervals 9016-13,110	19.6 MMCF	Pinedale anticline well
	McMurry Energy	7-31 Rainbow	SW NE sec31, T30N, R107W	Lance Fm. Mesaverde Fm.	4 intervals unreported depth	7.0 MMCF	Pinedale anticline well

Table 11. (Continued)

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
9	McMurry Energy	1A Jensen	SW NW sec 11, T31N, R109W	Mesaverde Fm.	4 intervals unreported depth	9.0 MMCF	Pinedale anticline well
	McMurry Energy	13-32 New Fork Unit	SW SW sec 32, T31N, R108W	Lance Fm. Mesaverde Fm.	3 intervals unreported depth	6.0 MMCF	Pinedale anticline well
	McMurry Energy	4A Pinedale-Federal	NE NW sec34, T32N, R109W	Lance Fm.	unreported	5.1 MMCF	Pinedale anticline well
	Ultra Resources	15-23 Warbonnet	SW SE sec 23, T30N, R108W	Lance Fm.	11 intervals 9135-12,667	5.6 MMCF 29 BBL cond	Pinedale anticline well
	Ultra Resources	5-23 Warbonnet	SW NW sec 23, T30N, R108W	Lance Fm.	4 intervals unreported depth	5.5 MMCF	Pinedale anticline well; completions planned in 11 Lance zones
10	Tom Brown, Inc.	19-21M Muddy Ridge-Tribal	NE NW sec 19, T4N, R3E	Lance Fm. Meeteetse Fm.	several intervals 8938-9944	3.3 MMCF 21 BBL cond 125 BBL H_2O	New well in Muddy Ridge Field
11	Double Eagle Petroleum	1-26 Lloyd	NW NE sec 26, T39N, R90W	Fort Union Fm.	3407-3426 3445-3464	1.2 MMCF 4 BBL H_2O	Shallower pool discovery in the Shotgun Ss. Member of the Fort Union in the Madden Field area
	Burlington Resources	8-35 Bighorn	SE SE sec 35, T39N, R90W	Madison Ls.	TD-24,711		Scheduled deep test
12	Tom Brown, Inc.	49 Graham Unit	SE SE sec 9, T37N, R89W	Fort Union Fm. Lance Fm.	several intervals 10,128-10,794	5.6 MMCF 10 BBL cond	New well in Frenchie Draw Field
13	Barrett Resources	9-13 Bullfrog Unit	NE SW sec 13, T36N, R87W	Frontier Fm.	17,914-18,261	1.4 MMCF 143 BBL H_2O	Extends Waltman Field's subthrust Frontier gas pool one mile to the southwest
14	Trend Exploration	16-1 Trend-State	SW NE sec 16, T55N, R72W	Minnelusa Fm.	8463-8470	100 BBL oil	Nearest Minnelusa production is two miles to the nw
15	Independent Production	42-8P Geer	SE NE sec 8, T47N, R73W	Parkman Ss.	6546-6569	56 BBL oil 16 BBL H_2O	NW offset to discovery
16	Devon Energy Production	62-2 House Creek	SE SE 15, T44N, R73W	Sussex Ss.	8142-8162	338 BBL oil 44 BBL H_2O	New well in House Creek Field
17	Abraxas Petroleum	3 Jackelope	SW SW sec 2, T38N, R67W	Turner Ss.	horizontal test		Scheduled horizontal Turner test in Brooks Draw Field

[1]Abbreviations include: MMCF=millions of cubic feet of natural gas; MMCFe=millions of cubic feet of natural gas equivalent; MCF=thousands of cubic feet of natural gas; BBL=barrels; cond=condensate; H_2O=water; Ss.=Sandstone; Ls.=Limestone; Fm.=Formation; Sh.= shale. *Wyoming State Geological Survey, September, 2001.*

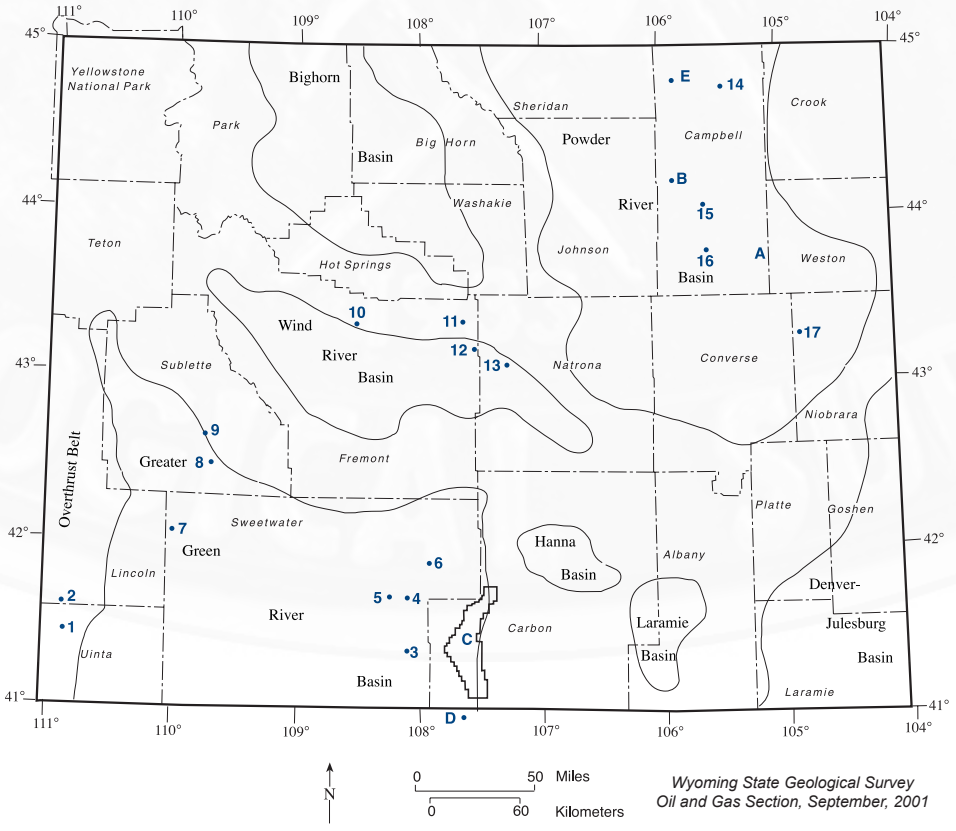

Figure 11. Oil and gas exploration and development activities (numbers) and coalbed methane activities (letters) in Wyoming during the second quarter of 2001. Locations are approximate and may represent more than one well location or project.

Coal Update

Robert M. Lyman

Staff Geologist–Coal, Wyoming State Geological Survey

During the second quarter of 2001, Wyoming coal continued its trend toward a new state annual coal production record. From Washington, D.C., the National Energy Policy Development Group (NEPD) released the National Energy Policy report. The report acknowledged the importance of coal in electrical generation and stands as a blueprint for the nation to ensure a steady supply of affordable energy for all Americans. The people of Wyoming can be proud of the important role they will play in meeting the nation's energy needs in the coming decades.

Production and prices

Wyoming coal deliveries appear to be on target to set a new state production record in 2001. During the second quarter of 2001, Wyoming mines shipped over 89 million short tons of coal (**Table 12** and **Figure 12**), bringing the state's first-half production to about 178.3 million short tons. If this rate continues, over 356.6 million short tons of coal could be produced in 2001. The Wyoming State Geological Survey's new forecast for 2001 is 354.5 million short tons (**Table 1**). These two estimates support an expected 4 to 5% increase in this year's production over last year's. Based on higher production rates this year and conservative annual increases of 1%, we have revised our earlier production forecast (*Wyoming Geo-notes No. 70*, July, 2001) accordingly (**Tables 1** and **13**). We expect all the additional production increases to be from mines in Campbell County.

Coal deliveries in 2001 continue to surge ahead of last year's deliveries, with deliveries of contract coal in March and June the highest ever (**Figure 13a**). Deliveries of coal on the spot market surged ahead in June (**Figure 13b**) after the high prices of March, April, and May decreased. Spot prices for Powder River Basin (PRB) coal continued strong the first two months of the second quarter and reached an estimated high between $11.81 and $13.78 per short ton (FOB mine) during the second week in May. During the last half of the second quarter, PRB spot prices continued downward to between $8.50 and $10.64 per ton, but still remained an amazing $5 to $6 per ton more than the spot prices offered at the end of 2000 (**Figure 14**). While the spot prices for PRB coal have soared in 2001, it is important to remember that these sales represent most likely only 8 to 10% of all the coal moving out of this coal field.

Some real gains in prices over the next two years should improve the state's economic outlook through 2004 and perhaps beyond.

In the second quarter, PRB coal producers reported that the higher spot market prices were also spiking some utilities' interest in negotiating coal deals for 2002 and beyond (COAL Daily, 4/14/01). Accordingly, we have revised our estimated average coal prices received for PRB and Wyoming coal for 2001 to 2006 (**Table 14**). Compare these prices to our earlier estimate (*Wyoming Geo-notes No. 70*, July, 2001). Some real gains in prices over the next two years should improve the state's economic outlook through 2004 and perhaps beyond.

Developments in the Powder River Basin

A U.S. Bureau of Land Management (BLM) notice in the May 24, 2001 Federal Register (66 FR 38758) invited

Table 12. Estimated monthly coal deliveries from Wyoming's mines in short tons (January, 1997 through June, 2001).

	1997		1998		1999		2000		2001	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
January	25,165,405	25,165,405	26,536,217	26,536,217	27,105,791	27,105,791	27,773,610	27,773,610	27,743,000	27,743,000
February	20,743,224	45,908,629	23,196,152	49,732,369	25,803,390	52,909,181	25,594,109	53,367,719	27,827,000	55,570,000
March	22,566,012	68,474,641	23,861,472	73,593,841	28,222,743	81,131,923	28,262,696	81,630,415	33,739,000	89,309,000
April	20,961,008	89,435,649	24,768,989	98,362,830	25,965,867	107,097,791	25,549,039	107,179,454	27,302,000	116,611,000
May	23,102,867	112,538,516	25,278,960	123,641,790	28,698,498	135,796,288	26,222,515	133,401,969	27,752,000	144,363,000
June	20,862,610	133,401,126	24,450,835	148,092,625	24,753,829	160,550,118	25,085,516	158,487,485	33,968,000	178,331,000
July	24,074,929	157,476,055	25,663,577	173,756,202	28,266,458	188,816,576	28,881,862	187,369,347		
August	23,002,254	180,478,309	26,591,950	200,348,152	28,346,757	217,163,333	29,075,295	216,444,642		
September	22,452,566	202,930,875	26,041,099	226,389,251	27,373,417	244,536,749	25,865,389	242,310,032		
October	21,623,057	224,553,932	26,659,121	253,048,372	26,837,295	271,374,045	26,441,615	268,751,646		
November	21,695,072	246,249,004	25,620,216	278,668,588	26,843,021	298,217,066	27,400,245	296,151,892		
December	24,695,740	270,944,744	26,102,620	304,771,208	26,834,927	325,051,993	28,300,773	324,452,665		
Total Utility Tonnage[1]		**270,944,744**		**304,771,208**		**325,051,993**		**324,452,665**		
Total Tonnage Other [2]		**10,536,772**		**10,190,883**		**11,407,945**		**14,399,483**		
Total Tonnage Produced[3]		**281,481,516**		**314,962,091**		**336,459,938**		**338,852,148**		

[1]From Federal Energy Regulatory Commission (FERC) Form 423 1997 through 1998, FERC Form 423 as modified by WSGS for 1999 through 2001. [2]Includes estimates of residential, industrial, and exported coal. [3]Wyoming State Mine Inspector's Annual Reports. *Wyoming State Geological Survey, Coal Section, September, 2001.*

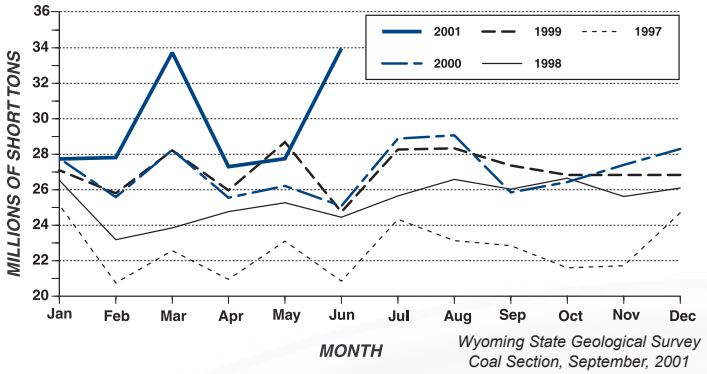

Figure 12. Reported monthly deliveries from Wyoming coal mines (1997 through June, 2001). From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the WSGS for 1999 through 2001.

interested parties to join with Ark Land Company (a part of Triton Coal Company) on a pro rata, cost-sharing basis to explore unleased federal coal deposits around their active mines (**Figure 15**) within the Powder River Known Coal Leasing Area. The targeted deposits are located in Campbell County, Wyoming, and the project is designed to gather data on the Wyodak coal zone.

Vulcan Coal Holdings was rumored to be interested in divesting the coal assets they purchased in late 1999 from AEI Resources. The assets include the Buckskin and North Rochelle mines operated by Triton Coal Company in the PRB (**Figure 15**). Talks with Rothschild, an investment banking firm, were confirmed by a spokesperson for Vulcan to be "of a general industry nature" (COAL Daily, 5/21/01).

As part of a settlement reached in a coal contract dispute with Black Hills Corp., PacifiCorp received the right to purchase a 10% interest in Black Hills' K-Fuel facility near Gillette (**Figure 15**). In the lawsuit, Black Hills (the coal supplier) and its mining subsidiary, Wyodak Resource Development Corporation claimed that PacifiCorp (the coal user) failed to live up to the terms of a 1987 coal supply agreement.

The K-Fuel plant is currently idle while Black Hills continues to look for potential investors in the project. The facility needs roughly $10 to 12 million in modifications before it can be put online. Assuming the enhanced coal plant goes online before December 31, 2003, PacifiCorp

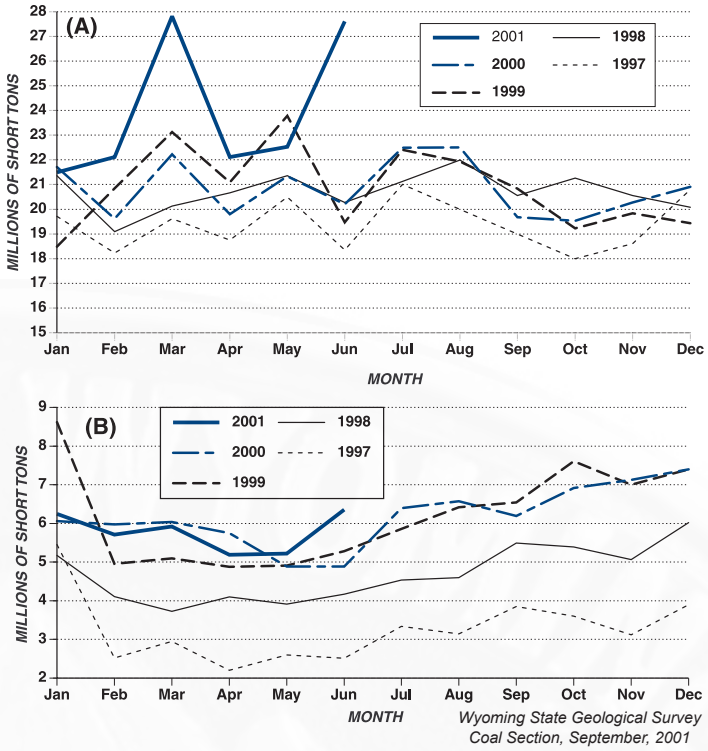

Figure 13. Monthly coal deliveries from Wyoming (1997 through June, 2001). (A) Coal sold on contract and (B) coal sold on the spot market. From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the WSGS for 1999 through 2001.

has an option to buy a 10% stake in the project, and has agreed to take delivery of up to 500,000 tons per year of K-Fuel from January 1, 2002 through the end of 2007 (COAL Daily, 6/23/01).

The BLM will hold a competitive lease sale on the 243.61-acre Belle Ayr 2000 Tract nominated as a Lease by Application (LBA) by RAG Wyoming Land Company to supplement the reserves of their Belle Ayr mine. The tract contains 29 million tons of recoverable federal coal. All the offered acreage has been determined suitable for mining assuming that a road is moved as approved in the proposed mine plan. There are no oil and gas wells on the tract, but these leasing rights are privately owned and are not included in this coal lease. The favorable Record of Decision was published in the Federal Register on June 30, 2001, after

Table 13. Wyoming coal production by county[1,2] (in millions of short tons), 1995 through 2000 with forecasts to 2006.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Powder River Basin												
Campbell County	232.4	245.3	246.3	274.1	296.3	299.5	311.5	315.0	316.6	325.3	328.9	332.6
Converse County	14.1	15.8	17.8	23.4	24.0	23.6	30.0	30.0	30.0	25.0	25.0	25.0
Sheridan County	M	M	M	M	M	M	M	M	M	M	M	M
Subtotal	246.5	261.1	264.1	297.5	320.0	323.1	341.5	345.0	346.6	350.3	353.9	357.6
Southern Wyoming												
Carbon County	3.8	4.7	5	3.5	3.5	2.0	M	M	2.0	2.0	2.0	2.0
Sweetwater County	9.1	8.2	7.8	9.2	8.0	10.0	8.0	8.0	8.0	8.0	8.0	8.0
Lincoln County	4.5	4.4	4.6	4.7	4.7	3.7	5.0	5.0	5.0	5.0	5.0	5.0
Subtotal	17.4	17.3	17.4	17.4	16.4	15.7	13.0	13.0	15.0	15.0	15.0	15.0
Total Wyoming[3]	**263.9**	**278.4**	**281.5**	**314.9**	**336.5**	**338.9**	**354.5**	**358.0**	**361.6**	**365.3**	**368.9**	**372.6**
Annual change	**11.4%**	**5.5%**	**1.1%**	**11.9%**	**6.9%**	**0.7%**	**4.6%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**
Higher-priced coal[4]	**26%**	**24%**	**22%**	**17%**	**13%**	**9%**	**6%**	**4%**	**4%**	**4%**	**4%**	**4%**

[1]Reported tonnage from the Wyoming State Inspector of Mines (1995 through 2000). [2]County estimates by the Wyoming State Geological Survey, February and September, 2001 for 2001 through 2006. Totals may not agree because of independent rounding. [3]Estimate modified from CREG's Wyoming State Government Revenue Forecast, October, 2000. [4]Estimated percentage of Powder River Basin coal production that is sold at prices above $5.00/ton (older long-term contracts that have not yet expired). M=minor tonnage (less than a million tons). *Wyoming State Geological Survey, Coal Section, September, 2001.*

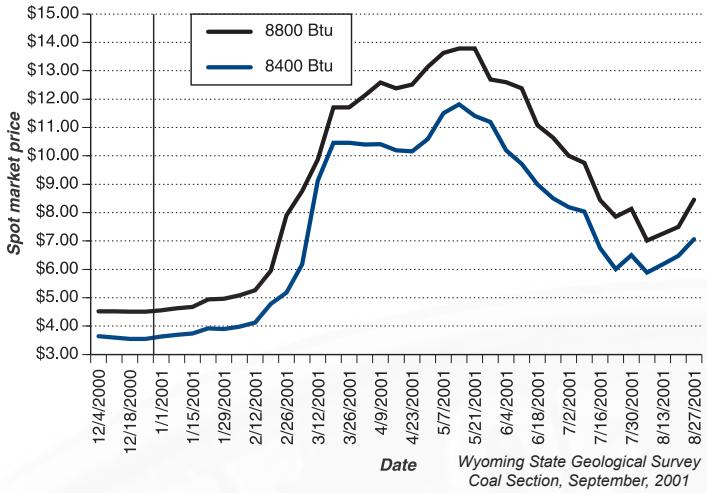

Figure 14. Wyoming PRB coal spot price watch (December 4, 2000 through August 27, 2001). Modified from COAL Daily's spot market index, and Coal Week's short term spot market price index.

which there was a 30-day period to allow for an appeal of the decision (COAL Daily, 6/20/01). Final date for the competitive sale was set for October 11, 2001, and is to be held in Cheyenne, Wyoming.

Developments in southern Wyoming

Bridger Coal Company is going ahead with an exploration program of approximately 10,200 acres of federal coal lands in Sweetwater County (*Wyoming Geo-notes No. 70*, July, 2001, p. 14). The principal area of interest is adjacent to lands currently being surface mined at the Jim Bridger mine (**Figure 15**). The program is aimed at gathering data on coals in the Fox Hills, Lance, and Fort Union formations.

Bridger is exploring some coals for their underground mining potential. A longwall mine may be in Bridger's future options, as current stripping ratios and longer haulage distances related to the surface operation continue to increase. Currently there are no active deep mines in the state as the underground operations at Hanna ceased in 2000. After the exploration data are analyzed and the technical and economic components deemed favorable, a new deep mine may open in the state by 2005 or 2006.

Coal-fired generating capacity in the U.S. is currently about 320,000 Mega-watts (MW) or 56% of the nation's total capacity

Transportation developments

In May, the Burlington Northern-Santa Fe Railroad (BNSF) brought out its first auction of railroad transportation options for coal. The first-of-its-kind program is designed to create market-based railroad rates as well as promote a trading market for option contracts. The options give the purchaser the right to move a trainload of PRB coal to one of 11 rail-water terminals at a specified price and at time intervals ranging from three to 18 months from the date of the auction. Each option will specify a publicly posted rail rate for each origin/destination pair and a time frame for the shipment. The party using the option must give BNSF a 15-day advance notice of the date on which shipping is required. The options can be resold, thus creating a trading market as the program goes forward (Coal Week, 5/14/01).

Table 14. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988 through 2000) with forecast to 2006.

	Year	Northeastern	Southern	Statewide
ACTUAL	1988	$7.35	$21.45	$9.16
	1989	$6.94	$19.76	$8.63
	1990	$6.86	$19.36	$8.43
	1991	$6.58	$18.81	$8.06
	1992	$6.61	$18.84	$8.13
	1993	$6.02	$17.72	$7.12
	1994	$5.62	$17.42	$6.62
	1995	$5.60	$17.35	$6.38
	1996	$5.40	$17.30	$6.15
	1997	$5.03	$17.19	$5.78
	1998	$4.73	$17.15	$5.41
	1999	$4.57	$16.58	$5.19
	2000	$4.93	$16.50	$5.45
FORECAST	2001	$5.08	$16.00	$5.48
	2002	$5.16	$15.00	$5.52
	2003	$5.22	$14.50	$5.59
	2004	$5.26	$14.50	$5.64
	2005	$5.29	$14.50	$5.73
	2006	$5.36	$14.50	$5.80

Statewide data for 1988 through 1990 are from reports by the U.S. Department of Energy's Energy Information Administration; data for 1991 through 2000 are derived from Wyoming Department of Revenue information; estimates for 2001 through 2006, and all regional breakdowns by the *Wyoming State Geological Survey, Coal Section, September, 2001*.

A ruling by the federal Surface Transportation Board (STB) has backed Arizona Electric Power Cooperative (AEPC) in a rate case against the BNSF and Union Pacific (UP) railroads. In the complaint, AEPC requested (and got) the STB to order the railroads to establish common carrier rail rates for the shipment of coal between the PRB and AEPC's Apache coal-fired plant east of Tucson (Coal Week, 5/14/01).

On May 18, the STB announced it had closed the record on environmental comments regarding the proposed Dakota, Minnesota & Eastern Railroad (DM&E) expansion into the PRB. The final environmental assessment of the project has begun and the Final Environmental Impact Statement (EIS) is expected sometime this fall. The STB said "While the Board has yet to make a final decision concerning the proposed DM&E project, pending completion of the environmental review process, it has already found the PRB project meets the transportation merits criteria of the ICC Termination Act. After consideration of the environmental record, which will include all public and agency comments, the Draft EIS and the Final EIS, the board will make a final decision in this case" (Coal Week, 5/21/01).

Spring floods forced the closing of vast stretches of the Mississippi River on April 14, and more than 45 days later

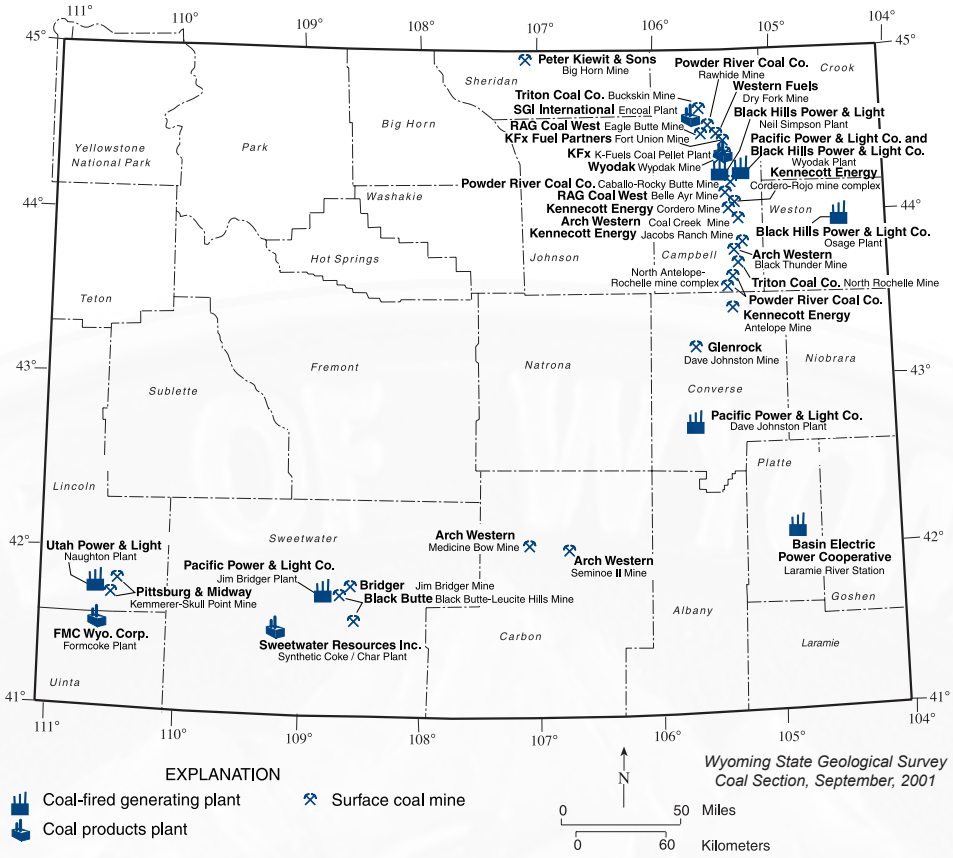

Figure 15. Map of coal mines, coal-fired power plants, and plants making coal-derived products in Wyoming.

barge companies were struggling to make up for lost time. River traffic was halted until May 22; initially 403 miles of the river were closed, followed later by an additional 83 miles. As river traffic resumed, barge lines scrambled to get operations back on schedule, all the while battling high waters, weakened levees, and fast currents (Coal Week 6/4/01). By the end of June the river was returning to normal levels.

UP began its annual flurry of maintenance work in southeastern Wyoming and western Nebraska the first week in June. This year's project cost an estimated $20 million and concentrated on the rail lines from Shawnee Junction, Wyoming east to North Platte, Nebraska. The project took months of coordination work with consumers at electric utilities and PRB coal producers to ensure a smooth transition of unit train deliveries before and after the maintenance project. No trains ran over the corridor while the work was in progress, although some trains operated at night over an alternate route. The project was due to be completed on June 20 (COAL Daily, 6/19/01).

Regulatory developments

A proposed rule by the U.S. Department of Interior's Minerals Management Service (MMS), as published in the June, 2001 Federal Register (66 FR 30123), would replace eight royalty and production forms for solid-mineral mining companies with a single form, MMS-4430 along with three data collection forms. MMS-4430 would combine most production and royalty reporting, it would eliminate reporting codes and converted lease numbers, and it would allow the creation of a central database for all lease/mine information accessible at any BLM office. The new form would also help eliminate errors in reporting, while saving industry an estimated $173,000 each year in compliance costs (Coal Week, 6/11/01).

The Wyoming Department of Environmental Quality (DEQ) has adopted by reference several of the federal government's clean air rules, including New Source Performance Standards, to reflect changes in the Code of Federal Regulations through July 1, 2000. The DEQ Air Quality Division updates its air-quality regulations once a year to keep in step with federal standards (Coal Week, 6/25/01).

Under a new rule proposed by the U.S. Environmental Protection Agency (EPA), operators of old power plants could be required to adopt technologies for combating haze-related pollutants. Nearly half the nation's coal-fired plants might be forced to install scrubbers. The proposal is designed to help states implement EPA's 1999 rule on regional haze and would apply to coal-burning plants and other industrial facilities constructed between 1962 and 1977 as well as those facilities that annually release more than 250 tons of visibility-obscuring pollutants. Coal-fired generating capacity in the U.S. is currently about 320,000 Megawatts (MW) or 56% of the nation's total capacity (Coal Week, 6/4/01).

Market developments and opportunities

Sunflower Electric is contemplating building an additional coal-fired unit at its Holcomb station in western Kansas. Holcomb presently burns PRB coal. The company is working to determine if another boiler is needed at the plant, which currently is rated at 360 MW. The company did not say what additional generating capacity was being targeted (COAL Daily, 4/4/01).

Several coal-fired plants in the U.S. are testing a biomass fuel, namely a rapidly growing reedy prairie grass known as switchgrass, which is co-fired with coal. Researchers involved with the project claim switchgrass contains about 60% of coal's heating value per pound. In one experiment, switchgrass along with other grasses will be co-fired with PRB coal at Alliant Energy's Ottumwa, Iowa generating plant (Coal Week, 4/2/01).

Peabody Energy, now a publicly traded company, is adopting a corporate strategy to become a more dynamic energy business rather than just a passive coal producer. The company is hoping to take some advantage of its vast resources to look at projects such as mine-mouth, coal-fired power plants (Coal Week, 5/7/01).

SynFuel Technologies is building a new coal gasification plant for Farmland Industries, a farmer-owned cooperative in Enid, Oklahoma. The plant would reportedly convert 10,000 short tons of PRB coal per day (3.5 million short tons per year) and would provide power, steam, and gas products to an adjacent ammonia fertilizer manufacturing facility. Construction on the project is scheduled to begin in August, 2002 and be completed in June, 2004. Facilities to be built at the site include a coal gasifier, an air separation plant, and coal storage and handling facilities (COAL Daily, 5/28/01).

. . . the [new 1500-MW] plant's fuel supply will be a blend of Wyoming PRB coal, Arkansas compliance coal, and Canadian coal.

Indiana Electric Corp. announced in late May that they would begin a major construction project in mid-June to reduce nitrogen oxide emissions at their Clifty Creek coal-fired generating plant. This project is designed to allow the 1290-MW plant in Madison, Indiana to continue its current fuel mix, which includes approximately 2.9 million short tons annually from Wyoming's PRB. The 40-year-old plant will be given new life when the estimated $100 to $150 million construction project is completed (Coal Week, 6/4/01).

On June 21, the Fort Chafee (Arkansas) Redevelopment Authority announced construction plans for a new 1500-MW plant that will also require building a new terminal complex on the Arkansas River, extending a railroad shortline, and constructing at least one new Arkansas coal mine. The site is a former military base near Fort Smith, Arkansas. The proposed plant would consist of two 750-MW gas-injected, coal-fired boilers, the first to be operational by mid-2003. Assuming the project comes to fruition, the plant's fuel supply will be a blend of Wyoming PRB coal, Arkansas compliance coal, and Canadian coal. The coals would be blended at the new terminal complex, which will include a blending facility capable of handling 32 to 50 million tons yearly. Besides supplying the new plant, hopefully the terminal will also be used to blend and ship coal to other utilities across the country (COAL Daily, 6/22/01).

Table 15 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal, announced during the second quarter of 2001.

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Table 15. Marketing activities for Wyoming coal producers during the second quarter of 2001*.

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
Euell Energy	LCRA and others	PRB	C	up to 1 mt/y	Delivery in 2003 to 2004
Grand River Dam Authority	System	Caballo/PRB	C	1.8 mt/y	10 years starting in 2002
Kentucky Utilities	Ghent	E or W compliance coal	Sp	unspecified	Delivery in second half of 2001
Lansing Board of Water & Light	Eckert Moores Park	PRB	So	1.5 mt	Delivery during 2002 to 2003
Otter Tail Power	Big Stone	PRB	C	1.8 to 2 mt/y	2 to 5 years starting in 2002
PacifiCorp	Dave Johnson	Bukskin/PRB	C	1 mt	Delivery in 2001
Portland General Electric	Boardman	Eagle Butte/PRB	C	1.1 mt	Delivery in 2002
Salt River Project	System	New Mexico and PRB	C	900,000 t	Delivery in 2002
San Antonio City Public Service Board	System	PRB	So	2.0 to 2.5 mt/y	3 to 5 years starting 2002
Tampa Electric Company	Gannon	PRB	Sp	500,000 t	Delivery in second half of 2001
TUCO (for Xcel Energy)	Harrington	Caballo/PRB	C	2 mt/y	Delivery in 2002 to 2004
TXU	System	PRB	C	7 mt/y	Delivery in 2002 to 2003

*Data obtained from: COAL WEEK, COAL Daily, Coal Age, FERC database, and personal contacts. Note: C = contract; E = eastern U.S.; Ex = export coal; mt = million short tons; mt/y = million short tons per year; PRB = Powder River Basin; Sp = spot coal; So = solicitation; T = test burn; t = short tons; and W = western U.S. *Wyoming State Geological Survey, Coal Section, September, 2001.*

Coalbed Methane Update

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Coalbed methane and other sources of natural gas were featured in the National Energy Policy Development Group's (NEPD's) report on the National Energy Policy issued in May. The NEPD expects that as many as 50,000 new coalbed methane wells will be drilled in the nation over the next decade. Coalbed methane is now being recognized as a rapidly expanding source of natural gas. The report claims that the nation's coal fields now contain untapped methane that accounts for almost 8% of the nation's natural gas reserves, which more than quadruples coalbed methane's share since similar studies were done in 1989. At the end of June, 2001, coalbed methane production in Wyoming was estimated at 660 million cubic feet (MMCF) per day. By the end of the second quarter, the number of producing coalbed methane wells in the state had grown to 5854 with over 2520 shut-in wells awaiting pipeline connections. Nearly all this production is from the Powder River Coal Field in the Powder River Basin (PRB).

Regulatory issues

Tom Fulton, a Deputy Assistant Interior Secretary, said the U.S. Department of the Interior plans to issue a report by July, 2002 analyzing the environmental impact of drilling as many as 50,000 new coalbed methane wells nationwide over the next decade. Besides the drilling boom in Wyoming, the study will also address the increased drilling expected in New Mexico, Colorado, Utah, West Virginia, Illinois, Kentucky, Alabama, and the Texas Gulf Coast.

The Wyoming Energy Commission has agreed to spend $56,000 over a 10-month period to study the impact of coalbed methane development in Campbell, Converse, Carbon, Johnson, Sheridan, and Sweetwater counties. A pilot project for the program will begin with Campbell County. The commission is also encouraging counties affected by coalbed methane activities to approach the Wyoming Legislature concerning changes in Industrial Siting Impact funding. Currently impact assistance money is not available to communities unless the cost of such a project reaches the $100 million level (Wyoming Tribune-Eagle, 8/21/01).

The Methane Operators Group (MOG) is putting together and distributing safety information offering best practice procedures.

Federal information

The U.S. Bureau of Land Management's (BLM's) Wyoming Reservoir Management Group, in response to a number of requests for information on coal gas contents in PRB coals, has made its publicly available data accessible on their website at http://www.wy.blm.gov/minerals/0g/res.mgt/. Data include the average methane adsorption capacity for as many as 41 synthesized isotherms for several different coal beds from the PRB of Wyoming. Data are from the Wyoming Oil and Gas Conservation Commission's files, the U. S. Geological Survey, and industrial sources. Data for seven of the isotherms for coal samples collected in section 9, T43N, R70W (**location A, Figure 11**) and section 32, T49N, R75W (**location B, Figure 11**) are available on the BLM's external ftp site at ftp://204.122.92.40 under wy/casper/rmg/CoalGasData.

Activities of coalbed methane companies

In hopes of reducing the number of accidents and injuries that the coalbed methane business has experienced over the past two years, the Methane Operators Group (MOG) is putting together and distributing safety information offering best practice procedures. If their guidelines don't improve safety practices in the state's coalbed methane play, MOG plans to start putting pressure on those that continue bad safety practices. Leading the campaign for improved safety in the industry is David Searle, head of MOG's recently formed Safety Committee and an employee of Marathon Oil.

According to State of Wyoming and Campbell County Sheriff's records, the industry's accident record includes at least five deaths and six serious burns among 1600 workers over the past two years. Russell Melton of the State Fire Marshall's Office said in a recent talk to the Coalbed Methane Coordination Coalition (CBMCC) that workers who, after training, refuse to follow safety procedures can either be "fired or buried" (Casper Star Tribune, 8/10/01).

The Atlantic Rim coalbed methane project (**location C, Figure 11**) described in the last issue of *Wyoming Geo-notes* (No. 70, July, 2001, p. 17) encompasses about 199,558 federal acres, 94,621 private acres, and 16,156 state acres, for a total of 310,355 acres. Petroleum Development Corporation (PDC) and three other companies are involved in the project, which will require an Environmental Impact Statement (EIS). While the EIS is being completed, BLM's Rawlins Field Office has developed an interim drilling policy based on recommendations from BLM's Reservoir Management Group, which will allow some limited drilling on the project.

Yates Petroleum Corp. is expanding its northwestern Colorado coalbed methane program (**location D, Figure 11**) approximately 6 to 12 miles south of Baggs, Wyoming. Yates has scheduled seven new coalbed methane exploratory test wells on the eastern flank of the Sand Wash Basin. The new wells are projected to depths of 3000 feet, and will test Fort Union coal beds for coalbed methane potential.

California-based Berry Petroleum Co. has acquired a 15.833% non-operating, working interest in Fort Union coalbed methane leases south of the Joe Creek Field in the PRB (**location E, Figure 11**). Composed of federal, state, and private leases totaling approximately 5800 acres, the company estimates proved reserves, net to its interest, to be in the neighborhood of 2.2 billion cubic feet (BCF) of gas. Price of the transaction was reported to be $2.1 million. Eighteen wells are currently in early stages of de-watering and net gas production is 1.8 MMCF per day. The company expects to complete 54 additional wells by the end of the year.

Several pipeline expansion projects were proceeding . . . to increase the flow of coalbed methane out of the PRB.

Pipelines

The Wyoming Oil and Gas Conservation Commission (WOGCC) reports production statistics for coalbed methane in Wyoming. Through May, 2001, over 94 BCF of coalbed methane had been produced, which is almost double what was produced in the same period last year (**Table 16**). We are projecting that about 225 BCF will be produced this year, which averages almost 19 BCF per month (compare this monthly production with past years using **Figure 16**).

Produced coalbed methane leaving the PRB in May, 2001 was approaching the current pipeline capacity of the area, thought to be approximately 650 MMCF per day (see *Wyoming Geo-notes No. 70*, July, 2001, p. 16-18). However, several pipeline expansion projects were proceeding in the second quarter of the year to increase the flow of coalbed methane out of the PRB and the state.

Clearly, projects for the addition of 200 MMCF per day in expanded capacity by Fort Union Gas Gathering, and 675 MMCF per day by Wyoming Interstate Co.'s Medicine Bow Lateral expansion (**Figure 17**) will be completed none too soon for many of the PRB's coalbed methane operators. Both projects are scheduled for completion by the end of the year.

Table 16. Monthly Wyoming coalbed methane production in MCF (1997 through May, 2001).

	1997		1998		1999		2000			
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	883,090	883,090	1,962,524	1,962,524	3,660,394	3,660,394	8,480,197	8,480,197	18,022,602	18,022,602
February	775,063	1,658,153	1,882,343	3,844,867	3,462,639	7,123,033	8,798,726	17,278,923	16,895,161	34,917,763
March	1,034,623	2,692,776	2,134,019	5,978,886	4,110,819	11,233,852	9,948,250	27,227,173	19,597,394	54,515,157
April	1,033,885	3,726,661	2,154,228	8,133,114	4,042,686	15,276,538	10,598,260	37,825,433	19,263,858	73,779,015
May	1,117,202	4,843,863	2,254,143	10,387,257	4,425,435	19,701,973	11,891,863	49,717,296	20,336,124	94,115,139
June	1,100,462	5,944,325	2,368,974	12,756,231	4,608,771	24,310,744	12,260,550	61,977,846		
July	918,571	6,862,896	2,455,849	15,212,080	4,879,316	29,190,060	13,092,297	75,070,143		
August	1,324,372	8,187,268	2,654,617	17,866,697	4,793,378	33,983,438	14,269,403	89,339,546		
September	1,220,247	9,407,515	2,988,509	20,855,206	5,126,269	39,109,707	14,405,398	103,744,944		
October	1,445,545	10,853,060	3,158,133	24,013,339	5,962,367	45,072,074	15,514,472	119,259,416		
November	1,536,287	12,389,347	3,188,968	27,202,307	5,947,893	51,019,967	15,249,807	134,509,223		
December	1,677,597	14,066,944	3,434,886	30,637,193	7,182,416	58,202,383	16,939,856	151,449,079		
Total Utility Tonnage[1]		**14,066,944**		**30,637,193**		**58,202,383**		**151,449,079**		

[1]Data from the Wyoming Oil and Gas Conservation Commission. *Wyoming State Geological Survey, September, 2001.*

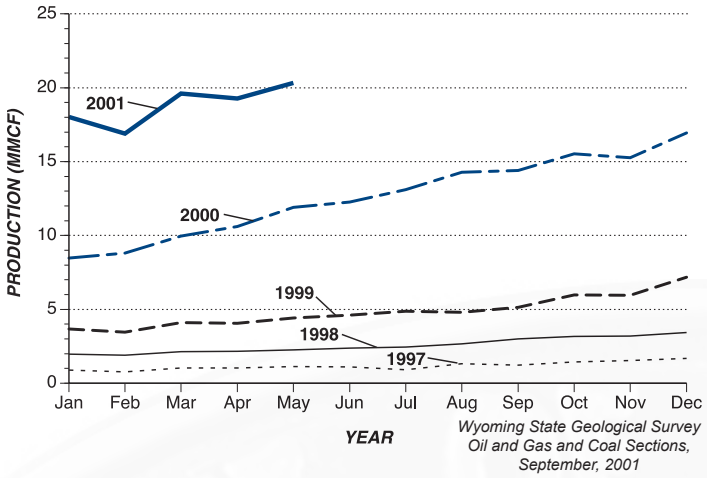

Figure 16. Coalbed methane production in Wyoming by month in MMCF (January, 1997 through May, 2001). Data from the Wyoming Oil and Gas Conservation Commission.

Figure 17. Construction of Wyoming Interstate Company's Medicine Bow Lateral expansion project where it crosses Interstate 80 between Laramie and Cheyenne. View to north; a 245-kilovolt powerline to left is from Basin Electric Power Cooperative's Laramie River Plant near Wheatland. Photograph by Richard W. Jones, September, 2001.

Industrial Minerals and Uranium Update

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Industrial mineral production in Wyoming peaks in the summer months as conditions are favorable for surface mining and quarrying, and the construction season for roads and other projects reaches its maximum. Wyoming's industrial mineral production so far in 2001 is similar to the past few years with no notable increases or decreases. If the regional economy declines, however, production of Wyoming's construction materials and related industrial minerals (e.g., aggregate, cement raw materials, and gypsum) could decrease. National and international economic conditions will affect the sales and production of trona and bentonite. Uranium production continues in the Powder River Basin at two *in situ* production sites and mills. Although the spot market price of uranium continues to increase, no significant increase in uranium production is expected.

Industrial minerals

According to new information released by the U.S. Geological Survey (USGS), in 1999 Wyoming ranked fifth among states in the value of its industrial mineral production and fourteenth (not sixteenth as reported in *Wyoming Geo-notes No. 70*, July, 2001, p. 21) in the value of its non-fuel mineral production. In 1999, Wyoming again ranked first in per capita non-fuel mineral production value as determined by the USGS (Smith, 2001).

Bentonite

Bentonite is quarried at numerous pits in several areas of northern Wyoming and refined bentonite products are produced at fifteen mills in Wyoming (**Figure 18**). Bentonite is dried, ground, screened, and blended into the various products at the mills. Kitty litter remains the primary product. Other products are binding clay for foundry molds, drilling mud, environmental adsorbents, water barriers, and other uses (see *Wyoming Geo-notes No. 70*, July, 2001, p. 22 for percentages).

Construction aggregate

Summer is the chief time for road construction, reconstruction, or sealing ("chip coating"). Most construction aggregate used in Wyoming is quarried at that time. Limestone is the preferred material for aggregate used in paving materials in Wyoming, and several limestone quarries were in operation in the second quarter of 2001 supplying the demand.

Decorative and dimensional stone

Dimensional stone is quarried by Raven Quarries in northern Albany

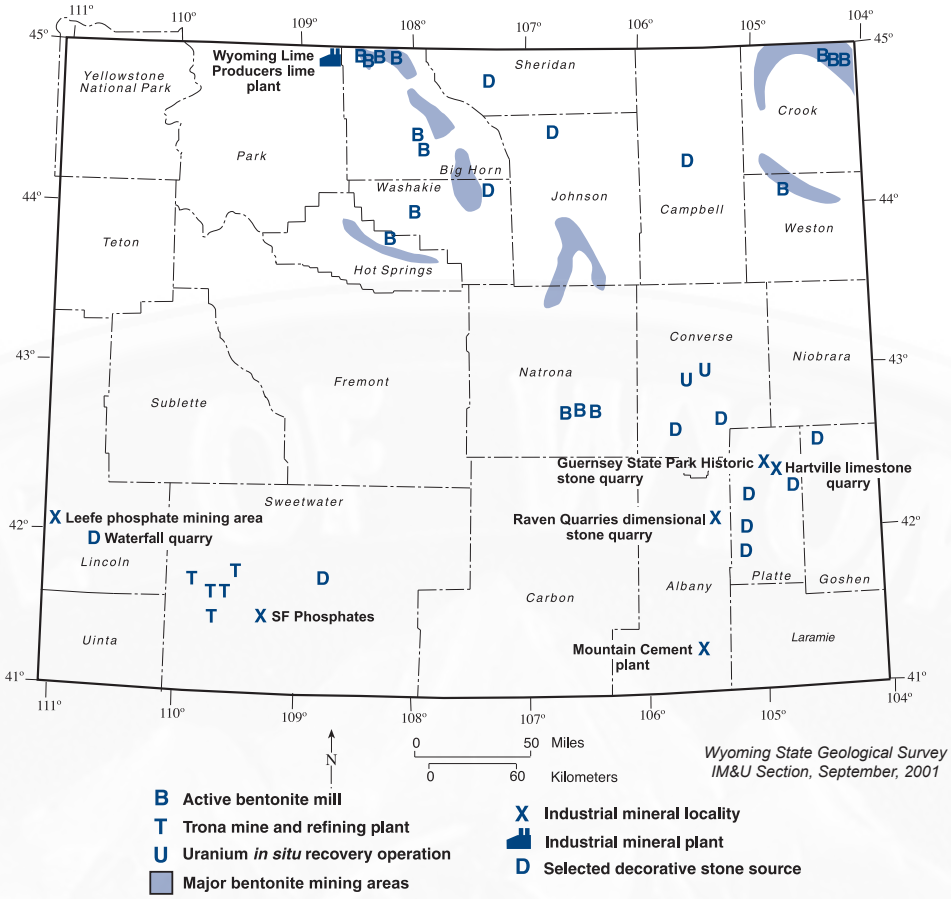

Figure 18. Index map of Wyoming showing the location of industrial mineral and uranium sites mentioned in the text. Locations and areas are approximate and may represent more than one site.

County (**Figure 18**). Raven produces a red or pink patterned granitic rock named Mirage®, and has produced a black granitic rock called Wyoming Raven®. Raven Quarries was recently awarded a contract to produce the stone that will be used for granite desktops for both chambers of the Wyoming State Legislature. The new desks will replace those now used by legislators in the Wyoming Capitol Building. Currently, six entities (up one from last quarter) are pursuing exploration and/or financing to develop additional dimensional stone quarries and large processing plants in Wyoming.

Decorative stone and aggregate is produced from many localities in Wyoming (**Figure 18**). These include the white marble produced at Wheatland by Imerys Marble, colored marble aggregate produced by Guernsey Stone at Guernsey, red clinker (scoria) quarried near Gillette by Wyoming Red Rock of Gillette, and moss rock gathered at several locations by individual producers and sold to stone retailers mostly in Colorado. The demand for buff-colored moss rock and flagstone (**Figure 19**) has increased greatly following newspaper articles on the popularity of "Wyoming Moss Rock."

Trona ranks first in value of industrial minerals produced in Wyoming, and fourth in total value of all raw materials produced in Wyoming.

In the past, blocks of dimensional stone have been quarried around Wyoming for mostly local use. During the 1930s, sandstone was quarried in Guernsey State Park for use on local structures built by the Civilian Conservation Corps (**Figure 20**). Sandstone from the Rawlins quarry was used on local structures, the Wyoming State Capitol, Merica Hall at the University of Wyoming in Laramie, and the Union Pacific Railroad Station in Ogden, Utah. Sandstone from the Waterfall Quarry (**Figure 21**) was quarried and shipped in the 1920s for use on the City Hall in Portland, Oregon. Other small quarries may be found throughout Wyoming.

Phosphate

Phosphate is currently mined in adjacent Idaho and Utah as well as in Florida (Jasinski, 2001). Phosphate was mined in Wyoming at the Leefe Mine and calcined in a mill at Leefe, west of Kemmerer (**Figure 18**), until 1977. Phosphate from the Uinta Mountains in Utah is currently slurried to the SF Phosphate plant southeast of Rock Springs (**Figures 18** and **22**) where it

Figure 19. Flagstone near Divide Peak in the Sierra Madre, Carbon County, Wyoming. Photograph by R.E. Harris, August, 2001.

Figure 21. The 1920s Waterfall Quarry is sited in a Cretaceous sandstone east of Kemmerer, Wyoming. Note that this site is now adjacent to houses. Photograph by R.E. Harris, June, 2001.

is calcined and mixed with Wyoming sulfur (from the processing of natural gas) to produce a soil conditioner for agricultural uses.

Limestone

Limestone is a rock composed primarily of calcium carbonate ($CaCO_3$). Most limestone is used in Wyoming for construction aggregate. Some chemical grade limestone (greater than 95% calcium carbonate) is quarried at two locations in Wyoming. Mountain Cement at Laramie (**Figure 18**) quarries around 500,000 short tons of the chemical grade for the manufacture of cement, and Colorado Lien is currently (September, 2001) quarrying limestone at the Hartville Quarry (**Figure 18**) for use as an emissions control agent in Basin Electric Power Cooperative's (BEPC's) Laramie River Power Plant north of Wheatland. Limestone from the Warren Quarry in Montana is refined into lime by Wyoming Lime Producers near Frannie, Wyoming (**Figure 18**), and this lime is used in BEPC's power plants in North Dakota. The quarried limestone is also used in the refining of sugar beets in western Nebraska.

Figure 20. "The Castle" was constructed in Guernsey State Park using locally quarried Pennsylvanian sandstone by the Civilian Conservation Corps in the 1930s. Photograph by R.E. Harris during the Wyoming State Historical Society's annual field trip, July, 2001.

Figure 22. SF Phosphate plant southeast of Rock Springs. Photograph by R.E. Harris, June, 2001.

Trona

Four companies in Wyoming mine trona by underground methods and solution recovery methods at five locations and produce sodium products at nearby plants (**Figure 18**). About 18 million short tons of trona are mined annually in Wyoming. Soda ash is also produced from recent lake brines and evaporite deposits at one plant in California and from nahcolite mined by *in situ* methods in northwestern Colorado. Trona ranks first in value of industrial minerals produced in Wyoming, and fourth in total value of all raw materials produced in Wyoming after oil, gas, and coal.

Uranium

Uranium is mined by *in situ* methods at two locations in the southern Powder River Basin, Converse County, Wyoming (**Figure 18**). Yellowcake from the two on-site recovery mills is shipped for enrichment and conversion into nuclear power plant fuel. In terms of product value,

uranium ranks behind oil, gas, coal, trona, bentonite, and construction aggregate in Wyoming.

The spot market price of yellowcake, the product of uranium mills, increased to US$9.20 per pound on September 3 (**Figure 23**) after reaching its lowest price since 1994 (US$7.10 per pound) on December 31, 2000 (see Wyoming Geo-notes No. 69, April, 2001), according to the Ux Consulting Company, LLC., the Uranium Exchange Company: http://www.uxc.com/top_review.html, and the Rocky Mountain Minerals Scout. The Rocky Mountain Minerals Scout contains an update on individual company operations, moves, plans, and other detailed items of interest regarding the uranium and nuclear power industries.

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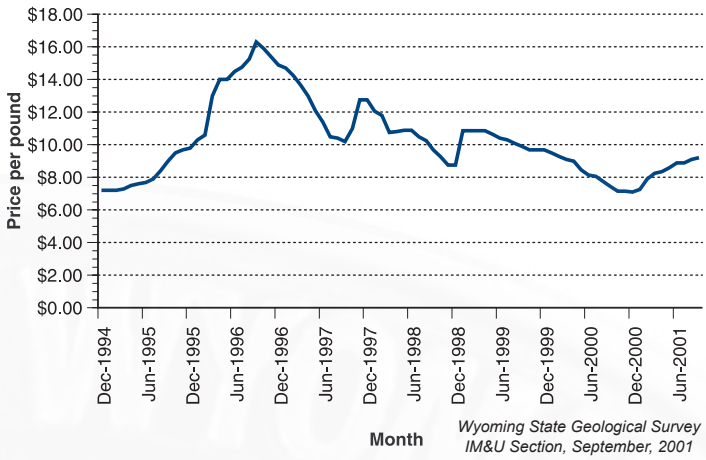

Figure 23. Spot market yellowcake prices, January, 1995 through August, 2001. Source: Uranium Exchange weekly reports

Metals and Precious Stones Update

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Highlighted items for this update include a series of field trips and lectures in August on the South Pass gold district attended by more than 200 people; a talk on platinum-group metals and nickel exploration targets in southeastern Wyoming and two talks on diamonds; reports of two Wyoming State Geological Survey (WSGS) publications being reviewed; the announced sale of the Kelsey Lake mine to a North Dakota company; and the recent display of high-quality, cut iolite and ruby gemstones from a Wyoming locality.

South Pass field trip

On August 10 and 11, 2001, more than 150 people attended two field trips to the South Pass area (**Figure 24**) in the southern Wind River Range south of Lander. This was the third year for WSGS-sponsored excursions for the public designed to highlight the incredible geology and potential mineral resources in Wyoming (see http://wsgsweb.uwyo.edu/pressrel.htm).

On Thursday, August 9, W. Dan Hausel discussed the geology of South Pass with the Geologists of the Jackson Hole. On Friday, members of the Rocky Mountain Prospectors and Treasure Hunters Club from Fort Collins, Colorado attended one of the South Pass field trips. The public field trip occurred on Saturday, followed by a discussion of potential gold deposits in the South Pass region with members of the Wyoming Prospectors Association at the Dredge in Atlantic City Saturday evening.

The South Pass area was selected this year for both its extraordinary rock exposures and its historical interest.

Figure 24. At the first stop on the South Pass field trip, the Atlantic City iron ore mine overlook along Highway 28, W. Dan Hausel discussed regional geology and past mining operations. Photograph by David R. Miller.

Gold was discovered at South Pass in 1842, and the region became a hotbed of conflict between some Indian nations and the white man that lasted for the next 40 years. Even so, by 1872 the district had 12 operating stamp mills and several gold mines (**Figure 25**). Total gold won from the district is estimated at 350,000 ounces (Hausel, 1991). Almost a century later, the Atlantic City mine began producing taconite (iron ore). In 1981, the mining and processing operations terminated after 20 years. More than 90 million tons of iron ore were recovered from the property during the life of the mine. Geologic mapping showed a sizable (300 to 400 million tons) *in situ* resource of iron ore that continued northeast of the open pit (Hausel, 1987a).

Gold prospecting and panning are part of the culture at South Pass. Hundreds of prospectors and treasure hunters search South Pass each year for gold, and many are successful. Typically, several ounces of fine gold and numerous nuggets are recovered from the district by prospectors (**Figure 26**). In the past few years, hundreds of nuggets have been recovered by prospectors and treasure hunters, including a 7.5-ounce nugget. Many nuggets weighing from 0.2 to 5 ounces have been found. Historical records describe the discovery of several spectacular specimens, including one boulder that reportedly contained as much as 630 ounces of gold. Rock samples with visible gold (**Figure 27**) are often found near many of the historical mines.

Published field trip guides describe the geology of South Pass (Hausel, 1984; Hausel and Love, 1991), and show that the area has similarities to many ancient greenstone belts around the world. Much of South Pass consists of an Archean-age (over 2.5 billion years old) synformal (basin-like) belt of metamorphosed rock that has been separated into four mappable units (Bayley and others, 1973; Hausel, 1991).

These mappable rock units in the greenstone belt were later intruded by granite, tonalite, diorite, and gabbro. The gabbros, in particular, were important in localizing gold at South Pass, as a large percentage of the gold-bearing shear zones lie adjacent to the lithologic contacts of the gabbro with metagreywacke of the Miners Delight Formation (Bayley, 1968; Hausel, 1987b). The close association of shears with this belt of metagabbros is due to the contrasting competency between the two rock types.

During regional metamorphism, gold was leached out of the metagreywackes and other sedimentary and volcanic rocks at depth, and mobilized to areas of low pressure, such as the permeable shear zones. Within the shears, differential pressure resulted in greater gold concentrations within fold closures, so today, high-grade ore shoots are often found within fold closures located within the auriferous shears

Figure 25. Field trip attendees viewed an operating 1/2-scale stamp mill at the South Pass City historic site. Photograph by David R. Miller.

(Hausel, 1991). Some textbook examples of folded shears were seen by the field trip attendees at the Carissa and Duncan mines (**Figure 28**).

The shear zones are typically narrow, foliation-parallel, cataclastic zones with strike lengths from dozens of feet to more than 11,000 feet that exhibit both brittle and ductile deformation (Hausel and Hull, 1990). Widths of the shears typically vary from 2 to 15 feet, although greater widths occur at several mines.

Figure 26. A South Pass prospector panning for gold. Pencil sketch by W. Dan Hausel, 2001.

Historical reports indicate that the tenor of the ore shoots at some of the mines ranged from a trace of gold (Au) to some rare, specimen-grade rock that yielded as much as 3100 ounces per ton (opt) Au. Average mine grades varied from 0.06 to 2.0 opt Au with minor silver (Hausel, 1989). The continuation of these structures at depth has not been fully tested since the deepest gold mine (Carissa) is only 400 feet deep, and drilling has penetrated the mineralized structures to depths of only 930 feet.

In addition to narrow mineralized structures, the possibility exists for large-tonnage, low-grade gold deposits. Possible large tonnage deposits investigated included the Carissa, Duncan, Lone Pine, Wolf, and Tabor Grand properties.

The Carissa mine along the northern flank of the greenstone belt was developed in a narrow 5- to 50-foot wide structure enveloped by a broad, 100- to 200-foot zone of weakly mineralized wallrock with rehealed fractures. A 1.5-foot long channel sample taken across the primary shear by the WSGS assayed 5.2 parts per million (ppm) (0.15 opt) Au (Hausel, 1989). Beeler (1908) reported the average ore from Carissa assayed 10.29 ppm (0.3 opt) Au. Composite chip samples collected in the adjacent wallrock also yielded anomalous gold over a 97-foot width (Hausel, 1989), and

Rock Hound's Corner: Garnet

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Garnet is a common accessory mineral found in many micaceous metamorphic rocks in Wyoming as well as in several kimberlites. Garnets have relatively high specific gravity (3.5 to 4.3) and hardness (6.5 to 7.5). The high specific gravity results in garnets being found in the heavy black sand concentrates in placer deposits. Because of its relative resistance to weathering and disaggregation during stream transport, garnet is often found in the black sands of stream deposits downstream from its host rock. When found in the host rock, garnets can range from tiny grains to single minerals as large as 5 to 6 inches in diameter.

Six pure end-member subspecies of garnet are recognized. These vary in color, specific gravity, chemistry, and index of refraction. The subspecies include pyrope [$Mg_3Al_2(SiO_4)_3$], almandine [$Fe_3Al_2(SiO_4)_3$], spessartite [$Mn_3Al_2(SiO_4)_3$], grossularite [$Ca_3Al_2(SiO_4)_3$], andradite [$Ca_3Fe_2(SiO_4)_3$], and uvarovite [$Ca_3Cr_2(SiO_4)_3$]. However, garnets in nature typically form solid solutions, or mixtures of the end members. Because of this, many garnets are described as solid-solutions. For example, a garnet containing both magnesium and iron may be described as a pyrope-almandine [Mg-$Fe_3Al_2(SiO_4)_3$] garnet, and so forth.

Garnets crystallize in the isometric crystal system, have no cleavage, may show parting, are typically transparent to translucent, and often exhibit well-formed dodecahedral or trapezohedral habit. Garnets are typically used for abrasives, although excellent musuem quality garnets are often found. Less commonly, transparent to translucent flawless garnets are found; these may be used as semi-precious gems. Garnets range in color from purplish-red, yellowish-orange, reddish-brown, black, white, or green.

A variety of garnets have been reported in Wyoming. Most are of abrasive quality, although some museum-quality specimens have been found. The latter garnets include translucent to opaque almandine garnets with good dodecahedral habit from the Teton Range, chlorite pseudomorphs after garnet from the Sierra Madre near Encampment, and large, rounded, pyrope-almandine garnets found in diamondiferous kimberlites south of Laramie.

The garnet psuedomorphs near Encampment exhibit excellent dodecahedral habit, but are opaque and completely replaced by chlorite and biotite mica, even though they retain the characteristic garnet crystal habit. Some extraordinary pyrope-almandine garnet megacrysts from the Colorado-Wyoming State Line district have also been recovered from some diamondiferous kimberlites. Some of these are as much as 5 to 6 inches across, and are rounded without any crystal faces.

Transparent, flawless, semi-precious garnets are uncommon in Wyoming but several gem-quality stones have been found in breccia pipes in the Greater Green River Basin near Cedar Mountain and in anthills near Butcherknife Draw. These are small (typically less than 6 mm in diameter), transparent, pyrope and pyrope-almandine garnets found in anthills and associated with emerald-green chromian diopside and chromian enstatite. Some collectors have faceted some of these garnets, producing very attractive yellowish-orange and reddish-purple gemstones.

Other transparent, gem-grade garnets have been reported in an area 20 miles northeast of Guernsey (Cheyenne Gem and Mineral Society, 1965). Many of these have apparently been cut, polished, and sold as gems. This occurrence has not been verified by the Wyoming State Geological Survey.

Reference cited

Cheyenne Gem and Mineral Society, 1965, The Wyoming rockhunter's guide: Cheyenne, Wyoming, 29 p.

Figure 27. A geologist looking for visible gold in a rock sample. A rule of thumb suggests that if you can see a tiny spec of gold with a 10x hand lens, the rock should assay as high as 1 ounce per ton in gold. Pencil sketch by W. Dan Hausel, 2001.

this zone is enveloped by an even larger structure as much as 1000 feet wide.

At the Duncan mine, the foliation-parallel shear is folded and splayed. Field trip attendees had the opportunity to see the folded shear in the glory hole at the mine. The splay has an aggregate width of more than 40 feet adjacent to the shaft, and is mineralized across its entire width. Within the fold closure, the gold values are enhanced, and the nose of the steeply plunging drag fold averages nearly ten times the amount of gold in the fold limbs.

At the nearby Tabor Grand mine, a 1- to 5-foot wide shear cuts hornblendic amphibolite. Samples of the shear yielded 0.06 to 58.0 ppm Au over a 350-foot length. During mapping of the mine by the WSGS, a second shear parallel to the first was discovered 20 feet south of the primary shear. Two samples taken in this shear yielded 1.7 and 7.0 ppm Au. Surface mapping of the primary shear also extended its length another 800 feet to the east where an 8-foot channel sample assayed 3.8 ppm Au (Hausel, 1991).

MacKenzie Bay announced plans to sell its subsidiary, Great Western Diamond Company, to Roberts Construction Company.

At the Lone Pine mine in the Lewiston district (along the southeastern margin of the greenstone belt), a hidden shear buried under a thin veneer of Tertiary South Pass Formation was discovered in 1987 through a trench that exposed a 17-foot wide shear (Hausel, 1991). Field trip participants were informed that the shear yielded gold values from 0.47 to 3.5 ppm. The maximum width and strike length of this structure has not been determined. At the Wolf mine in the Lewiston district, representative samples of the shear yielded 23.3 ppm (0.68 opt) Au (Hausel, 1989). An exploration company reported that the shear was mineralized over a 100-foot width and later examined this property.

Figure 28. A pot of gold may lie under the head frame of the Duncan mine. Photograph by W. Dan Hausel.

In summary, attendees of the field trips and lectures were provided with information and saw many of the localities that indicate that the South Pass region has very high potential for additional gold discoveries. The location of next year's WSGS field trip has not been determined.

Talks and lectures

On August 24, Hausel provided the Wyoming Geological Association (WGA) with a geologic summary of several platinum-group metal and nickel targets currently under exploration in southeastern Wyoming. On September 13 and 14, the Society of Mining Engineers (SME) and the WGA in Casper heard him discuss a book entitled *"Diamond and their host rocks."* Co-authored by Dr. Edward Erlich and W. Dan Hausel, the new book describes conventional and unconventional diamondiferous host rocks, their characteristics, famous diamonds, tectonics, and exploration methods for diamond deposits. The WSGS is expecting to have this book available for purchase at their sales desk in Laramie.

Book reviews

Volume 21, no. 3 (2001), of the Australia Gemmologist Journal, published by the Gemmological Association of Australia, contains a very favorable review of WSGS Bulletin

71, *"Gemstones and other unique minerals and rocks of Wyoming–A field guide for collectors."* Gems and Gemology, Volume 36, no. 3 (2000) published a favorable review of WSGS Report of Investigations 53, *"Diamonds and mantle source rocks in the Wyoming Craton with a discussion of other U.S. occurrences."* Both of these books can be purchased through WSGS publications sales.

Hausel recently provided technical information for a new mystery novel, *"Thunder Keeper,"* by national best selling author, Margaret Cole. The novel has a plot related to the intrigue of diamonds. Another book, *"Barren Lands,"* by Kevin Krajack, was released this fall. This is an excellent historical epic leading to the discovery of diamonds and eventual development of the Ekati diamond mine in Canada. The book reviews the pertinent historical facts, and includes discussions on diamond exploration in Colorado and Wyoming.

Kelsey Lake diamond mine

On September 10, 2001, MacKenzie Bay announced plans to sell its subsidiary, Great Western Diamond Company (the operators of the Kelsey Lake diamond mine), to Roberts Construction Company of North Dakota. Roberts will conduct diamond grade tests on the property in the future. The Kelsey Lake mine in northern Colorado (near the Wyoming state line) has been the source of several spectacular diamonds.

Palmer Canyon gems

Iolite (gem-quality cordierite), which was discovered at the Palmer Canyon metamorphic complex in the Laramie Mountains by Hausel in 1995, has yielded several thousand carats of potential gem-quality material (Hausel and Sutherland, 2000). Some of this material was recently cut by Eagle-Hawk Mining Company. The cut gems (**Figure 29**) are very high quality. Some cut iolite gems weighed 3.4 and 3.9 carats. In addition to iolite, this deposit hosts some sapphires, rubies, and decorative stone. A recently cut 1.1-carat ruby from the deposit was appraised at $300 per carat. Other cuttable material could be worth $1200 per carat.

Figure 29. Faceted iolite gems (in the lower left, upper right, and center of box) from the Palmer Canyon deposit in the Laramie Mountains and a faceted garnet (upper left of box) from the Green River Basin. The square presentation box is approximately 1 inch on a side. Cut samples from the Vic Norris collection. Photograph by W. Dan Hausel, 2001.

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MAPPING AND HAZARDS UPDATE

Geologic Mapping, Paleontology, and Stratigraphy Update

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The Geologic Mapping Section of the Wyoming State Geological Survey (WSGS) recently completed two new bedrock geologic maps, the Sheridan and Buffalo 30′ X 60′ quadrangles, as part of the STATEMAP 2000 Program in support of the Northern Powder River Basin geologic, hydrologic, and water quality database project. The Mapping Section has begun work on the Pilot Hill 1:24,000-scale Quadrangle west of Laramie to provide detailed geologic information to support the Laramie Drinking Water Protection Plan developed to protect the aquifer recharge area for the Casper Formation.

Paul Sereno, paleontologist with the University of Chicago, recently collected *Tyrannosaur* remains which may yield information on the nature of *Tyrannosaur* skin. This find might clear up the question of whether they may have had feathers rather than reptilian skin, as most researchers believe.

The Wyoming Geological Association held its 52nd Annual Field Conference in Casper. The theme for this year's conference was *Wyoming gas: Resources and technology*. Several presentations were given relating to Wyoming geology, specifically stratigraphy and structural geology. Many of these presentations will be included in the conference guidebook which will be published later this year.

New color digital geologic map of the Sheridan area published

The WSGS recently completed a new color digital geologic map of the Sheridan area. This map was first released as Preliminary Geologic Map 00-1 using funds from the STATEMAP 1999 Program. After review and editing during the fall of 2000, the map was updated and corrected, and with the aid of funding from the STATEMAP 2000 Program, the Hazards Section at the WSGS scanned and digitized the map.

The Sheridan Quadrangle is located in northern Wyoming, on the Wyoming/Montana border (**Figure 30**). The quadrangle includes bedrock ranging from Precambrian to Eocene in age. The structural axis of the Powder River Basin (PRB) runs southeast to northwest through the west-central part of the quadrangle, with the Bighorn Mountains uplift impinging on the southwest corner. In the southwestern corner of the quadrangle, high-angle reverse faulting brings the Piney Creek thrust block up and over Tertiary and Cretaceous rocks on the west flank of the structural basin. The remainder of the quadrangle is characterized by relatively flat-lying Tertiary Wasatch and Fort Union outcrops containing numerous coal beds that historically have been both underground and surface mined and are currently being tested for coalbed methane.

Recently collected *Tyrannosaur* remains . . . may yield information on the nature of *Tyrannosaur* skin.

The new map is entitled *Preliminary digital geologic map of the Sheridan 30′ x 60′ Quadrangle, Sheridan, Johnson, and Campbell Counties, Wyoming and southern Montana* and is available as Geologic Hazards Section Digital Map HSDM 01-1. The color map comes with a pamphlet containing a detailed description of map units and map symbols and a complete list of the sources of geologic data used in compiling the map. The map will be available as a plotted color map or on CD-ROM.

Buffalo geologic map completed

The Geologic Mapping Section, with funding from the STATEMAP 2000 Program, recently completed compiling a geologic map of the Buffalo 1:100,000-scale Quadrangle. The recent activity in coalbed methane exploration and production in the vicinity and the fact that the Buffalo area contains significant population prompted choosing this quadrangle. Geologic mapping at a wide variety of scales and coverages existed for much of this area and starting in August, 2000, this information was compiled at the 1:100,000 scale.

The Buffalo Quadrangle is located in northern Wyoming, adjacent to the previously completed Sheridan Quadrangle to the north and the Gillette Quadrangle to the east (**Figure 30**). The quadrangle includes bedrock ranging from Precambrian to Eocene in age. The structural axis of the PRB runs southeast to northwest through the central and southeastern part of the quadrangle, with the Bighorn Mountains uplift parallel to the axis and impinging on the west side of the quadrangle. In the northwestern

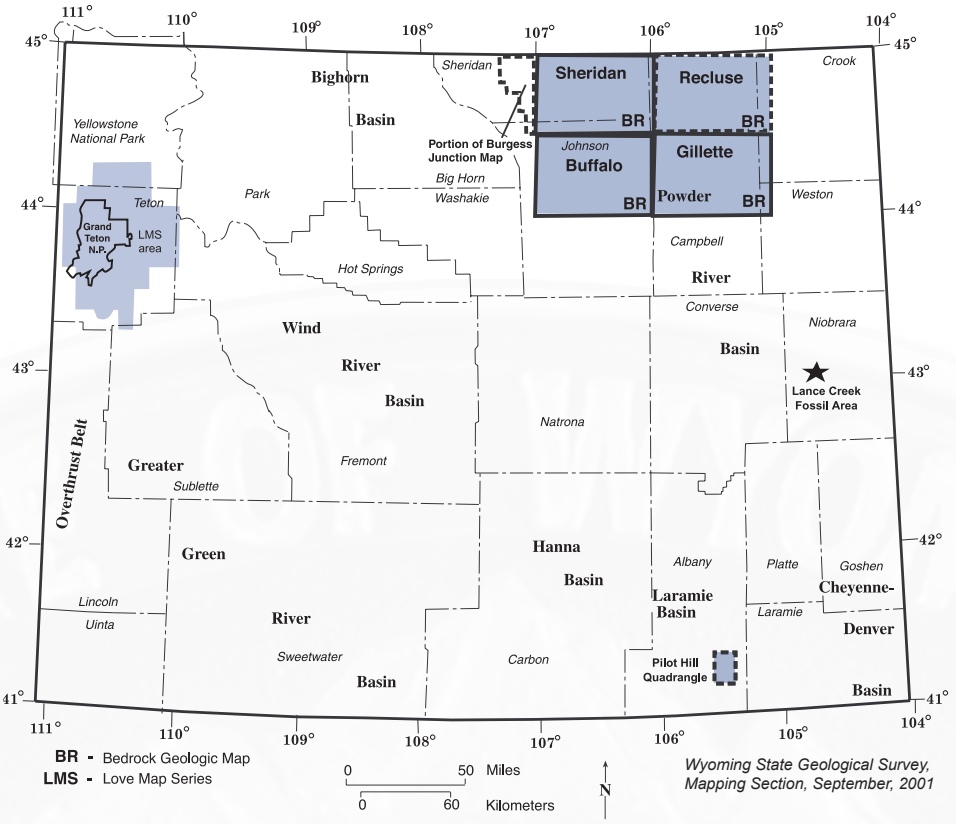

Figure 30. Index map showing recently completed and initiated geologic mapping projects, paleontologic discoveries relating to Wyoming geology, and general location of Love Map Series.

corner of the quadrangle, high-angle reverse faulting brings the southern part of the Piney Creek thrust block up and over Tertiary and Cretaceous rocks on the west flank of the structural basin. Similar thrust features also occur to the south, including the Clear Creek thrust. The Tensleep fault occurs in the southwestern corner of the map, exhibiting some lateral motion along with vertical, down-to-the-south motion. Two southeast- to northwest-trending anticlines, Billy Creek and West Billy Creek, occur in the Paleozoic and Mesozoic rocks that crop out in the southern part of the area. The remainder of the quadrangle is characterized by outcrops of relatively flat-lying Tertiary Wasatch and Fort Union formations containing numerous coal beds that historically have been both underground and surface mined and are currently being tested for coalbed methane.

With expanding construction in the Buffalo area, as well as in other localities within the quadrangle, accurate, up-to-date mapping is needed by the construction and concrete industries to locate aggregate and construction materials. Clinker, rock baked or partially fused by recent naturally ignited coal fires, is used locally as aggregate and light duty construction material. As the new map shows, numerous clinker quarries already exist and additional clinker deposits are common in the weathered outcrops of the Wasatch Formation, which occur east, north, and northeast of Buffalo. The new mapping will help mitigate identified geologic hazards in the area, as numerous landslides have been mapped in the foothills of the Bighorn Mountains west of Buffalo and north and south along the Bighorn uplift. In addition, accurate geologic information depicted on the map can enhance predictability in searching for coalbed methane and water well drill sites in the area.

The new Buffalo map, along with geologic maps of the Recluse Quadrangle and eastern part of the Burgess Junction Quadrangle will be merged with the existing Sheridan and Gillette 1:100,000-scale quadrangles (**Figure 30**) and serve as a digital geologic base map for another project. The geologic base map will help extrapolate subsurface data to the surface as part of the Northern Powder River Basin geologic, hydrologic, and water quality database project (see the description in *Wyoming Geo-notes No. 69*, April, 2001, p. 36-38).

Entitled *Preliminary geologic map of the Buffalo 30′ x 60′ Quadrangle, Sheridan, Johnson, and Campbell Counties, Wyoming* by A.J. Ver Ploeg and C.S. Boyd, the map is available as WSGS Preliminary Geologic Map PGM 01-1. Along with the black line map is a pamphlet containing a detailed description of map units and map symbols and the sources of geologic data used in compilation. An entirely digital version of the geologic map and base is in preparation and will be completed as part of STATEMAP 2001; the map will be available as either a plotted color geologic map or as a CD-ROM with the digital data by August, 2002.

Mapping initiated on Pilot Hill Quadrangle

The Mapping Section recently began mapping the geology of the 1:24,000-scale Pilot Hill Quadrangle east of Laramie (**Figure 30**). These mapping efforts support the Laramie Drinking Water Protection Plan developed by the City of Laramie Environmental Advisory Committee to protect the recharge area for the Casper Formation aquifer from contamination. Much of the recharge area is exposed on the quadrangle and detailed geologic mapping is needed to outline zones or outcrops in need of special protection. More detailed information on faulting in the recharge area is especially important to augmenting the protection plan.

The Section will begin with airphoto interpretation and field work this fall to substantiate existing interpretations and provide dip and strike information to better define the structural geology. Field work will place special emphasis on locating and better defining faulting in the Casper Formation, as some of the faults may serve as conduit(s) for contaminants. Plans are to complete the map over the winter months with a preliminary digital version being available by next summer.

Recent find could yield clues to **Tyrannosaur** *skin*

Paul Sereno, University of Chicago paleontologist, announced the discovery of a partial *Tyrannosaur* skeleton in the Lance Creek fossil area (**Figure 30**) this summer. The bones are embedded in four or possibly five boulders, with the largest measuring 4 by 5 feet. Sereno has indicated that the bones belong to a juvenile *Tyrannosaurus Rex* or an adult of a smaller *Tyrannosaur* species which to date had only been known by teeth found in the area. Mummified dinosaurs have been found in the area, which have provided information about dinosaur skin. Although this specimen was not mummified, Sereno feels that it may have been buried in such a way as to preserve the skin surface. This may be the first time the skin of a large predator has been preserved. Examination of the specimen in the laboratory will hopefully yield information that would help determine whether the dinosaur had scaly or leathery skin (as most paleontologists believe) or possibly a downy coat of feathers.

New articles on Wyoming geology

The Wyoming Geological Association, in cooperation with the Society of Petroleum Engineers, held its 52nd Annual Field Conference in Casper on September 8 through 12. The theme for this year's conference was *Wyoming gas: Resources and technology*. The WSGS had an information booth and display at the conference, which was attended by WSGS personnel Bob Lyman, Rod De Bruin, Alan Ver Ploeg, and Richard Jones. Several presentations, including one by WSGS geologist Rod De Bruin, were given relating to Wyoming mineral resources and geology. Many of these presentations will be included in the conference guidebook which is due out later this year. A list of the speakers and their presentations relating specifically to Wyoming geology included:

These mapping efforts support the Laramie Drinking Water Protection Plan . . . to protect the recharge area for the Casper Formation aquifer from contamination.

- Rodney De Bruin, WSGS, Wyoming's natural gas resources;
- Allen Middleman, Burlington Resources, An integrated analysis of the Madison Formation;
- Dan Schilling, Structural Geology International, Structural geology of the Owl Creek Mountains and the northern Wind River Basin, Wyoming;
- A.R. Prave, University of St. Andrews, Scotland, Depositional framework of the Mesaverde Formation;
- Randi Martinsen, University of Wyoming, Improved sequence stratigraphic and reservoir characterization models: Mesaverde Group, southwestern Wyoming;
- Carol Frost, University of Wyoming, Coalbed methane gas Sr isotopic characterization of coal and sandstone aquifers, Powder River Basin, Wyoming;
- Al Allen, Casper College, The long season of point bar deposition in the Lance Formation: Dinosaurs dying and a new order;
- Tim Cross, Colorado School of Mines, Stratigraphic controls on reservoir strata: A comparison of fluvial reservoirs and shoreface/tidal couplets in the Almond Formation, Wamsutter, Echo Springs, and Rock Springs Fields, Washakie Basin, Wyoming;
- John Robinson, McMurry Energy Co., Jonah and Pinedale Fields, Northern Green River Basin, Wyoming: Current status and future developments;
- William Almon, Texaco, Sequence stratigraphy, petrophysical variation and sealing capacity in deepwater shales, Upper Cretaceous Lewis Shale, south-central Wyoming;
- Mark Kramer, Interactive Earth Sciences, Structural and stratigraphic interpretation of the Muddy Formation using Manderson Field 3-D seismic survey, Big Horn County, Wyoming;
- Richard Postma, Interactive Earth Sciences, Pre-stack depth migration and the imaging of complex structures in the Wyoming Thrust Belt;

- John Horn, Orion International, Aeromagnetic definition of basement linears and their influence on depositional patterns;
- Charles Howell, University of Texas, Scales of facies architecture in top-truncated lowstand delta lobes, Upper Cretaceous Wall Creek Member, Powder River Basin, Wyoming;
- Steve Hollis, Double Eagle Petroleum, Upper Fort Union (Paleocene) deposition on the north flank of Madden Anticline, Wind River Basin, Wyoming;
- David Schmude, Alberta Energy, The Greybull Sandstone (Sykes Mountain Formation) a potential stratigraphic play in the Bighorn Basin, Wyoming; and
- Mike Hendricks, Hendricks and Associates, Lance Formation in the Greater Green River Basin, Wyoming.

Geologic Hazards Update: Jackson Hole Seismic Network at Risk

James C. Case

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The U.S. Bureau of Reclamation (BOR) is considering shutting down the Jackson Hole Seismic Network (JHSN). This network provides valuable information on patterns of seismicity in northwestern Wyoming. In addition, it serves as a monitor of seismic activity on the Teton fault, which is capable of generating a magnitude 7.5 earthquake. The network is operated and maintained by the BOR, with data obtained from the network analyzed by BOR's Seismotectonic Section in Denver, Colorado. If the shutdown occurs, a valuable source of data will be lost and earthquake detection limited. This article presents a short history of the network along with a discussion of actions being taken by the State of Wyoming.

History of the Jackson Hole Seismic Network

The BOR installed the JHSN in 1986 to better define seismicity in the region and on the Teton fault. This was needed to verify assumptions about seismicity and seismic response that were used in redesign and reconstruction of Jackson Lake Dam in the late 1980s. The dam was reconstructed because of concerns that it would not withstand a magnitude 7.5 earthquake on the Teton fault.

Originally the network was composed of sixteen seismometers. The network has been upgraded through the years, and is now composed of one broadband seismometer, twenty short-period seismometers, and four strong motion sensors. The strong motion sensors have been placed on Jackson Lake Dam.

The network has not yet detected any significant seismic activity on the Teton fault since operation began, although a few very small magnitude events may have been associated with the fault. The small magnitude events were closely monitored to determine if they were precursors to a larger event, but fortunately they were isolated incidents. The seismic network is important because it can detect very small events on the Teton fault. Any activity on the fault may be significant because it has been seismically quiet for such a long time. The fault is still thought to be capable of generating a magnitude 7.5 earthquake, and many scientists feel that it is overdue for activation.

The [Teton] fault is still thought to be capable of generating a magnitude 7.5 earthquake, and many scientists feel that it is overdue for activation.

Besides the Teton fault, the JHSN provides valuable data on the magnitudes and locations of other large and small earthquakes in the Jackson Hole region, with thousands of earthquakes detected since 1986. For example, in a one-week period from September 1 to 8, 2001, the network detected twelve earthquakes with magnitudes ranging from 2.0 to 3.2. Those earthquakes have not been reported on any of the other web sites for earthquakes in the region. The BOR web site that provided this dataisat:http://www.seismo.usbr.gov/seismo/eqdata.html.

Concerns of the State of Wyoming

The Wyoming State Geological Survey (WSGS) was recently notified that BOR might cease data collection from the network in 2001, and that they may cease operation of the entire network. The WSGS worked with the Wyoming Governor's Office to draft a letter to Gale Norton, Secretary of the U. S. Department of the Interior, concerning the fate of the seismic network. The key points in the letter are summarized below.

BOR proposes to reevaluate the performance of the modified Jackson Lake Dam under various earthquake

scenarios. Since very little seismic activity on the Teton fault has been detected by the JHSN, the State of Wyoming questions whether BOR has enough data to adequately characterize the earthquake-related ground motion and resulting site response at the dam that may occur during a magnitude 7.5 event on the Teton fault. BOR proposes to use data from other earthquakes in the region to characterize ground motion at the dam, which is not the same as using data from the Teton fault. The State of Wyoming feels that the BOR has a responsibility to maintain the network until the Teton fault itself can be adequately characterized using data from events directly associated with the fault.

When the Jackson Lake Dam was reconstructed, using a stabilization technique called dynamic compaction, it was designed to withstand earthquake-related ground accelerations of 0.5 to 0.7g. The BOR recently funded a study that found that Jackson Lake Dam may actually experience a peak ground acceleration of 1.19g. There is a significant difference between 0.5 to 0.7g and 1.19g. Data derived directly from the Teton fault may show an even greater difference. More data are now available on the propagation and attenuation of seismic waves and amplification of ground motions during an earthquake than were available when the dam was reconstructed. This means that a considerable difference may exist between estimates of design ground accelerations used in the late 1980s and today's models.

There are a number of Wyoming citizens who live near and downstream from the Jackson Lake Dam. There are also a great number of tourists from around the world that may be in the vicinity of the dam during peak tourist season. Because of these populations, the State of Wyoming feels that more data should be collected from the network before shutting it down.

If the network is lost, then the ability to detect small earthquakes on the Teton fault would also be lost.

Considering the limited number of seismic events with magnitudes greater than 3.0 that have occurred within 30 kilometers (19 miles) of the dam, the lack of seismic events associated with the Teton fault, and the residual uncertainty in the engineering analysis, the State of Wyoming feels that the BOR must demonstrate that the structural reassessment of the dam is so sound as to guarantee that residents living or vacationing in the vicinity of the dam will not be adversely affected by the dam itself during a large earthquake.

Summary

The State of Wyoming has formally requested (to BOR) that the Jackson Hole Seismic Network, data collection, and data analysis continue to be maintained by the BOR. If the BOR still decides to give up the network, then new operating partners may have to be found. This could not be done without considerable expense and personnel. It is by far more efficient and cost-effective for the BOR to continue in their role with the network.

If the network is lost, then the ability to detect small earthquakes on the Teton fault would also be lost. Considering the fact that the fault has been quiet for so long, any activity detected could be significant.

Concerned citizens are encouraged to express their thoughts to the new Commissioner of Reclamation: John W. Keys III, Commissioner of Reclamation, U.S. Bureau of Reclamation, Main Interior Building, 1849 C Street NW, Washington, D.C. 20240-0001.

PUBLICATIONS UPDATE

New Publications Available from the Wyoming State Geological Survey

Wyoming State Geological Survey publications

Carbon dioxide in Wyoming, by R.H. De Bruin, 2001: Information Pamphlet 8 - FREE.

*Coalbed methane activity in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, and L.L. Hallberg, 2001: Coalbed Methane Map CMM 01-6 (updated in October, 2001, replaces CMM 01-3), on-demand plotted color map, rolled only - $30.00; digital version (ESRI ArcInfo® / ESRI ArcView® format) on CD-ROM - $100.00.

*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, and M.M. Harrison, 2001: Coalbed Methane Map CMM 01-7 (updated in October, 2001, replaces CMM 01-4), on-demand plotted color map, rolled only - $30.00; digital version (ESRI ArcInfo® / ESRI ArcView® format) on CD-ROM - $100.00.

*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, and M.M. Harrison, 2001: Coalbed Methane Map CMM 01-8 (this is a reduced and combined version of CMM 01-6 and CMM 01-7 at 1:250,000 scale), on-demand plotted and laminated color map, rolled only - $50.00; on-demand plotted color map, rolled only - $40.00.

Coalbed methane in Wyoming, by R.H. De Bruin, R.M. Lyman, R.W. Jones, and L.W. Cook, 2001: Information Pamphlet 7 (revised edition) - Free upon request; larger quantities may be purchased for $1.00 each.

Glacial records in the Medicine Bow Mountains and Sierra Madre of southern Wyoming and adjacent Colorado, with a traveler's guide to their sites, by B. Mears, Jr., 2001: Public Information Circular 41, 26 p., ISBN1-884589-16-2 - $6.00.

J. David Love Historical Geologic Map Series, Geology of the Teton-Jackson Hole region (**Figure 30**), on-demand plotted color map, rolled only - $20.00; CD-ROM of digital map coverages in ESRI ArcInfo® format plus viewable, printable version in MrSid® - $10.00.

- Geologic map of the Cache Creek Quadrangle, Teton County, Wyoming, by J.D. Love and C.M. Love, 2000, scale 1:24,000 (LMS-1).
- Geologic map of the Teton Village Quadrangle, Teton County, Wyoming, by J.D. Love and J.C. Reed, Jr., 2000, scale 1:24,000 (LMS-2).
- Geologic map of the Moose Quadrangle, Teton County, Wyoming, by J.D. Love, 2001, scale 1:24,000 (LMS-3).
- Geologic map of the Gros Ventre Junction Quadrangle, Teton County, Wyoming, by J.D. Love, 2001, scale 1:24,000 (LMS-4).
- Geologic map of the Granite Basin Quadrangle, Teton County, Wyoming, by J.C. Reed, Jr., and J.D. Love, 2001, scale 1:24,000 (LMS-5).
- Geologic map of the Blue Miner Lake Quadrangle, Teton County, Wyoming, by J.D. Love, 2001, scale 1:24,000 (LMS-6).
- Geologic map of the Shadow Mountain Quadrangle, Teton County, Wyoming, by J.D. Love, 2001, scale 1:24,000 (LMS-7).

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The newest full-time permanent staff member at the Wyoming State Geological Survey (WSGS) is Joseph M. Huss (**Figure 31**), having joined the Survey in early August, 2001. As a specialist in Geographic Information Systems (GIS), Joe is the GIS Coordinator for the Survey. Although his position is attached to the Publications Section, Joe provides all the geologic sections with GIS expertise and coordination in projects, products, and training as well as the expertise for GIS database design and management. He participates in various projects that use GIS, helps generate maps and databases, and supervises other GIS specialists working on projects and grants.

Joe represents the WSGS, along with Alan Ver Ploeg of the Mapping Section, on the state's Wyoming Geographic Information Advisory Council (WGIAC). He is currently organizing a GIS day in cooperation with WGIAC, the Geographic Information Science Center (WyGISC), and the Department of Geography at the University of Wyoming (UW). This event will take place on November 14 on the UW campus (for details contact Joe at his Email address on the back cover of this issue). A list of speakers, displays, and demonstrations will be available as this event takes shape.

Joe is involved in a number of projects at the WSGS, and as he states, "there is a lifetime of work in GIS-related activities at the WSGS." He is actively assisting three other WSGS geologic sections in the interactive geologic, hydrologic, and water quality database for the northern Powder River Basin, Wyoming (see *Wyoming Geo-notes No. 69*, April, 2001) and has furnished guidance to set up GIS-based analysis and database management for the project. He is leading the Survey's

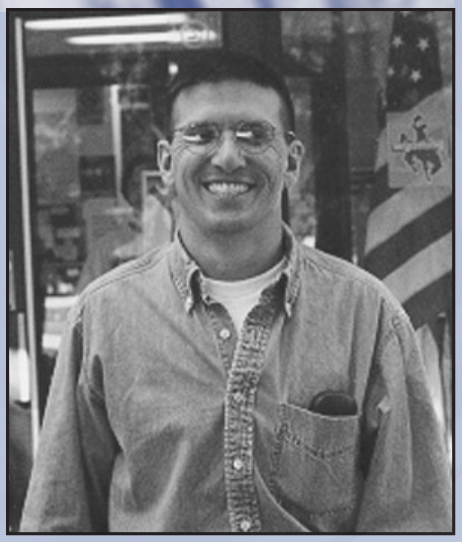


Figure 31. Joseph M. Huss is the GIS specialist at the Wyoming State Geological Survey.

efforts in a new project to produce a computerized GIS-based map and database of Wyoming's oil and gas pipelines. He is assisting the WSGS in the STATEMAP 2001 project, which consists of preparing digital geologic maps of surficial and bedrock units for 1:100,000-scale quadrangles in

(continued on next page)

Pyrophoricity (spontaneous combustion) of Powder River Basin coals–considerations for coalbed methane development, by R.M. Lyman and J.E. Volkmer, 2001: Coal Report CR 01-1, 12 p. - $2.00.

Wyoming geologists field camp, by P.A. Ranz, 2001: Postcard (4" x 5") - $0.25 each or 5 for $1.00.

Each geologic section of the Survey now prepares and releases some of its own numbered reports and maps. Please contact the Staff Geologists for coverage, availability, prices, or further information on specific commodities or topics (see **STAFF DIRECTORY** on back cover).

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

Free USGS hydrology reports available

The Wyoming State Geological Survey (WSGS) has a number of U.S. Geological Survey reports on the hydrology of coal areas in Wyoming. The five reports listed below cover most of Wyoming's coal fields and are free upon request. We do ask the requestor to pay the postage for sending these reports, however. Call our Publications Sales desk for postage charges. They can also be picked up at the Survey office in Laramie at no charge. Quantities are limited and will be distributed on a first-come first-served basis.

Hydrology of Area 48, Northern Great Plains and Rocky Mountain Coal Provinces, Montana and Wyoming, by S.E. Slagle and others, 1986, U.S. Geological Survey Water-Resources Investigations Open File Report 84-141. Includes Yellowstone, Clarks Fork of the Yellowstone, Musselshell River, and Pryor Creek drainages (mostly northern Bighorn Basin).

Hydrology of Area 50, Northern Great Plains and Rocky Mountain Coal Provinces, Wyoming and Montana, by M.E. Lowry, and others, 1986, U.S. Geological Survey Water-Resources Investigations Open File Report 83-545. Includes Powder River, Crazy Woman Creek, Clear Creek, Little Powder, Belle Fourche, and Cheyenne rivers, and Lance Creek (Powder River Basin, Wyoming and Montana) drainages.

Hydrology of Area 51, Northern Great Plains and Rocky Mountain Coal Provinces, Wyoming and Mon-

(continued from previous page)

Wyoming, and is working to develop Survey-wide GIS mapping and storage facilities and standards. Joe is also leading the WSGS effort in digital oil and gas field maps as well as in publication of digital geologic maps as part of the Love Map Series, a cooperative project with the U.S. Geological Survey and the U.S. Forest Service.

Joe was born in Minneapolis, Minnesota and lived in a number of states (his father was in the construction business) before graduating from high school in Salem, Virginia. He earned two degrees from Florida State University (FSU) in Tallahassee, a B.S. in Geography and a B.S. in Social Science, and then came to UW where he earned an M.A. degree in Geography in 1994. While in graduate school at Wyoming, Joe worked part-time as a cartographer for the WSGS and later as a teaching assistant in the Department of Geography. His thesis was on mima-like mounds in the Laramie Basin, and involved detailed stratigraphy, soil stratigraphy, and mapping sodium contents. While an undergraduate at FSU, he became interested in GIS, which he applied as a mapping tool for his thesis. Joe also worked as a lab manager and field assistant for a soil testing company, where he worked on geoarchaeology projects and developed a computer database for laboratory data.

Joe began his professional career when he moved back to Florida and joined a geotechnical firm in Fort Myers. He moved on to the Department of Environmental Protection for the State of Florida in Tallahassee where he became active in GIS projects as an analyst and planner. As a GIS analyst/planner and cartographer, Joe spent two years with a Tallahassee consulting firm in GIS planning, operations, analysis, and cartographic developments for a state-wide GIS system prepared for the Florida Department of Transportation. In 1998 he joined Lockheed Martin Information Services in Bellevue, Washington as a Senior Software Engineer/GIS Applications Engineer. Working out of Tallahassee, he designed, developed, and built GIS databases for military simulations using a variety of GIS data sources and ESRI ArcInfo®, ArcView®, and MapObjects® software.

When the WSGS developed a GIS position, Joe was an extremely well-qualified applicant. Since he had lived in Wyoming for a few years attending graduate school in Laramie, he became hooked on the state. He had always wanted to come back to the Rocky Mountains and Wyoming's uncrowded, open spaces to raise his family and settle permanently. The Survey is glad to have him back.

Joe is a strong advocate for serving his country, and has been active in the Army National Guard (NG) in most places he has lived. He has served in the Washington Army NG (Battery Commander), the Alabama NG (Battalion Fire Direction Officer and most recently Battery Commander), and has joined the Wyoming NG where he serves as Captain, 115th Field Artillery Brigade.

Joe and his wife Andrea have a daughter, Maggie, and a son, Rhylan. They enjoy camping and hiking in Wyoming's great outdoors and Joe does some big game hunting in the fall, but only when his alma mater, FSU, is not playing football. He is a huge fan of the Seminoles, as any visitor to his office can attest.

tana, by D.A. Peterson and others, 1987, U.S. Geological Survey Water-Resources Investigations Open File Report 84-734. Includes Shoshone, Bighorn, Greybull, Wind, and Popo Agie rivers (Bighorn and Wind River basins) drainages.

Hydrology of Area 52, Rocky Mountain Coal Province, Wyoming, Colorado, Idaho, and Utah, by H.W. Lowham and others, 1985, U.S. Geological Survey Water-Resources Investigations Open File Report 83-761. Includes Green, New Fork, and Big Sandy rivers, Blacks Fork, Bear River, and Great Divide Basin (Thrust belt, Greater Green River Basin) drainages.

Hydrology of Area 54, Northern Great Plains and Rocky Mountain Coal Provinces, Colorado and Wyoming, by G. Kuhn and others, 1983, U.S. Geological Survey Water-Resources Investigations Open File Report 83-146. Includes North Platte, Laramie, and Medicine Bow rivers (North Park, Saratoga Valley, Hanna, and Laramie basins) drainages.

Other publications

*A tapestry of time and terrain: Geologic age of rocks in color, superimposed on the digital shaded relief map of the U.S., U.S. Geological Survey Geologic Investigations Series Map I-2720, 2000, 1 sheet, 55" x 40" (scale 1:3,500,000) plus 24 p. pamphlet - $7.00.

*General purpose map of America, U.S. Geological Survey, 2001, scale 1:5,000,000 (42" x 30") - $7.00. This is a detailed, full color reference map that shows International and state boundaries, large and small cities, state capitals, highways, railroads and ferries, rivers and lakes, oceans and bays, natural features, forests, mountain elevations, and terrain.

Roadside geology of the Yellowstone Country, by W.J. Fritz, 1985: Roadside Geology Series, 149 p., ISBN 0-87842-170-X - $12.00.

*This dynamic earth, the story of plate tectonics, U.S. Geological Survey, 1996, 77 p. booklet - $6.00.

*This dynamic planet, world map of volcanoes, earthquakes, impact craters, and plate tectonics, U.S. Geological Survey, 1994 - $7.00.

Attention GPS users

The WSGS is now a dealer for Global Positioning Systems (GPS) accessories offered by Waypoint Enterprises. These are scales for plotting GPS coordinates on maps or for locating GPS coordinates from map locations, "cheat sheets" for operating and initializing the most common GPS units, and a book on GPS. The products listed below are available over the counter at the WSGS sales office in Laramie or by mail. These products do not qualify for our quantity discounts.

Original Waypointer. Used for measuring and plotting latitude and longitude for map scales of 1:24,000; 1:62,500; 1:100,000; 1:126,720; and 1:250,000 - $7.95.

UTM Waypointer. Used for UTM coordinate systems on 7.5-minute, 1:24,000-scale quadrangle maps; includes protractor for determining compass headings - $7.95.

Pocket Waypointer. Used for latitude/longitude (down to seconds or decimal minutes to hundredths of a minute) on 7.5-minute, 1:24,000-scale maps; includes miles for townships and meters for UTM grids -$6.95.

Multiscale UTM Waypointer. Used for UTM coordinate system on seven popular map scales and a protractor for plotting headings - $5.95.

Cheat sheets for quick references to basic functions on various Magellan, Garmin, and Globe GPS units (specify which model or call for availability) - $4.95.

GPS Land Navigation, by Michael Ferguson (1997). Soft cover book that explains principles, uses, and limitations of GPS, coordinate systems, datums, etc. associated with GPS, and other topics - $19.95.

Attention users of All Topo Maps: Wyoming

As a dealer for iGage *All Topo Maps: Wyoming* products, the WSGS is proud to announce a drop in prices and some changes in the configurations of the products:

- *All Topo Maps: Wyoming*, Release 3 now sells for $88.00 and contains over 260 new maps; a uniform color palette for all maps; the ability to search by township, range, and section; the ability to search by National Geodetic Survey (NGS) control points, zip codes, and area codes; and the latest versions of the map seamer, the GPS Tool, and the All Topo Viewer. Those that purchased their Wyoming All Topos before April 11, 2001 can upgrade to Release 3 for $29.00.
- PLS Tool, a $68.00 option ($34.00 when purchased with upgrade), offers users a real-time display of the cursor position to the nearest 1/4 1/4 section (plus township and range) while viewing All Topo Maps. The Public Lands Survey (PLS) tool enables legal descriptions to be read directly from All Topos.
- Big Topo Pro Tool enables creation of unlimited sized maps for those using large format plotters and requiring large seamed maps. Normally a $120 option, this tool is available with the Release 3 upgrade for $90.

Price list for All Topo Maps: Wyoming

Item	Normal	With PLS
All Topo Maps	$88.00	$124.00
Upgrade	$29.00	$63.00
PLS Tool	$68.00	
Big Topo Pro Tool	$120.00	

Ordering Information

Prepaid orders (preferred)

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

  30% discount: 10 of one title or 20 mixed titles
  35% discount: 20 of one title or 30 mixed titles
  40% discount: 30 of one title or 40 mixed titles

- No discounts on U.S. GEOLOGICAL SURVEY TOPOGRAPHIC MAPS and U.S. GEOLOGICAL SURVEY PUBLICATIONS. No discounts on POSTCARDS (PCs), INFORMATION PAMPHLETS (IPs), and some other publications.
- Include postage and handling charges for all prepaid orders (see **ORDER FORM** for chart).

Telephone or Email orders

- Telephone, Fax, or Email orders for maps and publications may be billed to a customer only with pre-approved credit. We may require completion of a credit application to complete your order.
- Payment is due on receipt of merchandise. All orders will be billed for postage charges. Overdue payment may be assessed service fees and/or interest.

Sales tax

- Shipments to addresses within the state of Wyoming must include sales tax of 6%, collected at the point of origin of the sale, which is the City of Laramie in Albany County.
- Sales tax is applied after adding shipping and handling charges, as prescribed by Wyoming statutes.
- All over-the-counter sales are charged 6% sales tax.
- Resellers or entities with tax exempt status should furnish a State of Wyoming Tax ID number or a copy of their State of Wyoming Sales Tax Exemption Certificate.

Mailing (in U.S.A.)

Please allow adequate time for delivery.

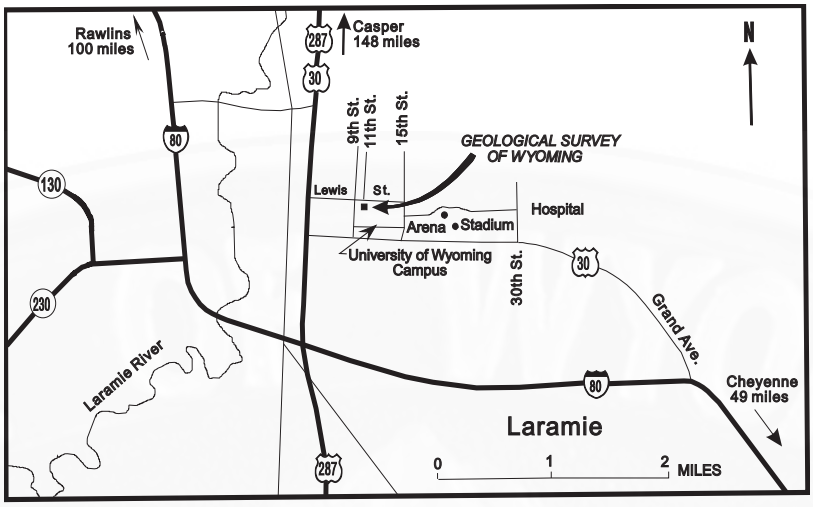
- Regular orders will be mailed FIRST CLASS or PRIORITY. Larger orders will be shipped UPS.
- Expedited mail is permitted if charged to your account number. We cannot guarantee date or time of delivery once your order leaves our building.
- Please allow extra time for handling of products that require plotting or computer processing.

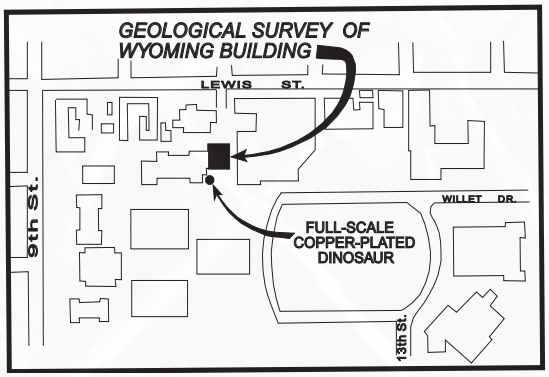
International orders

- International orders must be PREPAID with U.S. dollars through a U.S. Clearing House or with a money order in U.S. currency. Checks or money orders must have a nine-digit U.S. routing number for proper bank clearance.
- Overseas orders will be mailed SURFACE unless otherwise specified.
- PERFORMA information upon request.
- Maps **cannot** be mailed rolled.
- International orders for Memoir 5, *Geology of Wyoming*, must indicate preferred method of shipment (U.S. Postal Service SURFACE, U.S. Postal Service AIR, Federal Express, or United Parcel Service) and must include additional postage for areas outside North America. Memoir 5, which includes a custom shipping box, weighs about 10 pounds (4.6 kg).
- Sorry, we do not accept credit cards for payment at this time.

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

Location Maps for the Wyoming State Geological Survey





Improved Telephone System at the Wyoming State Geological Survey

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

Ext.	Name/section
0	Ordering, sales questions, and general information
223	Lance Cook–State Geologist
225	Jim Case–Geologic Hazards
226	Rod De Bruin–Oil and Gas
228	Ray Harris–Industrial Minerals
229	Dan Hausel–Metals and Precious Stones
230	Alan Ver Ploeg–Geologic Mapping
233	Bob Lyman–Coal
234	Joe Huss–GIS
238	Richard Jones–Publications
242	Susan McClendon–Information Technology

Publications Order Form

Make checks payable to :

Wyoming State Geological Survey
P.O. Box 3008
Laramie, WY 82071
Phone: 307-766-2286
Fax: 307-766-2605
Email: sales-wsgs@uwyo.edu

Please send to:

Name

Mailing Address

City

State Zip

Phone (order cannot be processed without phone #)

Quantity	Item #	Item name	Price	Total Price

Subtotal	
Shipping & handling (see chart below)	
Wyoming addresses add 6% sales tax on subtotal only	
TOTAL ENCLOSED	

Shipping & handling charges

Up to $10.00 ..... $2.55
$10.01 to $20.00 ..... $5.00
$20.01 to $30.00 ..... $6.00
$30.01 to $40.00 ..... $7.50
$40.01 to $50.00 ..... $8.50
$50.01 to $100.00 ..... $10.00
Over $100.00 and international orders (incl. Canada) – Please call for postage and best shipping methods.

Please include shipping and handling charges and 6% Wyoming sales tax (if applicable). Insufficient payment will delay your order. Prices may change without notice. Please allow 2 to 3 weeks for delivery of your order. Some items may not be immediately available, in which case the WSGS will notify you of expected availability.

Publications Order Form

Make checks payable to :

Wyoming State Geological Survey
P.O. Box 3008
Laramie, WY 82071
Phone: 307-766-2286
Fax: 307-766-2605
Email: sales-wsgs@uwyo.edu

Please send to:

Name

Mailing Address

City

State Zip

Phone (order cannot be processed without phone #)

Quantity	Item #	Item name	Price	Total Price

Subtotal	
Shipping & handling (see chart below)	
Wyoming addresses add 6% sales tax on subtotal only	
TOTAL ENCLOSED	

Shipping & handling charges

Up to $10.00 ..... $2.55
$10.01 to $20.00 ..... $5.00
$20.01 to $30.00 ..... $6.00
$30.01 to $40.00 ..... $7.50
$40.01 to $50.00 ..... $8.50
$50.01 to $100.00 ..... $10.00
Over $100.00 and international orders (incl. Canada) – Please call for postage and best shipping methods.

Please include shipping and handling charges and 6% Wyoming sales tax (if applicable). Insufficient payment will delay your order. Prices may change without notice. Please allow 2 to 3 weeks for delivery of your order. Some items may not be immediately available, in which case the WSGS will notify you of expected availability.

Survey Directory

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Change service requested.