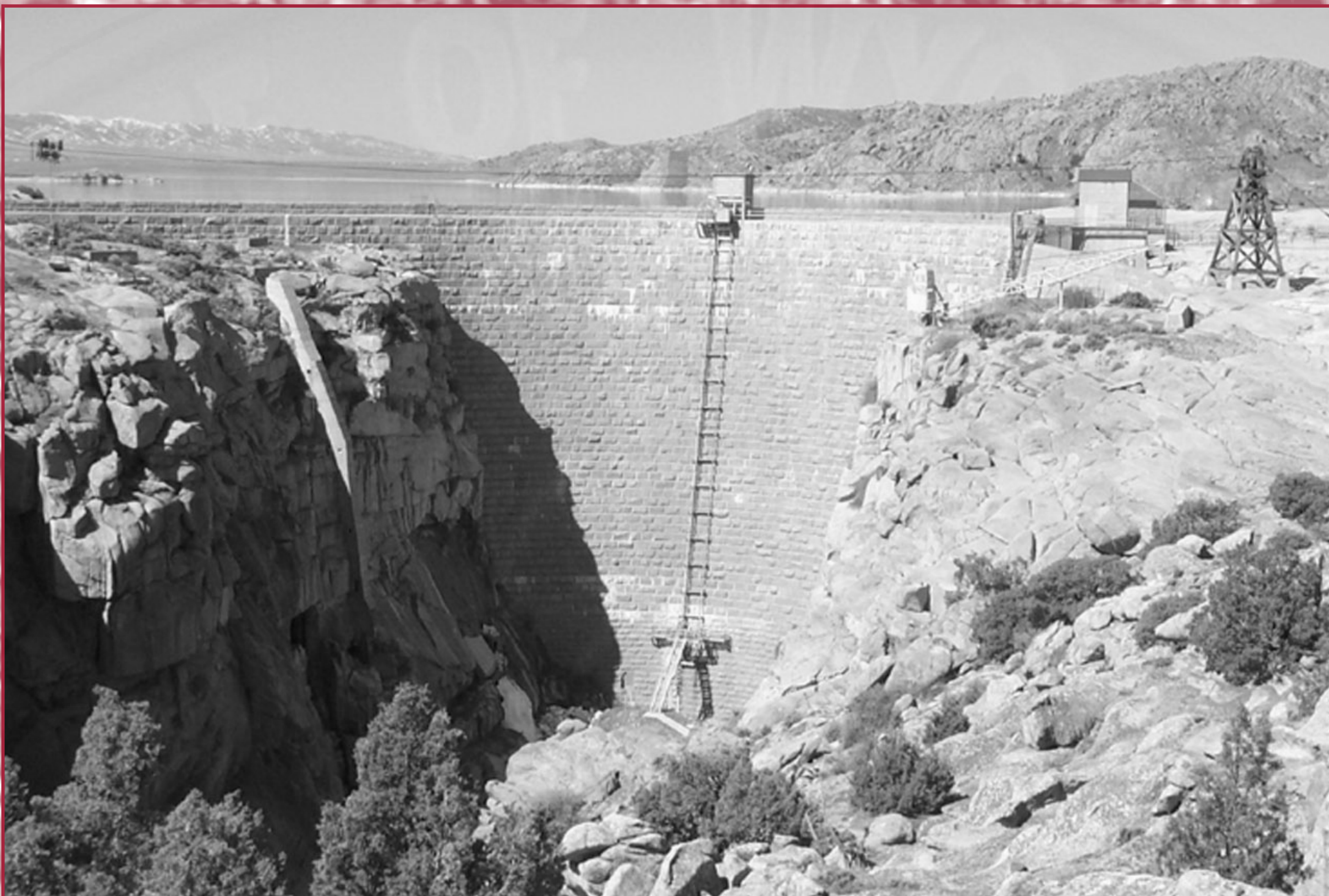
Wyoming Geo-notes

Number 70



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Memorial: Daniel N. Miller, Jr. (1924-2001)

STATE OF WYOMING GEOLOGICAL SURVEY 1933

Wyoming State Geological Survey
Lance Cook, State Geologist

Laramie, Wyoming
July, 2001

Featured Articles

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

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Richard W. Jones
Editor

Jaime R. Moulton
Layout and design

Front cover: Pathfinder Dam, 47 miles southwest of Casper, was the first dam constructed on the North Platte River system by the U.S. Bureau of Reclamation. The dam is situated in massive, coarse-grained granite at the head of Fremont Canyon where the 214-foot high structure impounds both the Platte and Sweetwater rivers in Pathfinder Reservoir. The dam was completed in 1909 for the remarkable cost of $2.2 million, and like Buffalo Bill Dam near Cody, is termed a cyclopean rubble, arch gravity type dam. Around 48% of the volume of the structure is entirely blocks of native granite set into concrete—the only steel used reinforces the upper 30 feet of the dam's faces. The dam (and 1 million acre-foot reservoir) were named after early explorer Captain John C. Fremont, nicknamed "The Pathfinder." In August, 1842 while Fremont and his party were traveling by boat down the canyon of the North Platte, they reportedly hit a submerged rock at the base of a fall, capsizing and losing their surveying instruments near the present dam site. Photograph by Ray E. Harris, June, 2001.

MINERALS UPDATE

Overview

Lance Cook

State Geologist–Wyoming State Geological Survey

Two years ago, the financial picture for the State of Wyoming was bleak. Commodity and energy prices were all low. The State faced a projected budget shortfall of $120 million or more and little financial relief was in sight. Then about a year ago, some very fundamental market forces came into the picture, in the form of supply and demand.

California began to suffer critical electrical shortages. Gasoline and crude oil prices started to show extreme volatility, generally moving prices upwards as demand increased. Coal, the slumbering giant in Wyoming's revenue picture, regained some market strength as people realized that the nation's electrical base load is enormously dependent on coal as a fuel, and is the cheapest energy source. Suddenly, the revenue forecast for Wyoming showed a $690 million surplus instead of a deficit, which amounts to an $800 million revenue swing in just a few months. That works out to over $1600 for every Wyoming resident.

So here we sit in the middle of an energy supply crisis, with Wyoming as the Btu (British thermal unit) capital of the Western Hemisphere. The Wyoming State Geological Survey (WSGS) estimates the state's energy reserves at 374 billion barrels oil equivalent (BOE) at present prices. We lead the nation in coal and uranium production and are the only state to have increased our natural gas production every year for the past six years, with more growth ahead. Oil production is declining but we have substantial resource potential from enhanced oil recovery. Wyoming residents are in an enviable position to attract new business and finance our State's needs. California created their own energy problems (in spite of their denial of culpability), Nevada is experiencing shortages now, and Florida may be next. Their citizens and other consumers are now and will continue to bear the cost of those states' policies by paying higher utility rates and fuel prices while Wyoming's fuel resources receive higher prices in a seller's market.

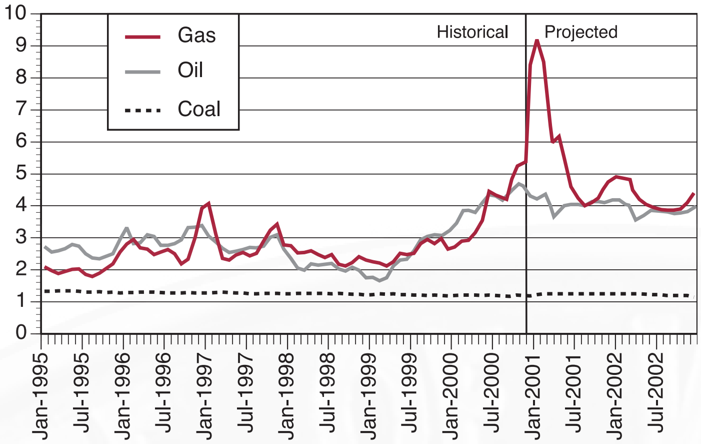
. . . the near-balance of supply and demand that existed in the past may give way to a period of protracted shortages of natural gas supplies.

The questions the WSGS is asked most frequently these days are "What lies ahead for Wyoming?" and "Will the boom last?" History tells us that the present boom will not last forever. Ideally, the strength we see in the energy markets will stabilize at present prices, but past experience suggests otherwise. The pattern we have seen in the commodity markets for energy over the past 15 years is one of very low prices, followed by brief panic-driven excursions to much higher prices, and then by a return to very low prices as more supply is brought onto the market than is necessary. This results in continued low prices, with no incentive for producers to bring new supplies into the market until the next imbalance occurs.

This time, the market fundamentals may be different. New gas-fired electrical generation capacity is accelerating the growth rate of natural gas demand. Coupled with the fact that the large gas-producing states such as Texas, Louisiana, and New Mexico appear to be unable to bring large amounts of new gas into the market, this accelerated growth suggests that the near-balance of supply and demand that existed in the past may give way to a period of protracted shortages of natural gas supplies. The net result will be a longer period of higher natural gas prices, and the side effect will be an increase in coal prices if gas-generated electricity continues to fall short of demand.

In the case of coal, the additional demand for coal-fired generating capacity will only add to the pressure applied to coal supply markets from limited natural gas supplies. As pointed out in the **COAL UPDATE** section in this issue of *Wyoming Geo-notes*, it may not be possible for Wyoming producers to physically process, load, and ship those additional amounts of coal without significantly upgrading their infrastructure. If the fuel supply situation becomes truly critical, nuclear-fueled generation might even cause some increased demand for uranium.

Figure 1 shows the major shift in the marketplace for natural gas. Following the disastrous year of 1999, when there was no premium for the winter heating season, natural gas prices moved upwards sharply. The bottom line is that when supply and demand curves cross because of a price imbalance **or** a supply shortfall, prices move sharply to correct the imbalance and then return in response to



Source: Energy Information Administration, 2001.

Figure 1. Fossil fuel prices (cost per million Btu) to electric utilities, 1995 through January, 2001 with projections through 2002.

market forces. But when supply and demand curves cross, driven **both** by a fundamental supply shortfall (after a prolonged period of price depression resulting in no new supplies being developed) and by an increase in demand growth rate, it heralds a profound market event. The higher energy prices may last as long as six or seven years, similar to the 1980s. There will be highs and lows during the coming years, but energy will command overall higher prices. However, high prices always result in new supplies, alternative sources, or enhanced conservation. The market demands balance, and the market will be served. The opportunity for Wyoming to capitalize on the energy supply situation will probably not last forever.

If Alaskan natural gas is brought into the market in six or seven years, if coal-fired plants are built quickly and brought on line in a timely manner, if consumers act aggressively to conserve, if utilities act to contract for non-conventional energy sources as a result of high prices, then the boom of 2001 could well become a bust by 2010. There are a lot of ifs in this vision and it has been a long time since major development projects were expedited in our country. Public opinion is much more easily focused on the "crisis-du-jour" rather than something as mundane as base electrical generating capacity and 10-year gas supply forecasts. Unfortunately, when your computer monitor grows dim and your microwave oven won't cook, it is too late to remember that you forgot to build that 500-megawatt (MW) generating plant.

. . . the good news for oil and gas is the improvement in prices, with a delayed upward effect on coal prices.

The next six or seven years should be good for Wyoming's revenue and employment. The nation may give us a few extra years if our citizens cannot understand the nature of the supply problem and will not support the steps necessary to restore balance to the energy marketplace.

Final production and prices for the past year became available in the first quarter of 2001 and they follow our predictions fairly close. As expected, natural gas production showed the largest increase, followed by a more modest increase in coal production. Modest decreases were observed in oil, trona, and uranium production, while other minerals stayed about the same (**Table 1**). As discussed in the sections that follow, the good news for oil and gas is the improvement in prices, with a delayed upward effect on coal prices. We revised our forecast prices upward for oil and methane in the last *Wyoming Geo-notes* (No. 69, April, 2001) and in this issue we revise our forecast coal prices upward for the first time in many years (**Table 2**).

As growth in production continues for both natural gas and coal, the infrastructure needed to move these fuels to market may be a limiting factor for future demand. For natural gas, it is the pipeline capacity within a gas-producing area as well as out of the state. The **OIL AND GAS UPDATE** discusses several new pipeline projects, as does the **COALBED METHANE UPDATE**. The infrastructure for coal could include processing and loadout facilities (see **COAL UPDATE**), trackage and rail movements, and rail car/unit train availability.

To continue our theme of addressing issues of concern in the minerals industry, we have included a guest article by Mickey Steward, Coalbed Methane Coordinator, detailing the work her office is involved in. Finally, this issue of *Wyoming Geo-notes* contains a memorial to Daniel N. Miller, former State Geologist. Certainly the WSGS (and probably the entire mineral industry in Wyoming) wouldn't be the same had it not been for Dan's influence and guidance.

Reference cited

Energy Information Administration, 2001, Short-term energy outlook–July, 2001: Energy Information Administration web site: http://www.eia.doe.gov.

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	5.13	37.90
2001	20.00	4.50	5.40	37.75
2002	18.00	3.00	5.45	37.75
2003	18.00	2.25	5.52	37.75
2004	18.00	2.25	5.57	37.75
2005	18.00	2.25	5.66	37.75
2006	18.00	2.25	5.73	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.

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	352.3	20.0	2.0	1.20
2002	58.0	1460.9	161.0	1.10	355.8	20.0	2.0	1.20
2003	55.1	1541.9	161.0	1.10	359.4	21.0	2.0	1.20
2004	52.4	1625.9	161.0	1.10	363.0	21.0	2.0	1.20
2005	49.8	1710.9	161.0	1.10	365.6	21.0	2.0	1.20
2006	47.3	1796.9	161.0	1.10	370.3	21.0	2.0	1.20

[1]Modified from Consensus Revenue Estimting Group's (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.

Oil and Gas Update

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Wyoming oil and gas producers received very good prices for their commodities during the first quarter of 2001. Although oil prices were slightly lower, natural gas prices were considerably higher than for the first quarter of 2000. The decline in oil production from 1999 to 2000 was only 1.3%, while natural gas production increased 12.4% in 2000. Most of the improvement in gas production can be attributed to higher average prices in 2000 than in several preceding years. A large increase in coalbed methane production in the Powder River Basin (PRB) also boosted gas production. In the first quarter, one Federal lease sale brought in over $9.1 million, and the number of applications for permit to drill, geophysical activity, and rig counts also remained healthy.

Production and prices

Prices paid to Wyoming oil producers during the first quarter of 2001 averaged $23.84 per barrel (**Table 3**). The average price for the quarter is $2.07 lower than for the first quarter of 2000, but $13.79 higher than for the first quarter of 1999. The posted sweet and sour crude prices and first purchase price for Wyoming oil averaged by month (**Figure 2**) reflect our projected prices at least for early in 2001 (**Figure 3**). Our final estimate for average crude oil price of $27.00 per barrel for 2000 was slightly more than the actual $26.87 now reported (**Table 2**).

Oil production reported by the Wyoming Oil and Gas Conservation Commission (WOGCC) for the year 2000 was 60.5 million barrels (**Table 4**). This production is a drop of only 1.3% from production in 1999. The decline in production has moderated over the last year (**Figure 4**) because of higher prices for Wyoming oil, but the actual production fell short of the 61.0 million barrels we predicted earlier (**Table 1**).

Spot prices for natural gas at Opal, Wyoming averaged $6.75 per thousand cubic feet (MCF) during the first quarter of 2001. This is $4.43 per MCF

Table 3. Monthly average price of a barrel of oil produced in Wyoming (1997 through April, 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	$24.66	$24.64
March	$17.99	$20.00	$10.97	$11.97	$11.77	$10.05	$27.24	$25.91	**$22.25**	**$23.84**
April	$16.81	$19.20	$11.54	$11.87	$14.34	$11.12	$22.92	$25.16	**$22.45**	**$23.50**
May	$17.74	$18.91	$11.19	$11.73	$15.16	$11.93	$26.06	$25.34		
June	$15.90	$18.41	$9.63	$11.38	$15.36	$12.50	$28.31	$25.84		
July	$16.29	$18.11	$10.20	$11.21	$17.39	$13.20	$27.12	$26.02		
August	$16.61	$17.92	$9.58	$11.01	$18.43	$13.86	$28.18	$26.29		
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	$29.56	$27.17		
December	$14.72	$17.41	$8.05	$10.66	$23.22	$16.44	$23.57	$26.87		
Average yearly price		**$17.41**		**$10.66**		**$16.44**		**$26.87**		

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, May, 2001.*

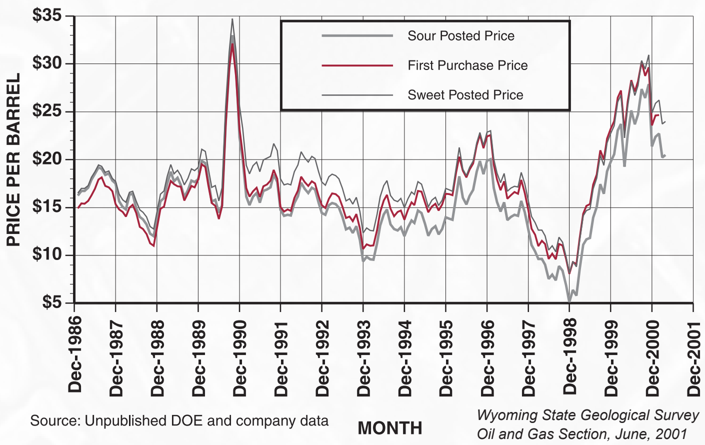

Figure 2. Wyoming posted sweet and sour crude oil prices and first purchase prices, averaged by month (January, 1987 through April, 2001).

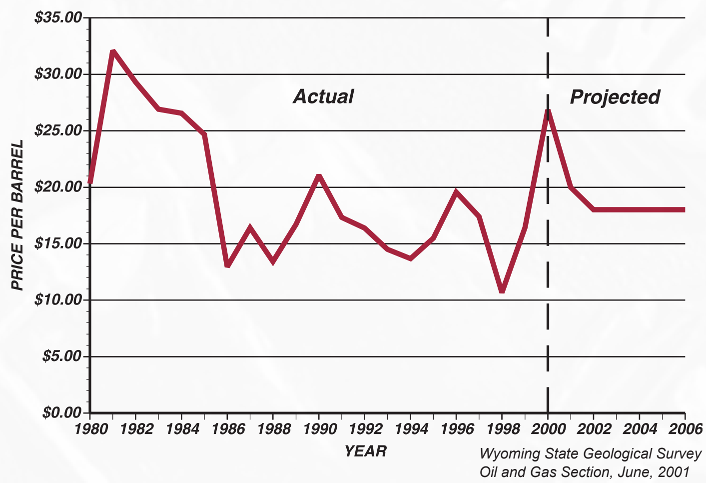

Figure 3. Average prices paid for Wyoming crude oil (1980 through 2000) with forecasts to 2006.

Table 4. Monthly oil production from Wyoming in barrels (1996 through December, 2000).

	1996		1997		1998		1999		2000	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	6,153,037	6,153,037	5,964,848	5,964,848	5,846,364	5,846,364	5,333,257	5,333,257	5,185,497	5,185,497
February	5,693,084	11,846,121	5,459,518	11,424,366	5,233,502	11,079,866	4,744,527	10,077,784	4,872,559	10,058,056
March	6,176,805	18,022,926	6,014,780	17,439,146	5,759,176	16,839,042	5,297,674	15,375,458	5,200,599	15,258,655
April	5,977,362	24,000,288	5,729,869	23,169,015	5,534,568	22,373,610	5,065,591	20,441,049	5,000,953	20,259,608
May	6,035,505	30,035,793	6,050,971	29,219,986	5,626,125	27,999,735	5,200,031	25,641,080	5,196,795	25,456,403
June	5,916,019	35,951,812	5,761,549	34,981,535	5,335,463	33,335,198	5,000,039	30,641,119	4,997,640	30,454,043
July	6,076,992	42,028,804	5,964,005	40,945,540	5,464,514	38,799,712	5,164,705	35,805,824	5,069,393	35,523,436
August	6,414,850	48,443,654	5,868,789	46,814,329	5,287,415	44,087,127	5,190,052	40,995,876	5,086,822	40,610,258
September	6,180,180	54,623,834	5,710,557	52,524,886	5,109,053	49,196,180	5,081,384	46,077,260	4,948,383	45,558,641
October	6,186,019	60,809,853	5,949,974	58,474,860	5,274,269	54,470,449	5,163,165	51,240,425	5,150,040	50,708,681
November	6,221,912	67,031,765	5,800,811	64,275,671	5,232,287	59,702,736	5,010,985	56,251,410	4,867,599	55,576,280
December	6,330,701	73,362,466	5,900,791	70,176,462	5,078,909	64,781,645	5,090,959	61,342,369	4,943,346	60,519,626
Total Barrels Reported[1]		**73,362,466**		**70,176,462**		**64,781,645**		**61,342,369**		**60,519,626**
Total Barrels not Reported[2]		**525,957**		**52,364**		**897,131**				
Total Barrels Produced[3]		**73,888,423**		**70,228,826**		**65,678,776**				

[1]Monthly production reports from Petroleum Information/Dwights LLC. Except for 1999 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, May, 2001.*

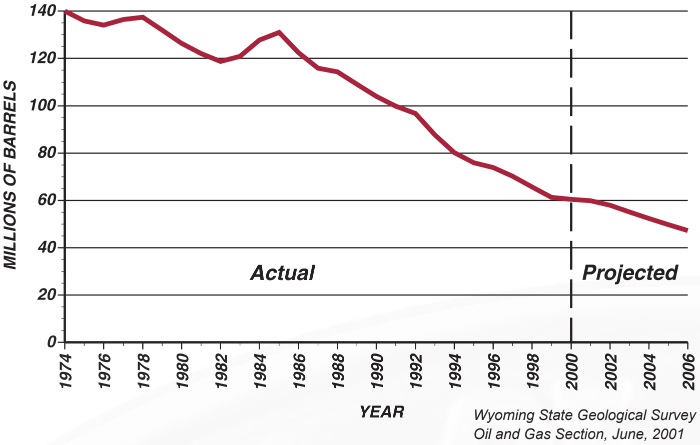

Figure 4. Annual crude oil production from Wyoming (1974 through 2000) with forecasts to 2006.

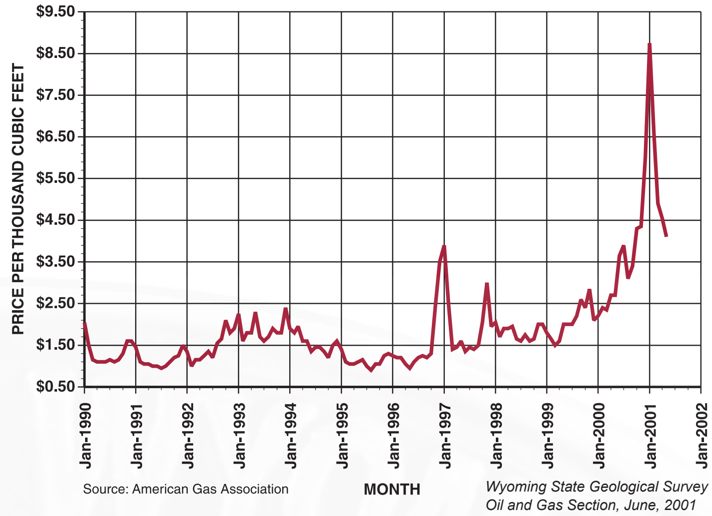

Figure 5. Spot sale prices for methane at Opal, Wyoming, averaged by month (January, 1990 through May, 2001).

higher than the average price for the first quarter of 1999 (**Table 5** and **Figure 5**). We are expecting the average price of natural gas to be about $4.50 for the year (**Table 2**) but our projections beyond year 2001 may in fact be too low (**Figure 6**) based on increased demand for energy.

Natural gas production in Wyoming for 2000 was about 1.455 trillion cubic feet (TCF) according to production figures from the WOGCC. This production is up 12.4% from 1999 (**Table 6**). Coalbed methane production from the PRB accounted for 151.2 billion cubic feet of that total and was 10.4% of Wyoming's natural gas production in the first eight months of 2000. Nearly all our projected increases in natural gas production (**Table 1**) will be from expected increases in coalbed methane production (**Figure 7**).

Table 5. Monthly average spot sale price for a thousand cubic feet (MCF) of natural gas at Opal, Wyoming (1997 through May, 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		
July	$1.45	$1.95	$1.60	$1.82	$2.00	$1.79	$3.90	$2.84		
August	$1.40	$1.88	$1.75	$1.81	$2.20	$1.84	$3.10	$2.88		
September	$1.50	$1.84	$1.60	$1.79	$2.60	$1.93	$3.40	$2.93		
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, May, 2001.*

Table 6. Monthly natural gas production from Wyoming in thousands of cubic feet (MCF) (1996 through December, 2000).

	1996				1998		1999		2000	
	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative	monthly	cumulative
January	101,359,648	101,359,648	99,579,818	99,579,818	103,640,214	103,640,214	108,524,793	108,524,793	122,064,217	122,064,217
February	96,303,300	197,662,948	91,766,159	191,345,977	94,501,819	198,142,033	94,288,888	202,813,681	114,229,927	236,294,144
March	103,541,127	301,204,075	104,157,578	295,503,555	103,906,999	302,049,032	111,012,987	313,826,668	121,102,432	357,396,576
April	99,479,609	400,683,684	99,459,039	394,962,594	98,201,007	400,250,039	102,363,550	416,190,218	118,803,903	476,200,479
May	97,900,863	498,584,547	101,070,371	496,032,965	96,741,237	496,991,276	104,746,697	520,936,915	118,229,726	594,430,205
June	87,069,612	585,654,159	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	100,219,275	685,873,434	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	99,874,019	785,747,453	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	93,510,551	879,258,004	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	95,441,022	974,699,026	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	94,015,007	1,068,714,033	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	99,141,298	1,167,855,331	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]		**1,167,855,331**		**1,192,144,713**		**1,200,569,406**		**1,295,222,498**		**1,454,713,286**
Total MCF not Reported[2]		**5,663,874**		**683,432**		**22,955,142**				
Total MCF Produced[3]		**1,173,519,205**		**1,192,828,145**		**1,223,524,548**				

[1]Monthly production reports from Petroleum Information/Dwights LLC. 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, May, 2001.*

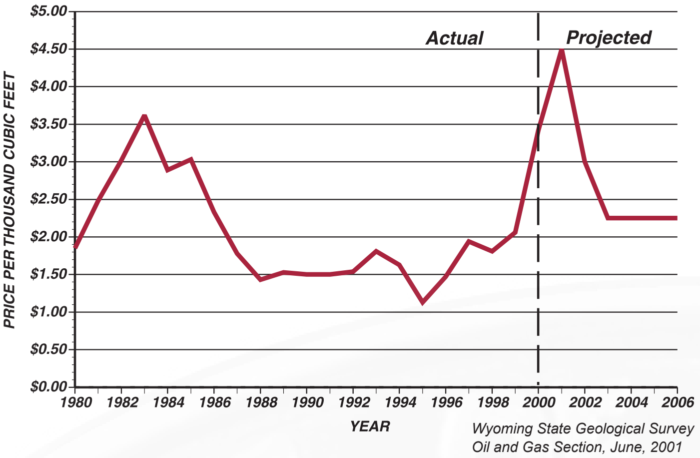

Figure 6. Average prices paid for Wyoming methane (1980 through 2000) with forecasts to 2006.

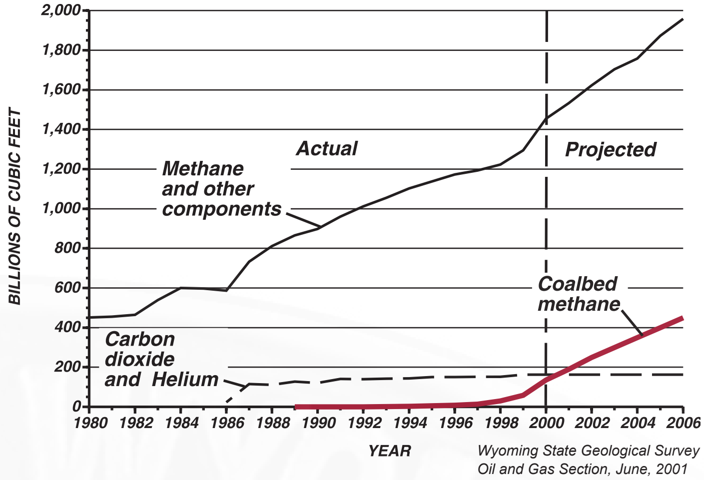

Figure 7. Annual natural gas production from Wyoming (1980 through 2000) with forecasts to 2006.

Projects, reports, and transactions

The U.S. Department of the Interior's Minerals Management Service (MMS) distributed more than $800.3 million in revenues from mineral production and lease sales to 35 states during 2000. This is an increase of $259.3 million from last year's total of $541 million. Wyoming received more than $333.5 million in 2000, and New Mexico was the second largest beneficiary with $258.6 million. Wyoming's total was over 41% of the amount distributed nationally.

The U.S. Department of Energy and the Gas Technology Institute are examining the commercial viability of drilling for oil and natural gas by using high-powered lasers. In the 2001 study, research will try to determine, both empirically and theoretically, the correct energy requirements to break, melt, or vaporize rock. Research will also try to determine if pulsed lasers will have a greater cutting effect than non-pulsed lasers. Drilling in a weighted fluid environment is a crucial barrier for the success of laser drilling technology. The technical challenge is to determine how much laser energy is required to vaporize and clear away fluid. Research will determine the change in energy required to remove material from water-saturated rock specimens versus corresponding dry rock samples. Progress of this 2001 study will be available at http://www.gastechnology.org/laser.

Anadarko Petroleum Corporation plans to spend $11.5 million in 2001 on conventional natural gas exploratory drilling (utilizing 3-D seismic) and on the acquisition of new leases that will focus on plays in the Greater Green River Basin and on overthrust/subthrust plays. The company also plans to drill 60 wells in the Wamsutter area in 2001, doubling their capital spending to more than $35 million and raising their gas production to 84 million cubic feet (MMCF) per day. In 2000, Anadarko drilled 32 wells in the Wamsutter area and produced an average of 75 MMCF per day.

The expansion ... will provide 900 MMCF per day of additional natural gas transportation capacity from southwestern Wyoming to southern California.

Williams Gas Pipeline plans to expand its Kern River Pipeline in a $1 billion project that will more than double the amount of gas transported on the 926-mile pipeline system. The expansion, planned for 2003, will provide 900 MMCF per day of additional natural gas transportation capacity from southwestern Wyoming to southern California. The expansion will loop about 700 miles of the existing Kern River Pipeline. Williams recently filed a California Emergency Action application with the Federal Energy Regulatory Commission (FERC) to install and operate emergency facilities on Kern River that would increase capacity from 700 MMCF to 835 MMCF per day. The $81 million emergency expansion will go into service by July 1, 2001 if approved by FERC.

The Wyoming Business Council (WBC) notified Rentech, Inc. that it would receive $800,000 to finance a gas-to-liquids feasibility study within Wyoming. The funding will be used to evaluate two potential gas-to-liquids projects that utilize Rentech's patented and proprietary Fischer-Topsch gas-to-liquids technology to produce sulfur- and aromatic-free, clean alternative fuels and other hydrocarbon products. Phase I involves studying the feasibility of retrofitting a portion of an existing methanol facility in Wyoming for production of 2500 barrels of gas-to-liquids products. Phase II will study the possibility of constructing a separate 10,000 barrel-per-day plant at the same site. Rentech estimates it will take six to nine months to complete the study. Under the terms of the agreement, WBC can recoup its investment from project financing and a limited term production royalty.

Howell Corp. traded properties in the Gulf of Mexico and $8 million in cash for a 26% non-operated working interest in the Salt Creek Field Light Oil Unit. The effective date of the trade was January 1, 2001. Howell is the current operator of Salt Creek Field and with this transaction now owns 98% working interest in the Light Oil Unit. The company acquired its original interest in Salt Creek Field in 1997 from Amoco Production. Howell also entered into a transaction that will give it 22,000 net undeveloped acres in the Bighorn Basin and a $160,000 cash payment in exchange for acreage in the Wind River Basin. In a separate deal Howell also purchased about 50,000 acres in the Bighorn Basin.

The U.S. Bureau of Land Management (BLM) prepared an Environmental Assessment (EA) for a 155-mile, 12-inch diameter liquid carbon dioxide pipeline proposed by Petro Source Corp. to run from the Bairoil terminal near Lost Soldier and Wertz fields to Hartzog Draw Field in the PRB. The carbon dioxide transported by the pipeline could be used for enhanced oil recovery at Salt Creek, Sussex, and Hartzog Draw fields as well as other fields in the PRB that are potential candidates for a carbon dioxide flood.

The average daily rig count for the first quarter of 2001 was 52, 18 more than for the first quarter of 2000.

The Oil and Gas Section at the Wyoming State Geological Survey (WSGS) recently completed an informative full color pamphlet on carbon dioxide (see **PUBLICATIONS UPDATE**). Done in the style of the popular WSGS information pamphlet on coalbed methane, this publication attempts to answer the most frequently asked questions about carbon dioxide in Wyoming.

Lease sales

Leasing activity at February's BLM sale was concentrated in the Wind River Basin and in southwestern Wyoming (**Figure 8**). Stone & Wolf, LLC. made the high per-acre bid of $1475 for a 160-acre lease that covers SW section 5, T39, R61W (**location A, Figure 8**). The lease is about three and a half miles west of Mule Creek Oil Field. The field has produced from the Dakota, Lakota, and Minnelusa formations. Stone & Wolf also made the sale's second high per-acre bid of $900 for a 360-acre tract that covers parts of sections 8 and 9, T39N, R61W (**location B, Figure 8**). Big West Oil and Gas made the sale's third high per-acre bid of $880 for an 880-acre lease that covers parts of sections 13, 14, 23, and 24, T34N, R70W (**location C, Figure 8**). The lease is in the area of Lewis Shale oil production at Lebar Field. The sale's fourth highest per-acre bid

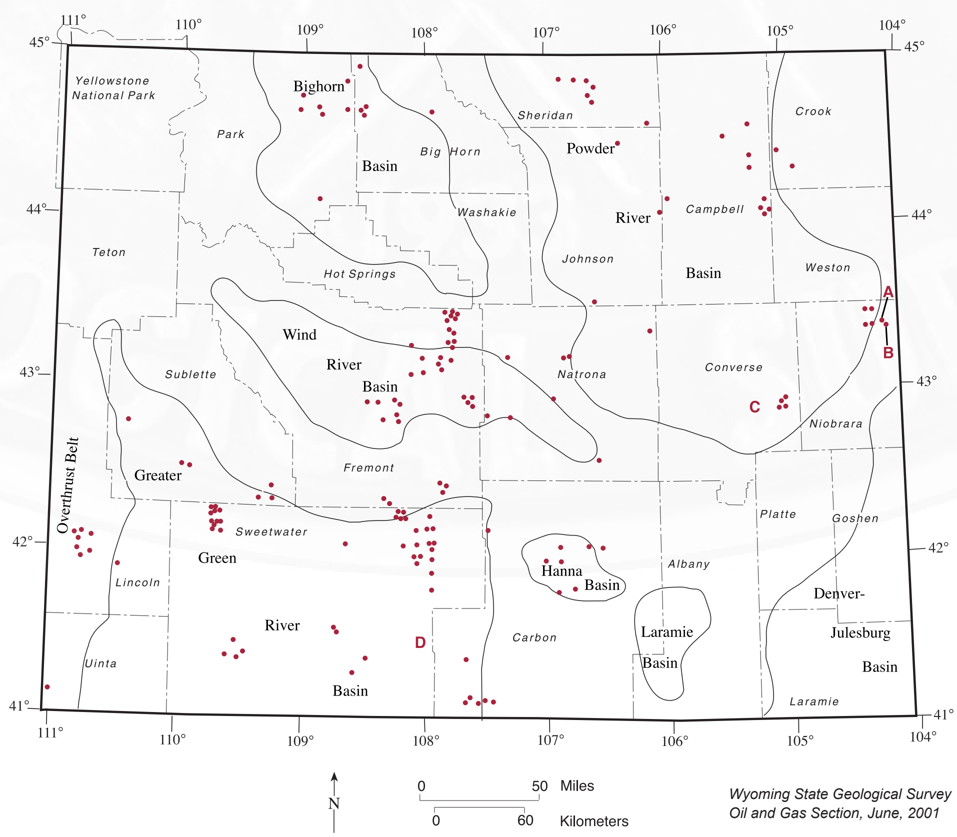

Figure 8. Locations of federal oil and gas tracts leased by the U.S. Bureau of Land Management at its February, 2001 sale.

of $875 was made by Coleman Oil & Gas for a 640-acre tract that covers all of section 12, T17N, R94W (**location D, Figure 8**). The lease is on the flank of Wild Rose Field, which produces gas and condensate from the Lewis Shale, the Almond Formation, and the Ericson Sandstone.

There were a total of 57 parcels at this sale that received bids of $50 or more per acre; 37 of the 57 leases sold for $100 or more per acre. A total of 159 parcels covering 148,972 acres were leased, generating revenue of over $9.1 million, and the average per-acre bid was $61.35 (**Table 7**).

Permitting and drilling

The WOGCC approved 1967 Applications for Permit to Drill (APDs) in the first quarter of 2001. The total for that quarter is more than the number of APDs approved in all of 1995, 1996, or 1997 (**Table 8**). Campbell County again led with about 61% of the total APDs that were approved in the first quarter. Sheridan and Johnson counties combined for another 17%. Nearly all of the approved APDs in these three counties were for coalbed methane tests.

The WOGCC permitted seven seismic projects in the first quarter of 2001 (**Table 9**). The number of permits issued and miles permitted is down slightly from the first quarter of 2000. The number of permitted conventional miles is higher than the total for the first quarter of 2000, but one less permit was issued and the number of permitted 3-D square miles is down. Geophysical activity is a good indicator of future exploration and production drilling.

The average daily rig count for the first quarter of 2001 was 52, 18 more than for the first quarter of 2000. The rig count does not include approximately 75 rigs drilling for coalbed methane. **Figure 9** shows the Wyoming daily rig count averaged by month and by year.

Exploration and development

Company data, news releases, and information compiled and published by Petroleum Information/Dwights, LLC. are used to track oil and gas exploration and development activity in Wyoming. **Table 10** reports the most significant activities exclusive of coalbed methane (see the **COALBED METHANE UPDATE** for development in this industry) during the first quarter of 2001. The numbers correspond to locations on **Figure 10**.

Table 7. Federal and State competitive oil and gas lease sales in Wyoming (1996 through March, 2001).

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1996							
TOTAL	$11,487,567	1828	1125	1,403,444	739,505	$15.53	$1,450.00
1997							
TOTAL	$31,976,603	1787	1485	1,578,938	1,206,642	$26.50	$600.00
1998							
February	$5,262,908	369	285	366,787	241,654	$21.78	$415.00
April	$10,287,111	247	227	192,561	162,393	$63.35	$395.00
June	$14,737,117	463	367	498,339	368,816	$39.96	$430.00
August	$8,033,029	306	245	349,605	278,095	$28.89	$500.00
October	$10,251,074	455	308	421,900	293,141	$34.97	$430.00
December	$15,229,257	407	278	388,783	277,538	$54.87	$800.00
TOTAL	$63,800,496	2247	1710	2,217,975	1,621,637	$39.34	$800.00
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
June	$8,358,363	179	155	233,599	207,978	$40.19	$32,000.00
August	$3,294,339	206	197	215,631	208,777	$15.78	$290.00
Octoer	$4,395,288	214	175	195,827	142,525	$30.84	$580.00
December	$5,598,020	176	164	128,480	124,093	$28.99	$410.00
TOTAL	$24,197,991	1,069	945	1,060,674	929,674	$26.03	$32,000.00
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
June	$6,387,887	230	184	260,294	190,306	$33.57	$410.00
August	$5,213,595	240	222	174,040	154,920	$33.65	$475.00
October	$5,028,610	147	129	149,934	124,724	$40.32	$510.00
December	$6,352,525	185	179	182,935	180,380	$35.22	$725.00
TOTAL	$31,537,729	1183	1055	1,058,204	898,612	$35.09	$725.00
2001							
February	$9,138,921	202	159	224,225	148,972	$61.35	$1,475.00

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
1996							
TOTAL	$2,325,497	1049	508	418,111	206,814	$11.24	$206.00
1997							
TOTAL	$3,151,020	1198	704	438,296	263,230	$11.97	$340.00
1998							
April	$1,203,792	300	161	115,646	63,848	$18.85	$320.00
June	$1,660,438	300	148	108,654	52,501	$31.63	$600.00
October	$1,313,792	298	178	98,856	65,212	$20.14	$590.00
December	$1,045,447	300	187	121,551	77,852	$13.43	$215.00
TOTAL	$5,223,469	1198	674	444,707	259,413	$20.14	$600.00
1999							
April	$1,815,526	299	196	123,119	89,194	$20.35	$890.00
June	$1,002,039	300	190	108,310	69,858	$14.34	$400.00
October	$2,369,527	300	216	109,140	77,261	$30.67	$475.00
December	$956,113	291	129	115,502	51,674	$18.50	$500.00
TOTAL	$6,143,205	1,190	731	456,071	287,987	$21.33	$890.00
2000							
April	$1,475,661	299	191	120,319	71,933	$19.54	$525.00
June	$2,119,198	300	197	127,798	79,743	$26.58	$775.00
October	$1,660,315	300	216	117,598	81,603	$20.35	$268.00
December	$1,240,442	300	192	109,375	62,636	$19.80	$210.00
TOTAL	$6,495,616	1199	796	475,090	295,915	$21.95	$775.00

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, May, 2001.*

Table 8. Number of Applications for Permit to Drill (APDs) approved by the Wyoming Oil and Gas Conservation Commission (1995 through March, 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	1
Campbell	151	554	941	1586	4461	5580	1202
Carbon	50	77	84	96	127	174	48
Converse	29	20	16	6	19	70	12
Crook	15	37	26	29	30	47	6
Fremont	30	26	58	76	67	136	37
Goshen	0	0	0	0	0	0	0
Hot Springs	13	24	42	1	8	6	0
Johnson	6	16	6	49	304	769	133
Laramie	10	2	3	2	0	2	1
Lincoln	64	55	122	105	51	70	7
Natrona	80	74	59	36	51	53	7
Niobrara	4	7	8	8	5	18	2
Park	20	30	25	11	12	18	12
Platte	0	0	0	0	0	0	0
Sheridan	0	0	2	35	416	891	210
Sublette	61	118	179	230	189	338	117
Sweetwater	153	136	210	181	124	335	150
Teton	0	0	0	0	0	0	0
Uinta	11	10	27	26	26	53	10
Washakie	31	30	36	9	0	7	10
Weston	10	10	5	6	4	20	2
Totals	**755**	**1280**	**1908**	**2505**	**5900**	**8598**	**1967**

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

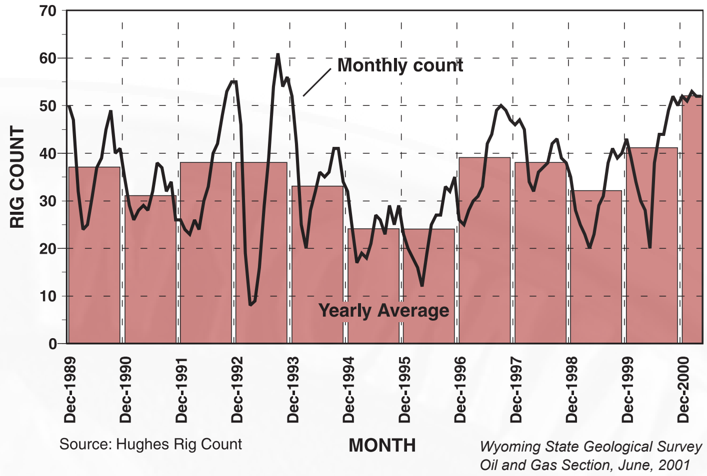

Figure 9. Wyoming daily rig count, exclusive of coalbed methane rigs, averaged by month and year (December, 1989 through April, 2001).

Table 9. Number of seismic projects and miles permitted by the Wyoming Oil and Gas Conservation Commission (1997 through March, 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	0	0	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	0	0	0
Fremont	6	43	126	2	100	0	1	0	88	4	25	116	1	70	0
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	0	0	0
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	1	0	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	0	0	0
Sublette	1	0	61	2	1	115	3	0	308	4	77	44	0	0	0
Sweetwater	4	66	296	6	214	66	9	0	530	13	54	1004	4	45	164
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**	**7**	**115**	**180**

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

Table 10. Significant exploration and development wells in Wyoming, first quarter of 2001. Number corresponds to location on Figure 10.

	Company name	Well name/number	Location	Formation tested	Depth(s) interval(s) tested	Tested prod. (per day)	Remarks
1	Chevron USA	3-6F Chevron-Federal	SW SE sec 6, T18N, R119W	Phosphoria Fm. Weber Ss. Madison Ls.	12,910-13,174 13,640-13,660 15,298-15,682	10.3 MMCF	New producer in Whitney Canyon-Carter Creek Field
	Chevron USA	3-30M-ST Chevron-Federal	NW NE sec 30, T19N, R119W	Madison Ls.	14,880-15,494	4.7 MMCF	Sidetracked hole in Whitney Canyon-Carter Creek Field
2	Condor Expl.	Horse Trap Field	T23N, R115W	Amsden Fm.			Proposed 24-well program
3	Texaco E & P	1 Mariposa-Federal	SE NE sec 3, T22N, R113W	Dakota Ss.	12,160-12,172	974 MCF	New discovery
4	McMurry Oil	1-9 Antelope	NE NE sec 9, T29N, R107W	Lance Fm.	11,275-11,484	1.1 MMCF 28 BBL cond 273 BBL H_2O	Four miles NE of production in Jonah Field
	McMurry Oil	12-26 Stud Horse Butte	NW SW sec 26, T29N, R108W	Lance Fm.	8778-11,052 nine intervals	11.5 MMCF 150 BBL cond	Infill well in Jonah Field
	McMurry Oil	4-35 Stud Horse Butte	NW NW sec 35, T29N, R108W	Lance Fm.	8667-11,350 nine intervals	9.5 MMCF 178 BBL cond	Infill well in Jonah Field
	McMurry Oil	10-35 Stud Horse Butte	NW SE sec 35, T29N, R108W	Lance Fm.	8977-10,836 nine intervals	12.5 MMCF 245 BBL cond	Infill well in Jonah Field
	McMurry Oil	10-12 Yellow Point	NW SE sec 12, T28N, R109W	Lance Fm.	7910-10,308 nine intervals	6.4 MMCF 102 BBL cond	Infill well in Jonah Field
	McMurry Oil	12-25 Cabrito	NW SW sec 25, T29N, R108W	Lance Fm.	9267-11,378 nine intervals	9.7 MMCF 95 BBL cond	Infill well in Jonah Field
	McMurry Oil	10-33 Stud Horse Butte	NW SE sec 33, T29N, R108W	Lance Fm.	8308-10,637 eight intervals	7.5 MMCF 110 BBL cond	Infill well in Jonah Field
	McMurry Oil	12-12 Yellow Point	NW SW sec12, T28N, R109W	Lance Fm.	8114-10,276 seven intervals	6.3 MMCF 75 BBL cond	Infill well in Jonah Field
	Devon Santa Fe/ Snyder Opr.	Devon Santa Fe/ Snyder Opr. 6-1-28-109	SE SW sec 1, T28N, R109W	Lance Fm.	7969-10,425 10 intervals	7.1 MMCF 38 BBL cond 7 BBL H_2O	Infill well in Jonah Field
	Devon Santa Fe/ Snyder Opr.	14-14-28-109 Yellow Point	SE SW sec 14, T28N, R109W	Lance Fm.	7857-9988 eight intervals	5.7 MMCF 32 BBL cond	Infill well in Jonah Field
	Devon Santa Fe/ Snyder Opr.	4-1-28-109 Yellow Point	NW SW sec 1, T28N, R109W	Lance Fm.	7977-10,086 10 intervals	11.1 MMCF 87 BBL cond 42 BBL H_2O	Infill well in Jonah Field
	Amoco Production	14-30 Corona Unit	SE SW sec 30, T29N, R108W	Lance Fm.	7360-10,366 13 intervals	2.3 MMCF 27 BBL cond 52 BBL H_2O	Infill well in Jonah Field
	Ultra Resources	8-23 Stud Horse Butte	SE NE sec 23, T29N, R108W	Lance Fm.	9448-12,600 12 intervals	5.9 MMCF 101 BBL cond 47 BBL H_2O	Infill well in Jonah Field
5	Ultra Resources	15-23 Warbonnet	SW SE sec 23, T30N, R108W	Lance Fm.	Undisclosed 11 intervals	4.2 MMCF 25 BBL cond	Offset to Warbonnet Field discovery well
6	Amoco Production	19 Frewen Unit	C SE sec 9, T19N, R94W	Almond Fm.	9521-9676 9740-9851	3.8 MMCF	Wamsutter arch area
	Amoco Production	31-3 Fivemile	SE NE sec 31, T21N, R93W	Lewis Shale Almond Fm.	9039-9140 10,459-10,614 10,641-10,783	4.9 MMCF	Fivemile Field, Wamsutter arch area
	Amoco Production	30-2 Two Rim Unit	SE SW sec 30, T19N, R94W	Almond Fm.	9678-10,016 seven intervals	2.8MMCF	Wamsutter arch area
	Amoco Production	16 Frewen Unit	SE SW sec 16, T19N, R94W	Almond Fm.	9572-9926 three intervals	3.2 MMCF	Wamsutter arch area[2]
	Tom Brown Inc	10-34 Janet-Federal	NE NW sec 34, T20N, R93W	Almond Fm.	9546-9572	2.5 MMCF 32 BBL cond 22 BBL H_2O	Echo Springs Field, Wamsutter arch area
	Tom Brown Inc	40-34 Janet-Federal	SE SE sec 34, T20N, R93W	Almond Fm.	9809-9864	1.9 MMCF 10 BBL cond 5 BBL H_2O	Echo Springs Field, Wamsutter arch area
7	Breitburn Energy	5 Lost Dome Federal	NW NE sec 13, T37N, R83W	Tensleep Ss.	5009-5733 horizontal interval	225 BBL oil 337 BBL H_2O	New producer in Lost Dome Field
8	Tom Brown Inc	49 Graham Unit	SE SE sec 9, T37N, R89W	Fort Union Fm. Lance Fm.	10,128-10,794 several intervals	5.6 MMCF 10 BBL cond	Infill well in Frenchie Draw Field
	Tom Brown Inc	52 Graham Unit	NW NW sec 23, T37N, R89W	Lance Fm.	10,276-10,330	4.0 MMCF	Infill well in Frenchie Draw Field
9	Louisiana Land & Exploration	56X Madden Deep Unit	SE SW sec 1, T38N, R90W	Fort Union Fm.	5793-5952	6.9 MMCF 34 BBL H_2O	Infill well in Madden Field
10	Tom Brown Inc	30-32 Muddy Ridge-Tribal	SW NE sec 30, T4N, R3E	Meeteetse Fm.	10,080-10,614 two intervals	5.9 MMCF 28 BBL cond 87 BBL H_2O	Infill well in Muddy Ridge Field
11	Marathon Oil	40 Tribal "C"	NE SE sec 30, T4N, R1W	Tensleep Ss.	6934-6982	2,287 BBL oil 23 MCF 1406 BBL H_2O	Northwestern edge of Steamboat Butte Field
12	Enre Corp	25-1 Skull Creek	SW SE sec 25, T55N, R103W	Frontier Fm.	Unknown		Completion attempt in Frontier at stepout from Heart Mountain Field
13	Termo Co		SA Creek Field	Minnelusa Fm.			Waterflood program[3]
14	Citation Oil & Gas	34-20H Triangle U East-Fed	SW SE sec 20, T47N, R75W	Sussex Ss.	8530-12,265 horizontal interval	35 BBL oil 9 BBL H_2O	Triangle U East Field
15	Stone & Wolf	10-5H Turner	SW NW sec 10, T47N, R69W	Turner Ss.	6300 true vertical depth		Location stated for a horizontal test in the Turner
16	Americomm Resources	1-AH Timber Draw Unit	SW NW sec 15, T39N, R66W	Newcastle Ss.	8548-10,578 horizontal interval	345 BBL oil 575 MCF	Wildcat discovery

[1]Abbreviations include: MMCF=millions of cubic feet of natural gas; MCF=thousands of cubic feet of natural gas; BBL=barrels; cond=condensate; H_2O=water; Ss.=Sandstone; Ls.=Limestone; Fm.=Formation; Sh.= shale. [2]In a related activity, Helmerich & Payne contracted five rigs to Amoco for drilling operations in the Wamsutter arch area. [3] This program has increased production from the field's two wells from 75 barrels per day to 1,000 barrels per day. *Wyoming State Geological Survey, May, 2001.*

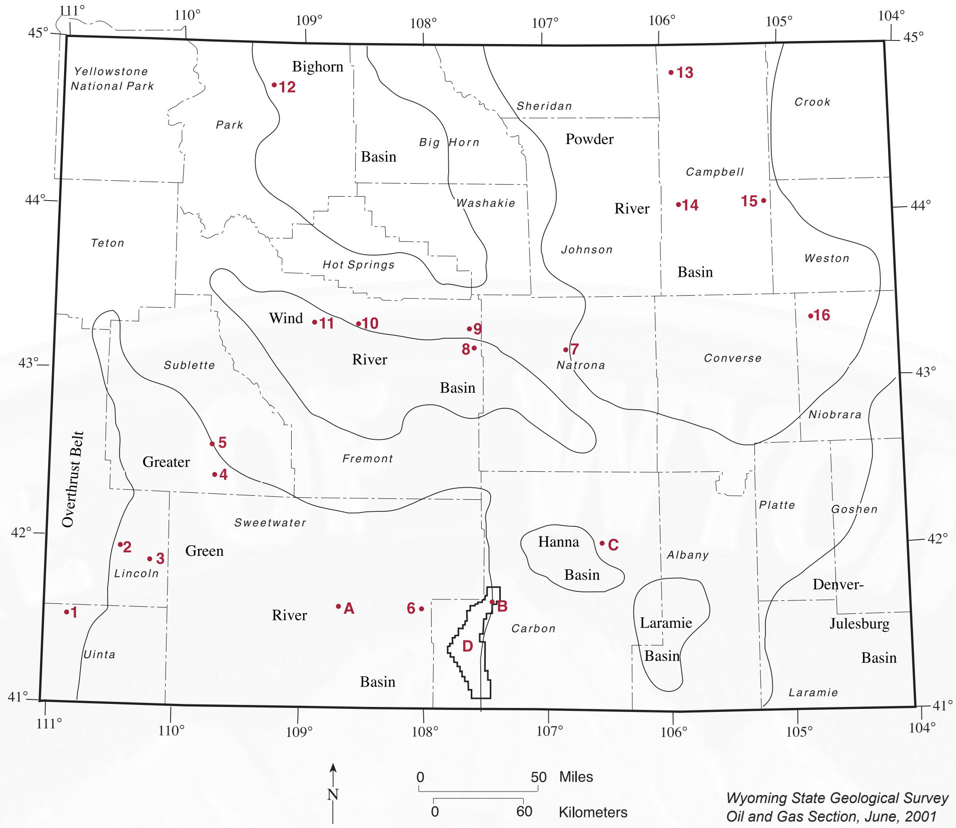

Figure 10. Oil and gas exploration and development activities (numbers) and coalbed methane activities (letters) in Wyoming during the first quarter of 2001. Locations are approximate and may represent more than one well location or project.

Coal Update

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If first quarter deliveries are any indication, coal production from Wyoming in 2001 appears headed for another record. Increased demand for coal-fired electricity, improvement in spot market prices, and new projects to increase the nation's overall generating capacity are positively affecting the outlook for Wyoming coal production. Expanding markets for steam coal are developing as construction of another in-state generating plant was announced, new generating plants in Arkansas, Missouri, and Iowa are expected to use Wyoming coal, and a lignite-fired plant in Texas is planning to convert to Powder River Basin (PRB) subbituminous coal.

Production and prices

Estimated Wyoming coal deliveries in the first three months of 2001 set a new first quarter record of 83.9 million short tons (**Table 11**). Wyoming coal mines are well on their way to produce over 350 million tons of coal during the current year. The production forecast by the Wyoming State Geological Survey (WSGS) for 2001 of 352.3 million tons is about a 4% increase over last year's total (**Table 12**). Production increases for 2002 through 2006 are expected to be at 1% per year (**Tables 1** and **12**), which may be conservative in view of the new projects announced below.

. . . over 12,580 megawatts (MW) of newly proposed coal-fired electrical generation was announced during the first quarter of 2001.

Deregulation of the electric power industry (and the resultant shift from public to private ownership) has made tracking steam coal deliveries more difficult. During the period from 1998 through 2000, many plants dropped off the Federal Energy Regulatory Commission (FERC) Form 423 screen (which reports deliveries to utility

Table 11. Estimated monthly coal deliveries from Wyoming's mines in short tons (January, 1997 through March, 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	28,267,511	28,267,511
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	25,648,682	53,916,193
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	30,032,809	83,949,002
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		
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		
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		
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, May, 2001.*

Table 12. 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	309.3	312.8	314.4	323.0	325.6	330.3
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	339.3	342.8	344.4	348.0	350.6	355.3
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**	**352.3**	**355.8**	**359.4**	**363.0**	**365.6**	**370.3**
Annual change	**11.4%**	**5.5%**	**1.1%**	**11.9%**	**6.9%**	**0.7%**	**3.9%**	**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, 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, February, 2001.*

companies). In 2000 for example, nearly 40 million tons of utility coal sold out of the Wyoming portion of the PRB was not required to be reported to FERC. To reflect recapture of this coal, **Table 11** and **Figures 11** and **12** have been revised for 1999, 2000, and 2001.

Spot prices for PRB coal increased dramatically in late February and early March (**Figure 13**) and continued strong into the second quarter of 2001. As promised in the last *Wyoming Geo-notes* (No. 69, April, 2001, p. 12), we have revised our price forecasts to reflect the current strong spot market (**Tables 2** and **13**; **Figure 14**). We are now predicting an increase in overall Wyoming coal prices. The drop in coal prices predicted for southern Wyoming coal is now more than offset by modest, but important, improvements in PRB coal prices. The true strength of this improvement will become clearer when new term contracts are negotiated with PRB coal producers for deliveries beyond 2002. While the near term spot prices have at least tripled it is important to remember that coal sales at current spot price levels represent probably less than 8 to 10 % of the total coal moving out of the PRB, so the yearly change (**Figure 14**) is not as dramatic as the weekly changes in **Figure 13**.

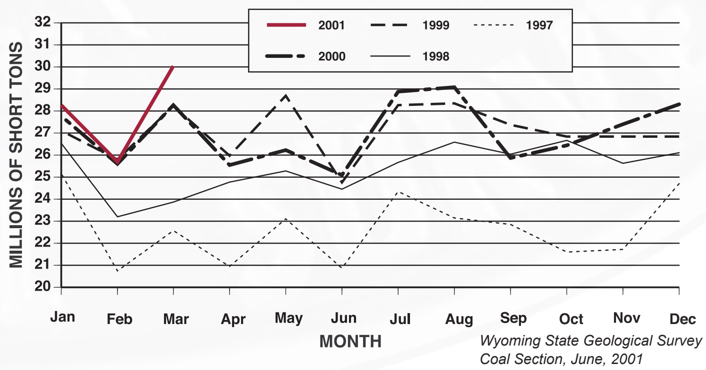

Figure 11. Reported monthly deliveries from Wyoming coal mines (1997 through March, 2001). From Form 423 of the Federal Energy Regulatory Commission (FERC) as modified by the WSGS for 1999 through 2001.

In response to electrical power shortages from California to New York, over 12,580 megawatts (MW) of newly proposed coal-fired electrical generation was announced during the first quarter of 2001. Wyoming coal may be the fuel of choice in over 46% of the new plants currently on the nation's drawing boards (**Figure 15**).

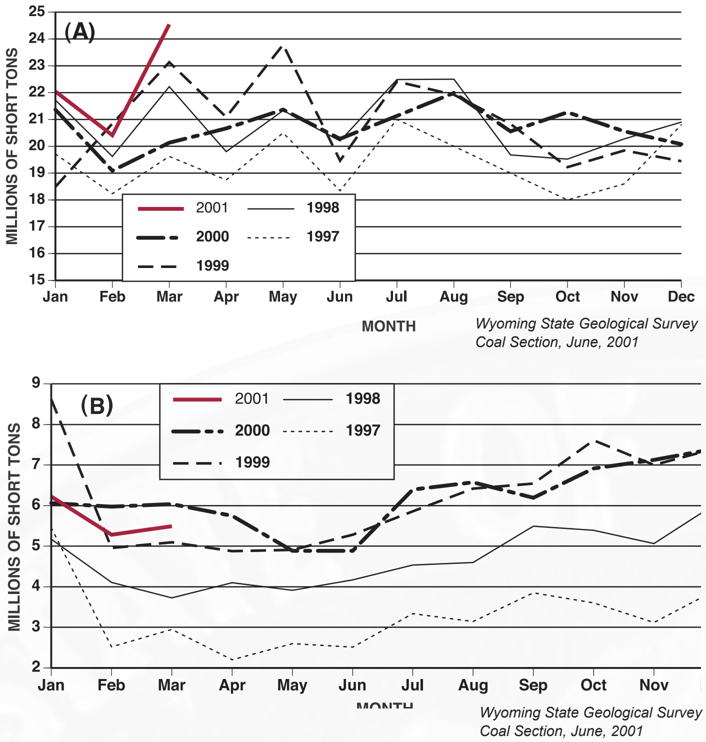

Figure 12. Monthly coal deliveries from Wyoming (1997 through March, 2001). (A) Coal sold on contract and (B) coal sold on the spot market. From Form 423 of the Federal Energy Regulatory Commission (FERC)as modified by the WSGS for 1999 through 2001.

Developments in the Powder River Basin

Concern has resurfaced in the PRB that loading capacity could constrain some operations in meeting future demand growth. Mines in the southern pod with the higher Btu coal in particular are feeling the strain as yet another record year for PRB coal production looms. Mining companies are reluctant to expand loadout facilities based only on current high spot market prices–most companies will wait until

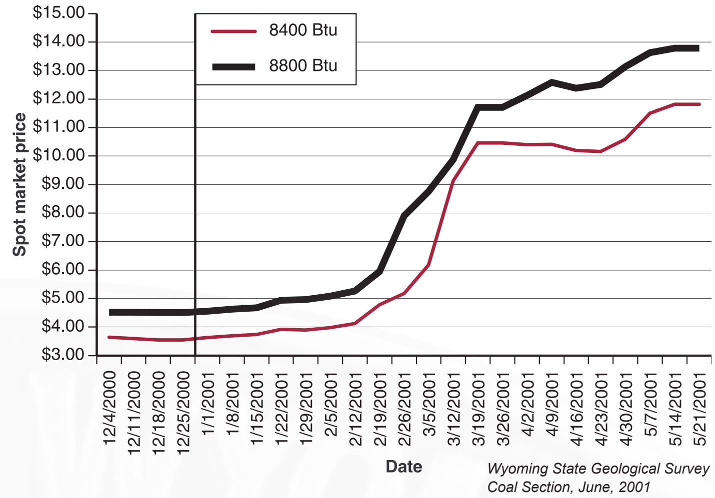

Figure 13. Wyoming PRB coal spot price watch (December 4, 2000 through May 21, 2001). Modified from COAL Daily's spot market index, and Coal Week's short term spot market price index.

the longer term market prices show a sustained increase before undertaking new capital projects. This means that coal contracts in the 2002-2003 time frame will have to be garnered at higher prices before starting projects to increase loadout capacity. Therefore, extensive upgrades probably won't be seen for at least a few years (COAL Daily, 3/2/01).

KFx, Inc. and Kennecott Energy Co. announced on February 7, 2001 that they had successfully upgraded the K-Fuel coal manufacturing process. Developed over the past 16 months, the new process is similar to the existing process except for a more continuous operation at lower temperatures, abating the need for superheat in the system. The resulting product has low levels of SO_2, NO_x, mercury, and chlorine. The new fuel differs from existing K-Fuel in that it retains some water in the fine pores of the coal. This reduces dust and reduces the occurrence of spontaneous

Table 13. 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	$4.63	$16.50	$5.13
FORECAST	2001	$4.99	$16.00	$5.40
	2002	$5.09	$15.00	$5.45
	2003	$5.13	$14.50	$5.52
	2004	$5.19	$14.50	$5.57
	2005	$5.18	$14.50	$5.66
	2006	$5.26	$14.50	$5.73

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, June, 2001.*

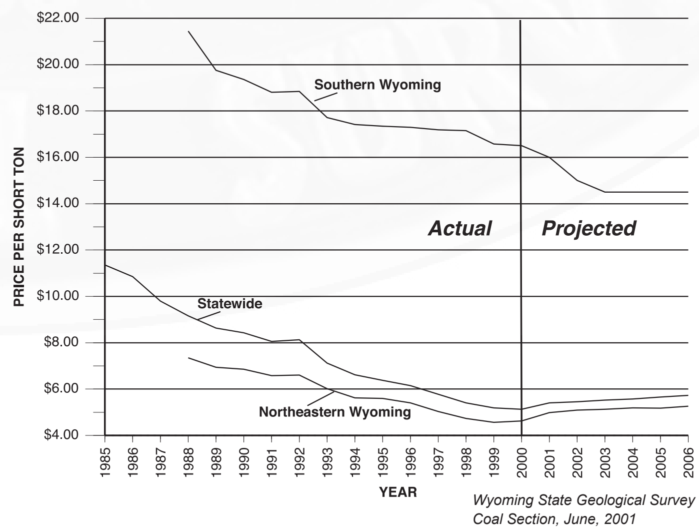

Figure 14. Average prices paid for Wyoming coal by producing area (1985 through 2000) with forecasts to 2006. Sources: U.S. Energy Information Administration (1985 through 1990); Wyoming Department of Revenue (1991 through 2000); and CREG (2001 through 2006).

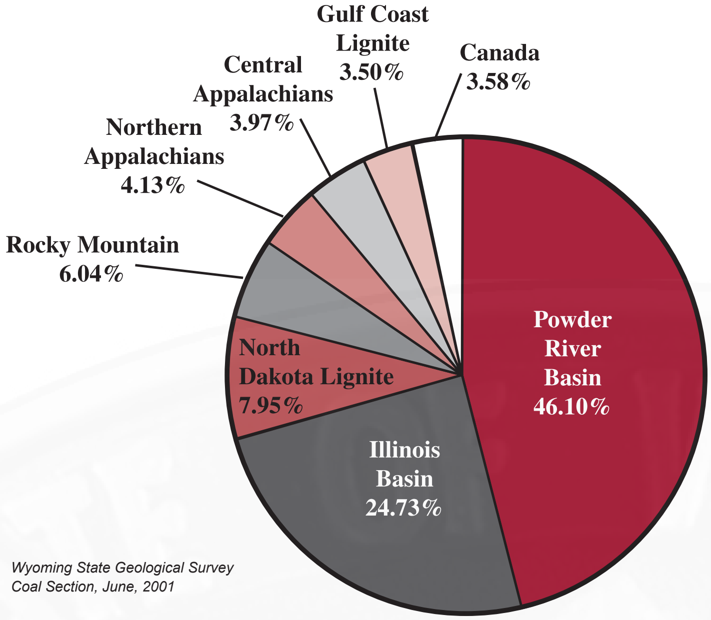

Figure 15. Percentages of new coal-fired electrical generation in the U.S. by likely fuel source areas (modified from COAL Daily, 4/10/01).

combustion in the new fuel. The new fuel has from 11,000 to 12,000 Btu per pound on an as-received basis (COAL Daily, 2/8/01).

A research project scheduled later this year was announced at the University of North Dakota. The project will try to determine whether power plants that burn PRB coal could potentially reduce the life of the catalysts in their selective catalytic reduction (SCR) systems. The catalysts, which are expensive to replace, trigger reactions that turn NO_x gas emissions into harmless nitrogen and water. Fly ash from coal combustion may mask or hinder the catalyst. The study is being funded by the Department of Energy, the Electric Power Research Institute, and a consortium of utilities (COAL Daily, 2/12/01).

While PRB coal fuels nearly a third (32%) of the nation's coal-fired power plants, the New Madrid plant in Missouri is the only facility with SCR controls currently burning PRB coal. The plant's SCR system has been in use since February, 2000 and reportedly 97 to 98% of the system's vanadium pentoxide catalyst is still active. While this is encouraging, additional research is warranted to study the potential problem in SCR units (COAL Daily, 2/14/01).

Developments in southern Wyoming

Softwall Equipment Corporation announced it was involved in talks to begin contract-mining operations for a mine in southern Wyoming. The mine plan calls for Softwall to conduct highwall mining, with the coal going to the domestic spot market. The company expects to produce 200,000 short tons in 2001 from the site, which the company declined to identify (COAL Daily 2/22/01). Highwall system mining was done with success in the Hanna Basin several years ago. This effectively allows continued extraction of coal after conventional surface mining highwalls reach their economic limits.

The U.S. Bureau of Land Management (BLM) has invited interested parties to share with Bridger Coal Co. in the exploration of approximately 10,250 acres of federal coal land in Sweetwater County. The area consists of unleased federal coal reserves in the Red Desert and Rock Springs Known Recoverable Coal Resource Area. The project will provide data on coals in the Fox Hills, Lance, and Fort Union formations (COAL WEEK, 2/26/01).

Transportation developments

In March, the Cowboy Indian Alliance, a coalition of Native Americans and ranchers, held a meeting in Rapid City, South Dakota to gather comments on the draft Environmental Impact Statement (EIS) for the proposed Dakota, Minnesota & Eastern Railroad (DM&E) build-in for the PRB. The group has opposed the project. The ranchers fear the project will have a negative impact on their property values, and harm the environment. Native Americans charge that the new rail line will damage historic sites and violate treaties. The final red or green light on the project will come when the federal Surface Transportation Board issues its final EIS, and then comes to a record of decision on the project (COAL WEEK, 2/26/01).

The start of the 2001 coal-shipping season on the Great Lakes began on March 17 when the Superior Midwest dock sent one shipment of western coal to a Wisconsin Electric Power Co. plant at Marquette, Michigan. Low water levels again this year continue to be a concern for shipping companies: as water levels drop, docks continue to light load, following the pattern started last year. The late start of shipping and low water levels indicate that 2001 lake coal shipping will not reach the 2000 level. Last year's season started on March 3, 2000 and by the end of that month, 1.3 million tons had shipped. Last year the lakes shipped 43.4 million tons of coal, the highest volume in over 20 years (COAL Daily, 3/20/01).

Regulatory developments

The Wyoming Legislature in February created the Wyoming Energy Commission under the supervision of the Wyoming Business Council. The new commission will be charged with pursuing opportunities for Wyoming in the energy business. A bill signed into law by Governor Geringer on February 2, 2001 gave the new (15-member) body a very broad agenda, including developing a state energy policy and finding ways to "market Wyoming energy" to other states. The commission's duties will involve streamlining timetables and rules for permitting energy projects while also establishing transmission corridors to move Wyoming-generated electricity to other states. A full copy of the enabling legislation (S.B. 185) is available at http://legisweb.state.wy.us (COAL Daily, 2/28/01).

The recent increase in market prices for PRB coal attracted the attention of Wyoming State Senator John Schiffer (R) and Representative Bruce Burns (R) who introduced legislation aimed at increasing the annual state severance tax on coal production by an additional 1.5 percentage points. Currently Wyoming coal producers pay an annual severance tax of 7% on the value of every ton they surface mine. The severance tax consists of 5.5% charged as established by the State Legislature and a 1.5% excise tax imposed by the Wyoming Constitution. The joint resolution (S.J. 0002) would have raised the annual excise tax from 1.5 % to 3% (COAL Daily, 2/8/01). On February 29, 2001 the joint resolution was defeated on its third reading in the Senate.

Federal legislation that would extend the collection of reclamation fees on produced coal until 2011, the Abandoned Mine Lands Reclamation Reform Act of 2001 (H.R. 297), was introduced in Congress. Twice before Congress has passed laws to extend the fees, which were initially due to expire in 1992 (COAL WEEK, 2/2/01). Wyoming recently received more than $28 million from the Interior Department's Office of Surface Mining and Enforcement to help fund the state's abandoned mine lands reclamation program (COAL Daily, 3/8/01).

Market developments and opportunities

Independent power producer LS Power, LLC. announced that it would construct a new 1000- to 1600-MW power plant in Arkansas. With construction beginning in 2002, the Plum Point Energy Station is expected to be operational by 2005. Located near the Mississippi River south of Osceola, Arkansas, transportation of coal to the plant may be by rail or rail-to-barge.The company said that although the transportation logistics are yet to be worked out, they anticipated fueling the new plant with PRB coal (COAL Daily, 1/24/01).

Since last November, Kentucky Utilities has taken delivery of a few trainloads of PRB coal to their Ghent Station. Source of the coal was reported to be Arch Coal Sales. It is thought that amounts (15,000 to 90,000 tons per month) of spot coal are being sought by utilities in the region to offset higher priced eastern coal (COAL WEEK, 1/29/01).

Big Brown, which traditionally burns lignite, is anticipating replacing its lignite with PRB coal.

Kansas City Power & Light Co. announced it was seeking to increase coal-fired generating capacity at its Iatan plant in Missouri. Iatan currently burns PRB coal under contract from Thunder Basin Coal Company's Black Thunder mine under terms that expire in 2003. The company plans spot purchases for any additional coal required (COAL Daily, 2/9/01).

Black Hills Corp. said it would build a 500-MW independent power plant adjacent to its other generating facilities east of Gillette. The target date for bringing the new plant on line is 2005. The electricity produced will be sold in the wholesale energy market. The minemouth plant, located at the Wyodak mine, will require approximately 500,000 tons of coal annually (COAL Daily, 2/27/01).

Black Hills Corp. also announced that its proposed 90-MW minemouth power plant (see *Wyoming Geo-notes No.68*, December, 2000, p. 14) near Gillette will supply electricity to Cheyenne Light Fuel and Power as well as the Municipal Electric Agency of Nebraska. Under contracts written for ten-year electricity supplies, a majority of the unit's electricity will be transmitted to Cheyenne, with most of the remaining power sold to Nebraska (COAL Daily, 3/22/01).

TXU Electric & Gas has scheduled a test burn at the Big Brown, Texas generating plant using coal from Western Fuels' Dry Fork mine. Plans call for 10 trainloads of Dry Fork coal to be burned in a blend with lignite sometime in April or May. Big Brown, which traditionally burns lignite, is anticipating replacing its lignite with PRB coal. Currently it is expected to burn up to 3.5 million tons of coal from the Black Thunder mine. Eventually the plant will need an additional 1.5 to 2 million tons of PRB coal annually (COAL Daily, 3/9/01).

Alliant Energy has proposed to develop 1200 MW of new generating capacity in Iowa. Fuel choice for the new plant(s) is still undecided but the company said coal is in the running. The day before this announcement the company unveiled plans for a new 500-MW coal-fired plant in Wisconsin (but did not reveal its choice for a coal supply). The company plans to use the next few months to review potential Iowa sites for the new plant(s). The company's subsidiary, IES Utilities, owns several coal-fired plants in Iowa, including Burlington, Ottumwa, Prairie Creek, Sixth Street, and Sutherland (COAL Daily, 3/23/01).

Table 14 tabulates some of the contract, spot sales, test burns, and solicitations for Wyoming coal, announced during the first quarter of 2001.

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Stauffenberg, D.G., 2000, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 2000: Office of the State Inspector of Mines, Rock Springs, Wyoming, 81 p.

Table 14. Marketing activities for Wyoming coal producers during the first quarter of 2001*.

Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
Ameran (Union Electric and Central Illinois Public Service)	System	PRB	So	25 mt	1 mt for 2001 and 4 mt for 2002 to 2007
Basin Electric Power	Laramie River	Caballo Rojo/PRB	C	3 mt	For 2001
Detroit Edison	System	Antelope/PRB	C	2.5 mt	.5 mt in 2001, and 1 mt in 2002 and 2003
FirstEnergy Corp.	Lake System Plants	PRB	Sp	100,000 t per month	Deliveries beginning March 1, 2001.
Grand River Dam Authority	GRDA	PRB	Sp	200,000 t	Delivery in second half of 2001
Kansas City Power & Light	Hawthorne	PRB	So	1 to 1.5 mt/y	Starting in June 2001 term of supply contract unspecified
Kentucky Utilities	Ghent	PRB	T	Unspecified	Test Burn in 2001
Lower Colorado River Authority	Fayette	Buckskin/PRB	Sp	1 mt	Delivery in 2001
Marquette Board of Light & Power	System	PRB	So	170,000 t/y	Starting in 2003
Mid American Energy	System	PRB	So	Less than 1 mt	For 2001 delivery
Muscatine Power & Water	Muscatine	PRB	So	1.1 mt/y	To supply system starting in 2002
Northern Indiana Public Service Co.	System	PRB	Sp	5-8 trains/month	Delivery in 2nd and 3rd Quarters of 2001
Ohio Vally Electric Corp.	Kyger Creek	PRB	T	Unspecified	Test burn in late 2001
Otter Tail Power	Big Stone	PRB	So	2 mt/y	2 to 5 years starting in 2002
Public Service of Colorado	Arapahoe	Black Tunder/PRB	Sp	680,000 t	Delivery in 2001
Southwest Public Service Co.	Harrington	Black Thunder/PRB	C	2.75 mt/y	5 year contract starting 2001-2006
Tampa Electric Co.	Gannon	PRB	So	500,000 t	Delivery between May-Dec. 2001
TXU Electric & Gas	System	PRB	So	7 mt	Delivery during and after 2002. Currently testing PRB coals at Big Brown Plant
Wisconsin Electric Power Company	System	PRB	T	Uspecified	Planning to test burn PRB coals of various Btu values.
Wisconsin Public Service	Pulliam and Weston & North Antelope/PRB	Black Thunder	C	4 mt/y	1 to 5 years starting in 2001

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

Coalbed Methane Update

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Coalbed methane (CBM) production in Wyoming reached 151.2 billion cubic feet (BCF) in 2000 and accounted for 10.4% of the state's total gas production. In the Powder River Basin (PRB), Wyoming there were 4466 producing wells and 2291 shut-in wells in December, 2000. In January, 2001, the number of producing wells grew to 4884 with 2074 shut-in wells. Currently, the gas gathering and pipeline infrastructure in the PRB can only handle about 650 million cubic feet (MMCF) of gas per day. In January, daily production in the basin averaged 642 MMCF of coalbed methane per day. With the tremendous growth in numbers of coalbed methane wells and methane production, additional infrastructure in the basin is needed as soon as possible.

Regulatory issues

The U.S. Bureau of Land Management (BLM) approved the Drainage Environmental Assessment (EA) in March, 2001, that will allow production of up to 2500 new CBM wells on the federal oil and gas estate within the original Wyodak project area of 3600 square miles. Mineral ownership in this area of the PRB is approximately 50% federal, 5% state, and 45% private. There are nearly 7000 non-federal wells in the area compared to only 1500 federal wells. Scattered mineral ownership and extensive drilling and production of private and state wells creates a situation where federal CBM is being drained by wells on state and fee land. These additional federal wells will help to alleviate this situation.

Coalbed methane company activities

Phillips Petroleum Co. acquired the CBM properties of three unidentified companies in the PRB during 2000. Phillips announced plans to open a regional exploration and production office in Denver by the end of February. The office will employ about 42 people in three asset teams. The PRB team will primarily handle the company's CBM assets in northeastern Wyoming. Those assets were once the responsibility of the company's Odessa, Texas office. The three PRB acquisitions increased the company's gross acreage position by 90,000 acres, with Phillips as operator and more than a 90% working interest. This brought the company's total acreage position in the basin to

430,000 gross acres. These properties are in the early stages of development, and plans are to drill more than 500 wells in 2001.

Anadarko Petroleum Corp. has an interest in seven different CBM projects in Wyoming. In the PRB, 35 net wells will be drilled in 2001. Capital spending is expected to exceed $10 million during 2001 with production targeted to peak in 2002.

Marathon Oil Co. has completed their previously announced acquisition of Pennaco Energy Inc. through a merger (see *Wyoming Geo-notes No. 69*, April, 2001). Under the terms of the merger, shares not held by Marathon were converted into the right to receive $19 per share in cash. The total cost of the acquisition was approximately $500 million, including net debt of $54 million.

With the merger, Pennaco is now a wholly owned subsidiary of Marathon. Marathon's Pennaco operations will be run from Pennaco's office in Denver; Terry Dobkins, former vice president of production for Pennaco, will head the new unit. Pennaco is one of the largest leaseholders in the Powder River Basin CBM play with over 400,000 net acres and current net production of more than 50 MMCF per day. Net proven gas reserves are estimated at about 200 BCF, with probable reserves of over 800 BCF. Marathon estimates that the ultimate development and acquisition costs of their proven plus probable reserves will be approximately $4.50 per barrel of oil equivalent.

Infinity Oil & Gas scheduled three new CBM tests in an area of the Great Divide Basin. The wells are projected to depths ranging from 2352 to 3050 feet and will be drilled in SW NE sec 23, T19N, R100W; NE SW sec 23, T19N, R100W; and in NE SW sec 1, T18N, R100W (**location A, Figure 10**). Infinity leases about 24,000 acres in the project area, which is located near three interstate gas pipelines.

The expansion will increase capacity on the existing system from 434 MMCF to 634 MMCF per day...

Petroleum Development Corp. staked 12 exploratory tests of the Almond Formation on the southeastern flank of the Great Divide Basin in an area 11 to 15 miles southwest of Rawlins. The projected depths of the tests range from 1500 to 3100 feet. The tests will be drilled in sections 5 and 7, T19N, R89W, and section 33, T20N, R90W (**location B, Figure 10**). A scoping statement has been issued for an EIS covering development in this area (see below). A year ago North Finn drilled six shallow Almond CBM tests in section 5, T17N, R90W. At last report, these wells were in the dewatering stage.

BLM's Rawlins Field Office asked the public to review a proposed CBM exploration project in the northeastern Hanna Basin. Barrett Resources (recently acquired by Williams Companies Inc. for $2.8 billion) proposes to explore and potentially develop 18 wells and construct a 20-mile-long natural gas pipeline from the project area to an existing interstate pipeline. The project area in T23N, R81W, and T24N, R81W (**location C, Figure 10**) includes approximately 3200 acres, of which 1280 acres are federal surface and mineral estate.

Pipelines

Fort Union Gas Gathering announced an expansion of its existing gathering system in the PRB. The expansion will increase capacity on the existing system from 434 MMCF to 634 MMCF per day and is expected to be in service by October, 2001. Fort Union Gas Gathering is a limited liability corporation (LLC.) whose partners are affiliates of CMS Energy Corp., Northern Border Partners, Western

Scoping Statement for Atlantic Rim CBM Project

The U.S. Bureau of Land Management (BLM) in Rawlins has issued a scoping notice for an Environmental Impact Statement (EIS) covering a proposed 3880-well CBM project in the Atlantic Rim area of southwestern Carbon County. Four companies, led by Petroleum Development Corporation (PEDCO) of Gillette and including Merit Energy Company, Double Eagle Petroleum and Mining Company, and Julander Energy Company, have proposed an exploration and development program for targeting coal beds of the Almond Formation (Upper Cretaceous) in the eastern Washakie Basin.

The area includes all or parts of Ts 13 through 20 N, Rs 89 through 92 W (**location D, Figure 10**). The exploration/drilling phase may last from six to 10 years with a project life of 20 to 30 years. Interim drilling of 200 exploratory wells in nine pod locations (a pod is a group of CBM wells drilled to maximize gas production) will be allowed to acquire data on the CBM reservoir to complete the EIS. Depths to coals are expected to range from 300 feet near the outcrop on the eastern edge of the area to 6000 feet downdip on the western edge. Based on the age and apparent rank of the coals, thermogenic methane may be the dominant form of CBM here. Two public meetings are scheduled in early July to hear comments on the proposal.

Gas Resources Inc., Colorado Interstate Gas Co., and Barrett Resources Corp.

Downstream from Fort Union, Wyoming Interstate Co.'s Medicine Bow Lateral expansion will increase its capacity to over one BCF per day. The Medicine Bow expansion should be completed by December, 2001. The Fort Union Gas Gathering system extends about 106 miles from near Gillette southward to Glenrock. The pipeline then interconnects with the Medicine Bow Lateral, as well as with Colorado Interstate's Powder River lateral and Kansas-Nebraska Energy Co.'s interstate system.

Northern Border Partners signed a letter of intent to purchase Bear Paw Energy for $370 million. The purchase was targeted for completion at the end of the first quarter of 2001. Bear Paw has 600 miles of high- and low-pressure gas gathering pipelines in the PRB. The company also owns over 2880 miles of gathering pipelines and four processing plants with 90 MMCF per day of total capacity in the Williston Basin in Montana, North Dakota, and Saskatchewan.

Revised activity maps for Powder River Basin

The Oil and Gas and Coal Sections at the Wyoming State Geological Survey (WSGS) have recently completed revisions on the CBM activity maps for the Powder River Basin, Wyoming. Coalbed methane maps CMM 01-3 and CMM 01-4, of the eastern and western parts of the PRB, respectively, contain updated information as of June 1, 2001 and replace maps CMM 01-1 and CMM 01-2, which were updated in January, 2001. We have added a new map to this CMM series, CMM 01-5, a map of the entire CBM activity in the PRB. This map is a reduced version (scale 1:250,000), which combines the larger, more detailed maps of the eastern and western parts of the basin. For ordering information and prices, see the **PUBLICATIONS UPDATE** on page 40 of this issue.

Coalbed Methane Coordination Coalition

Mickey Steward

Coalbed Methane Coordinator, Coalbed Methane Coordination Coalition

The Coalbed Methane Coordination Coalition (CBMCC) was established as an independent entity to help deal with coalbed methane (CBM) development issues in Wyoming. The coalition consists of representatives of five counties, two conservation districts, the State of Wyoming, and the CBM industry as well as the CBM Coordinator, Mickey Steward, and Assistant Coordinator, Bj. Kristiansen. This is a summary of the organization, activities, and responsibilities of the CBMCC and what it plans to accomplish.

Introduction

After more than a year in preparation, the CBMCC was created late in 2000. Founding members of the coalition, and seated on the Joint Powers Board (JPB) that supervises the activities of the coalition, are Campbell, Carbon, Converse, Johnson, and Sheridan counties, and the Lake DeSmet and Campbell County conservation districts. The State Geologist represents the State of Wyoming on the JPB via a Memorandum of Understanding (MOU). Members of the coalition provide its financial basis, with the State providing funding equal to that contributed by all other government members of the JPB.

Also seated on the board is a member of the CBM industry. This industry member is currently participating in JPB activities with the expectation that individual CBM companies will enter into separate MOUs similar to that under which the State of Wyoming participates. It is believed that several CBM companies will find it useful to join the coalition and provide financial support for the activities of the JPB. These activities are designed to provide information and education for residents of CBM areas and facilitate communication between producers, landowners, and governmental agencies for issues surrounding development.

The board operates under the requirements of the Wyoming Joint Powers Act and complies with the Uniform Municipal Fiscal Procedures Act. The JPB meets monthly on the first Thursday after the first Tuesday of the month. Meeting locations vary to accommodate board membership. The agenda for the meetings is posted in the Johnson County Courthouse and is available on CBMCC's web page at http://www.cbmcc.vcn.com.

Administrative organization

A coordinator for the coalition was hired following its creation via the JPB Agreement and signing of the MOU with the State. The responsibilities that the JPB expects the coordinator to fulfill are wide-ranging:

- Serve as chief advisor to the JPB on CBM issues.
- Serve as a liaison and facilitate communication and dissemination of information between the JPB and local, state, and federal service agency personnel, landowners, and industry on CBM issues.
- Coordinate and facilitate monitoring needs between state and federal agencies, landowners, and industry on CBM issues.
- Facilitate development of monitoring parameters and plans with key technical staff of industry and techni-

cal staff of resource agencies on CBM issues.

- Develop outreach and educational materials, guidance and background materials, and fact sheets containing an overview of CBM development. This includes (but is not limited to): public, industry, state, and federal government participation plans; remedy/mit-igation agreements; reclamation/restoration agreements; providing general guidance on mon-itored natural attenuation; internal guidance related to balancing the criteria for evaluating remedies, including risk reduction and cost considerations; evaluating and com-piling existing literature related to CBM development; establishing points of compliance for soils, surface water, groundwater, and discharge water; and tabulating regional values and providing internal guidance for establishing regional background levels for pos-sible soil, groundwater, and surface water contamination.

Mickey Steward, an environmental engineer experienced in project devel-opment, was selected as coordinator in mid-December, 2000. The first full board meeting followed quickly in early January, with Alan Weakly elected as Chairman, Marilyn Conally as Vice-Chairman, Brenda Schladweiler as Secretary, and Bill Welles as Treasurer. After an initial delay of several weeks, an office in the Lake DeSmet Conservation District Office in Buffalo was furnished, telephone service connected, computing hardware and software purchased, and a vehicle selected and purchased. Another early task was creation of the CBMCC logo. This logo is a blue drop, representing both a methane flame and a droplet of water. The blue is underlain by a rolling field of black (for coal) and green (for prairie). The rolling field signifies dynamic flow within the system.

Early in March, Bj. Kristiansen was contracted as Assistant Coordinator. Bj. is a geologist with many years of drilling and exploration experience in the coal industry. His job is to support the coordinator in the execution of her duties. Both the coordinator and assistant coordinator are contract positions, with no benefits except holiday and vacation time. The coordinator is responsible for professional liability insurance for both her position and that of the assistant coordinator. The contract documents developed for these positions spell out at some length the activities of the JPB and the coordinator. These contracts have been signed by the JPB and the contractors and await ratification by the State.

. . . the coalition assists in clarifying, supporting, and presenting information so that appropriate action can be taken.

Mission statement and methods of operation

After some thought, the mission statement "Effective Information Transfer for Rational Development" was selected to capture the essence of CBMCC activities. The activities and operations of the coalition are manifested in several ways. Personal, face-to-face contacts, either one-on-one with the coordinator/assistant coordinator or in group presentations, provide the primary means of communication and information transfer. Contact forms are used to document contacts with individuals. Several types of written information are regularly prepared: "Fact Sheets," which are written on topics of interest and published in the Campbell County Conservation District newsletter; "News of the Moment," which are bulletins posted on the Methane Operators Group web site as a courtesy to the coalition; and meeting minutes and agendas, which are published on the CBMCC web site.

Significant contacts

Both the coordinator and assistant coordinator make several contacts each week. Many of these contacts are with landowners seeking remedy for situations that they believe to be associated with CBM development. Such situations include impacts from *transboundary effects,* defined as those that pass beyond an immediate area of disturbance and beyond any clearly defined "circle of influence" or surface use agreement. They may or may not affect the landowner on which development occurs, but have the potential to affect landowners and residents beyond the boundary of the property on which development occurs. Persons that have no direct financial benefit from development may be affected by transboundary effects.

Transboundary effects represent some of the most contentious concerns that have so far been brought to the attention of the coalition. These include water trespass, water loss, gas migration, noise (during drilling and from compressors), light (from drilling and compressor stations), deterioration of the visual resource, and dust. Primary transboundary concerns to date affecting the counties have been road maintenance, including gravelling and crossing permits, taxation issues such as licensing, and compressor noise. Other transboundary effects also discussed include sedimentation (and erosion), wildlife habitat, weed expansion and spread of non-native species used for reclamation, wetlands (disturbed or created), and power lines.

Many of the issues brought to the attention of the coalition require the industry or the State to take the lead in their resolution. In these cases, the coalition assists in clarifying, supporting, and presenting information so that appropriate action can be taken. Often the coordinator searches for information that will help to improve understanding between parties. These efforts have been surprisingly successful.

Making presentations and giving talks to interested groups is an important activity for both the coordinator and the assistant coordinator. To date, these groups have included the county commissioners, the WDC Basin Advisory Groups, several Chambers of Commerce, several industry trade associations, Rotary and Kiwanis clubs, citizen's groups, trade shows, the Institute of Environment and Natural Resources at the University of Wyoming, the Wyoming Congressional delegation, and various state agencies such as the Wyoming Department of Environmental Quality and the Wyoming Department of Game and Fish.

White paper on CBM issues

At the request of the JPB, the coordinator and assistant coordinator are preparing a white paper on issues or concerns of particular importance to the counties and conservation districts. An annotated list has been issued in draft form for review by the JPB. Once this list has been approved and prioritized, it will be circulated to stakeholders in order to develop workable solutions to the challenges contained within the issues. This information will be used as a reference guide for counties and other interested stakeholders in identifying and controlling undesirable effects associated with development. In brief, the primary issues and challenges are:

Safety

- Access Control–Untrained persons or animals could access facilities such as wells, gas gathering points, and compressor units with uncontrolled results.
- Electrical–Electrical safety is one of the greatest challenges because of the possibility of gas explosions set off by static discharge. Electrical safety and explosions are currently the main sources of emergency response and accidents in the CBM areas. Enhancing Wyoming Occupational Safety and Health Administration (WOSHA) manpower resources to aid in workplace safety may be advisable.

Water

- Utilization–Utility of water for the individual landowner or group of landowners must be evaluated on a case-by-case basis. For example, if water production declines quickly with time, positive impacts such as irrigation and stock watering will be very short term. Local watershed-based water management plans would help manage the water resource.
- Storm water discharge plans–Pipeline routes and compressor facilities that disturb 5 acres or more must have a plan in place and will soon need a plan for 1-acre sites.
- Reserves–As development continues to expand, significant water reserves may be needed for fire control and probably dust control.

Services

- Roads–Increased road use creates serious dust, which increases the risk of silicosis for frequent road users or nearby residents. Roads, bridges, and culverts need to be maintained or upgraded. In some areas, traffic control may be necessary and in the winter, snow removal could be required. Trash and debris must be removed from roads.
- Emergency Response–Particularly to methane excursions.
- Control of noxious weeds.
- Law enforcement.
- Social services.
- Aggregate quarries–More gravel is needed for roads, which impacts a limited resource.
- Assessment and auditing–This involves checking to ensure taxes are being fully paid. How to fund services while waiting for tax money to roll in is an issue of concern to taxpayers and county government.

Nuisance

- Mediation/Reconciliation–A consistent method should be considered for a means to resolve disputes that are not appropriate to be heard by the Wyoming Oil and Gas Conservation Commission (WOGCC).
- Noise/Light–Operators of compressor stations near populated areas should carefully consider the installation of special noise control as needed.
- Viewscape–Power line proliferation and dust are the most common effects on the viewscape.

Monitoring/oversight

- Water–Water quality data collected as part of the National Pollution Discharge Elimination System (NPDES) discharge should be reviewed, summarized, and made available for interpretation and management. A project for accomplishing this is currently underway at the Wyoming State Geological Survey [see article in the last *Wyoming Geo-notes* (No. 69, April, 2001)].
- General–Aerial reconnaissance would provide for rapid assessment of field situations and would be less expensive than ground monitoring.

Resource management

Private landowners need information on different resources (e.g., soil, water, vegetation, drilling prospects) so they can make good resource management decisions. Increased funding of Conservation Districts and County Extension agents would provide this at a grass roots level. The CBMCC has prepared a proposal for funding that is currently being reviewed by the staff of the Wyoming Congressional delegation. Wildcat Creek north of Gillette has been used as the model for this effort.

Environmental assessments and impact statements

The coalition has been granted cooperating agency status that allows it to work as part of a group preparing environmental assessments (EAs) and environmental impact statements (EISs). This participation is particularly important in inserting the "county view" into an important Federal document. Recently, the U.S. Bureau of Land Management (BLM) has been very cooperative in encouraging participation in the process.

Challenges for the coalition

Credibility of the coordinator is of key importance to the coalition. The Coordinator must balance between providing technical information and guidance to the coalition and providing general informational services to all stakeholders. Obtaining, understanding, summarizing, and distributing accurate information in a timely manner is essential to execution of the job function. To be successful, the coalition must have access to decision and policy makers, and have the administrative and technical support necessary to facilitate effective information transfer.

Plans for the future

Plans for the future center around the *Issues* white paper with identification and selection of appropriate control strategies in concert with industry. More presentations are planned, notably at the Wyoming Natural Gas Fair in Jackson this fall. The coalition plans to move forward rapidly to assist counties and their residents in creating an environmentally sound and financially profitable place to do business in the Powder River Basin and other CBM areas in the state. A review of the CBM Coordinator's job description and modifications in its scope are also likely in the future.

Industrial Minerals and Uranium Update

Ray E. Harris

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The production of soda ash from mined trona in 2001 may be less than last year, due in part to the startup of a soda ash plant in Colorado. However, most other industrial minerals production in Wyoming in 2001 is equaling or exceeding last year's rate. Five companies are active in dimensional stone exploration and Raven Quarries continues to produce multicolored granite blocks for counter top and specialty uses. Numerous small operators are harvesting fieldstone, moss rock, and landscape rock. Decorative aggregate is being produced at several quarries and construction aggregate is being consumed at a rate greater than last year. Using material quarried and stockpiled in 2000 may satisfy some of this demand. The increased cost of energy affects industrial minerals by increasing the cost of manufacturing since processing plants need energy to produce their products. So far, however, energy costs have not adversely affected production in Wyoming.

Probably because of renewed interest in nuclear power due to the electricity shortage, the spot market price of uranium has increased from a low of $7.10 per pound of yellowcake on December 31, 2000, to $8.90 per pound as of June 11, 2001. New construction of domestic nuclear power plants is needed to permanently increase the price of yellowcake and increase the production of domestic uranium, but this construction will take a long time to accomplish. However, some operating nuclear power plants are considering constructing new reactors on operating, permitted power plant sites.

Industrial minerals

Industrial minerals are defined in the *Glossary of Geology* (Bates and Jackson, 1987) as "any rock, mineral, or other naturally occurring substance of economic value exclusive of metallic ores, mineral fuels, and gemstones." Industrial minerals found in Wyoming are listed in **Table 15**. Other mineral commodities currently manufactured but not quarried in Wyoming include lime from limestone quarried in Montana and expanded perlite from perlite mined in Colorado. Wyoming ranked fifth among states in 1999 in the value of its industrial mineral production and sixteenth

Table 15. Industrial minerals that occur in Wyoming. Boldtype indicates minerals currently produced, italics indicate minerals with past production, and asterisks indicate minerals produced (used) by Native Americans prior to 1800.

Abrasives	Garnet	Salt*
Aggregate, construction*[1]	Glauconite	Sericite
Aggregate, decorative	*Graphite*	**Shale (siliceous)**
Alum	**Gypsum**	*Silica sand and rock**
Andalusite	**Helium**	Sillimanite
Anorthosite	*Industrial sand*	**Sodium sulfate**
Asbestos	*Iron and iron additives*	Sphene
Barite	Kyanite	Spinel
Bentonite	**Leonardite**	**Stone, dimensional**
Beryl	**Limestone** and marlstone	**Stone, ornamental**
Calcite and aragonite	Magnetic sand	*Sulfur (mineral)*
Clay (common)	*Mica*	**Sulfur (recovered)**
Clinker (scoria)	*Mineral pigments**	Talc and steatite*
Cordierite	Nepheline syenite	*Tripolite*
Corundum	Nitrate	Tourmaline
Diamond (industrial)	Obsidian*	*Travertine and sinter*
Diatomite	*Peat*	**Trona**
Dolomite	*Phosphate*	*Vermiculite*
Doping agents	Potash	Wavellite
Epsomite	Pumice and *pumicite*	Wollastonite
Feldspar	Quartz*	*Zeolite*
Fluorite	Rutile	Zircon

[1]Stone was used by Native Americans for tipi rings, fireplaces, retaining walls, and monuments. *Wyoming State Geological Survey, May, 2001.*

in the value of its nonfuel minerals according to the U.S. Geological Survey (USGS).

Bentonite

Bentonite production in the U.S. increased in 2000 over 1999 production, according to the USGS (Virta, 2001). Bentonite is sodium montmorillonite clay used as a binder in foundry molds (24%), pet litter (22%), drilling mud (18%), iron ore pelletizing (15%), and other uses (21%) (Virta, 2001). Most of the sodium bentonite mined in the U. S. is mined in Wyoming with the rest mined in adjacent Montana and South Dakota. According to the State Inspector of Mines of Wyoming (Stauffenberg, 2000), 4,179,503 tons of bentonite were mined in Wyoming in 2000, an increase of 105,738 tons over 1999. The use of bentonite in foundry molds may decrease in 2001 if an economic slowdown occurs. However, the use of bentonite in drilling mud may increase if domestic oil exploration drilling increases this year.

Last year Wyo-Ben reopened the Lucerne bentonite mill north of Thermopolis in Hot Springs County. There are now 15 operating bentonite mills in Wyoming (**Figure 16**) operated by six producers. The increasing cost of energy may affect the bentonite producers because they use natural gas in their plants; its increasing cost will increase the cost of producing bentonite, and ultimately increase the cost of bentonite products to consumers.

Construction aggregate

Contracts totaling more than $36.3 million for 12 highway projects around the state were awarded by the Wyoming Transportation Commission during its March meeting in Cheyenne, according to the Wyoming Department of Transportation (WYDOT). These projects and their locations are described on WYDOT's website at: http://wydotweb.state.wy.us/Docs/News/March_Contracts01/march_contracts.html. The projects that will require construction aggregate sources are those involving highway reconstruction or paving. Since the transportation of aggregate can constitute most of the cost of the material, it is always advantageous to locate aggregate sources as close to the point of use as possible. One way to reduce transportation costs is to establish stockpiles of material at strategic locations near highways that can be used for several projects (**Figure 17**). Transporting aggregate in large quantities at one time is less expensive than transporting the same amount of material in smaller quantities for each project.

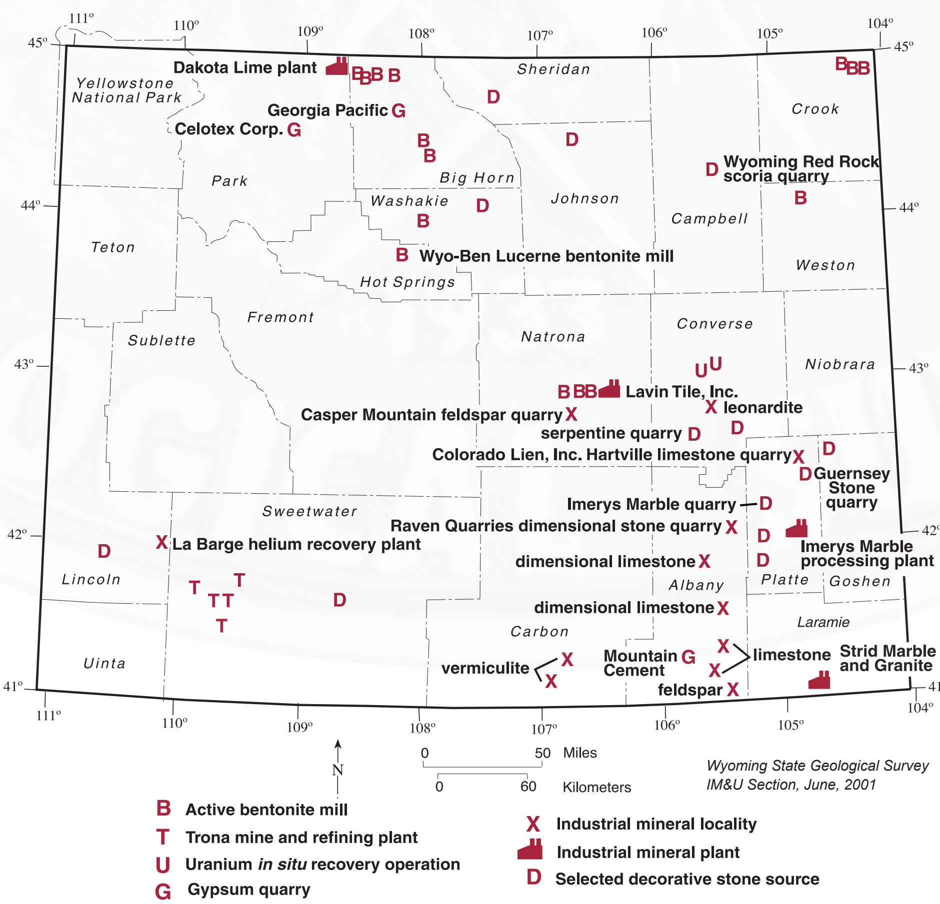

Figure 16. Index map of Wyoming showing the location of industrial mineral and uranium sites mentioned in the text. Locations are approximate and may represent more than one site.

Figure 17. Stockpile of crushed limestone aggregate near I-25 south of Midwest.

Figure 18. Dimensional stone (blocks and split-face fieldstone) at the quarry site operated by Raven Quarries in northern Albany County, Wyoming.

Decorative and dimensional stone

Decorative stone is any rock that is produced with appearance as a criterion for its value. The rock may have to qualify for other properties such as strength or durability. Dimensional stone is any rock quarried to specific dimensions, usually larger than 1′ x 1′ x 1′ (**Figure 18**).

Dimensional stone is quarried in 33 states and Puerto Rico. In order of tonnage, the leading producing states are Indiana, Vermont, Wisconsin, Georgia, and Texas. Around 1.4 million short tons of dimensional stone were quarried and sold in the U.S. in 2000. Domestic production in 2000 remained steady from 1999, while the amount of imported stone sold in the U. S. increased 31% (Dolley, 2001). The U.S. imported $1.2 billion worth of dimensional stone in 2000 (Dolley, 2001).

In 2000, the U.S. imported five times the amount of dimensional stone produced domestically, mostly from Italy but also from Canada, Spain, India (Dolley, 2001), and many other countries notably Brazil, China, Finland, Mexico, Norway, Russia, Saudi Arabia, South Africa, and Taiwan. Most of the world's quarried dimensional stone is shipped as block to Italy for processing. Dimensional stone processed in Taiwan is all quarried outside of Taiwan. Wyoming contains enough dimensional stone resources to replace most of the imported material currently used in the U.S.

Dimensional stone is quarried by Raven Quarries in northern Albany County (**Figure 16**). Raven produces a red or pink patterned granitic rock named Mirage® (**Figure 19**) which is cut on site, cut and polished by Strid Marble and Granite in Cheyenne (**Figure 16**), or shipped to Western Granite in Tijuana, Mexico for processing into slab (approximately 4′ x 8′ x 3/4″) or tile (1′ x 1′ x 3/8″). The finished slab and tile are sold in California. Raven Quarries also produces monument stone (usually 6″ thick or greater), mainly for tombstones, and other sizes of dimensional stone on site. Currently, Raven Quarries is not quarrying the black amphibolite called Raven® from which they took their name.

. . . five entities are pursuing exploration and/or financing to develop additional dimensional stone quarries and large processing plants in Wyoming.

Strid Marble and Granite in Cheyenne and Lavin Tile Inc. in Casper (**Figure 16**) operate sawing and polishing equipment capable of processing stone blocks into polished slab or other stone products. The slab is sold to finishers for the manufacture of products such as counter tops, exterior and interior cladding, flooring, tabletops, and many other products. Wyoming Tile and Terrazzo (WTT) in Cheyenne processes polished slabs into counter tops and other pieces using smaller saws and a water jet cutting machine. WTT can also cut and polish smaller stones.

Currently, five entities are pursuing exploration and/or financing to develop additional dimensional stone quarries and large processing plants in Wyoming. In February, the Wyoming Senate Minerals Committee killed a bill that, amongst other things, would have allowed dimensional stone quarries to qualify for a 10-acre permit if they were less than 10 acres in size. Some of the non-dimensional stone-related provisions in the bill were controversial. Currently, limestone, marble, and feldspar dimensional stone products qualify for a 10-acre permit. The remaining stone products, such as granite, qualify for a Small Mining Permit (40 acres). The Wyoming Contractors Association has assisted the Land Quality Division of the Wyoming Department of Environmental Quality to develop a guide to preparing an application for a Small

Figure 19. Cut and polished slab of Mirage® quarried by Raven Quarries and cut and polished by Strid Marble and Granite.

Mining Permit, removing much time and expense in its preparation.

Decorative stone is produced from many localities in Wyoming (**Figure 16**). These include the white marble produced at Wheatland by Imerys Marble, colored marble aggregate produced by Guernsey Stone at Guernsey, green serpentine quarried south of Glenrock and 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. Wyoming Red Rock has applied for a discontinuance of the serpentine permit south of Glenrock.

Feldspar

Feldspars are a group of aluminosilicate minerals with varying amounts of calcium, potassium, or sodium in the framework structure. In glassmaking, feldspar provides alumina for improving hardness, durability, and resistance to chemical corrosion. In ceramics, feldspar is used as a flux, lowering the vitrifying temperature of a ceramic body during firing and forming a glassy phase. Potassium and sodium feldspars are best suited for ceramics. Glass and ceramics continued to be the major end uses of feldspar in 2000 (Potter, 2001a).

In Wyoming, small amounts of feldspar are quarried on Casper Mountain in Natrona County (**Figure 16**). This material is shipped to the Pacer Corporation in Custer, South Dakota, where it is ground to a fine powder and mixed with other material to make ceramic glazes. Small amounts of feldspar are also quarried south of Laramie for decorative aggregate (**Figure 16**). Before the 1960s, several feldspar deposits east and south of Laramie were mined. Some of that feldspar went to a Denver company that made false teeth.

Gypsum

Wyoming gypsum production in 2000 decreased 12% according to the State Inspector of Mines (Stauffenberg, 2000) and the Wyoming Department of Revenue. However, the U.S. Geological Survey reported that U.S. gypsum production increased in 2000 (Olson, 2001). Two companies in Wyoming, The Celotex Corporation in Cody and Georgia-Pacific south of Lovell, mine gypsum and manufacture wallboard at nearby plants (**Figure 16**). Mountain Cement in Laramie (**Figure 16**) also mines a smaller amount of gypsum for use as a retardant in cement. Unless an economic downturn significantly impacts wallboard demand, Wyoming's 2001 production should again be around 560,000 short tons.

Helium

Helium is considered to be a nonfuel mineral product by the USGS Minerals Information Service (see http://minerals.usgs.gov/minerals/pubs/commodity/). This gas fits the definition of industrial minerals, as given above. Like recovered sulfur, helium is also recovered during the refining of natural gas. One natural gas refining plant, the LaBarge plant in Lincoln County, (**Figure 16**) produces 3.2 million cubic feet of Grade-A helium per day, or around a billion cubic feet per year. Grade-A helium is also produced in Colorado, Oklahoma, Texas, and Utah. Wyoming ranks second to Texas in the amount of Grade-A helium produced. Thirteen other plants (in Kansas, Oklahoma, and Texas) produce a helium product that contains from 50% to 80% helium. Helium is an inert gas used for cryogenic (very cold refrigeration) applications, in pressurizing and purging operations, as a cover gas in welding, in producing controlled atmospheres, in leak detection applications, in breathing gases, and other uses (Peterson, 2001).

Leonardite

Leonardite is oxidized lignite or subbituminous coal. It is used as a dispersant and viscosity control in drilling fluids, as a stabilizer for ion-exchange resin in water treatment, and as a soil conditioner (U. S. Geological Survey, 2000). It is also used as a coloring agent in wood stain. Around 25,000 short tons of leonardite are mined by Black Hills Lignite north of Glenrock in Converse County (**Figure 16**).

Limestone

Limestone is a rock composed primarily of calcium carbonate ($CaCO_3$). Most limestone is used in Wyoming for construction aggregate. Chemical grade limestone (greater than 95% calcium carbonate) is quarried at two locations in Wyoming. Mountain Cement in Laramie (**Figure 16**) quarries around 500,000 short tons for the manufacture of cement, and last year Colorado Lien quarried around 92,000 short tons at the Hartville Quarry (**Figure 16**) for use as an emissions control agent at Basin Electric Power Cooperative's Laramie River Power Plant north of Wheatland. Limestone from the Warren Quarry in Montana is refined into lime by Dakota Lime north of Frannie (**Figure 16**), and this limestone is used in the refining of sugar beets in western Nebraska. The sugar beet refining plant in Torrington uses limestone quarried near Pringle, South Dakota.

Limestone is also used for dimensional stone. More limestone is quarried in the U.S. for dimensional stone than any other rock type, if measured in terms of both quantity and value (Dolley, 2001). Two of the companies exploring for dimensional stone in Wyoming (mentioned above) are considering quarrying limestone. Two sites northeast of Laramie have been leased for dimensional limestone (**Figure 16**). Limestone can be quarried under a 10-acre permit, no matter what its end use may be.

Trona

Four companies in Wyoming mine trona by underground and solution recovery methods at five locations and produce sodium products including soda ash at nearby plants (**Figure 16**). 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 no*rthwes*tern Colorado. The Colorado operation went into production in January, 2001 (Kostick, 2001).

In 2000, soda ash was used in the manufacture of glass (51%), as a sodium chemical base (26%), soap and detergents (11%), mineral fillers (5%), flue gas desulfurization (2%), pulp and paper manufacture (2%), water treatment (2%), and other uses (1%). Other products produced from mined trona in Wyoming include sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and caustic soda (Kostick, 2001).

According to producers, sodium chemical production from the Wyoming plants is less in 2001 than it was for the same period in 2000. Wyoming production may be down in part due to the new production from Colorado without a corresponding increase in domestic and export consumption. The trona refineries use natural gas, and the increasing cost of natural gas is increasing the cost of production, as it is with some other refined minerals. These costs can make domestically produced soda ash more expensive and less competitive with foreign synthetically produced soda ash.

Vermiculite

The mineral vermiculite contains interlayered water in its structure. When flakes of vermiculite are heated rapidly to a temperature above 870°C, the water flashes into steam, and the flakes expand into accordion-like particles. This process is called exfoliation, or expansion, and the resulting lightweight material is chemically inert, fire resistant, and odorless. It is used in lightweight plaster, concrete, and insulation. Expanded vermiculite is also used to absorb liquids such as fertilizers, herbicides, and insecticides. Two companies in South Carolina and Virginia mine vermiculite and ship unexpanded vermiculite. Nineteen exfoliation plants in the U.S. produce expanded vermiculite (Potter, 2001b).

A major vermiculite producer in Montana closed its operations in the early 1990s. Since then, the western markets for vermiculite have had to import the product from either the eastern U.S. or from foreign sources. Wyoming contains vermiculite occurrences, and deposits near Encampment were mined (**Figure 16**). In the first quarter of 2001, there have been several inquiries to the Industrial Minerals and Uranium Section at the Wyoming State Geological Survey regarding the vermiculite resources of Wyoming. Other resources are located in Colorado, Nevada, North Carolina, and Texas (Potter, 2001b).

Uranium and nuclear power

Uranium is mined by *in situ* methods at two locations in the southern Powder River Basin in Converse County (**Figure 16**). Yellowcake from the two on-site recovery mills is shipped for enrichment and conversion into nuclear power plant fuel. In the last issue of *Wyoming Geo-notes* (No. 69, April, 2001), it was mistakenly reported that all the yellowcake produced in Wyoming was shipped to France. Rio Algom Mining Corporation does not ship yellowcake to France from Wyoming. A small amount of yellowcake from Wyoming is sold under contract to Duke Power of Charlotte, North Carolina. In terms of product value in Wyoming, uranium ranks behind oil, gas, coal, trona, bentonite, and construction aggregate. Uranium is exempt from severance taxes in Wyoming as long as the spot market price of yellowcake is below $15.00 per pound. According to the U.S. Energy Information Administration (EIA), yellowcake is presently produced at only two other locations in the U.S.: Crow Butte, Nebraska by *in situ* recovery methods, and Cañon City, Colorado by conventional milling methods.

The price of yellowcake (the product of uranium mills) increased to $8.90 per pound as of June 11 after reaching its lowest price since 1994 ($7.10 per pound) on December 31, 2000 (see *Wyoming Geo-notes No. 69*, April, 2001), according to the Ux Consulting Company, LLC. and the Uranium Exchange Company: http://www.uxc.com/top_review.html.

Since California and possibly other parts of the country are or will be experiencing electricity shortages, there is increased interest in nuclear power generation in the U.S. Currently, there are 103 operating nuclear power plants in the U.S., which supply 19.8% of all the electricity used, according to the EIA. Recently, one plant in Maryland, which had planned a permanent shutdown, has been modernized and its operating license renewed. Other plants are considering renewing their operating licenses instead of shutting down. The spot market price increase may be a reflection of this interest. It will however, require new domestic nuclear plant construction and a much greater increase in the price of yellowcake to significantly increase the production of uranium in Wyoming.

In late March, the Nuclear Energy Institute (NEI) mentioned that additional power units might be constructed at existing nuclear power plants without as much permitting required as for an entirely new power plant location. These new units would increase the electricity supply in the country.

According to the NEI, production costs (outlays for fuel and operations and maintenance) at nuclear power plants in 1999 averaged 1.83 cents per kilowatt-hour (kwh), compared with coal-fired plants at 2.07 cents per kwh, oil-fired plants at 3.18 cents per kwh, and natural gas plants at 3.52 cents per kwh. This is another reason for the recent renewal of interest in nuclear power in the U.S. The NEI also published a recent survey that shows support for building new nuclear power plants has increased in all regions of the U.S., especially in the West. The NEI reports:

Fifty-one percent of 1,000 participants in a January 2001 survey agreed that "we should definitely build more nuclear energy plants in the future," compared to 42 percent in October 1999.

Since October 1999, those agreeing we should definitely build more nuclear energy plants in the future increased:

- *To 52 percent from 33 percent in the West (+19 percentage points)*
- *To 53 percent from 42 percent in the North Central region (+11)*
- *To 49 percent from 40 percent in the Northeast (+9)*
- *To 52 percent from 49 percent in the South (+3)*

Support for extending the operating licenses of the nation's 103 power reactors remains strong at 81 percent.

The Palo Verde Nuclear Generating Station in Arizona (**Figure 20**) generates more electricity annually than any other U.S. power plant of any kind, including coal, oil, natural gas, and hydroelectric according to the NEI. The plant generated 32,095,426 megawatt-hours of electricity in 1999. The nearest nuclear power plants to Wyoming are in eastern Nebraska, eastern South Dakota, and eastern Washington. The thorium-powered nuclear plant at Fort St. Vrain, Colorado, was completely decommissioned in 1989. A small nuclear power source operated in Wyoming around 1962. This powered the Warren Peaks facility in the Bear Lodge Mountains northwest of Sundance. An identical nuclear power source supplied electricity to the U.S. scientific base at Little America, Antarctica at the same time. Coincidentally, the rock underlying the Wyoming site is one of the most naturally radioactive rocks in Wyoming and constitutes part of a thorium resource.

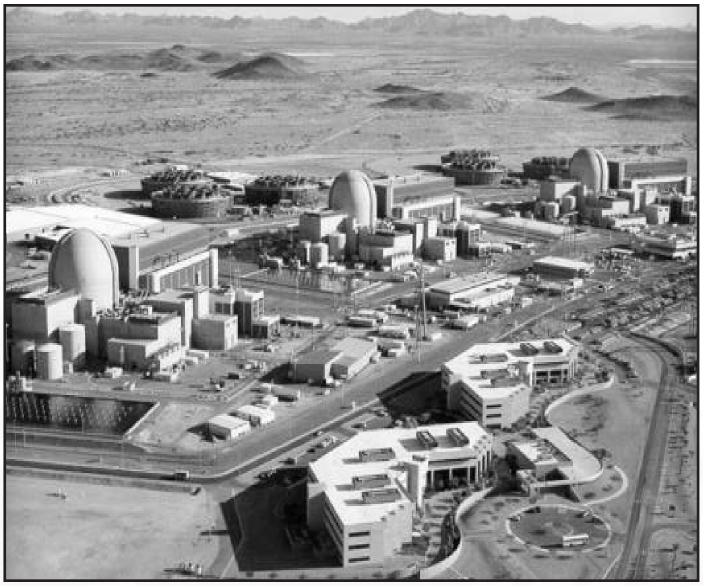

Figure 20. The Palo Verde Nuclear Generating Station 55 miles west of Phoenix, Arizona and operated by Arizona Public Service, is the largest electricity generating plant in the U.S. The three 1270-megawatt units bring the net generating rating of the plant to 3810 megawatts. Cooling water for the plant is recycled wastewater from the Phoenix area. Photograph used with the permission of Pinnacle West Energy, 2001.

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Staff Profile – Ray E. Harris

Ray E. Harris

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

Ray Eldon Harris (**Figure 21**) is the Head of the Industrial Minerals and Uranium Section (IM&U) at the Wyoming State Geological Survey (WSGS). He is responsible for originating, obtaining, interpreting, and distributing information about Wyoming's industrial and radioactive mineral resources, deposits, and mines. His current major projects include industry-funded studies of the decorative and dimensional stone resources of Wyoming, promoting dimensional stone fabrication plants and glass manufacturing plants in Wyoming, characterizing Wyoming's limestone resources and their value-added potential, and planning a future soda ash conference (jointly with the Nevada Geological Survey).

Ray was born in Bloomington, Indiana, and spent his early years on his family's apple, tobacco, and sorghum farm near the town of Beanblossom, in the hill country of southern Indiana. There he acquired an interest in geology, collecting geodes, minerals, and fossils from nearby outcrops and calcite rhombs from a limestone quarry managed by his grandfather. He also panned gold from nearby creeks. His parents later moved to Indianapolis where he became an Eagle Scout, built and raced canoes, and graduated from Broad Ripple High School in 1965.

Ray escaped from the city to earn a B.A. in geology from the University of Wyoming (UW) in 1969. He continued in graduate school at UW and completed the courses and examinations for a Ph.D. in Economic Geology. His thesis on sandstone uranium mineralization in New Mexico and Wyoming was financed by Teton Exploration of Casper, Wyoming. He completed the thesis for an M.S. in Geology in 1982. He also completed postgraduate curricula in geochemical exploration and mineral economics at the Colorado School of Mines in Golden, Colorado; investment and risk in exploration and mining at the Mackay School of Mines in Reno, Nevada; and nuclear radiation at Rice University in Houston, Texas.

Ray began his geological career during his undergraduate years at UW, working summers in remote areas of the Western U.S. for uranium exploration companies. During his graduate years, he worked on uranium and other projects for Teton Exploration and Champlin Petroleum, and also worked part-time for the WSGS.

He began permanent full-time employment as a geologist with Lucius Pitkin, Inc., a geologic contractor to the U.S. Atomic Energy Commission, in Casper. He was transferred to the Grand Junction, Colorado, Regional Office and was subsequently transferred and promoted to chief geologist for the Northeastern U.S. Region (Pennsylvania, New York, New Jersey, and New England).

After one of Ray's former supervisors helped organize the Burlington Northern Railroad (BN) / Westinghouse Electric Corporation Uranium Joint Venture headquartered in Billings, Montana, Ray returned to the West and joined that firm as Senior Geologist. At this job, Ray located uranium targets from Washington to Wisconsin. He became Joint Venture Manager one week before the crash in uranium prices and demand caused by the Three Mile Island event; the joint venture was terminated six months later. However, BN Minerals retained him as Chief Geologist, Metals, in which capacity he originated gold, molybdenum, rare earth element, and other exploration projects in Alaska, Colorado, Montana, Nevada, North Carolina, and Virginia. When BN closed its mineral division in 1982, Ray returned to Wyoming and joined the WSGS in Laramie as the head of the newly formed IM&U Section.

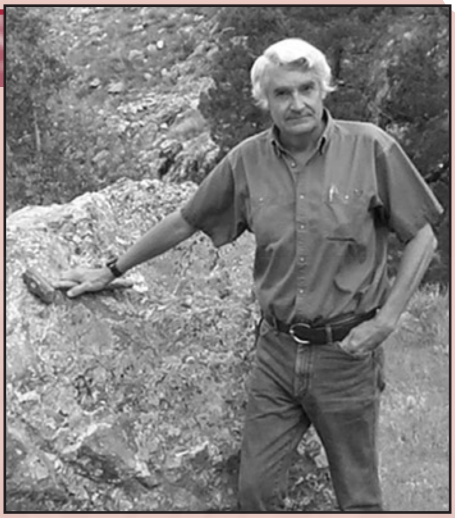

Figure 21. Ray E. Harris is the Head of the Industrial Minerals and Uranium Section at the Wyoming State Geological Survey.

Ray is a Licensed Professional Geologist in Wyoming (# 46) and Indiana (# 758), and is a Certified Professional Geologist of the American Institute of Professional Geologists (# 7746). He is a member of the Wyoming Geological Association and the Montana Geological Society, and is a Past Host of the Annual Forum on the Geology of Industrial Minerals. Ray has authored more than 250 published reports, maps, and articles on industrial minerals, uranium, and natural radiation.

Ray and his wife Mary have three grown daughters, a son-in-law, and a year-old granddaughter. His nongeologic interests include canoeing, a Datsun 1600, and working Border Collies. He is a former airplane pilot and keeps current in aviation and computer-simulated pilotage. He is the Director of Lay Speaking for the Wyoming Subdistrict of the United Methodist Church, a member of the Laramie Traffic Commission, and a member of the National Eagle Scout Association. Ray is also known for the fact that mechanical equipment tends to self-destruct in his vicinity, and for his frequent rattlesnake encounters in the field.

Metals and Precious Stones Update

W. Dan Hausel

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

Overall exploration activity for claimable minerals was sluggish throughout last year, partially because of restrictions on mining, exploration, and access on public lands. Most domestic companies that survived the last few years searched outside the U.S. for mineral resources, and few international companies opted to initiate new projects in the U.S. Even so, the high platinum-group metal (PGM) prices stimulated the search for these rare metals in Wyoming, as Wyoming is considered to have some of the highest potential in the U.S. for discovery of significant PGM resources. Exploration and prospecting for diamonds has been at a low level the past year, even though Wyoming contains the two largest kimberlite fields in the U.S. and the largest lamproite field in North America. The Metals and Precious Stones Section at the Wyoming State Geological Survey (WSGS) has initiated a mapping project in central Wyoming, emphasizing the Precambrian rocks, and continues to investigate an iolite-gneiss deposit in the Laramie Mountains that also contains a kyanite schist with sapphires and rubies. The iolite-gneiss deposit is described in *Wyoming Geo-notes No. 68* (December, 2000).

Platinum-group metals

Exploration targets for PGMs have been identified within the Wyoming platinum-palladium-nickel province in southeastern Wyoming. This province approximately parallels the Cheyenne Belt, a major suture or shear zone that separates Archean cratonic rocks to the north from cratonized Proterozoic oceanic and island arc rocks to the south. Platinum-bearing mafic and ultramafic rocks south of the suture occur in the eugeoclinal terrain, which represents ophiolite remnants stacked against the Proterozoic suture (subduction) zone. Mafic and ultramafic rocks also occur north of the suture along the edge of the cratonic terrain.

A number of rock samples from this province have yielded anomalously high values for platinum and other metals compared to their average crustal abundance. For example, nine mineralized samples from the historical New Rambler mine in the Medicine Bow Mountains averaged 1750 parts per billion (ppb) Pt+Pd. Seventeen mineralized samples from five different historical mines in the area averaged 3050 parts per million (ppm) Cu (Houston and others, 1975). Other samples collected from mines and prospects in this region have yielded anomalous Cu, Au, Ag, Pb, Zn, Ni, Pt, and Pd.

The Wyoming platinum-palladium-nickel province encloses a group of mafic and ultramafic intrusives in southeastern Wyoming (**Figure 22**)(Hausel, 2000). These intrusives include the Lake Owen and Mullen Creek layered mafic complexes and the Centennial Ridge amphibolite in the Medicine Bow Mountains; the Puzzler Hill ultramafic complex, Elkhorn gabbro, Wood Mountain peridotite, and Blackhall Mountain complex in the Sierra Madre; and the Laramie anorthosite batholith (1.5 Giga-annum or Ga) in the Laramie Range, which intrudes the Cheyenne Belt. In addition, several unexplored mafic and ultramafic bodies and fragments lie near or along the Cheyenne Belt, and a geophysical anomaly along the northern edge of the Sierra Madre, north of the Cheyenne Belt, suggests the presence of a hidden, mafic complex underlying Phanerozoic rocks in that region (Paul J. Graff, personal communication, 1997).

A rush for PGMs continued throughout the year 2000. A group of companies initiated projects in Wyoming to search for these strategic precious metals, and claims were reportedly staked in the Lake Owen, Mullen Creek, Centennial Ridge, Puzzler Hill, and other areas within and near the Medicine Bow National Forest. To date, exploration activity has included stream sediment sampling, soil and rock sampling, and some airborne geophysical surveys.

In a December 17, 1999 press release on their activity at the Lake Owen complex, Trend Mining Company reported that "*…13 diamond drill holes had been completed for a total of 5,214 feet along with over 700 rock chip samples, geological mapping and ground and aerial geophysical surveys. Three separate zones of platinum mineralization have been identified and traced for over 6 miles in strike length. Best values to date include 4.22 ppm platinum plus gold in drill core, and 4.212 ppm palladium, platinum, and rhodium in surface rock chip samples.*"

Another significant discovery was made by Ursa Major near the historical New Rambler mine. According to STOCKWATCH (September 13, 2000), *"significant palladium-platinum-copper was discovered in the Mullen Creek complex in the Medicine Bow Mountains by Ursa Major International. Eleven float samples collected over a strike length of 1,500 feet, 1.8 miles west of the historic New Rambler Mine, assayed 10.97 gm/t to 89.22 gm/t palladium, 3.23 to 20.24 gm/t platinum, and 2.92 to 32.5% copper."* The source of the mineralization was apparently not identified.

In another press release from Trend Mining Company (February 22, 2001), the company reported that it began *"re-logging and will commence a sampling and assaying program of some 5,214 feet of drill core from the Lake Owen property, in southeastern Wyoming. The diamond drill core was originally obtained by Chevron Minerals between 1983 and 1992 and comprises 13 holes that are generally less* *than 250 feet in vertical depth. Approximately 30% of the core was originally assayed for platinum group elements by Chevron."*

Two of the more promising areas in the province are the Lake Owen and Mullen Creek layered complexes. Some platinum and palladium were mined from the 60-square-mile, highly deformed, layered Mullen Creek mafic complex at the New Rambler mine from 1900 to 1918. Production at the mine prior to 1919 reportedly included 1,750,000 pounds of copper, 170 ounces of gold, 7350 ounces of silver, 910 ounces of platinum, and 16,870 ounces of palladium.

More than 21 cyclic units have been recognized in the Mullen Creek complex. Much of the platinum and palladium that has been recognized is associated with shear zones in hydrothermally altered metadiorite, metagabbro, metapyroxenite, and metaperidotite. The epigenetic platinum and palladium in shear zones suggests remobilization of the metals from an undiscovered platinum reef at depth (McCallum and Orback, 1968).

The Lake Owen mafic complex east of Mullen Creek forms a large relatively undeformed layered complex tilted on edge. Cumulate sulfides have been reported in 12 horizons. The mineralized zones are reported to include lenses up to 15 feet thick with strike lengths of more than 1 mile. Four of these zones are reported to contain PGM+Au mineralization at grades over 1 ppm. In one horizon, bornite was reported with ppm-level concentrations of Au+Pt±Pd that were continuous over a strike interval of 1.2 miles. In another unit, mineralization was reported over a strike interval of 6 miles (Loucks and Glasscock, 1990).

At Centennial Ridge north of Lake Owen, some gold and platinum were recovered during the early 1900s in shear zones in amphibolite. The richest ores were found in sulfide-rich zones in mafic mylonites, graphitic fault gouge, and in strongly chloritized zones in the amphibolite (McCallum, 1968).

In 1995, the WSGS discovered a significant anomaly at the Puzzler Hill complex in the Sierra Madre west of the Medicine Bow Mountians. Samples collected from prospect pits yielded 0.01% to 4.43% Cu, 66 ppm to 3.72% Ni, 14 ppb to 0.29 opt Au, less than (<) 5 to 828 ppb Pt, 5 ppb to 0.12 opt Pd, <0.1 ppm to 0.19 opt Ag, 21 to 831 ppm Co, and 64 to 294 ppm Cr (Hausel, 1997).

The Laramie anorthosite area in the central Laramie Mountains forms a large 350-square-mile batholith with several massive titaniferous-magnetite deposits. Recent exploration identified a large, disseminated, titaniferous magnetite deposit with associated pyrite, chalcopyrite, and pyrrhotite containing pods of massive titaniferous magnetite. The property was drilled and 300 million tons of titaniferous magnetite was identified (John Simons, personal communication, 1990). The batholith also has potential for other metals. For example, samples from the historical Strong mine in the southern portion of the batholith yielded anomalous Cu, Au, Ag, Ni, and W (tungsten).

The WSGS has initiated a project to study the Blackhall Mountain complex in the southern Sierra Madre. . .

With the 2001 field season upon us, we anticipate increased activity in the province. The WSGS has initiated a project to study the Blackhall Mountain complex in the southern Sierra Madre (**Figure 22**) for Pt, Pd, Ni, Cu, Zn, Pb, Ag, Au, and Cr. The geology of the complex shows a roughly circular outcrop of mafic gneiss and amphibolite with some localized pyroxenites and rare peridotites. Although the area is unexplored, it may have potential as a PGM target.

Diamonds

Exploration and prospecting activity for diamonds was at a low level during 2000. Even so, research by the Section indicates the Wyoming craton has been intruded by major swarms of kimberlite, lamproite, and lamprophyre, many of which originated within the diamond stability field. It is very surprising that there isn't more diamond exploration in the Wyoming craton, as the craton hosts the two largest kimberlite fields in the U.S. and the largest lamproite field in North America. In addition, diamonds have a significant value. Some of the most valuable diamonds mined in recent years from Australia have values of 200,000 to 500,000 times that of an equivalent mass in gold or platinum.

More than 300 kimberlitic indicator mineral anomalies were identified by the WSGS in the Laramie, Seminoe, and Medicine Bow mountains of southeastern Wyoming. Microprobe analyses of some garnets from some of these anomalies show G10 (diamond-stability) pyrope garnets in stream sediment samples taken within the Elmers Rock greenstone belt, Cooney Hills, Mule Creek, and Middle Sybille Creek areas in the central Laramie Mountains. G10 pyropes have also been recovered from several kimberlites in both the State Line and Iron Mountain districts in the central and southern Laramie Mountains.

Diamond-stability (G10) garnets were also detected in stream sediment samples from the Seminoe Mountains west of the Laramie Mountains. Reports of G10 pyropes from the southern Bighorn Mountains in northern Wyoming, and diamond-stability chromites detected in some lamproites in the Leucite Hills in southwestern Wyoming, support the fact that a large portion of the Wyoming craton is favorable for diamonds.

The WSGS recently received a reliable report of a kimberlite located east of Laramie Peak in the northern Laramie Mountains. We intend to investigate the report as soon as access can be established.

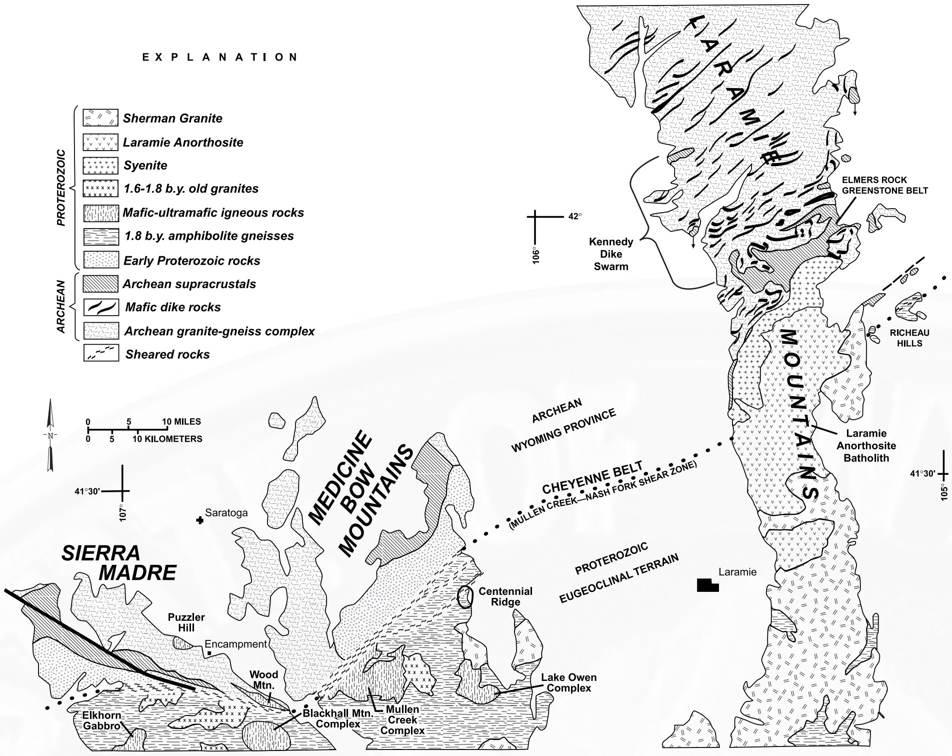

Figure 22. Location map showing the Wyoming platinum-palladium-nickel province and the Cheyenne belt (Mullen Creek—Nash Fork shear zone). Areas of highest exploration interest are shown in bold face type.

Geologic Mapping

The Section initiated reconnaissance mapping of the Rattlesnake Hills 1:100,000-scale Quadrangle, which covers a large portion of the Granite Mountains in central Wyoming. Most of the Precambrian outcrops in the Granite Mountains are essentially mapped as undifferentiated. The Granite Mountains lie in the core of the Wyoming craton, and are known for gold, gemstones, and uranium. The mapping project is one of two funded projects under the STATEMAP 2001 Program (see *Wyoming Geo-notes No. 68*, December, 2000, p. 30). The Barlow Gap 1:24,000-scale Quadrangle in the center of the area was mapped earlier as part of STATEMAP 1998.

The area is dominated by Archean granites and supracrustal rocks in a sea of Tertiary sediments and middle Eocene volcanic rocks. The mapping will concentrate on differentiating the Precambrian complex and compiling maps of sedimentary units. In the past, this area has proven to be of significant economic importance with the Gas Hills uranium district as well as the southern end of the Wind River Basin oil and gas area in the north. The Rattlesnake Hills gold district east of the Gas Hills apparently contains significant gold deposits and the Tin Cup district in the southwest contains significant gemstones and other materials (Hausel and Sutherland, 2000).

South Pass Field Trip

A field trip through the South Pass greenstone belt in the southern Wind River Range is scheduled for Saturday, August 11, 2001. W. Dan Hausel, Senior Economic Geologist at the Wyoming State Geological Survey (WSGS) will lead the trip into the historical gold mining area, where attendees will see some unique geologic formations, view several gold mines, and learn how to pan for gold. The area continues to hold interest as it contains high potential for new discoveries.

To attend this trip, meet at the Atlantic City iron mine overlook along the west side of Wyoming Highway 28 southwest of Lander at 9:00 AM sharp. Participants should provide their own transportation, preferably a vehicle with good tires and good clearance (family cars are discouraged), as well as their own lunch. There will be some walking required and participants should wear proper shoes and field clothing. For further information, contact Dan Hausel at the WSGS.

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Rock Hound's Corner: Fluorite

W. Dan Hausel

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

Most private mineral collections include nice crystalline samples of fluorite. Many of the better fluorite specimens have been collected from replacement deposits in limestones. Although Wyoming has some fluorite occurrences, the known deposits in our state are relatively poor compared to many other localities in the world.

Fluorite (CaF_2) forms massive, granular, and less commonly isometric crystals that are typically translucent to opaque in appearance. Although quite attractive in mineral collections, fluorite is a poor choice for a gemstone simply because it is relatively soft. On the Mohs hardness scale which ranges from the softest mineral talc (H=1) to the hardest mineral diamond (H=10), fluorite rates only 4, and is thus easily scratched. Additionally, it is easily crushed to a white powder.

As an example of fluorite's crushability, during a diamond research project conducted by the Wyoming State Geological Survey (WSGS) several years ago, a widespread (greater than 40 square miles) fluorite anomaly was discovered in the Happy Jack area of the Laramie Mountains between Laramie and Cheyenne. Fluorite has a similar appearance to a diamond indicator mineral known as pyrope garnet, which may also occur commonly rounded, violet to purple in color, and isometric. Several pyrope garnet anomalies, along with several fluorite grains, were found in the black sand concentrates collected from panning in the area. The fluorite grains were evidently captured along with other minerals of similar specific gravity. Fluorite has a specific gravity of 3.18, and the various diamond indicator minerals have specific gravities that range from about 3.2 to 4.2

But with further processing, the pyrope garnet and fluorite mineral grains were easily differentiated from one another. To test their index of refraction, suspected pyropes were crushed and placed on a microscope slide. Garnets resist crushing and tend to scratch the microscope slides. Fluorite, considerably softer than garnet, is easily crushed to a fine, white powder.

Because of its brilliant luminescence, fluorite is a prized mineral sought after by collectors of fluorescent minerals. In fact, the word fluorescence is derived from the mineral fluorite (Vanders and Kerr, 1967). Fluorite typically luminesces violet-blue under ultraviolet light.

Fluorite typically is purple to blue, but has also been found as yellow, blue-green, pink, white, and colorless cubes and granular masses with perfect octahedral cleavage. Sometimes octahedral fluorite is also found.

In Wyoming, the best fluorite occurrences are in sedimentary rocks closely associated with alkalic igneous rocks in the Black Hills of northeastern Wyoming. In the Bear Lodge Mountains, Mineral Hill, and Black Butte areas, fluorite is found as replacements in limestone and sandstone beds that were intruded by the igneous rocks. The fluorite occurs as granular masses with some cubes up to 0.25 inch in diameter in the Pahasapa Limestone and in sandstones of the Minnelusa Formation. It is typically deep purple and found in lenses and as replacements along bedding planes.

Hausel and Sutherland (2000) described some other fluorite occurrences in Wyoming. In northwestern Wyoming, fluorite is reported as colorless to pale-yellow, botryoidal layers in tuffa and paleo hot spring deposits as well as in solution cavities in the Mississippian Madison Limestone on the slopes of Cedar Mountain west of Cody. The fluorite layers (typically only about 1 inch thick) are exposed in some road cuts, and are closely associated with white, radiating, fibrous 0.5-inch-long barite crystals.

In the area of the large fluorite anomaly described above in the Laramie Mountains, one fluorite deposit was found several years ago in the Middle Lodgepole Creek area. Pegmatites intruding Sherman Granite contained clear grains of fluorite measuring from 0.8 to 2.5 inches across. Approximately 20 tons of fluorite were mined from the pegmatite as a by-product of feldspar mining in 1944.

Another fluorite occurrence, discovered by the WSGS in the southern Sheep Mountain area of the Medicine Bow Mountains west of Laramie, occurs in hydrothermally altered Sherman Granite. Where mineralized, the granite contained ilsemannite ($MoO_8 \bullet xH_2O$), chalcopyrite, chalcocite, bornite, cuprite, and malachite with accessory fluorite replacing biotite. The fluorite is granular, occurring in grains only 1 to 2 mm across (Hausel, 1997).

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Mineral Resource and Reserve Base Estimates for Wyoming

Petroleum

Remaining Technically Recoverable Resources (January 1, 2000)
- Discovered (includes oil, gas liquids, and condensate) ... 3.35 billion barrels[1]
- Undiscovered ... 6.12 billion barrels[1]
- Total ... 9.47 billion barrels

Remaining Reserve Base (January 1, 2000)
- Measured reserves (Proved reserves) (Includes: 0.59 barrels of oil and 0.515 billion barrels of gas liquids and condensate) ... 1.105 billion barrels[2]
- Indicated and inferred reserves (Reserve growth in conventional fields) ... 2.41 billion barrels[1]
- Total ... 3.515 billion barrels

Natural Gas

Remaining Technically Recoverable Resources (January 1, 2000)
- Discovered (Includes 35.6 trillion cubic feet (TCF) of methane[1], 121.2 TCF of CO_2[3], and 31.7 TCF of coalbed methane[4] ... 188.5 trillion cubic feet
- Undiscovered (Includes 14.72 TCF of conventional methane[1]; 5.43 TCF of coalbed methane; 119.3 TCF of methane in tight gas sands in the Green River Basin; and 31.2 TCF of CO_2[3]) ... 170.6 trillion cubic feet
- Total ... 359.1 trillion cubic feet

Remaining Reserve Base (January 1, 2000)
- Measured reserves (Proved reserves) (Includes 14.2 TCF of methane[2] and 59.5 TCF of CO_2[3]) ... 73.7 trillion cubic feet
- Indicated and inferred reserves (Reserve growth in conventional fields) ... 22.8 trillion cubic feet
- Total ... 96.5 trillion cubic feet

Coal

Remaining Resources (January 1, 2000)
- Identified and Hypothetical (Discovered) ... 1426.0 billion tons[5]
- Speculative (Undiscovered) ... 31.5 billion tons[5]
- Total ... 1457.5 billion tons

Remaining Reserve Base (January 1, 2000)
- Demonstrated strippable (Measured and indicated reserve base) ... 24.4 billion tons[6]
- Demonstrated underground-minable (Measured and indicated reserve base) ... 42.5 billion tons[6]
- Total ... 66.9 billion tons

Trona

Original Resources
- Trona ... 76.0 billion tons[7]
- Mixed trona and halite ... 51.0 billion tons[7]
- Total ... 127.0 billion tons

Uranium

Remaining Resource (December 31, 1989) ... 1.99 billion pounds U_3O_8[8]

Remaining Reserve Base (December 31, 1989)
- Uranium oxide recoverable at $30.00 per pound ... 66 million pounds[8]

Oil Shale

Original Resources (January 1, 1981)
- Identified (Discovered) ... 320 billion barrels of shale oil[9]

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[1]Modified from U.S. Geological Survey National Oil and Gas Resource Team, 1995, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Circular 118, 20 p. [2]Modified from Energy Information Administration, 2000, U.S. crude oil, natural gas, and natural gas liquids reserves: 1999 Annual Report: Washington, D.C., 156 p. [3]De Bruin, R.H., 2001, Carbon dioxide in Wyoming: Wyoming State Geological Survey Information Pamphlet 8, 11 p. [4]De Bruin, R.H., Lyman, R.M., Jones, R.W., and Cook, L.W., 2001; modified from Gas Research Institute (1999) and Finley and Goolsby (2000), Coalbed methane in Wyoming: Wyoming State Geological Survey Information Pamphlet 7 (revised), 19 p. [5]Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:500,000-scale (color) and 44 p. pamphlet. [6]Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Wyoming State Geological Survey Open File Report 92-4, 26 p. [7]Wiig, S.V., Grundy, W.D., and Dyni, J.R., 1995 Trona resources in the Green River Basin in southwest Wyoming: U.S. Geological Survey Open File Report 95-476, 88 p. [8]Energy Information Administration, 1989, Uranuim industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121p. [9]Knutsen, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

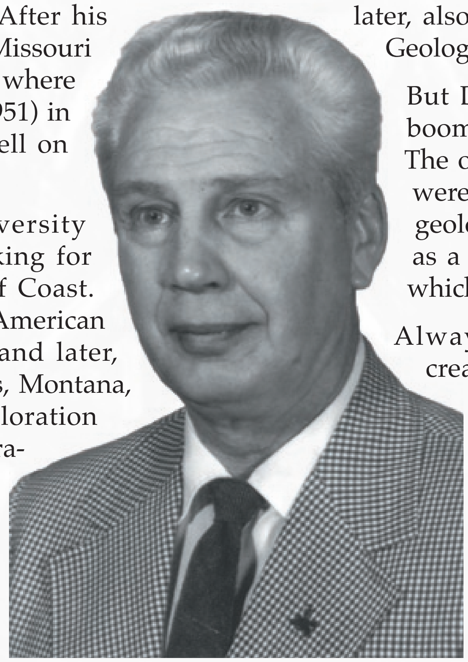
MEMORIAL: DANIEL N. MILLER, JR. (1924-2001)

Gary B. Glass

Former Wyoming State Geologist (retired)–Laramie, Wyoming

Dr. Daniel N. Miller, Jr. (Dan to many of us) died on March 26, 2001, at his home in Chapel Hill, North Carolina, at the age of 76. Dan will be remembered not only as a respected geologist, educator, and public servant, but also as an untiring advocate for the petroleum and minerals industries of Wyoming and the nation. This calling not only won him the distinction of being named Wyoming's Mineral Industries Man of the Year in 1975, but ultimately carried him to a 1981 Presidential appointment as the Department of the Interior's Assistant Secretary for Energy and Minerals. This appointment was perhaps the highlight of Dan's 46-year career. It was an awesome achievement.

Dan was born August 22,1924, in St. Louis, Missouri. He was a veteran, serving in the U.S. Army Air Force during World War II. Dan was multi-rated as a combat pilot and radar observer on B-29 aircraft in the Pacific Theater, where he flew 17 missions with decorations. After his discharge in 1946, Dan returned to the Missouri School of Mines and Metallurgy in Rolla where he earned both a B.S. (1949) and M.S. (1951) in geology. He married Esther Faye Howell on September 9, 1950.



He completed his Ph.D. at the University of Texas at Austin in 1955 while working for Stanolind Oil and Gas Co. on the Gulf Coast. After graduation, Dan worked for Pan American Petroleum Corp. (formerly Stanolind and later, Amoco Production Company) in Billings, Montana, and Casper, Wyoming, as a senior exploration geologist. In 1960, he became senior exploration geologist for the Lion Oil Division of Monsanto Chemical Co. in Casper. In 1961, he joined Barlow and Haun, Inc. in Casper as a geological consultant.

In 1963, Dan took a new direction. He became Professor of Geology and Chairman of the geology department at Southern Illinois University. During his tenure, enrollment in the department more than doubled and new classroom, office, and laboratory facilities were acquired. In 1969, Dan left the university and began yet another distinguished part of his career, this time as a public servant at both state and national levels.

In Wyoming, Dan is perhaps best remembered as the State Geologist and Executive Director of the Wyoming State Geological Survey, a position he held between 1969 and 1981. He was first appointed by Governor Stan Hathaway and then appointed for a second six-year term by Governor Ed Herschler. While serving under both Republican and Democratic administrations, Dan and the Survey remained apolitical, providing factual, unbiased geologic and mineral information for all to use. During this time, Dan also served the state in other capacities as well, and represented Wyoming on many national boards, advisory councils and research committees for the National Academy of Science, U.S. Department of Energy, Interstate Oil Compact Commission, and the U.S. Department of the Interior.

This was a particularly important time in the history of the Wyoming State Geological Survey as it had just been separated from the University of Wyoming. It had not been a separate agency since rolling into the University's geology department back in 1933. The fledgling Survey consisted of Dan, one other geologist, a secretary, and a clerk-typist. Initially it was housed within the Geology Building and later, also occupied a Butler-style hut behind the Geology Building.

But Dan had taken over the Survey during boom times and he wisely capitalized on it. The oil and gas, coal, and uranium industries were all growing. Dan saw the need for more geological expertise within the Survey as well as a future need for much larger facilities in which to carry out its mission and goals.

Always looking at the big picture, Dan created the oil and gas, minerals, and coal sections of the Survey. In support of them and other needs of the state, he added the stratigraphy and environmental geology sections. He also added a technical editor and cartographers to assist in the preparation of the Survey's increasing number of publications and thematic maps. The most notable Survey publications conceived by Dan were its large, statewide maps, which depicted Energy Resources, Mines and Minerals, Oil and Gas Fields, and Coal Fields. These maps were best sellers. Demand for these and other maps and publications of the Survey increased at a rapid pace. The Survey's *Tectonic map of the Overthrust Belt* was another best seller as the Overthrust Belt of western Wyoming was fast becoming a major play in the continental U.S. Dan also helped guide the development of that exploration and development as a member of the Wyoming Oil and Gas Conservation Commission, which is the State's oil and gas regulatory agency. In addition, discovery of gem-quality diamonds in southeastern

Wyoming added a unique dimension as Dan orchestrated the leasing of state lands to aid in the exploration and development of these precious stones. It was an exciting time for Dan and for those of us who worked for and with him. To use one of Dan's expressions, it was a time for blowin' and goin'.

In 1971, Dan saw the need for a separate building for the Survey. Supporting Dan's plans for a Survey building, 100 individuals each pledged $100 toward the cost of the proposed building. Following the raising of this $10,000 in private pledges, Dan succeeded in getting a $920,000 legislative appropriation for its construction in 1974. The Survey's new 22,400-square-foot building was completed in 1976. Without these new quarters, the Survey's expansion would have been stymied and its value to the state greatly diminished. By 1981, under Dan's able leadership, the staff had grown to 12 full-time employees as well as positions for another 14 part-time employees.

It was at this time that Dan's capable direction of the Survey and his advocacy for the petroleum and minerals industry opened a new opportunity for him. In 1981, he accepted a nomination by President Ronald Reagan for Assistant Secretary for Energy and Minerals in the U.S. Department of the Interior. In March, he moved to Washington, D.C. in an acting capacity. This was where Dan felt he was needed at that moment. The Senate unanimously confirmed him in June of 1981.

As Assistant Secretary, his responsibilities included "policy development and implementation involving research and technical programs and regulatory matters" for the U.S. Geological Survey, U.S. Bureau of Mines, Office of Surface Mining, Office of Minerals Policy and Research Analysis, and the Minerals Management Service. Collectively, these agencies had more than 21,000 employees and a budget in excess of $1 billion. Among his accomplishments at Interior were the reorganization and reform of the Office of Surface Mining; the development of a National Materials and Minerals Program Plan; oversight of the new Minerals Management Service; and the implementation of a new five-year leasing plan, which opened the entire Outer Continental Shelf area to oil and gas exploration. Dan left the Assistant Secretary's position in May, 1983, having met the goals set before him.

Perhaps Dan's own words say it best as he departed Washington. "Washington, D.C. is not for me." He went on to say that as a lecturer, "I can continue to deliver my same old message across the country, that private exploration is the key to America's energy and mineral policies." In 1983, with those departing remarks, Dan started IWO Exploration, his own geologic consulting practice in Boise, Idaho. At the same time, Dan gave many talks on the professional lecture circuit and served as an adjunct professor and guest lecturer to the Department of Geology and Geophysics at Boise State University.

Then in 1989, Dan accepted the position of Director of the Anaconda Geological Documents Collection and Curator of International Archives of Economic Geology in the American Heritage Center at the University of Wyoming in Laramie. The Anaconda Collection alone consisted of 1.8 million documents. This, again, was a relatively new entity. It required imagination and effort as the collection and archives lacked adequate funding and facilities. Dan helped it through these early years leaving it much improved when he retired in 1992.

Perhaps "retired" is not the best choice of words for these latter years of Dan's career, as Dan was never one to keep silent on important issues. Dan maintained professional and governmental contacts and remained as dedicated to the geological profession and to the support of the petroleum and minerals industry as he was at the beginning of his career.

Also testifying to Dan's accomplishments are his many service awards and honors. In 1964, Dan received a Certificate of Merit from Southern Illinois University; in 1971, he was named as a Distinguished Lecturer for the American Association of Petroleum Geologists; in 1975, he was given Wyoming's Mineral Industries Man of the Year Award; in 1983, the Rocky Mountain Association of Geologists awarded him the Distinguished Public Service to the Earth Sciences Award; in 1988, the American Association of Petroleum Geologists awarded Dan its Public Service Award; in 1993, the American Institute of Professional Geologists awarded him its distinguished Ben H. Parker Memorial Award; in 1994, it also awarded Dan its Martin Van Couvering Memorial Award; and in 1999, the University of Missouri-Rolla awarded Dan an Honorary Professional Degree for his achievements as a professional geologist and public servant.

In regard to professional organizations, Dan was President of the Illinois Geological Society in 1966-1967; an active member as well as the 1979-1980 President of the American Association of State Geologists; a member of the American Association of Petroleum Geologists and 1987 President of its Rocky Mountain Section; a charter member and active participant in the American Institute of Professional Geologists; and a long-time member of the Wyoming Geological Association, serving on various committees and giving numerous luncheon and conference talks. Dan also authored more than 45 scientific and technical reports.

I am personally proud to have worked for Dan and remember him as a friend and mentor. While Dan will be very much missed by many of us, he will be missed much more as the husband, father, and grandfather that he was to his family. I know they join us in this salute to a man that dedicated his professional life to ideals that he firmly believed in and that he championed throughout his career.

Dan is survived by his wife, Esther, of Chapel Hill, North Carolina; a son, Jeffrey S. Miller, of Denver, Colorado; a daughter, Gwendolyn Sarnoff, of New York, New York; and two grandchildren.

MAPPING AND HAZARDS UPDATE

Geologic Mapping, Paleontology, and Stratigraphy Update

Alan J. Ver Ploeg

Senior Staff Geologist–Geologic Mapping, Wyoming State Geological Survey

Compilation of geologic maps for the Buffalo, Recluse, and eastern Burgess Junction 1:100,000-scale quadrangles was recently completed in preparation for digitizing. The digitized maps will be merged with digital versions of the Sheridan and Gillette 1:100,000-scale quadrangles to create a geologic base map which will be used in a project to generate an interactive geologic, hydrologic, and water quality database for the northern Powder River Basin (PRB). The Wyoming Geological Association recently awarded grants for field expenses to nine students planning geology field mapping projects in the Rocky Mountain area. Significant additional dinosaur tracks have been noted on a state section in the vicinity of the Red Gulch Tracksite discovered in 1997. The University of Wyoming's Geological Museum has applied for a scientific fossil removal permit, which will allow the Museum to complete a paleontological survey of the tracks.

Update on bedrock geologic mapping efforts

The Geologic Mapping Section of the Wyoming State Geological Survey (WSGS), with the aid of funding from the STATEMAP 2000 Program, recently completed compiling a geologic map of the Buffalo 1:100,000-scale Quadrangle (**Figure 23**) (see *Wyoming Geo-notes No. 69*, April, 2001, p. 34-35 for details). The Section also completed mapping and compiling the eastern segment of the Burgess Junction 1:100,00-scale geologic map (**Figure 23**) to complete the geologic mapping for the interactive database of the northern PRB. The WSGS Coal Section completed the Recluse 1:100,000-scale map (**Figure 23**), which was compiled and modified from Kent and Berlage (1980). These three maps have been scanned and are now being digitized.

The three aforementioned maps will be merged with the existing Sheridan and Gillette digital quadrangle maps (Ver Ploeg and Boyd, 2000 and Boyd and Ver Ploeg, 1999, respectively) (**Figure 23**) to serve as a digital geologic base map, part of a project to generate an interactive geologic, hydrologic, and water quality database for the northern PRB (see the complete discussion of this project in *Wyoming Geo-notes No. 69*, April, 2001, p. 36-38). This geologic base map will be used to extrapolate subsurface data in the database to the surface as part of this project.

Upon completion of the digital version in July, 2001, the WSGS will release a preliminary color geologic map of the Buffalo 30′ x 60′ Quadrangle. It will be accompanied by a pamphlet containing a detailed description of map units and map symbols and the sources of geologic data used in compilation. A final digital version of the map will be completed as part of STATEMAP 2001; the map will be available in hard copy (plotted) or as digital data on a CD-ROM by August, 2002. The Recluse Quadrangle and eastern part of the Burgess Junction

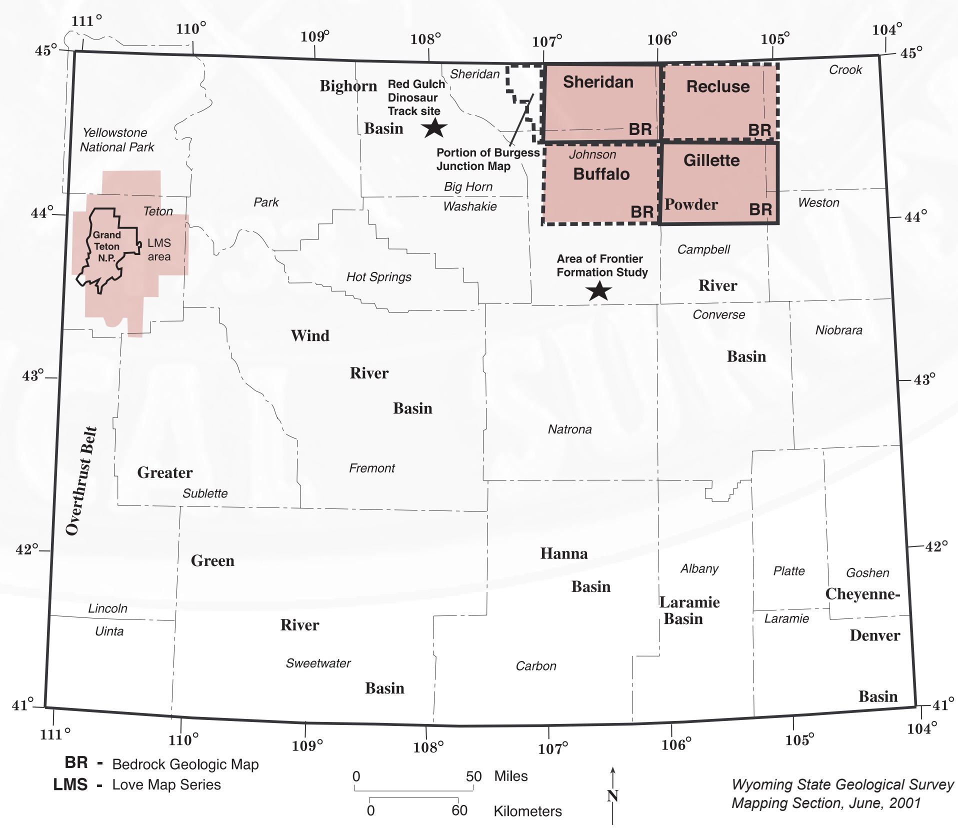


Figure 23. Index map to current geologic mapping projects, paleontology studies, recent articles relating to Wyoming geology, and general location map for area covered by J.D. Love Historical Geologic Map Series (LMS).

Quadrangle will remain unpublished until field checking and revisions are completed.

In a geologic mapping related note, the National Cooperative Geologic Mapping Program (NCGMP) has awarded the WSGS Mapping Section $6500 to enter bibliographic information for published Wyoming geoscience maps into the Map Catalog part of the National Geologic Map Database (NGMDB). The Mapping Section previously entered data on geologic maps published by the WSGS and this funding will allow entry of data on University of Wyoming thesis and dissertation geologic maps, WSGS landslide and surficial geologic maps, and geologic maps published by the Wyoming Geological Association (WGA).

Grants awarded for field mapping projects

The WGA recently awarded grants for field expenses to nine students planning 2001 field mapping projects in the Rocky Mountain area. The grants were made from the WGA's J. David Love Field Geology Fellowship in support of field geology projects and in honor of J. David Love, renowned for his distinguished career as a field geologist in Wyoming with the U.S. Geological Survey. Recipients of the fellowship included:

- Jessica Scott, University of Wyoming–study of the upper Miocene Moonstone Formation, southcentral Wyoming;
- Emilie Nyberg, University of Wyoming–structural analysis work on a Precambrian shear zone in the Northern Medicine Bow Mountains, southeastern Wyoming;
- Amanda Tyson, University of New Mexico–mapping and structural study of a possible paleosuture zone in the North Park Range, Colorado;
- Cal Ruleman, Montana State University–study of Late Quaternary tectonic activity and associated seismic hazards in the Madison Range, southwestern Montana;
- Jennifer Wilson, New Mexico Tech–mapping and work on faults in the non-welded tuffs from the Pajarito Plateau, northern New Mexico;
- Thomas Goergen, University of Missouri–evaluating the timing of Paleoproterozoic reworking of the southeast margin of the Wyoming Archean Province, southeastern Wyoming;
- Gareth Cross, State University of New York at Buffalo–study of the geometry and mechanics of explosive tectonic brecciation of the Madison Limestone in Wyoming;
- Jacob Dunston, Boise State University–mapping to determine the timing of thrust emplacement of the Golconda allochthon, Sonoma Range, Nevada; and
- Brian Fagan, South Dakota School of Mines and Technology–relating surface geology to the subsurface geology of Jewel Cave National Monument, South Dakota.

Tracksites such as these in the Middle Jurassic are rare throughout the world and very little is known about dinosaurs of this time period.

There were 19 worthy applicants this year making the decision on the awards, as always, a tough one. The J. David Love Field Geology Fellowship does an excellent job of stimulating field geology and specifically field mapping, an important discipline which has been overlooked by many university geology programs in recent years.

Study of Middle Jurassic dinosaur tracks continues

In 1997, the Worland District Office of the U.S. Bureau of Land Management (BLM) announced the discovery of rare fossil footprints on public lands near Shell, Wyoming (**Figure 23**). Referred to as the Red Gulch Dinosaur Tracksite, this significant discovery has led to reinterpreting traditional views about the paleoenvironment of the Middle Jurassic Period (160 to 180 million years ago) for this part of the Bighorn Basin. Scientists traditionally interpreted the Middle Jurassic Sundance Formation as deposited in a shallow marine environment with fossil oyster shells (*Gryphaea*), and fossil squidlike creatures (*Belemnitella*), commonly found in outcrops of the green glauconitic shales, sandstones, and limestones. The discovery of these dinosaur tracks provides some of the first evidence that this part of Wyoming included an emergent land mass during at least part of the Middle Jurassic, since dinosaurs are considered terrestrial animals.

Eric Kvale, a research geologist from the Indiana Geological Survey, discovered theropod (meat-eating) dinosaur tracks in a ripple-marked, oolitic limestone outcrop of the Sundance Formation on the Red Gulch road south of Shell. The exposures are found in the Canyon Springs Member of the lower Sundance Formation, tentatively dated at 167 million years old (Schmude, 2000). Tracksites such as these in the Middle Jurassic are rare throughout the world and very little is known about dinosaurs of this time period. Brent Briethaupt, director of the University of Wyoming (UW) Geological Museum, along with scientists from Dartmouth College, Department of Geological Sciences - Indiana University, Kansas State University, BLM National Science and Technology Center, South Dakota School of Mines and Technology, and the Smithsonian Institution have studied the Red Gulch Tracksite since the spring of 1998. This 40-acre site has provided an excellent opportunity for paleontology and geology students and researchers to study a little known part of the paleontologic and geologic record.

To date, the majority of the work on the Red Gulch Dinosaur Tracksite has centered on public lands managed by the BLM. Significant additional tracks have been noted on an adjacent State of Wyoming section in an area referred to as the "Yellow Brick Road." Briethaupt has applied for a scientific fossil removal permit through the Wyoming Office of State Lands and Investments. This permit will allow the Museum with help from student assistants, to complete a paleontological survey of the tracks on that section. The tracks will be located, measured, mapped, photographed, described (including taking molds of various tracks), and compared to documented tracks from other Middle Jurassic localities in the U.S.

Once the field work at the site is completed, interpretations and comparisons will be made allowing for possible identification of the track-makers, along with their estimated size. Information gathered will allow researchers to characterize the group behavior of dinosaurs as well as their dynamics, traveling speed, and interaction with the environment. The size and overall trend of Red Gulch Dinosaur Tracksite will be better defined by this study. Initial results of the study will be presented as a student poster session at the 2001 Annual Meeting of the Society of Vertebrate Paleontology. Breithaupt anticipates the work will continue in the area for several seasons.

New articles on Wyoming geology

Bhattacharya and Willis (2001) have detailed the sequence stratigraphy of the lower Belle Fourche Member of the Frontier Formation in the PRB, Wyoming (**Figure 23**). Previous students of these Cretaceous sandstone deposits had interpreted them as marine sandstone ridges or offshore bars. Based on the distribution, geometry, and internal facies of these sandstones from examination of nearly 100 measured outcrop sections and approximately 550 subsurface well logs, the authors concluded that the sandstones are a series of delta lobes offset laterally within the basin rather than stacked vertically. This interpretation can have profound affects on the search for petroleum reservoirs in these types of deposits.

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Ver Ploeg, A.J., and Boyd, C.S., 2000, Preliminary geologic map of the Sheridan 30' x 60' Quadrangle, Sheridan, Johnson, and Campbell Counties, Wyoming and southern Montana: Wyoming State Geological Survey Preliminary Geologic Map PGM 00-1, scale 1:100,000, 2 colors.

Geologic Hazards Update

James C. Case

Staff Geologist–Geologic Hazards, Wyoming State Geological Survey

Seven new geologic quadrangle maps are now available for the Teton-Jackson Hole area. These are the first maps released in a 45-map series that recently debuted. This is an entirely digital map set prepared by two of the sections at the Wyoming State Geological Survey (WSGS). The new maps contain basic geologic data that can be used in a variety of ways, including land use planning, analysis of geologic hazards (e.g., landslides and active faults), stratigraphic and structural analysis, geomorphology, and many others. The WSGS has also published an Information Circular on glacial features in southeastern Wyoming, including the Laramie and Medicine Bow mountains and Sierra Madre. This guide to glaciated areas incorporates a large amount of previously unpublished work by Dr. Brainerd Mears and a number of his students. The new report shows where older (Bull Lake), younger (Pinedale), and youngest (Neoglaciation) glacial deposits occur in southeastern Wyoming, provides descriptions of localities, and contains a number of maps to the sites of interest.

Seven geologic maps in Teton County completed

The Geologic Hazards and Publications sections of the WSGS have recently completed seven digital geologic maps as part of a new 45-quadrangle map series, the J.David Love Historical Geologic Map Series (LMS), Geology of the Teton-Jackson Hole Region. The maps include the Cache Creek (LMS-1), Teton Village (LMS-2), Moose (LMS-3), Gros Ventre Junction (LMS-4), Granite Basin (LMS-5), Blue Miner Lake (LMS-6), and Shadow

Mountain (LMS-7) 7.5-minute, 1:24,000-scale quadrangles in Teton County, Wyoming (**Figures 23** and **24**). Funding for the project was supplied by a grant from the Geologic Division of the U.S. Geological Survey (USGS).

The quadrangles in the map series were mapped by J. David Love, USGS Scientist Emeritus, at various times starting in the 1940s and continuing even through the 1990s, with minor modifications made in 2000 and 2001. They represent over half a century of research and investigations in the area.

The original geologic mapping was transferred to mylar where needed, scanned, converted from a raster file to a vector coverage, and attributed in ESRI ArcInfo®, ESRI ArcView®, and ESRI QuadView®. Since digital files were not available for individual layers on the base (i.e., topography, hydrology, public land survey, transportation, and boundaries), vector coverages also had to be generated for each base map. The final versions of the maps meet the most current USGS and WSGS editorial and cartographic standards for geologic maps.

The maps should be popular with the public, as they are located in areas of current or proposed development or in areas of high tourist, scenic, and recreational interest. Some of the quadrangle maps cover large parts of Grand Teton National Park, the National Elk Refuge, several national forests, and several wilderness areas.

The maps each contain geologic hazards, such as landslides or active faults. The digital versions of the mapped geologic hazards will be used for other applications in the Geologic Hazards Section of the WSGS.

In addition to the geologic hazards, the color geologic maps depict bedrock units, surficial deposits, and other geologic features such as glacial form lines, lineations and faults, terrace sequences, and traces of paleo-channelways that represent streams and drainages that have moved through recent geologic history.

Also shown are locations of type, reference, and other key measured sections of stratigraphic units; locations of selected fossil, mineral, and age-date sample sites; and other geology-related features. The glacial sequence is mapped in detail.

The maps are available in either paper (as color, plotted maps) or digital form. The digital form, which will be available on a CD-ROM, contains all the files necessary to print the map of interest. In addition, it contains digital files that can be imported into ESRI ArcInfo® or ESRI ArcView®. For those that want the map in a digital form, but do not have the sophisticated Geographic Information Systems (GIS) software, we have included software that allows for viewing the map.

For ordering and pricing information, see the **PUBLICATIONS UPDATE** near the back of this issue. The maps should be available for viewing at the WSGS web site in the near future.

Report on glaciated areas in southeastern Wyoming

A new WSGS publication entitled *Glacial records in the Medicine Bow Mountains and Sierra Madre of southern Wyoming and adjacent Colorado, with a traveler's guide to their sites*, discusses evidence for both very ancient (Late Precambrian) and recent (Quaternary) glacial episodes that occurred in the area. Public Information Circular 41 (2001) describes the area's glacial landforms and deposits and contains a number of regional and detailed maps that show ages, locations, and access to these features.

The author, Dr. Brainerd Mears, Jr., Professor Emeritus in the Department of Geology and Geophysics at the University of Wyoming (UW), taught geology and geomorphology for 40 years until his retirement in1989. Dr. Mears has drawn on his many years of field work and observations, plus the work of many UW graduates and

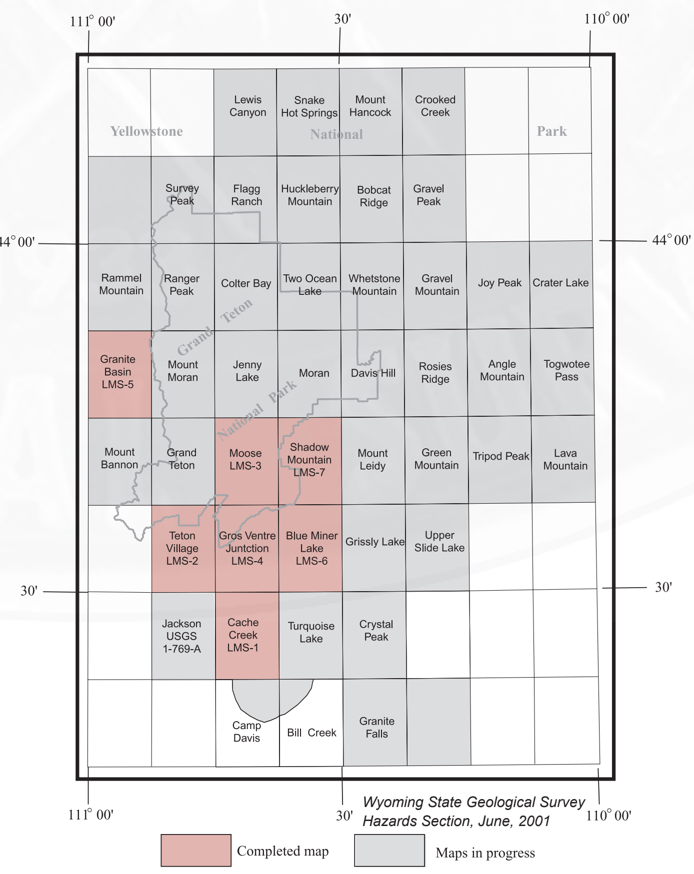

Figure 24. Index to Love Map Series showing locations of 7.5-minute quadrangles and progress of mapping.

undergraduate students, to summarize glacial events in southern Wyoming and relate them to events in other parts of Wyoming, the Rocky Mountains, and North America. Many previously unpublished studies have been incorporated into the new publication.

The Medicine Bow Mountains are, along with the Laramie Mountains, the northward extension of the Colorado Front Range. In Wyoming, the Medicine Bow Mountains are separated from the Laramie Mountains by the Laramie Basin. Similarly, the Saratoga Valley separates the Medicine Bow Mountains from the Sierra Madre to the west (**Figure 25**). In Colorado, the southward extension of the Sierra Madre is the Park Range, which is separated from the Rawah Peaks by North Park. The Rawah Peaks are the southern extension of the Medicine Bow Mountains of Wyoming.

Evidence of mountain glaciers is spectacularly shown in the Snowy Range and Rawah Peaks, where two or three late Pleistocene glacial episodes, some older than 100,000 years (referred to as pre-Bull Lake and Bull Lake) and as many as five younger episodes between about 10,000 and 35,000 years old (referred to as Pinedale) can be seen. Evidence of the Neoglaciation (or "Little Ice Age") is preserved especially well in the higher parts of the Rawah Peaks (at least three glacial episodes ranging from 3000 years ago to only 350 to 130 years ago are present) and the Snowy Range (one glacial episode is definitely present). The evidence for the younger glacial deposits can only be seen in person by hiking on mountain trails.

A less well preserved glacial record is present in the Sierra Madre, which lack the high elevation ridgetops present in the Snowy Range and Rawah Peaks that protrude about 1000 feet above a subsummit surface. Nevertheless, glacial deposits of pre-Bull Lake, Bull Lake, and Pinedale episodes have been identified in the Sierra Madre. No evidence of glaciation is present in the Laramie Mountains, but there is evidence from ice wedge casts that periglacial conditions (temperatures were low enough but not enough snow accumulated seasonally to form glacial ice) did exist in both the Laramie Mountains and the Laramie Valley.

For ordering and pricing information on this publication, see the **PUBLICATIONS UPDATE** at the back of this issue.

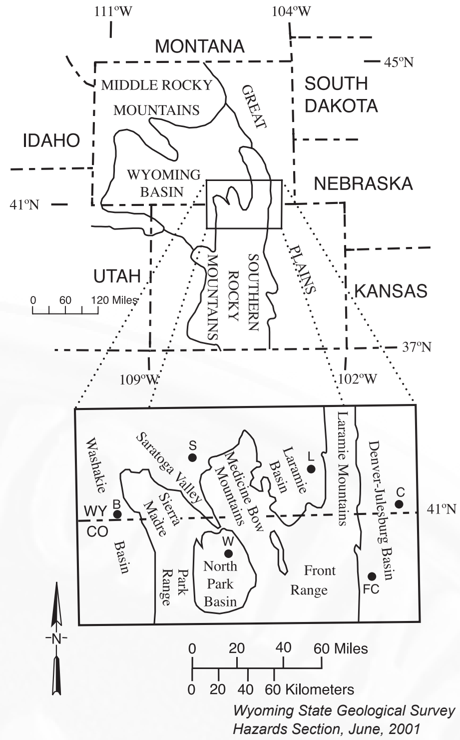

Figure 25. Regional setting of southeastern Wyoming and central northern Colorado showing geomorphic provinces (top) and major mountains and basins (bottom). B=Baggs, C=Cheyenne, FC=Fort Collins, L=Laramie, S=Saratoga, and W=Walden.

PUBLICATIONS UPDATE

New publications Available From the Wyoming State Geological Survey

Wyoming State Geological Survey publications

*Coalbed methane activity in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming, by R.H. De Bruin, R.M. Lyman, and L.L. Hallberg, 2001: Coalbed Methane Map CMM 01-3 (updated in June, 2001, replaces CMM 01-1), 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, 1999: Coalbed Methane Map CMM 01-4 (updated in June, 2001, replaces CMM 01-2), 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 01-5 (this is a reduced and combined version of CMM 01-3 and CMM 01-4 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.

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

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.

J. David Love Historical Geologic Map Series, Geology of the Teton-Jackson Hole region, 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).

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.

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 Montana, 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

(Topographic) Travel map of Yellowstone and Grand Teton National Parks and adjacent areas, by GTR Mapping, 2000: Folded map, scale 1 inch=4 miles, ISBN 1-881262-15-4 - $3.95.

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

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

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.

Other Publications News

The Publications Section at the WSGS welcomes two new staff members, Lisa J. Alexander (**Figure 26**) and Joseph M. Huss. Lisa moved over from the Administrative Assistant's position and is the new Publications Sales Manager, replacing Paula S. Becker. Lisa joined the WSGS last August and was previously with Albany County School District. Lisa is also an active member of the U.S. Naval Reserves.

Figure 26. Lisa J. Alexander is the new Publications Sales Manager at the Wyoming State Geological Survey.

Joe Huss will fill our recently advertised Geographic Information Systems (GIS) specialist position and will join us in early August. He will coordinate all the different GIS-related activities at the WSGS. Joe has a B.S. degree from Florida State University and a M.A. degree from the University of Wyoming in Geography. He comes to us from Tallahassee, Florida where he was employed by Lockheed Martin Information Services.

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.

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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.

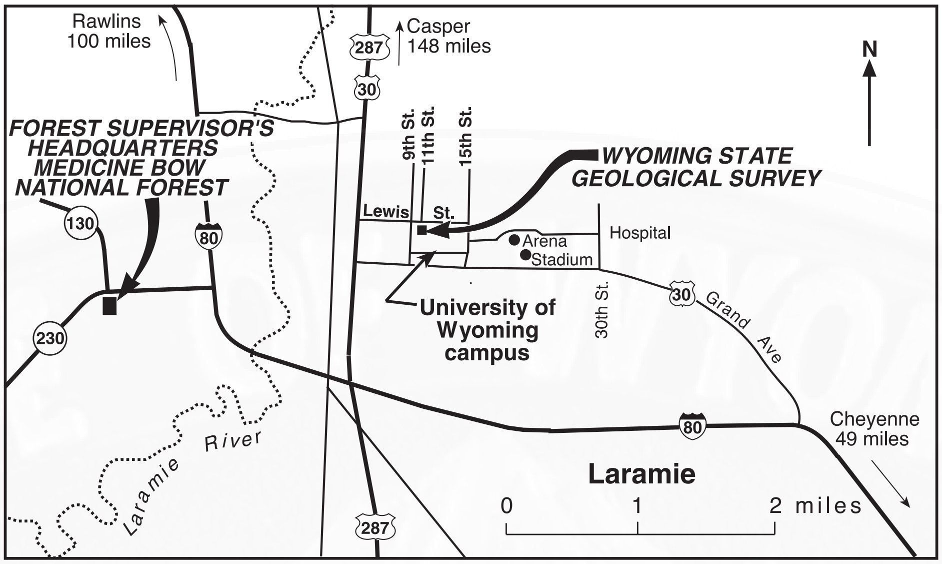
✈ Maps **cannot** be mailed rolled.

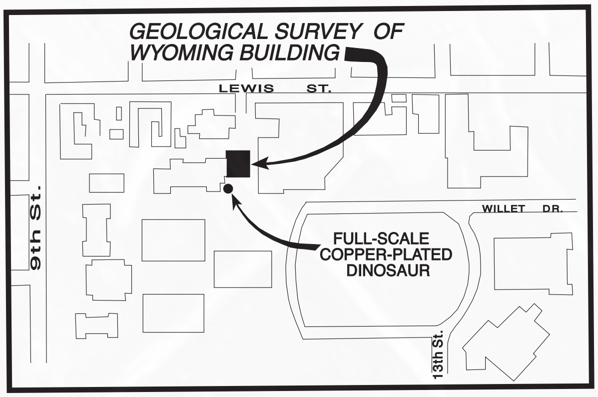
✈ International orders for Memoir 5, *Geology of Wyoming*, must indicate preferred method of shipment (U.S. Postal Service SURFACE, U.S. Postal Service AIR, Federal Express, or United Parcel Service) and must include additional postage for areas outside North America. Memoir 5, which includes a custom 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.

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226	Rod De Bruin–Oil and Gas
228	Ray Harris–Industrial Minerals
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230	Alan Ver Ploeg–Geologic Mapping
233	Bob Lyman–Coal
238	Richard Jones–Publications
242	Susan McClendon–Information Technology

Publications Order Form

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$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

Phone: (307) 766-2286
Fax: (307) 766-2605
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Web Page: http://www.wsgsweb.uwyo.edu

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