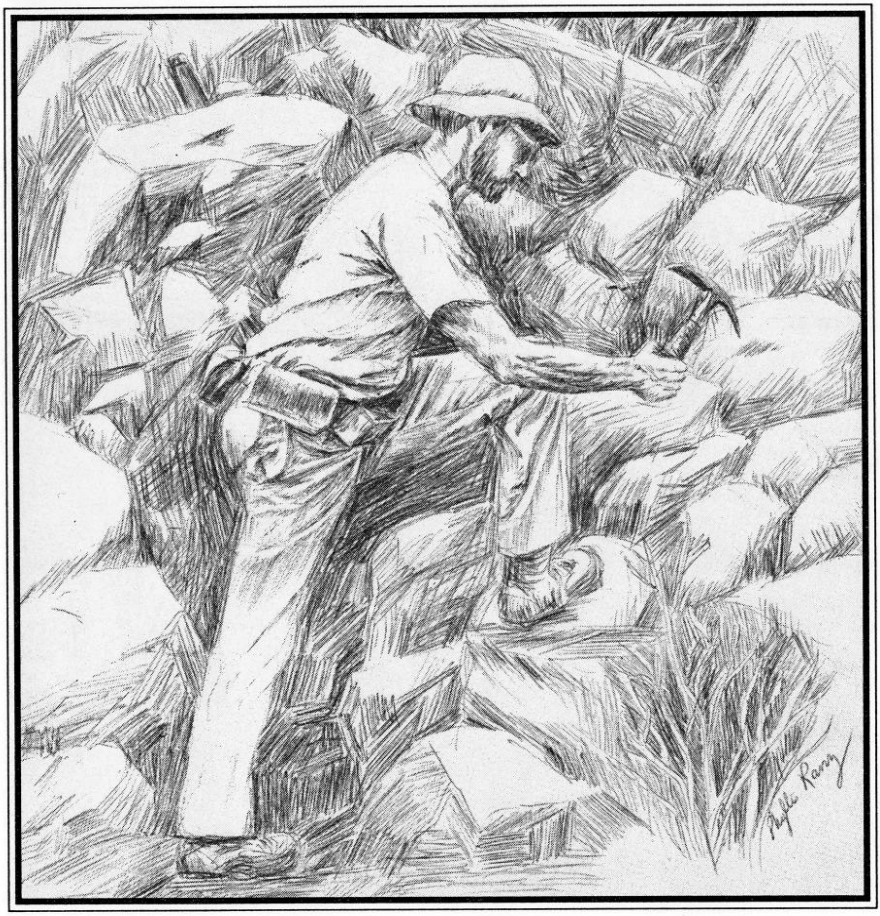
Wyoming Geo-notes

Number 34



The Geological Survey of Wyoming
Gary B. Glass, State Geologist

Laramie, Wyoming
May, 1992

WYOMING GEO-NOTES
This quarterly digest on the State's geology and mineral resources and activities of the Geological Survey is available by subscription (four issues for $7.00) or as single copies at $2.00 each. Two-year subscriptions are accepted.

Printed on 50% recycled fiber paper.

Cover illustration by Phyllis Ranz.

The Geological Survey of Wyoming
P.O. Box 3008, University Station
Laramie, Wyoming 82071-3008
(307) 766-2286
FAX (307) 766-2605

Table of Contents

MINERALS UPDATE

OVERVIEW

by Gary B. Glass
State Geologist, Geological Survey of Wyoming

There has been one small change in the forecast prices (Table 1 and Figures 1, 2, and 3) and the forecast production estimates (Table 2, and Figures 4, 5, and 6) that were presented at the end of the last quarter. Coal production in 1991 was increased slightly, based on preliminary figures.

As expected, the prices received for oil and gas in Wyoming remained low in the first quarter of 1992. Figure 7, which shows the first purchase price for Wyoming crude oil, indicates how close that price is to the posted price for Wyoming Sour. Figure 7 also shows that since early 1991, the first purchase price has been slightly higher than the posted Sour price, rather than lower as in previous years. This phenomenon is a function of the widening gap between the prices received for Sweet and Sour crudes. The price difference is now over $3.00.

Although the spot market price for natural gas at Opal, Wyoming, at least ended the first quarter slightly above March of 1991, the January and February prices were lower than last year. There is a possibility that recent actions taken by the Texas Railroad Commission could firm up or cause increases in natural gas prices across the country. The potential effects, however, are debatable and only time will tell.

Table 1. Average price paid for Wyoming oil, natural gas, coal, trona, and uranium, forecast to 1995[1].

Calendar Year	Oil[2]	Natural Gas[3]	Coal[4]	Trona[5]	Uranium[6]
*1985	23.61	3.03	11.35	35.18	36.82
*1986	13.10	2.51	10.71	34.80	52.45
*1987	16.50	2.02	9.54	36.56	43.55
*1988	13.41	1.74	9.09	36.88	25.77
*1989	16.64	1.64	8.63	40.76	22.09
*1990	20.10	1.54	8.31	41.86	21.16
1991	17.21	1.41	7.97	45.00	21.00
1992	14.50	1.44	7.70	46.00	21.00
1993	15.00	1.60	7.47	47.00	21.00
1994	15.00	1.76	7.26	48.00	21.00
1995	15.00	1.92	7.08	49.00	21.00

* Actual value for comparison.

[1] Modified from Consensus Revenue Estimating Group, [Revised] Wyoming State Government Revenue Forecast FY91-FY95, January, 1992, 21 p.

[2] First purchase price in dollars per barrel.

[3] Wellhead price in dollars per MCF (includes carbon dioxide and natural gas liquids).

[4] Dollars per short ton (weighted average price for coal mined by surface and underground methods).

[5] Dollars per ton of trona, not soda ash.

[6] Uranium prices are all estimated by the Geological Survey of Wyoming; in dollars per pound of yellowcake (weighted average price for in-situ and surface-mined uranium).

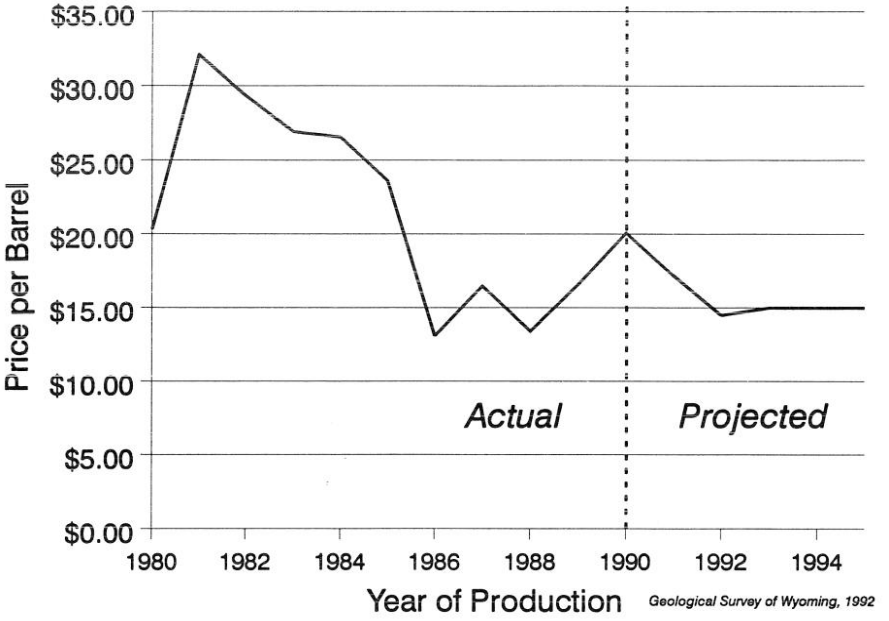


Figure 1. Average price paid for Wyoming oil (1980 to 1990) with forecast to 1995.

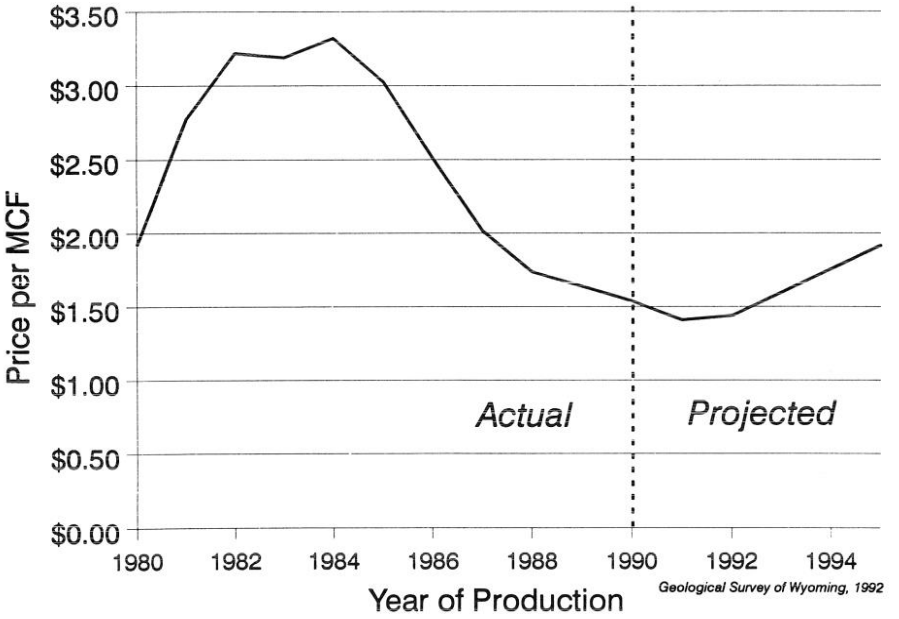


Figure 2. Average price paid for Wyoming natural gas (1980 to 1990) with forecast to 1995 (includes carbon dioxide and natural gas liquids).

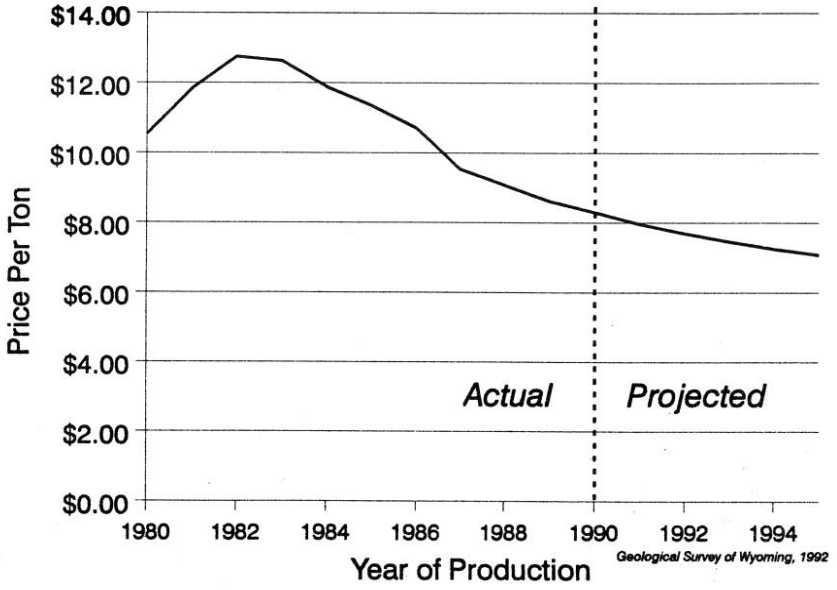


Figure 3. Average price paid for Wyoming coal (1980 to 1990) with forecast to 1995.

Table 2. Wyoming mineral production, forecast to 1995[1].

Calendar Year	Oil[2]	Methane[3]	Carbon Dioxide[3]	Helium[4]	Coal[5]	Trona[5]	Mined Uranium[6, 7]	In-situ Uranium[8]	Sulfur[9]
*1981	122.1	408.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	424.7	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	444.0	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	516.7	—	—	130.7	11.0	1.6	—	0.71
*1985	131.0	416.6	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	403.3	23.8	0.15	136.3	11.9	0.2	0.04	0.76
*1987	115.9	498.0	114.2	0.86	146.5	12.4	0.2	0.06	1.19
*1988	114.3	509.1	110.0	0.83	163.6	14.9	0.3	1.16	1.06
*1989	109.1	587.4	126.1	0.94	171.1	16.2	0.1	1.07	1.17
*1990	104.0	681.4	131.0	0.98	184.0	16.2	0.2	1.1	0.91
1991	100.0	728.0	131.0	0.98	*193.9	16.2	0.3	1.1	1.00
1992	99.5	787.0	131.0	0.98	203.1	16.3	0.1	1.6	1.00
1993	95.5	846.0	131.0	0.98	213.0	16.6	—	2.2	1.00
1994	91.6	905.0	131.0	0.98	223.7	17.2	—	2.5	1.00
1995	88.0	963.0	131.0	0.98	234.8	17.4	—	2.5	1.00

*Actual values for comparison; [1]Geological Survey of Wyoming, April, 1992; [2]millions of barrels; [3]billions of cubic feet; [4]billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [5]millions of tons; [6]millions of tons of uranium ore (not yellowcake); [7]although the Shirley Basin mine is closing in 1992, some production of stockpiled ore may be reported in future years; [8]millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1985 because it was reported only as taxable valuation; estimates for 1991-1995 are based on company information); [9]millions of tons.

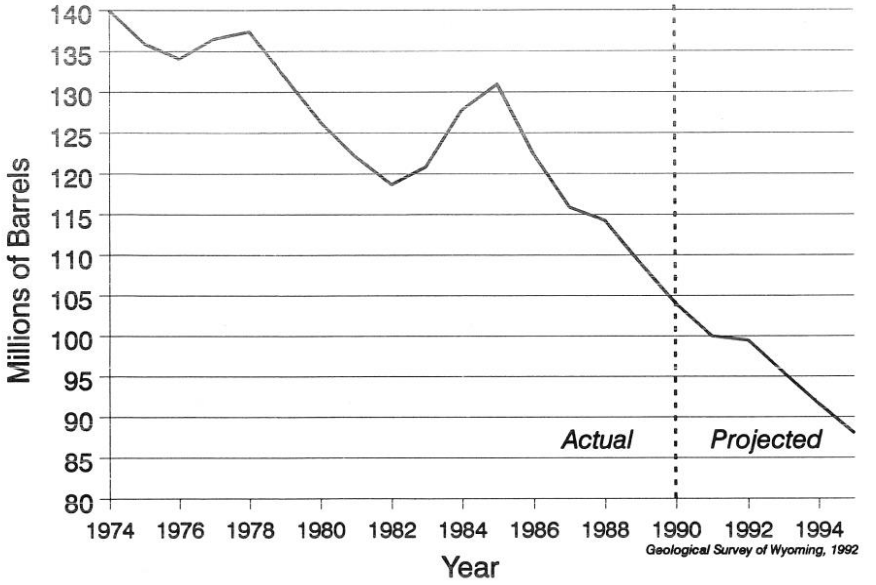


Figure 4. Annual oil production from Wyoming (1974 to 1990) with forecast to 1995.

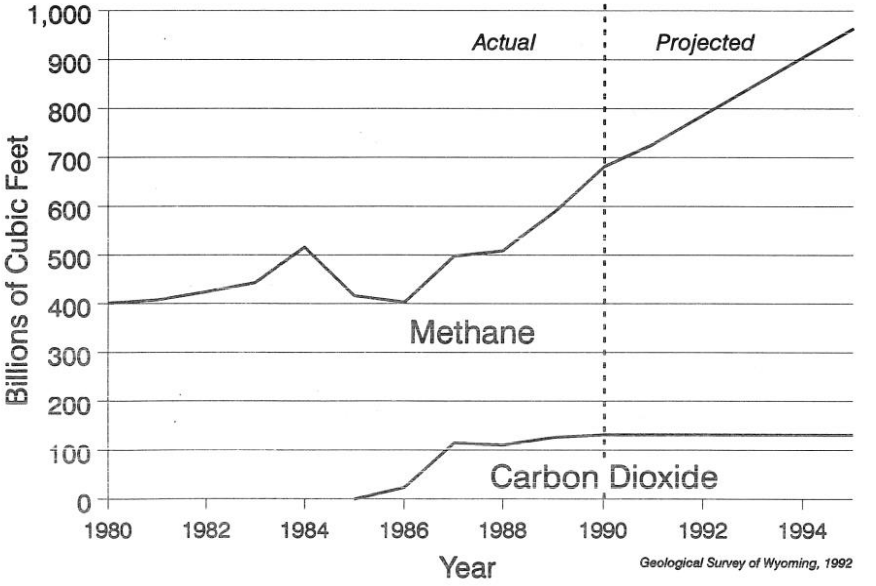


Figure 5. Annual gas production from Wyoming (1980 to 1990) with forecast to 1995.

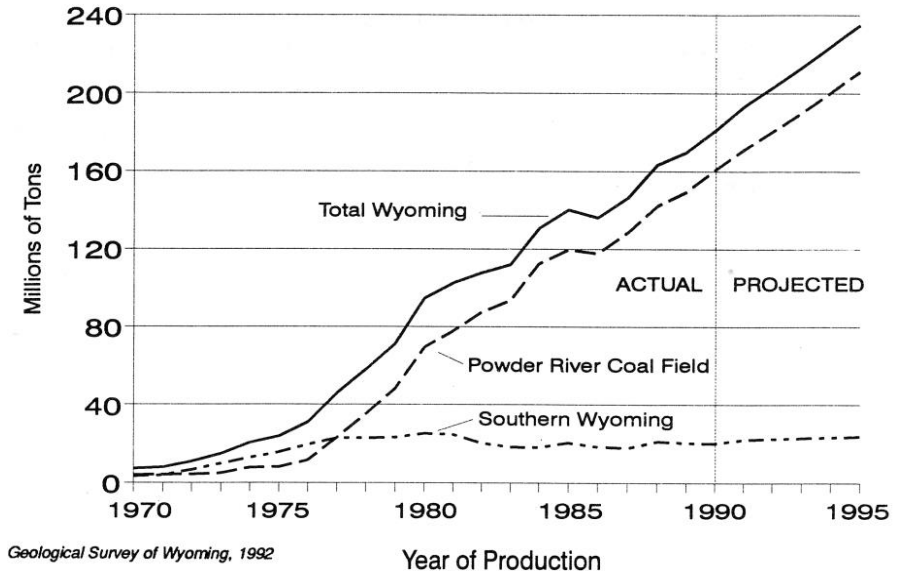


Figure 6. Annual coal production from Wyoming (1970 to 1990) and forecast to 1995.

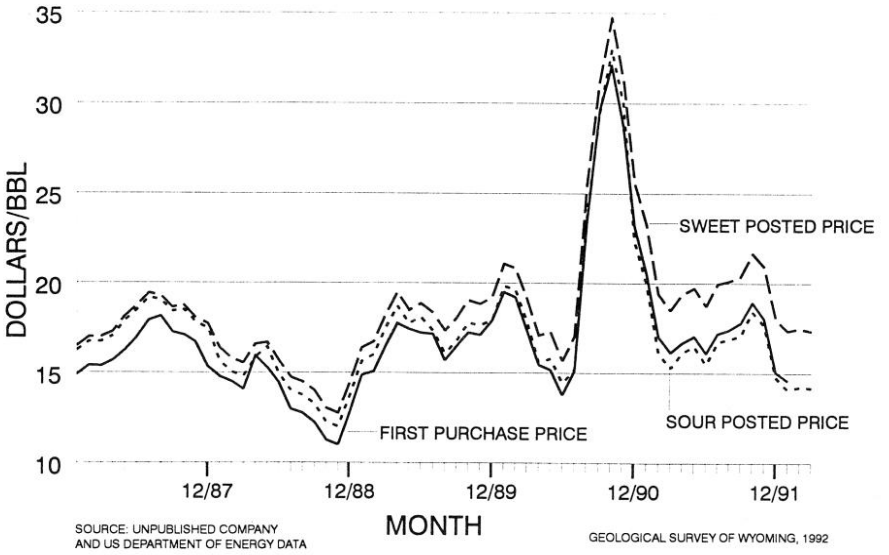


Figure 7. Wyoming posted Sweet and Sour crude prices and first purchase prices averaged by month (1987 to present).

Not surprisingly, given the low oil and gas prices, the State and Federal oil and gas lease sales also did very poorly in the first quarter. As a result, the Wyoming State Land and Farm Loan Office will only have two more sales in 1992, one in May and one in November.

Only one spot sale price and one contract price for coal from the Powder River Coal Field were announced in the first quarter. They were $3.79 and $4.35 per ton FOB the mine, respectively.

Oil production in Wyoming is continuing to decline, but at a slower rate than in 1991. Natural gas and coal production are increasing slowly, but steadily.

In mid-April, the Wyoming Oil and Gas Conservation Commission passed new regulations aimed at getting dormant oil and gas wells plugged more rapidly. A dormant well is defined as a well which is no longer actively producing, monitoring, or injecting; or which does not qualify as permanently abandoned, shut in, or temporarily abandoned. The definitions of these latter three kinds of wells are also new. The new regulations provide for additional bonds of $2.00 per foot for dormant wells if there are no acceptable plans for their use and if they are not plugged. Operators have up to 180 days to reclassify all their wells and 24 months to come into compliance by either submitting plans or bonds or plugging the wells. Copies of the new rules are available from the Wyoming Oil and Gas Conservation Commission, P.O. Box 2640, Casper, Wyoming, 82602.

Two company announcements dominated the headlines in March and April. Amoco announced that they and Chevron were considering the closure of one or the other of their natural gas processing plants in the Whitney Canyon-Carter Creek Field in Lincoln and Uinta counties (see p. 7). Apparently the companies

Table 3. Production history of selected Wyoming mineral commodities[1].

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Bentonite [2]	*2.35*	*2.18*	*3.08*	*2.59*	*1.82*	*2.16*	*2.32*	*2.22 [6]*	*2.43 [6]*
Clay [4]	*15.7*	*36.4*	*59.6*	*35.9*	*23.2*	*1.31*	*61.1*	*23.6*	*NA*
Decorative Stone [2]	*0.05*	*0.07*	*0.08*	*0.09*	*0.07*	*0.06*	*0.07 [7]*	*0.06 [6]*	*0.06 [6]*
Dolomite [2]	*0.61*	*0.66*	*0.86*	*0.87*	*0.81*	*0.46*	*0.19 [6]*	*0.15 [6]*	*0.21 [6]*
Feldspar [4]	*0.17*	----	----	----	----	----	----	*2.0*	*NA*
Gypsum [2]	*0.26*	*0.33*	*0.33*	*0.35*	*0.41*	*0.35*	*0.40 [7]*	*0.20 [6]*	*0.44 [6]*
Iron Ore [2]	*3.28*	*2.48*	----	----	----	----	----	*minor [8]*	*minor [8]*
Leonardite[4]	----	----	----	----	----	----	----	----	*41.7 [6]*
Limestone [2, 5]	*0.59*	*0.56*	*0.65*	*0.32*	*0.33*	*0.32*	*0.64*	*0.60 [6]*	*1.37 [6]*
Sand and Gravel [2, 3]	*6.24*	*6.72*	*8.31*	*6.40*	*5.01*	*4.12*	*3.15*	*6.46 [6]*	*6.11 [6]*
Shale [4]	----	----	*20.3*	*14.7*	*9.88*	*49.0*	*50.2 [6]*	*1.8*	*43.5 [6]*
Sodium Sulfate [4]	*3.17*	*3.19*	*3.25*	*2.71*	*2.03*	----	*2.10 [6]*	*3.2*	*1.9 [6]*

Sources: [1]Ad Valorem Tax Division, unless otherwise noted. [2] Millions of short tons. [3]Includes ballast, scoria, and limestone used for aggregate. [4]Thousands of short tons. [5]Includes limestone used for cement rock, sugar beet refining, and other uses. [6]Wyoming State Inspector of Mines. [7]Estimated by Geological Survey of Wyoming. [8]Less than 1,000 tons of iron ore were sold for pigment. Prepared by Geological Survey of Wyoming, July, 1991.

have been discussing the possibility for some time. The relatively low gas prices are obviously a factor.

In addition, Tenneco announced the pending sale of their trona mine and soda ash refinery in Sweetwater County. The potential buyer is Solvay S.A. of Brussels, Belgium. The $500 million sale should be completed in June of 1992. Tenneco is selling their 80 percent interest in the facility.

And for the first time, the predominant market for bentonite is no longer drilling muds (see p. 36).

OIL AND GAS UPDATE

by Rodney H. De Bruin
Staff Geologist-Oil and Gas, Geological Survey of Wyoming

In the first quarter of 1992, the average posted prices for Wyoming Sweet and Wyoming Sour crude oils were $17.40 and $14.15, respectively. The gap in price between these two types of crude oil is now $3.25 per barrel. This gap was only 25 cents per barrel in 1987 (Figure 7), but has widened in recent years. A larger percentage of Wyoming's oil production is now lower quality than in past years and refiners are paying much lower prices for this lower grade crude oil. Since late in 1988, the average price that Wyoming producers received for their oil (first purchase price) has been closer to the average posted price of Wyoming Sour crude oil than the posted price of Wyoming Sweet (Figure 7).

At Opal, Wyoming, the spot price of natural gas was lower in January and February, 1992, than in corresponding months in 1989, 1990, and 1991. The March, 1992, price rebounded somewhat and was slightly higher than last year's spot price for March (Figure 8). The average spot price for the first quarter of this year was $1.17 per thousand cubic feet (MCF), compared to an average first quarter price of $1.38 per MCF in 1991, $1.53 per MCF in 1990, and $1.33 per MCF in 1989.

The daily rig count averaged by month during the first quarter of 1992 is a reflection of the low prices Wyoming producers are receiving for oil and gas (Figure 9). This monthly average has not been above 40 since late 1990 and has been relatively low since early 1986.

Amoco Production Co. and Chevron USA may consolidate their gas sweetening operations in the Overthrust Belt north of Evanston. The companies cited low gas prices and high operating costs as the reasons. Amoco's Whitney Canyon plant and Chevron's Carter Creek plant process sour gas from the Madison Limestone at Whitney Canyon-Carter Creek Field. In 1990, the two plants processed 90 billion cubic feet of natural gas and produced 528,000 tons of sulfur and 3.3 million barrels of gas liquids.

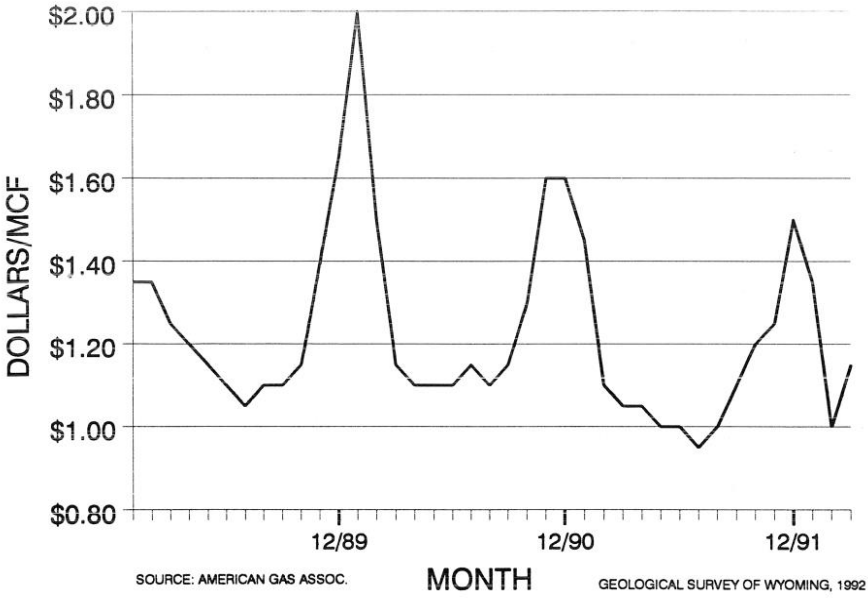


Figure 8. Spot prices for natural gas sales at Opal, Wyoming, averaged by month (1989 to present).

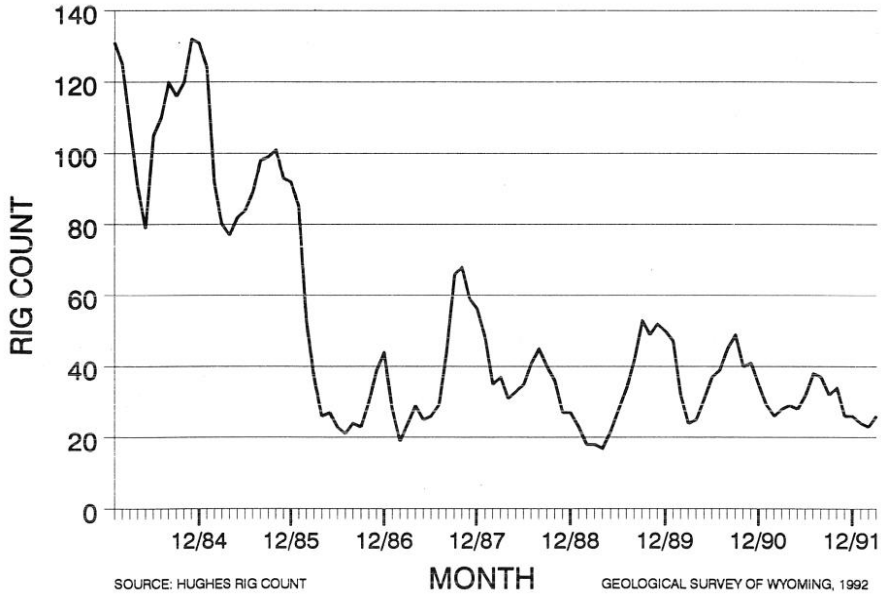


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

The Wyoming Natural Gas Authority in February, 1992, decided to look into a $30 million State loan to finance a carbon dioxide pipeline from Bairoil to the Powder River Basin. The Authority invited major oil operators to attend a meeting in May to get their input on the economic potential of the pipeline. Carbon dioxide is injected into reservoirs to recover oil that is left after primary and secondary production methods have recovered as much oil as possible.

On February 15, 1992, Kern River Pipeline began transporting natural gas from southwestern Wyoming to southern California. The pipeline has an operating capacity of 700 million cubic feet of gas per day which can be increased to 1.2 billion cubic feet per day by increasing compression. The company estimates that 77 percent of the natural gas initially shipped through the pipeline will come from U.S. producers, primarily in Wyoming. The company estimates that it will pay annual property taxes of $760,000 in Wyoming.

In a related item, Southern California Gas Co. and San Diego Gas and Electric Co. began negotiations with Pemex, a government-owned company in Mexico. The California utilities would supply natural gas to Mexico for use in power plants that presently burn oil. Option 1 provides for delivery of 24 million cubic feet of gas per day in the first year and 144 million cubic feet of gas per day thereafter. Gas would flow within one year after an agreement is signed. Option 2 provides for delivery of daily volumes between 50 million and 500 million cubic feet of gas per day. Under this option, gas would flow three years after an agreement is signed. The California utilities believe new supplies of natural gas, primarily shipped through the Kern River Pipeline, will be more than the local market can use.

Union Pacific Fuels Inc. announced that their Overland Trail Transmission Co. will expand its facilities. The $9 million expansion project will include added compression, 28 miles of new line, and interconnections with the Kern River Pipeline, the Colorado Interstate Gas Pipeline, and with the Patrick Draw gas processing plant. Capacity of the system will increase by 40 million cubic feet per day. The Overland Trail Transmission Co. was formed earlier this year to supply 20 million cubic feet of gas per day to the Rhone-Poulenc soda ash plant near Green River and to supply 40 million cubic feet of gas per day to the Kern River Pipeline.

In other pipeline news, Wind River Gathering Co., a joint venture between KN Gas Gathering Co. and Tom Brown Inc., entered into a letter of understanding to acquire 110 miles of gas pipeline and related facilities from Williston Basin Interstate Pipeline Co. The facilities are primarily within the Wind River Basin and will provide transportation for natural gas to markets outside of the basin.

KN Energy Inc. agreed to purchase the utility distribution systems owned by Texas Eastern Corp. and will supply natural gas to over 5,000 retail customers in Gillette, Moorcroft, Newcastle, Upton, and Wright.

The Washakie Basin will have an increased level of drilling for natural gas over the next several years if two plans are approved by the U.S. Bureau of Land

Management (BLM). The BLM is preparing an Environmental Assessment for a maximum of 70 wells that Union Pacific Resources, Barrett Resources, Amoco Production, and PG and E Resources plan to drill in 1992 and 1993. The wells would test the Almond Formation in T16N-T21N, R92W-R95W. The BLM will also prepare an Environmental Impact Statement for the Mulligan Draw area in T14N-T16N, R94W-R96W, where Celsius Energy and Amoco Production plan to drill 45 wells over the next five to eight years to test the Almond Formation.

Wyoming and Federal lease sales in the State did very poorly in the first quarter of 1992. Total revenue, acres leased, and average price per acre were all lower than they were for any sales in recent years (Table 4).

The high per-acre bid at the State Land and Farm Loan Office's January sale was $65 by Charles L. Mitchell for a 640-acre lease which covers section 16, T49N, R68W. The lease is just southeast of Donkey Creek Field, which produces oil from the Muddy and Dakota. Celsius Energy Co. paid $60 per acre for a 160-acre lease in NE section 35, T57N, R73W. The lease is just over a mile north of Chan Field which produces oil from the Muddy and gas from the Fort Union.

The high per-acre bid at the State's March sale was $103 by LCM Ltd. for a 160-acre tract in S/2 S/2 section 16, T15N, R112W. The lease is two miles southwest of a shut-in Dakota gas and condensate producer in Butcher Knife Springs Field. LCM paid $65 per acre for a 40-acre parcel in SE SE section 5, T53N, R69W. The parcel is less than a half mile from Minnelusa oil production in York Field.

The high per-acre bid at the February sale by the U.S. Bureau of Land Management was $210 by AEXCO Petroleum Inc. for a 39.38-acre lease in NE NW section 15, T52N, R69W. The lease is within a mile of Minnelusa oil production at Rule, Little Mitchell Creek, and Gibbs fields. Energy Partners Nominee Co. made the sale's highest total bid of $71,680. The company paid $56 per acre for a 1,280-acre lease which covers E/2 section 23, section 26, and N/2 section 35, T35N, R76W. The lease is less than a mile east of V-Two Draw Field, a one-well field which produces oil and gas from the Frontier.

Exploration and development

Company data and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the first quarter of 1992. Activities related to horizontal drilling and coalbed methane are discussed in separate sections. The letters preceding discussions below refer to locations on Figure 10.

A. Chevron USA began drilling a 17,000-foot wildcat well in the Overthrust Belt. The well will evaluate the gas and condensate potential of the Nugget Sandstone and the Twin Creek Limestone. The 1-14 Chevron Federal well is located in SW NW section 14, T14N, R120W. The well was spudded on March 5, 1992.

Table 4. Federal and state competitive oil and gas lease sales in Wyoming.

BLM SALES								STATE SALES							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1988								**1988**			
TOTAL	$27,688,861	4,119	1,591	4,412,513	1,350,897	$20.50	$6,500.00	TOTAL	$6,202,724	1,200	873	445,953	331,943	$18.69	$465.00
				1989								**1989**			
TOTAL	$15,832,105	4,286	1,360	4,028,750	972,403	$16.28	$3,000.00	TOTAL	$3,123,984	1,199	792	461,852	311,274	$10.04	$540.00
				1990								**1990**			
February	$3,301,479	524	259	335,275	141,555	$23.32	$340.00	January	$190,921	200	100	74,987	38,884	$4.91	$46.00
April	$2,163,988	513	218	399,790	138,909	$15.58	$275.00	March	$668,262	200	132	79,405	54,193	$12.33	$85.00
June	$3,480,557	511	315	305,550	172,798	$20.14	$240.00	May	$690,310	199	146	79,667	60,986	$11.32	$270.00
August	$2,892,191	533	251	493,185	187,259	$15.44	$325.00	July	$521,824	200	154	78,507	62,999	$8.28	$60.00
October	$2,580,072	423	265	255,886	141,707	$18.21	$200.00	September	$1,472,248	200	200	80,197	80,197	$18.75	$240.00
December	$3,578,846	467	285	379,452	185,065	$19.34	$260.00	November	$1,435,529	200	192	85,335	83,133	$17.27	$265.00
TOTAL	$17,997,133	2,971	1,593	2,169,138	967,293	$18.61	$340.00	TOTAL	$4,979,094	1,199	732	478,098	380,382	$13.09	$270.00
				1991								**1991**			
February	$4,333,861	370	200	275,600	122,225	$35.46	$16,000.00	January	$2,050,868	300	295	117,677	115,998	$17.68	$401.00
April	$1,880,742	470	217	332,764	132,278	$14.22	$170.00	March	$642,191	197	170	69,652	62,226	$10.32	$110.00
June	$2,002,440	490	176	430,576	120,992	$16.55	$275.00	May	$539,556	199	173	79,156	70,081	$7.70	$77.00
August	$2,005,511	557	211	472,103	120,292	$16.67	$325.00	July	$396,569	200	124	73,179	52,850	$7.50	$70.00
October	$1,616,314	507	175	397,011	94,899	$17.03	$340.00	September	$411,971	200	146	69,025	50,908	$8.09	$260.00
December	$1,095,409	421	168	283,408	85,091	$12.87	$1,600.00	November	$416,730	199	129	71,286	53,847	$7.74	$130.00
TOTAL	$12,934,277	2,815	1,147	2,191,462	675,777	$19.14	$16,000.00	TOTAL	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
				1992								**1992**			
February	$940,581	342	126	213,469	67,205	$14.00	$210.00	January	$138,165	200	96	72,027	37,840	$3.65	$65.00
								March	$200,000	200	114	70,294	41,034	$4.88	103.00

Sources: State Land and Farm Loan Office, Petroleum Information Corporation - Rocky Mountain Region Report, and U.S. Bureau of Land Management.

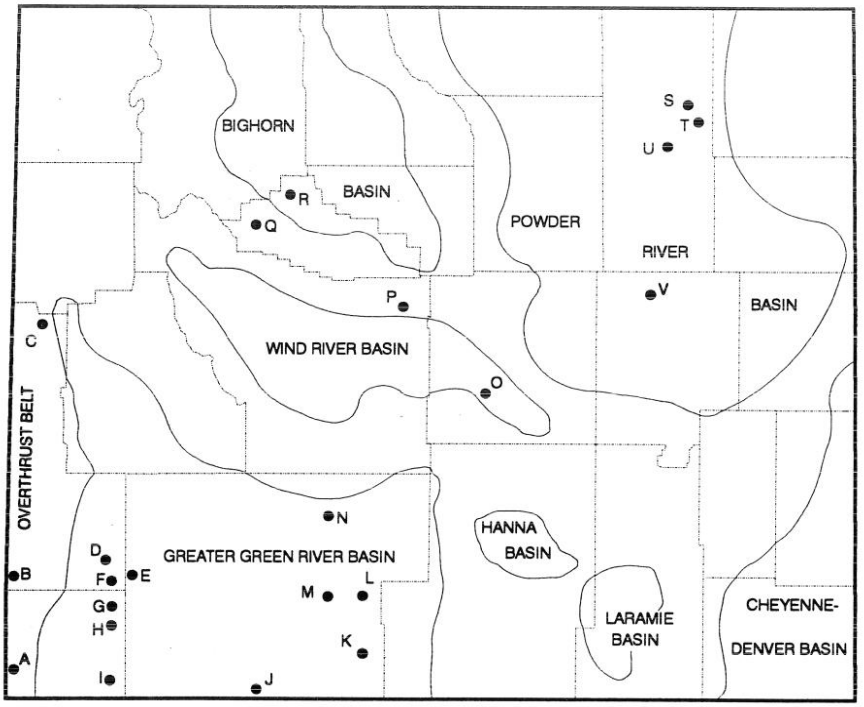


Figure 10. Oil and gas exploration and development activity in Wyoming during the first quarter of 1992.

B. Mobil Oil Corp. staked a 19,400-foot wildcat in the Overthrust Belt to test subthrust Bear River at a depth of 17,500 feet. The well will also test the Nugget at a depth of about 5,300 feet, the Phosphoria at about 10,500 feet, the Madison at about 11,700 feet, the Frontier at about 15,800 feet, and the Aspen at about 16,900 feet. The 1-4 Spring Creek-Federal well will be drilled in NW SE section 4, T19N, R120W.

C. Chevron USA staked a location for a 7,000-foot wildcat well in the Overthrust Belt to test the Madison Limestone at a depth of about 3,300 feet. A secondary objective is the Weber Sandstone at a depth of about 2,400 feet. Other expected formation tops are the Bighorn Dolomite at about 5,100 feet and the Mesaverde Formation at a depth of about 5,500 feet. The 1-27 Chevron-Hunter Creek-Federal well will be drilled in NE NW section 27, T38N, R115W.

D. Amoco Production Co. completed seven new development gas wells in Whiskey Butte Field. Amoco's 57 Whiskey Butte Unit well in SE NE section 10, T21N, R112W flowed 3.5 million cubic feet of gas, six barrels of conden-

sate, and 44 barrels of water per day from the Frontier. The 58 Whiskey Butte Unit well in SE NE section 11, T21N, R112W flowed 2.5 million cubic feet of gas, four barrels of condensate, and four barrels of water per day from the Frontier. The 59 Whiskey Butte Unit well in SE NE section 12, T21N, R112W flowed 2.0 million cubic feet of gas, nine barrels of condensate, and 38 barrels of water per day from the Frontier. The 60 Whiskey Butte Unit well in NE section 20, T21N, R112W flowed 1.8 million cubic feet of gas, eight barrels of condensate, and eight barrels of water per day from the Frontier. Amoco's 48 Whiskey Butte Unit well in SE NE section 21, T21N, R112W flowed 2.8 million cubic feet of gas, 10 barrels of condensate, and 250 barrels of water per day from the Frontier and 350,000 cubic feet of gas per day from the Dakota. The 61 Whiskey Butte Unit well in NW NE section 26, T21N, R112W flowed 1.1 million cubic feet of gas, seven barrels of condensate, and 21 barrels of water per day from the Frontier. The 54 Whiskey Butte Unit well in SE NE section 36, T21N, R112W flowed 3.2 million cubic feet of gas, 87 barrels of condensate, and 87 barrels of water per day from the Frontier.

E. Amoco also completed a new gas well in Seven Mile Gulch Field. The 16 Seven Mile Gulch well in SW NE section 23, T20N, R112W flowed 4.1 million cubic feet of gas, 44 barrels of condensate, and 35 barrels of water per day from the Dakota and 623,000 cubic feet of gas, 22 barrels of condensate, and four barrels of water per day from the Frontier.

F. Celsius Energy Co. completed their 2-32 Lawler-Federal well in NW SE section 32, T19N, R112W. A sand-fractured interval in the Frontier flowed 5.3 million cubic feet of gas per day.

G. Wexpro Co. completed two new development gas wells in Bruff Field. Their 13 Bruff Unit well in NE SE section 16, T18N, R112W flowed 6.0 million cubic feet of gas per day from the Dakota. The 4-2 Haley-Federal well in SW SE section 4, T17N, R112W flowed 5.2 million cubic feet of gas per day from the Frontier.

H. Wexpro also completed the 98 Church Buttes Unit well in SW NW section 20, T17N, R112W. The well flowed 1.6 million cubic feet of gas, eight barrels of condensate, and three barrels of water per day from the Dakota.

I. Washington Energy Resources Co., Celsius Energy Co., Texaco Exploration and Production, and 28 other working interest owners in Henry Field received final approval for an enhanced oil recovery project from the Wyoming Oil and Gas Conservation Commission and the U.S. Bureau of Land Management. The new unit contains about 7,380 acres and 14 active wells. Four new wells will be drilled to inject 15 to 20 million cubic feet of gas per day into the Dakota. The companies expect to recover an additional 6.4 million barrels of hydrocarbon liquids and 24 billion cubic feet of gas.

J. Exxon Corporation's wildcat test of the Madison Limestone on the southwestern flank of the Canyon Creek anticline in NW NE section 9, T12N, R101W was a dry hole. The well was drilled to a depth of 17,975 feet.

K. Enron Oil and Gas Co. completed a new gas producer in Dripping Rock Field. The 23-5 North Dripping Rock well in NE SW section 5, T14N, R94W produced an average of 6.8 million cubic feet of gas per day during 22 days of production in December, 1991. Production is from the Almond.

L. Barrett Resources Corp. also completed a new Almond gas well. The 2-1 Two Rim Unit well in C NW section 21, T19N, R94W flowed 1.4 million cubic feet of gas, 103 barrels of condensate, and seven barrels of water per day.

M. Texaco Exploration and Production Inc. discovered a new reservoir in Table Rock Field. The 104 Table Rock Unit well in NE SW section 19, T19N, R97W flowed 4.3 million cubic feet of gas and 45 barrels of water per day from the Frontier.

N. Presidio Exploration Inc. completed two new Lewis gas wells in Hay Reservoir Field. The 52 Hay Reservoir well in NE NE section 21, T24N, R97W flowed 4.9 million cubic feet of gas, 28 barrels of condensate, and 13 barrels of water. The 51 Hay Reservoir well in SW SW section 21, T24N, R97W flowed 1.8 million cubic feet of gas, 30 barrels of condensate, and one barrel of water per day.

O. Amerada Hess Corp. completed the third Muddy oil well in Saddle Rock Field. The 27-22 Saddle Rock Unit well in NE NW section 27, T33N, R86W pumped 826 barrels of oil per day. Amerada discovered Saddle Rock Field in late 1989. Through December, 1991, the first two wells had produced 191,000 barrels of oil and 494 million cubic feet of gas.

P. Louisiana Land and Exploration has drilled 23,071 feet at their 3-36 Big Horn well in SE SE section 36, T39N, R91W. The well was spudded in January, 1991 and will test the Madison at a depth of 25,000 feet. [In late April, however, this well blew out and caught fire. It was not brought under control until early in May.]

Q. Bruce Reed set production casing at the 16-1A Holy City well in NE SE section 16, T44N, R101W. The well was drilled to test the Tensleep Sandstone. No other details are available.

R. Natural Gas Processing Co. completed a Frontier producer in Little Grass Creek Field. The 4NGP-Fee well in SE SW section 11, T46N, R99W flowed 1.3 million cubic feet of gas per day.

S. Brown Operating completed a new Minnelusa discovery. The 2-15 Clark-Fee well in NE NE section 15, T52N, R70W pumped 75 barrels of oil per day.

T. Plains Petroleum Operating Co. also completed a new Minnelusa discovery. The 43-27 Plains-Federal well in NE SE section 27, T52N, R70W pumped 400 barrels of oil per day. Ampolex Inc. drilled an east offset to Plains' discovery. Their 13-26 Cundy-Federal well in NW SW section 26, T52N, R70W is testing

a Minnelusa sand which had oil saturations in the core that ranged from 14.6 to 27.1 percent.

U. Conley P. Smith Oil Producer recovered oil on a drillstem test of two Minnelusa sands. Their 34-10 McCreery well in NW SE section 34, T49N, R72W recovered 3,006 feet of slightly gas-cut oil from one sand and 7,481 feet of gas and 2,969 feet of highly gas-cut oil from another sand.

V. M. John Kennedy recovered oil at the rate of 50 barrels per day from the Sussex Sandstone at the 44-28 Federal well in SE SE section 28, T38N, R73W.

Horizontal Drilling

During the first quarter of 1992, the following significant activities related to horizontal drilling occurred. The letters preceding the discussions below refer to locations on Figure 11. The discussions are based on company data and information compiled and published by Petroleum Information.

A. Several Niobrara wells were completed and several new locations were staked for Niobrara tests in and around Silo Field. Union Pacific Resources Co. staked a location for their 1H Berry 41-13 well at a surface location in NE NE section 13, T16N, R66W. Union Pacific Resources also began drilling the 1H Dino-State 12-8 well from a surface location in SW NW section 8, T15N, R64W. Union Pacific Resources will also drill the 1H Berry 41-22 well from a surface location in NE NE section 22, T16N, R65W. The company is currently testing the Niobrara at their 1H McConnaughey 41-27 well in NE NE section 27, T16N, R65W. Silverado Oil completed their 1-18-16-H State well in SE SE section 18, T16N, R64W. The well is producing 60 barrels of oil per day from an acidized Niobrara interval. Chesapeake Operating Inc. tested their 1H Frances Goertz well in S/2 SW section 1, T15N, R65W. The Niobrara interval had a calculated daily flow rate of 1,992 barrels of oil, 300,000 cubic feet of gas, and 96 barrels of water. Gerrity Oil has plans to drill their 10-1H well from a surface location in NE NE section 10, T15N, R64W.

B. Presidio Exploration Inc. staked a location for a Niobrara test. The 44-9H Voight well will be drilled from a surface location in SE SE section 9, T21N, R67W.

C. Presidio swabbed 32 barrels of oil during a three-hour period at their 11-15H Phillipi well in NW NW section 15, T23N, R66W. This well is the first horizontal producer in Platte County and is on Presidio's 16,000-acre Bordeaux prospect in T23N, R66W.

D. Amoco Production Co. will drill the 1-25H Morton Ranch well from a surface location in SW SW section 25, T33N, R72W to test the Frontier and Niobrara. The well is just over a mile south of Orpha Field, which produces oil and gas from the Frontier and Sussex.

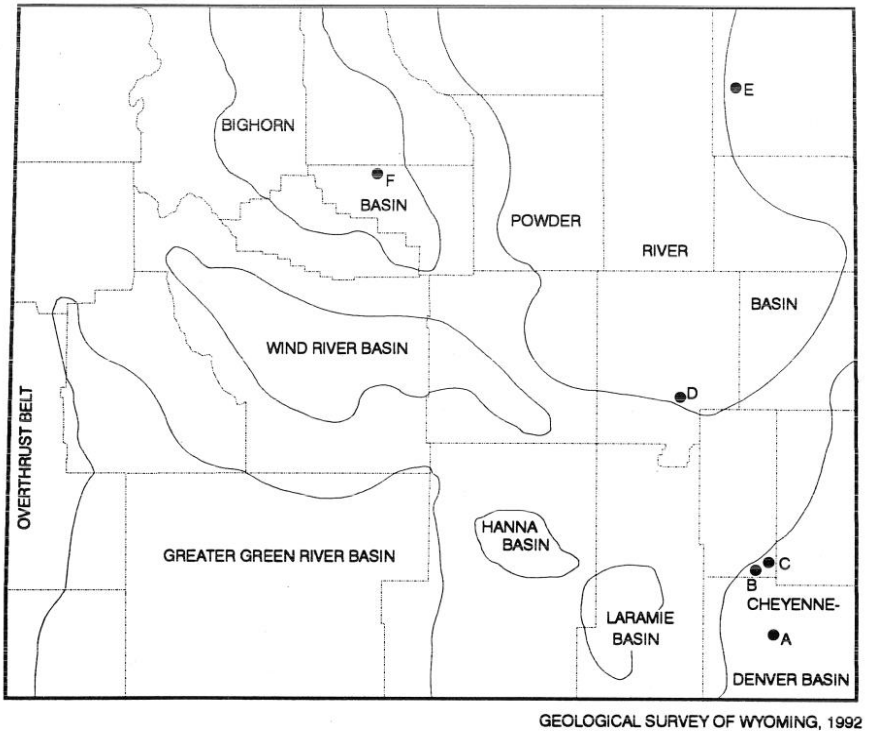


Figure 11. Horizontal drilling activity in Wyoming during the first quarter of 1992.

E. L and J Operating Inc. plans to reenter the 1-H Berger well at a surface location in SW SW section 17, T53N, R67W to test the Minnelusa Formation. The well was first completed in 1988 as a vertical Minnelusa producer. The well produced over 35,000 barrels of oil before it was shut in in 1991.

F. Union Pacific Resources will drill the 1H Bass-Federal 33-24 well from a surface location in NW SE section 24, T48N, R92W to test the Phosphoria Formation in the Marshall Field area. Union Pacific Resources recently purchased 75 percent of Hayes Oil and Gas Company's interest in 40,000 acres in the area.

Coalbed Methane

During the first quarter of 1992, the following significant activities related to coalbed methane occurred. The letters preceding the discussion below refer to locations on Figure 12. The discussions are based on company data and on information compiled and published by Petroleum Information.

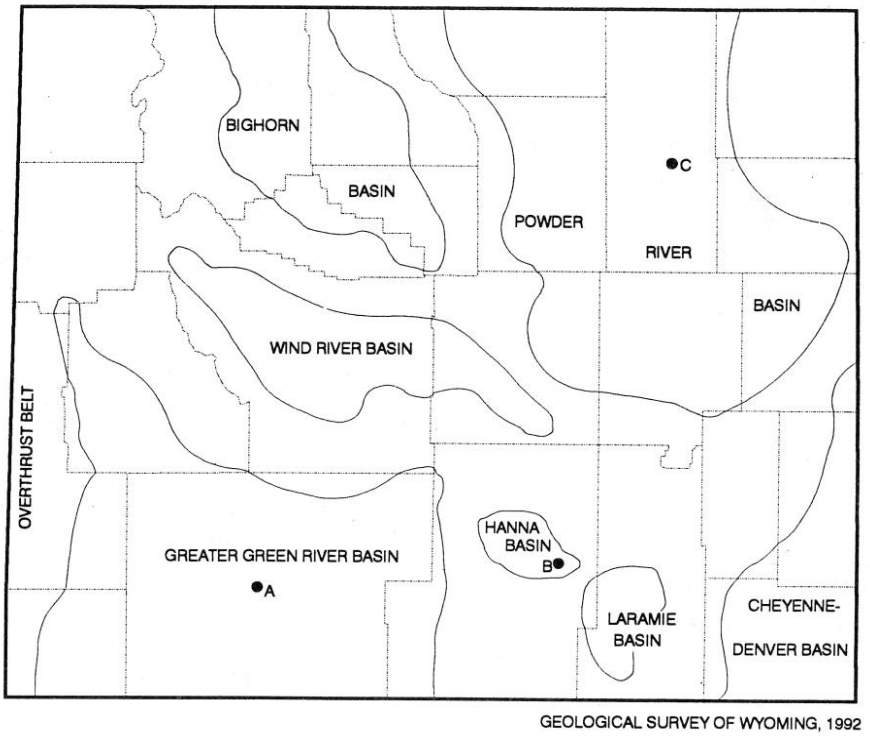


Figure 12. Coalbed methane activity in Wyoming during the first quarter of 1992.

A. The Texas Bureau of Economic Geology's final report on the coalbed methane potential of the Greater Green River Basin, Piceance, Powder River, and Raton Basins is now available. The report (GRI-91/0315) by Tyler and others (1991) can be ordered from the Gas Research Institute, 8600 West Bryn Mawr Avenue, Chicago, Illinois 60631.

B. Metfuel has staked six locations in sections 1, 5, and 11, T23N, R81W to test the coalbed methane potential of the Hanna Formation. Metfuel notified the BLM that they intend to drill as many as 130 coalbed methane wells in the Hanna Basin (*Wyoming Geo-notes No. 33*, p. 17).

C. Martens and Peck Operating staked 17 locations for coalbed methane tests in the Fort Union Formation. The locations are in sections 13, 22, 26, 27, 28, 34, and 35, T48N, R72W, near a new, 380-foot deep, coalbed methane well completed by Martens and Peck last quarter (*Wyoming Geo-notes No. 33*, p. 17).

COAL UPDATE

by Richard W. Jones
Editor and Acting Staff Geologist-Coal, Geological Survey of Wyoming

Figures released by the Wyoming State Inspector of Mines during the first quarter of 1992 indicate that Wyoming produced 193.9 million tons of coal in 1991 and for the fifth consecutive year, set a new record for the State. Coal production in 1991 increased by 9.9 million tons (5.4 percent) over production in 1990 (Table 5). Wyoming's 1991 coal production accounted for about 19 percent of the 998 million tons produced in the United States and about 48 percent of the 405 million tons produced in the western U.S. National production in 1991 was about 31 million tons or three percent less than the record 1.029 billion tons produced in 1990; production in the western U.S. rose by about 7 million tons or 1.8 percent. Although final coal production figures for 1991 are not available for many top coal-producing states, preliminary data indicate that Wyoming continued its ranking as the Nation's leading coal-producing state for the fourth year in a row.

1991 coal production in Wyoming was slightly more than our most recent forecast (*Wyoming Geo-notes No. 33*, p. 20). In the Powder River Coal Field, production increased by about 6.5 percent from 1990 to 1991 (Tables 5 and 6), as compared with a predicted 5 percent increase. For 1992, statewide production should increase slightly less than 5 percent (Table 6). The National Coal Association expects U.S. coal production to increase by about 3 percent (or 31 million tons) in 1992, with about half of the total increase in tonnage expected from mines in the western U.S.

Future increases in Wyoming coal production will be driven by electric utility companies' demands for low-sulfur coal for use in reducing sulfur dioxide emissions at their coal-fired generating plants. However, increased demand may not translate into higher prices for the coal, primarily because of the large production overcapacity at coal mines in the Powder River Coal Field and secondarily because of the oversupply and low prices for competing fuels (e.g., natural gas). In addition, protectionist policies of some large coal-producing states may significantly limit the use of Wyoming coal in those states.

It is too early to assess the full impact of the Clean Air Amendments Act of 1990 on Wyoming's coal industry, because each electric utility company will select the most appropriate methods for it to respond to the new emission regulations. For example, Associated Electric Cooperative, Inc. recently signed a 15-year coal supply contract with Rochelle Coal Company (see item (A) below, in Contracts-Powder River Coal Field). This new contract will completely replace high-sulfur eastern coal that currently supplies a Missouri power plant and will eliminate the need to install scrubbers at the plant. In contrast, the Illinois Legislature is requiring two of the state's largest utilities (which under the new regulations are facing extensive clean-up of emissions by 1995) to install scrubbers at their generating plants. This strategy locks out low-sulfur coal usage in those plants. In between these extreme cases is the Tennessee Valley Authority

Table 5. 1990 and 1991 Wyoming coal industry employees and coal production by coal field and mine.

Company	Mine Name	1990 Employees	1990 Production (short tons)	1991 Employees	1991 Production (short tons)
POWDER RIVER COAL FIELD					
Amax Coal Co.	Belle Ayr (surface)	235	15,529,327	243	14,748,346
	Eagle Butte (surface)	205	15,396,412	205	13,924,000
Antelope Coal Co.	Antelope (surface)	99	5,211,642	97	5,448,268
Ash Creek Mining Co.	PSO No. 1 (surface)	1	—	1	—
Big Horn Coal Co.	Big Horn (surface)	18	134,104	7	158,055
Carter Mining Co.	Caballo (surface)	218	14,312,971	226	15,267,657
	Rawhide (surface)	173	11,442,355	194	11,766,870
Cordero Mining Co.	Cordero (surface)	226	12,922,653	230	13,703,094
Dry Fork Coal Co.	Dry Fork (surface)	37	815,056	47	2,796,061
Fort Union Coal Co.	Fort Union (surface)	4	38,528	5	28,913
Glenrock Coal Co.	Dave Johnston (surface)	173	2,679,028	174	2,776,349
Kerr-McGee Coal Corp.	Jacobs Ranch (surface)	367	16,724,780	367	17,743,542
Caballo Rojo, Inc.[1]	Caballo Rojo (surface)	153	8,566,831	150	9,383,108
North Antelope Coal Co.	North Antelope (surface)	128	8,242,231	134	9,648,953
Rochelle Coal Co.	Rochelle (surface)	161	12,030,237	162	12,635,888
Shell Mining Co.	North Rochelle (surface)	1	13,000	1	25,765[2]
Thunder Basin Coal Co.	Black Thunder (surface)	488	27,919,411	500	30,851,751
	Coal Creek (surface)	6	140,250	7	151,165
Triton Coal Co.	Buckskin (surface)	131	7,695,009	143	9,435,021
Wyodak Res. Dev. Corp.	Wyodak (surface)	57	2,907,640	57	2,741,809
TOTAL		2,881	162,721,465	2,950	173,234,615
HANNA COAL FIELD					
Arch of Wyoming	Seminoe No. 2 (surface)	29	—	14	—
Cyprus-Shoshone Coal Co.	Shoshone No. 1 (deep)	183	1,420,980	192	2,026,065
Arch of Wyoming	Medicine Bow (surface)	91	2,813,212	91	2,418,573
Rosebud Coal Sales	Rosebud (surface)	16	176,264	16	11,365
Wyoming & W.V., Inc.	Blue Sky No. 1 (deep)[3]	9	100,746	10	247,978
TOTAL		328	4,511,202	323	4,703,981
GREEN RIVER COAL FIELD					
Arch of Wyoming	Pilot Butte (deep)	31	189,824	27	261,603
Black Butte Coal Co.	Black Butte (surface)	449	5,797,238	439	5,290,400
Bridger Coal Co.	Jim Bridger (surface)	406	5,842,017	389	5,746,925
Lion Coal Co.	Swanson (deep)	53	107,446	74	131,353
TOTAL		939	11,936,525	929	11,430,281
HAMS FORK COAL FIELD					
FMC Wyoming Corp.	Skull Point (surface)	101	950,000	98	839,454
Pittsburg and Midway	Kemmerer (surface)	365	3,785,548	349	3,552,190
TOTAL		466	4,735,548	447	4,391,644
BIGHORN COAL FIELD					
Northwestern Res. Co.	Grass Creek (surface)	9	101,961	14	103,285
TOTAL		9	101,961	14	103,285
TOTAL UNDERGROUND		276	1,818,996	303	2,666,999
TOTAL SURFACE		4,347	182,187,705	4,360	191,196,807
GRAND TOTAL		4,623	184,006,701	4,663	193,863,806

Source: Annual report of the Wyoming State Inspector of Mines, 1990 and preliminary data for 1991.

[1]Subsidiary of Marigold Land Company; formerly owned by Mobil Coal Producing, Inc.

[2]This mine is still under construction. Production probably represents test shipments.

[3]Remotely-controlled underground mining operation at the Medicine Bow mine.

Table 6. Coal production (1983 to 1991) with forecast to 1995 (millions of tons).

	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1988[1]	1989[1]	1990[1]	1991[1]	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	154.7	164.9	170.8	179.4	188.8	198.5
Converse County	2.7	3.3	3.6	4.8	5.1	5.7	6.1	7.9	8.2	9.5	10.5	11.5	12.5
Sheridan County	2.9	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.2	M[2]	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.7	4.5	4.1	3.8	3.5
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	12.0	11.9	11.4	13.0	13.5	14.0	14.5
Lincoln County	4.0	4.1	4.3	4.0	3.8	4.9	4.8	4.7	4.4	5.3	5.5	5.6	5.8
Hot Springs County	M	M	M	M	M	M	M	0.1	0.1	M	M	M	M
Total Wyoming[3]	112.2	130.7	140.7	135.7	146.5	163.6	171.1	184.0	193.9	203.1	213.0	223.7	234.8
Annual change	4%	16.5%	7.7%	-3.6%	8.0%	11.7%	4.6%	7.5%	5.4%	4.7%	5%	5%	5%
Low-priced coal[4]			6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%

Forecast by Geological Survey of Wyoming, April, 1992. [1] These are actual values for comparison. [2] M means minor tonnage (less than 0.1 million tons). [3] Totals may not equal sum of components because of independent rounding. [4] Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under $5.00.

(TVA). Their choices for meeting the 1995 emission standards consist of scrubbers at some generating plants and switching to low-sulfur western coal in other plants (see item (M) below, in Coal Contracts-Powder River Coal Field).

The largest market for coal in both Wyoming and the Nation is the electric utility industry. Of the 892 million tons of coal consumed in the U.S. in 1991, about 776 million tons (or 87 percent) were used by electric utilities to generate over 55 percent of the Nation's electricity. About 189 million tons or 97 percent of Wyoming's coal production went to electric utilities in 1991.

Wyoming mines reported deliveries of 184.2 million tons of coal to electric utilities in 1991 (Table 7). Unreported deliveries accounted for about 9.7 million tons, of which about 5 million tons were used for industrial and commercial purposes; the remaining 4.7 million tons were for small-tonnage test burns or deliveries to electric utility plants rated at less than 50 megawatts.

Monthly coal deliveries in August, October, and November of 1991 were slightly less than those same months in 1990 (Table 7 and Figure 13). The 16.7 million tons of coal delivered in December, 1991, however, was the largest amount ever recorded for a single month from Wyoming. Significant increases in coal tonnages delivered to individual states in 1991 were recorded for Oklahoma, Missouri, Arkansas, and Texas (up from 1990 by 1.8, 1.6, 1.4, and 1.3 million tons, respectively). Significant decreases in coal tonnages were recorded in Kansas and Georgia (down from 1990 by 1.3 and 1.1 million tons, respectively).

The amount and percentage of Wyoming coal sold on the spot market in 1991 continued to increase as it has done each year since 1985. Almost 30 million tons or 16 percent of the total reported Wyoming coal sales to electric utility companies in 1991 were spot sales. In December, 1991, spot sales accounted for one-fourth of all reported coal sales to power plants. If these spot sales are combined with the sales of other low-priced coal, i.e., coal sold for less than $5.00 per ton, about 31 percent of the Wyoming coal sold in 1991 was priced below $5.00 per ton ("low priced coal" on Table 6).

Most of the increase in Wyoming coal production in 1991 occurred in the Powder River Coal Field, which recorded a 10.5-million-ton, 6.5 percent increase over 1990 production (Table 5). Campbell County coal production increased by 10.2 million tons and accounted for about 85 percent of the State's total 1991 production. Production from Converse and Sheridan counties also increased slightly from 1990 to 1991. The three producing counties in the Powder River Coal Field accounted for 89.4 percent of Wyoming's coal production (Table 8).

In 1991, coal production increased in the Hanna and Bighorn Coal Fields, but decreased in the Green River and Hams Fork Coal Fields (Table 5). The net result was a 0.7-million-ton, 3.1 percent decrease in coal production for these four coal fields ("southern Wyoming coal fields" on Figure 6). 1991 coal production in the Hams Fork Coal Field (Lincoln County) decreased by 7.3 percent since 1990 and in the Green River Coal Field (Sweetwater County) by 4.2 percent. Each of the

Table 7. Coal deliveries by month from Wyoming mines[1].

	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE	1990 MONTHLY	1990 CUMULATIVE	1991 MONTHLY	1991 CUMULATIVE
JANUARY	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020	15,059,530	15,059,530	14,960,450	14,960,450
FEBRUARY	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160	13,328,290	28,387,820	15,480,110	30,440,560
MARCH	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490	14,535,270	42,923,090	16,278,870	46,719,430
APRIL	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940	14,155,470	57,078,560	14,820,240	61,539,670
MAY	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110	13,882,590	70,961,150	14,589,790	76,129,460
JUNE	11,953,650	65,840,160	12,595,480	72,586,970	12,948,350	79,482,460	13,649,070	84,610,220	14,007,600	90,137,060
JULY	12,850,240	78,690,400	13,905,670	86,492,640	14,043,350	93,525,810	15,368,280	99,978,500	16,451,090	106,588,150
AUGUST	13,460,470	92,150,870	15,041,090	101,533,730	15,428,210	108,954,020	16,046,910	116,025,410	15,940,620	122,528,770
SEPTEMBER	12,651,550	104,802,420	13,433,610	114,967,340	13,795,760	122,749,780	15,166,020	131,191,430	15,314,490	137,843,260
OCTOBER	12,248,080	117,050,500	13,696,190	128,663,530	14,523,480	137,273,260	15,244,760	146,436,190	14,810,510	152,653,770
NOVEMBER	12,340,720	129,391,220	13,889,890	142,553,420	14,507,130	151,780,390	15,569,280	162,005,470	14,783,000	167,436,770
DECEMBER	13,008,300	142,399,520	14,540,510	157,093,930	13,527,880	165,308,270	14,479,970	176,485,440	16,716,630	184,153,400
TOTAL TONNAGE REPORTED		142,399,520		157,093,930		165,308,270		176,485,440		184,153,400
TOTAL TONNAGE NOT REPORTED		4,089,128		6,494,270		5,831,734		7,521,261		9,710,406
TOTAL TONNAGE PRODUCED[2]		146,488,648		163,588,200		171,140,004		184,006,701		193,863,806

[1] Source: COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities.

[2] Source: Wyoming State Mine Inspector's Annual Reports.

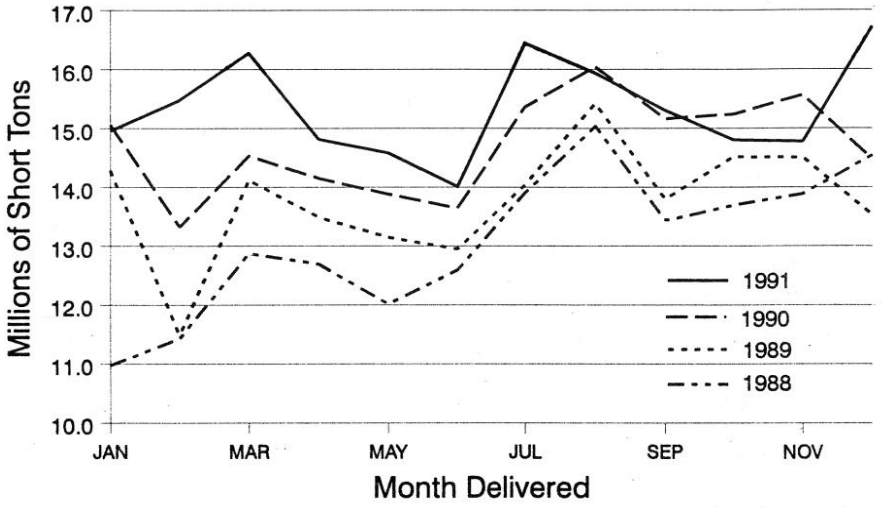


Figure 13. Reported deliveries from Wyoming coal mines *(from COALDAT Marketing Report by Resource Data International, Inc. compiled from FERC Form 423 filed monthly by electric utilities).*

above four coal fields accounted for a smaller share of the State's total production (Table 8).

A total of 30 coal mines in Wyoming produced coal in 1991 (Table 5 and Figure 14). Two coal mines, the PSO No. 1 and the Seminoe No. 2, did not report production in 1991, but they are listed on Table 5 because they reported some employment for the year. All but four of the 30 mines that produced coal in 1991 are surface mines.

1991 coal production from Wyoming's four underground mines was about 2.7 million tons, an increase of 46.6 percent (or 0.8 million tons) over 1990 production (Table 5). Most of the increase in underground production was from Cyprus-Shoshone Coal Company's Shoshone No. 1 mine (in the Hanna Coal Field), which produced slightly over 2.0 million tons of coal in 1991. All the underground coal mines in Wyoming increased production in 1991. About 1.4 percent of the State's total production was mined underground in 1991.

Employment at Wyoming coal mines in 1991 increased by 40 (Table 5). This is the fourth consecutive year that total employment in Wyoming's coal industry has grown (Figure 15). Mines in the Powder River Coal Field increased a total of 69 employees; the mine in the Bighorn Coal Field gained 5 employees. The Hanna, Green River, and Hams Fork Coal Fields all lost employees in 1991. The increased employment in the Powder River Coal Field, however, more than offset

Table 8. 1991 Wyoming coal production and employment by county and coal field.

County	Production	Percent of Total Production	Number of Mines	Number of Employees
POWDER RIVER COAL FIELD				
Campbell	164,851,943	85.0%	16	2,671
Converse	8,224,617	4.2%	2	271
Sheridan	158,055	0.1%	1	8
TOTAL	173,234,615	89.4%	19	2,950
GREEN RIVER COAL FIELD				
Sweetwater	11,430,281	5.9%	4	929
HAMS FORK COAL FIELD				
Lincoln	4,391,644	2.3%	2	447
HANNA COAL FIELD				
Carbon	4,703,981	2.4%	4	323
BIGHORN COAL FIELD				
Hot Springs	103,285	<0.1%	1	14
TOTAL WYOMING	193,863,806	100%	30	4,663

Source: Wyoming State Inspector of Mines, preliminary data for 1991.

the decreased employment in southern Wyoming coal fields. Employment in surface mines increased by 27 and employment in underground mines increased by 13 (Table 5).

Developments in western and southwestern Wyoming

This area of Wyoming includes the Bighorn, Green River, and Hams Fork Coal Fields. While 1991 coal production in the latter two fields was less than that reported in 1990, coal production in the Bighorn Coal Field was slightly more. In the Green River Coal Field, two underground and two surface mines produced coal in 1991 (Table 5 and Figure 14). Although both underground mines increased coal production in 1991, both surface mines decreased production. The Swanson

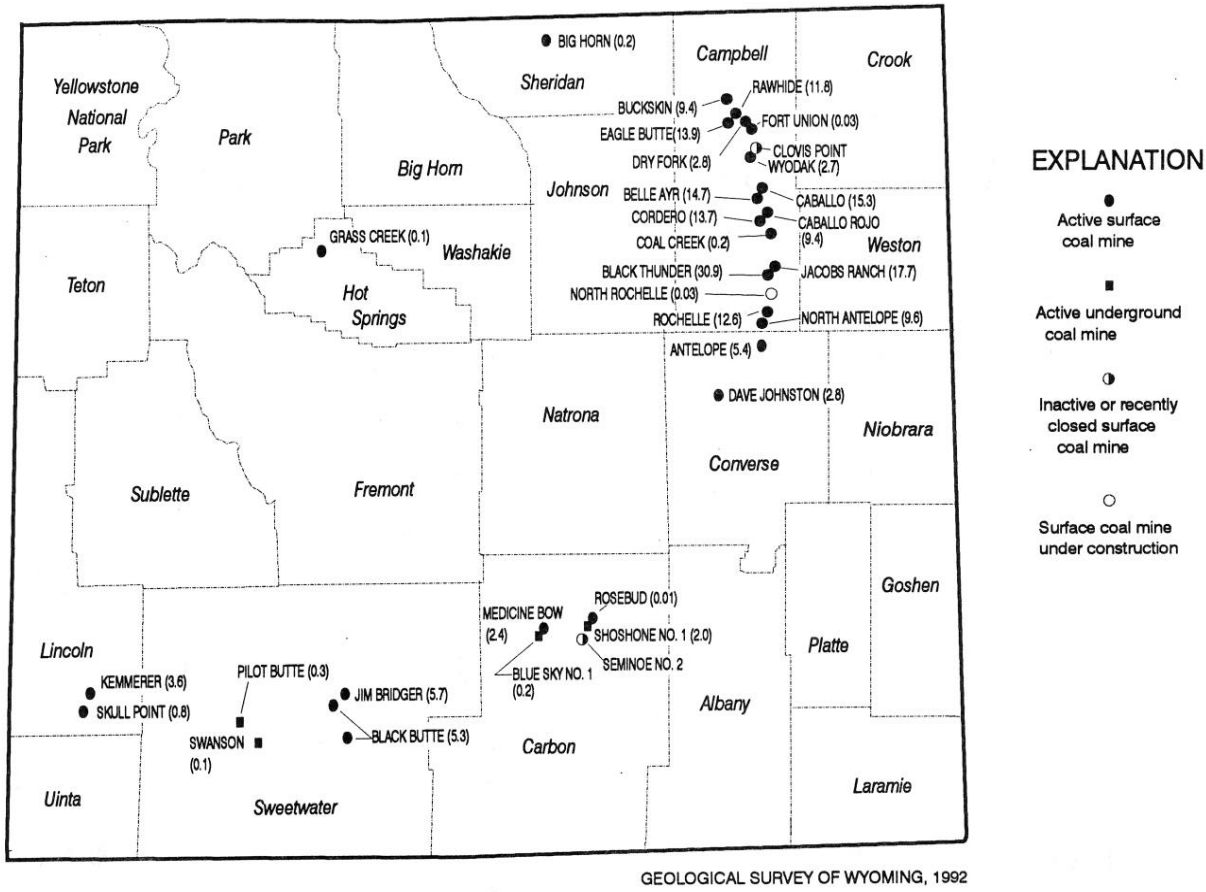


Figure 14. Wyoming coal mines and production in 1991, in milions of tons (193.9 million tons from 30 mines).

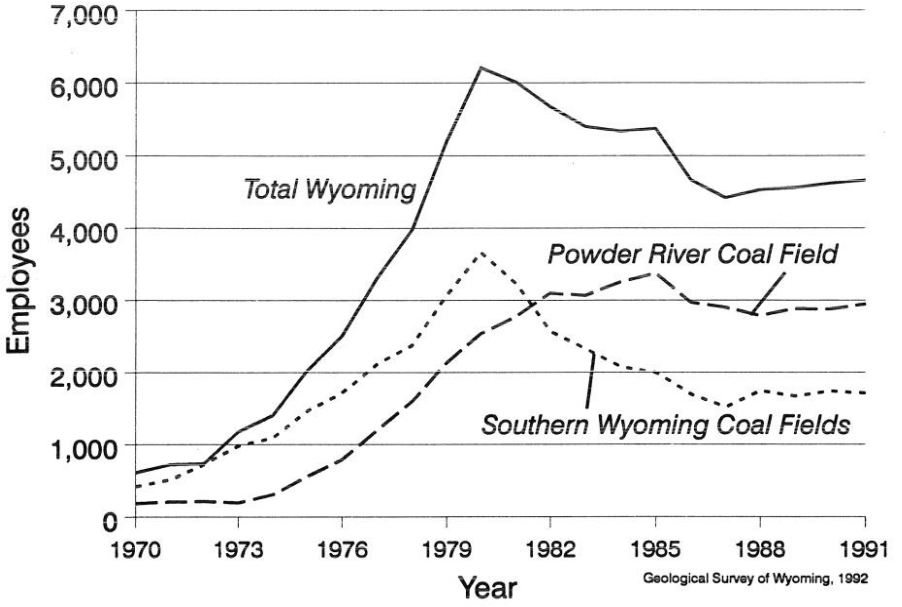


Figure 15. Coal industry employment in Wyoming.

and Pilot Butte underground mines produce bituminous coal from the Late Cretaceous Rock Springs Formation of the Mesaverde Group. The Black Butte mine, which now includes the Leucite Hills mine, mines both bituminous and subbituminous coal from either the Late Cretaceous Almond Formation of the Mesaverde Group, the Late Cretaceous Lance Formation, or the early Tertiary (Paleocene) Fort Union Formation. The Jim Bridger mine extracts subbituminous coal from the Fort Union Formation.

Both active surface mines in the Hams Fork Coal Field in 1991 produced less coal than in 1990 (Table 5 and Figure 14). FMC Wyoming Corporation's Skull Point mine and Pittsburg and Midway Coal Mining Company's (P&M's) Kemmerer mine also had a total of 19 fewer employees in 1991. Both of these mines produce subbituminous coal from the Late Cretaceous Adaville Formation.

The Bighorn Coal Field had only one active mine in 1991, Northwestern Resource Company's Grass Creek mine in Hot Springs County (Table 5 and Figure 14). This small mine supplies bituminous coal from the Paleocene (early Tertiary) Fort Union Formation to bentonite plants in the area, which use the coal in drying the bentonite products. Transportation of the coal from the mine is by truck. Both the production and the employment at this mine increased in 1991.

Black Butte Coal Company, a subsidiary of Kiewit Mining Company, signed a contract with PacifiCorp Electric Generation Company, the fuel procurement arm of PacifiCorp, to supply up to 1.1 million tons of coal to the Jim Bridger power plant east of Rock Springs (no. 1, Figure 16). Coal from Black Butte's Pit No. 22 (formerly the Leucite Hills mine) will be trucked to the nearby generating plant. The contract's duration was not announced, but it is probably for one year.

In the Hams Fork Coal Field, P&M announced that 19 employees had been laid off from its Kemmerer coal mine in late March. Citing decreased coal sales and production, P&M idled one coal shovel and three coal hauling trucks. Coal production at the mine has decreased each year since 1988. Employment at the mine in 1991 was 349; peak employment at Kemmerer was 630 in 1981, when the mine produced over 4 million tons. P&M is currently in arbitration with Utah Power and Light Company (a subsidiary of PacifiCorp) over a coal contract for the nearby Naughton power plant (*Wyoming Geo-notes No. 31*, p. 22).

Developments in the Hanna Coal Field

Coal production from four active mines in this field in 1991 was up 0.2 million tons (Table 5 and Figure 14). Arch of Wyoming's Seminoe No. 2 mine did not report coal production for 1991, but it did employ 14 workers involved in reclamation at the mine. Both underground mines in the coal field increased coal production in 1991. Production at Cyprus-Shoshone Coal Company's Shoshone

Figure 16. Index map of coal contracts and sales activities involving Wyoming coal mines during the first quarter of 1992.

No. 1 mine north of Hanna increased by about 0.6 million tons; production at Wyoming and West Virginia, Inc.'s underground mining operation at the Medicine Bow mine increased by about 147,000 tons.

Coal mined in the Hanna Coal Field occurs in the Late Cretaceous-early Tertiary Ferris Formation and the early Tertiary Hanna Formation. The Rosebud and Shoshone No. 1 mines produce bituminous coal from part of the Hanna Formation that is Paleocene in age. The Medicine Bow and Blue Sky No. 1 mines (west of the town of Hanna) produce subbituminous coal from part of the Ferris Formation that is Paleocene in age.

Arch of Wyoming and Kansas Power and Light Company (KPL) signed a new two-year coal supply contract in the first quarter of 1992. The new contract renews a previous contract that expired at the end of 1991. About 1.2 million tons of coal per year will be supplied from the Medicine Bow mine to KPL's Tecumseh and Lawrence, Kansas, power plants (no. 7 and 8, respectively, Figure 16). An optional 100,000 tons of coal per month (1.2 million tons per year) was also part of the new contract. The Lawrence plant will use about three-fourths of the coal with the remainder going to the Tecumseh plant. The coal will be transported on the Union Pacific (UP) and Santa Fe railroads.

Developments in the Powder River Coal Field

The 19 active surface mines in this coal field (Figure 14) collectively produced 10.5 million tons more coal in 1991 than in 1990 (Table 5). Thunder Basin Coal Company's Black Thunder mine produced almost 3 million tons more coal in 1991, with year-end production reaching 30.9 million tons. This is the tenth consecutive year that the Black Thunder mine has led both the State and the Nation in coal production from a single mine. Eight surface mines, including the Belle Ayr, Eagle Butte, Caballo, Rawhide, Cordero, Jacobs Ranch, Black Thunder, and Rochelle mines, each produced in excess of 10 million tons in 1991. Only three coal mines in the Wyoming portion of the Powder River Coal Field were not in Campbell County (Figure 14 and Table 8).

Only four mines in the field produced less coal in 1991. These were the Belle Ayr and Eagle Butte mines operated by Amax Coal Company, the Fort Union mine, and the Wyodak mine.

Recent coal production from mines in both the Montana and the Wyoming portions of the Powder River Coal Field is presented on Table 9. A total of 25 surface coal mines in the coal field produced almost 211 million tons of coal in 1991, an average of 8.4 million tons per mine. Three coal mines in Montana, the East Decker, the West Decker, and the Spring Creek mines, are located just across the Wyoming-Montana border a short distance north of Sheridan, Wyoming. The other three Montana mines are located in the extreme northern end of the coal field. All the coal produced in the Powder River Coal Field except that from the Dave Johnston mine in Converse County, Wyoming, is from the Tongue River Member of the Fort Union Formation. All coal produced in the field is

Table 9. Coal production in the Powder River Coal Field, Montana and Wyoming (1980-1991).

Company	Mine name	1981 Production (short tons)	1982 Production (short tons)	1983 Production (short tons)	1984 Production (short tons)	1985 Production (short tons)	1986 Production (short tons)	1987 Production (short tons)	1988 Production (short tons)	1989 Production (short tons)	1990 Production (short tons)	1991 Production (short tons)
	WYOMING MINES											
Amax Coal Co.	Belle Ayr	15,256,750	15,161,298	13,825,240	13,417,442	12,829,379	12,145,900	13,329,591	13,296,739	13,600,000	15,529,327	14,748,346
	Eagle Butte	8,144,997	9,055,800	11,030,880	13,399,363	11,808,014	12,000,280	12,977,000	12,915,476	13,567,000	15,396,412	13,924,000
Antelope Coal Co.	Antelope					66,344	1,709,787	2,554,333	3,141,088	3,541,184	5,211,642	5,448,268
Ash Creek Mining Co.	PSO No. 1		835	1,018	715	2,589	20					
Big Horn Coal Co.	Big Horn	2,753,913	2,990,564	2,946,680	2,530,755	2,400,000	1,360,805	1,201,093	945,116	106,147	134,104	158,055
Carter Mining Co.	Caballo	3,523,611	5,537,070	6,706,928	8,164,752	8,977,927	7,272,741	11,684,193	12,779,942	12,856,387	14,312,971	15,267,657
	Rawhide	6,154,313	8,147,218	8,627,719	9,351,952	12,236,695	12,403,975	10,672,913	10,810,785	10,628,737	11,442,355	11,766,870
Cordero Mining Co.	Cordero	8,312,578	7,719,367	10,024,803	10,391,218	10,085,299	11,314,275	11,943,375	13,541,225	12,602,336	12,922,653	13,703,094
Dry Fork Coal Co.	Dry Fork										815,056	2,796,061
Fort Union Coal Co.	Fort Union	34,887	206,650	302,032	298,119	532,716	219,313	394,004	508,263	42,092	38,528	28,913
Glenrock Coal Co.	Dave Johnston	3,626,932	3,351,065	2,684,011	3,338,677	3,508,059	3,051,331	2,546,808	2,607,442	2,575,184	2,679,028	2,776,349
Kerr-McGee Coal Corp.	Clovis Point	3,671,793	2,678,982	3,045,202	1,558,304	1,423,649	1,435,045	1,508,524				
	Jacobs Ranch	8,722,262	10,495,719	11,847,552	14,366,752	12,967,996	12,050,711	11,158,874	14,532,789	14,662,159	16,724,780	17,743,542
Caballo Rojo, Inc.[1]	Caballo Rojo		47,063	1,440,000	3,446,221	4,221,574	3,989,622	6,489,799	7,126,693	8,368,787	8,566,831	9,383,108
North Antelope Coal Co.	North Antelope			64,248	3,000,000	5,720,425	5,689,608	5,337,503	6,088,207	6,909,325	8,242,231	9,648,953
Rochelle Coal Co.	Rochelle					206,565	3,571,177	6,436,359	8,694,125	10,892,567	12,030,237	12,635,888
Shell Mining Co.	North Rochelle										13,000	24,765
Thunder Basin Coal Co.	Black Thunder	14,694,507	16,828,240	15,193,140	21,200,000	23,207,616	21,868,336	19,272,751	24,862,429	29,536,578	27,919,411	30,851,751
	Coal Creek		1,106,812	1,877,056	1,800,000	2,608,592	1,111,305	2,362,059	684,322	139,116	140,250	151,165
Triton Coal Co.	Buckskin	350,647	1,406,343	1,709,958	3,515,426	3,958,420	3,996,492	5,773,967	7,174,718	7,693,929	7,695,009	9,435,021
Wyodak Res. Dev. Corp.	Wyodak	2,712,617	2,830,000	2,486,000	2,895,072	3,163,026	2,600,000	2,976,398	2,709,526	2,348,085	2,907,640	2,741,809
WYOMING SUBTOTAL		77,959,807	87,563,026	93,812,467	112,674,768	119,924,885	117,790,723	128,619,544	142,418,885	150,069,613	162,721,465	173,234,615
	MONTANA MINES											
Coal Creek Mining Co.	Coal Creek	64,142	16,608									
Decker Coal Co.	East Decker	5,350,113	4,914,970	5,040,018	5,019,186	5,191,701	5,397,476	4,042,597	3,655,067	3,582,885	2,595,829	2,408,968
	West Decker	5,277,648	4,884,920	5,308,799	5,278,365	6,149,987	6,706,592	6,355,523	7,068,653	6,495,027	6,602,744	7,576,380
Peabody Coal Co.	Big Sky	3,193,570	2,891,428	2,571,861	3,945,865	3,336,907	2,594,306	3,234,538	3,788,137	3,715,325	3,602,851	3,104,829
Spring Creek Coal Co.	Spring Creek	4,368,885	1,352,181	2,102,606	2,962,008	2,837,037	4,664,238	6,557,228	4,704,442	5,979,405	7,133,285	6,740,401
Western Energy Co.	Rosebud	10,352,966	9,424,857	9,544,062	11,957,724	12,275,351	12,074,698	12,022,894	16,155,867	13,677,234	12,800,898	13,802,840
Westmoreland Resources	Absaloka	4,450,296	4,158,578	3,868,844	3,621,544	3,112,595	2,028,595	1,858,315	3,304,822	4,011,156	4,471,345	4,101,847
MONTANA SUBTOTAL		33,057,620	27,643,542	28,436,190	32,784,692	32,903,578	33,465,905	34,071,095	38,676,988	37,461,032	37,206,952	37,735,265
GRAND TOTAL		111,017,427	115,206,568	122,248,657	145,459,460	152,828,463	151,256,628	162,690,639	181,095,873	187,530,645	199,928,417	210,969,880

[1]Formerly owned by Mobil Coal Producing, Inc.

subbituminous in rank. Wyoming mines accounted for 82 percent of the total coal produced in the entire coal field.

In January, 1992, the U.S. Supreme Court ruled in favor of the State of Wyoming in its lawsuit against the State of Oklahoma's legislation requiring electrical utilities in that state to use Oklahoma coals to produce 10 percent of their energy. The so-called "buy Oklahoma coal" law [which is generally thought of as protectionist legislation that benefits an in-state coal industry by penalizing out-of-state competitors] was ruled unconstitutional by a 6-3 decision of the Court. In 1989, the State of Wyoming began its effort to overturn the legislation, charging that the Oklahoma law was unconstitutional because it restricted free trade and had deprived Wyoming of severance tax revenues by decreasing the amount of coal sold to Oklahoma utilities. In its decision, the Supreme Court found that: the State of Wyoming did indeed have standing to sue Oklahoma; "original jurisdiction" did apply to this case, which allows the Supreme Court to bypass all lower courts and settle disputes between states; and the Oklahoma law violated the Commerce Clause of the U.S. Constitution by "discriminating against interstate commerce." Although this case may have ramifications on similar protectionist and coal preference laws passed by other states, the Supreme Court's decision only addressed the Oklahoma law. Long-term effects of the decision on Wyoming coal markets won't be known for some time. However, after the decision, one short-term contract between an Oklahoma coal producer and a utility company was significantly reduced in size, in favor of additional coal from Wyoming.

A settlement has been reached in the dispute between Whitney Benefits, Inc. and Peter Kiewit Sons' Company over the division of a multi-million dollar award given to the two companies in a recent judgment (*Wyoming Geo-notes No. 33*, p. 25). The award followed a U.S. Court of Appeals decision involving unminable coal in an alluvial valley. Although the amount of the final award has yet to be determined (several motions by the U.S. Government to reevaluate the earlier decisions are still pending), Whitney Benefits will receive 32.5 percent and Peter Kiewit Sons will receive 67.5 percent of the award, respectively. The award could be for $160-200 million, depending on how much interest has accrued on the original award of $60.3 million.

Several other lawsuits involving coal supply contracts with Wyoming coal companies were pending in the first quarter of 1992. These lawsuits could affect millions of tons of coal per year and generally involve disputes over coal prices, transportation costs, and coal quality (or combinations of the above). A settlement appears near in a lawsuit involving Triton Coal Company (a division of Shell Mining Company), Western Fuels Association (a fuel procurement/contracting company), and Cajun Electric Cooperative of Louisiana. At issue here are transportation costs and contract clauses that take effect when coal is blended for specific contract specifications.

Another lawsuit could affect a contract for 7 million tons of Wyoming coal per year. Amax Coal Company and Southwestern Electric Power Company (SWEPCO) have sued each other over the price of coal delivered to the utility company's Flint

Creek, Arkansas, and Welsh, Texas, generating plants. SWEPCO challenged the price they were paying for Amax coal delivered to these two plants because lower spot coal prices were being paid by utility customers farther away in Georgia for higher quality coal from the Powder River Coal Field. Amax filed suit claiming that the coal prices they charged SWEPCO were valid, that SWEPCO's lawsuit was filed on frivolous grounds, and that Amax was due punitive and unspecified damages. SWEPCO, in turn, filed a lawsuit claiming that Amax had incorrectly computed their current prices. SWEPCO asked a state court in Louisiana to compute a new coal price and to award them damages plus interest on their overpayments.

Kerr-McGee Coal Corporation laid off 9 salaried employees at its Jacobs Ranch mine in southern Campbell County as part of Kerr-McGee Corporation's worldwide layoffs of 160 employees in their coal, oil and gas, and chemicals departments. Ten other Kerr-McGee coal jobs were eliminated at a coal mine in Illinois and four jobs were eliminated at the coal corporation's headquarters in Oklahoma. The Jacobs Ranch mine employed 367 workers and produced 17.7 million tons of coal in 1991 and was the State's second largest coal producer.

Coal contracts - Powder River Coal Field

Coal purchasing activities during the first quarter of 1992 were numerous as electric utility companies announced both new contracts and spot purchases for 1992. Numerous purchases of coal for test burns were also announced during the first quarter.

New contracts and sales are summarized below:

A) Rochelle Coal Company, an operating unit of Powder River Coal Company (a subsidiary of Peabody Holding Company) signed a 15-year, 4.0 million tons per year contract with Associated Electric Cooperative, Inc. (AEC) to supply coal to the New Madrid, Missouri, power plant (no. 17, Figure 16). Coal from the Rochelle mine will be delivered via the Chicago and North Western (C&NW), Missouri Pacific, and St. Louis Southwest railroads beginning in mid-1994 and running through 2010. This supply contract will replace high-sulfur coal from Illinois, Indiana, and Kentucky and enable the plant to meet 1995 clean air standards required by the Clean Air Act Amendments of 1990. Based on test burns of Rochelle coal in 1990, AEC decided that it was cheaper to purchase low-sulfur coal than to install scrubbers at the plant and continue to burn high-sulfur coal.

B) Antelope Coal Company (a subsidiary of Nerco Coal Company) supplied a total of 110,000 tons of spot coal to Northern Indiana Public Service Company's (NIPSCO's) Dean H. Mitchell, Indiana, power plant (no. 16, Figure 16). Coal from the Antelope mine in northern Converse County was supplied under an "as-needed, as-available" purchase agreement.

C) Caballo Rojo, Inc., a subsidiary of Marigold Land Company, also supplied 77,000 tons of spot coal to NIPSCO's Dean H. Mitchell power plant in Indiana

(no. 16, Figure 16). This coal (from the Caballo Rojo mine south of Gillette) was also supplied under an "as-needed, as-available" purchase agreement.

D) Antelope Coal Company's Antelope mine will supply about 1.0 million tons of coal to San Antonio City Public Service Board's J.T. Deely power plant in Texas (no. 3, Figure 16). The coal will be delivered via the Union Pacific Railroad (UP) during 1992. Publicly-released bid data indicate that the 8,800 Btu/pound (as-received) coal sold for $4.35 per ton F.O.B. the mine. Some of this coal may be used in the utility company's nearly-completed and nearby Spruce generating plant.

E) Rochelle Coal Company's Rochelle mine will supply up to 0.5 million tons of spot coal to West Texas Utilities' Oklaunion, Texas, generating plant (no. 2, Figure 16). The coal will supply the plant's spot coal needs during the second quarter of 1992. Shipments of the coal began in February via the Burlington Northern Railroad (BN).

F) During 1992, Caballo Rojo, Inc. will supply about 100,000 tons of spot coal to the Hastings, Nebraska, Utility Department's Energy Center (no. 10, Figure 16). This is a renewal of last year's spot coal supply agreement, but could involve less tonnage because of a five-year maintenance outage scheduled for generating units at the Energy Center this summer.

G) In 1992, Cordero Mining Company (a subsidiary of Sun Coal Company) will supply spot coal to Iowa Public Service Company's (IPS's) George Neal No. 3 unit in Iowa (no. 11, Figure 16). The Cordero mine south of Gillette will provide from 1.0 to 1.2 million tons of coal for the unit. The coal will be transported by the C&NW and UP. In a related item, this year IPS will merge with another Iowa utility, Iowa Power Company, to form Midwest Power Systems, Inc. The two utility companies will combine their fuel procurement offices into a separate department.

H) Antelope Coal Company will supply 0.4 million tons of coal per year to Cyprus Silver Power Group's 135-megawatt cogeneration plant at Silver Bay, Minnesota (no. 12, Figure 16). Although the duration of the contract was not announced, the new contract is thought to be multi-year. Coal deliveries to this plant, which powers a nearby taconite pelletizing operation, were first noted in early 1991 (*Wyoming Geo-notes No. 30*, p. 35). The sale was arranged by Venture Fuels, a joint venture of Nerco Coal Company and Midwest Energy Resources Company. BN will provide transportation of the coal from the Antelope mine to the plant.

I) The Antelope mine will supply 0.2 million tons of spot coal in 1992 to Dairyland Electric Power Cooperative's Alma and Genoa, Wisconsin, power plants (nos. 13 and 14, respectively, Figure 16). The coal will be delivered from May through August, originating on the BN to St. Paul, Minnesota, where it will be barged down the Mississippi River to the power plants. The coal will be blended with eastern coal.

J) Carter Mining Company, a subsidiary of Exxon Coal and Minerals, was the apparent low bidder on a 200,000-ton, spot coal solicitation for Lower Colorado River Authority's (LCRA's) Fayette power project near Austin, Texas (no. 4, Figure 16). Pending LCRA's final evaluation and award, the coal would be delivered during the last three quarters of this year from the Caballo mine. Published bids for this coal ranged from Carter's low bid of $3.79 per ton for 8,500 Btu/pound (as-received) coal to a high bid of $5.15 per ton for 8,750 Btu/pound coal, both F.O.B. the mine. No transportation details were announced.

K) In 1992, Amax Coal Company's Belle Ayr mine will supply from 0.75 to 1.5 million tons of coal to Houston Lighting and Power Company's Parish, Texas, power plant (no. 5, Figure 16).

L) Rochelle Coal Company and Grand River Dam Authority (GRDA) signed a 0.5-million ton coal supply contract for the Choteau power plant in Oklahoma (no. 6, Figure 16). The contract calls for spot coal deliveries during the second and third quarters of 1992 plus options on another 0.3 million tons for the last quarter of the year. The coal will originate on the BN at the Rochelle mine and will terminate on the UP.

Coal purchased for test burns is summarized below:

M) Thunder Basin Coal Company (a subsidiary of Arco Coal Company) will supply up to 150,000 tons of spot coal for testing at Tennessee Valley Authority's (TVA's) Gallatin, Tennessee, power plant (no. 18, Figure 16). Deliveries began in late February. Although the originating railroad was not announced, CSX Transportation, Inc. is the terminating carrier. Coal from the Black Thunder mine will be blended in various amounts with eastern coals as well as burned separately. Evidently, this plant has been chosen for fuel switching as part of TVA's system-wide efforts to meet 1995 requirements of the Clean Air Act Amendments. Apparently, other TVA plants that have tested coals from the Powder River Coal Field will install scrubbers on their generating units, which will allow them to continue burning high-sulfur eastern coals.

N) Antelope Coal Company supplied about 11,000 tons of test coal to Ohio Edison's Burger, Ohio, generating plant (no. 21, Figure 16). The coal was blended in various amounts (from 30 to 50 percent) with eastern high-sulfur coals. Coal from the Caballo Rojo mine was tested at this plant in 1991 (*Wyoming Geo-notes No. 33*, p. 28-29).

O) Antelope Coal Company also supplied about 72,000 tons of test coal to Indiana-Kentucky Electric Corporation's Clifty Creek, Indiana, power plant (no. 20, Figure 16). The test burn, which ran from late January through March, used an 80/20 percent blend of Antelope to eastern high-sulfur coal. This is one of several test burns of blended western and eastern coals conducted by member utilities in American Electric Power Cooperative's generating system (*Wyoming Geo-notes No. 31*, p. 27).

P) Rochelle Coal Company will supply up to 143,000 tons of coal to Wisconsin Power and Light Company's Nelson Dewey No. 1 unit in Wisconsin (no. 15, Figure 16). Test burns of this coal are planned for mid-April through September of this year. The coal will be burned separately and in blends with eastern coals.

Q) Coal from an unspecified mine in the Powder River Coal Field was tested at PSI Energy's Gallagher, Indiana, power plant (no. 19, Figure 16).

R) Thunder Basin Coal Company's Black Thunder mine furnished test coal for use in cyclone boilers at Missouri Public Service Company's Sibley, Missouri, power plant (no. 9, Figure 16). Coals from both Utah and Colorado were blended in various amounts with coal from Black Thunder.

S) The Antelope mine provided 22,000 tons of coal in January for testing at NIPSCO's Mitchell, Indiana, generating plant (no. 16, Figure 16).

T) Rochelle Coal Company provided some test coal to West Texas Utilities' Oklaunion, Texas, power plant (no. 2, Figure 16). This coal was included as part of the utility company's purchase of 0.5 million tons of spot coal from Rochelle for the second quarter of 1992 (see item (E), above).

INDUSTRIAL MINERALS AND URANIUM UPDATE

by Ray E. Harris
Staff Geologist-Industrial Minerals and Uranium, Geological Survey of Wyoming

Aggregate (Construction)

The outlook for the production of construction aggregate in Wyoming for the last half of 1992, 1993, and the first half of 1994 is not good. Many State-funded highway construction projects planned for this period have been rescheduled or postponed due to program cuts resulting from budget reductions. Construction of the new Denver airport, however, may increase production of non-highway aggregate. Granite fines from Meridian Aggregates' ballast quarry west of Cheyenne (Figure 17) are already being used at the airport site. Nationally, the production of construction sand and gravel and crushed stone is expected to increase, according to the U. S. Bureau of Mines (Tepordei, 1992a & b).

In Wyoming, Rissler & McMurry Co. of Casper, has applied for a mining permit to expand their limestone aggregate quarry on Bessemer Mountain, west of Casper (Figure 17). The existing operation was permitted under the 10-acre rule, which allows companies and individuals to mine or quarry on sites of 10 acres or less. To expand the quarry and continue operating, Rissler & McMurry must

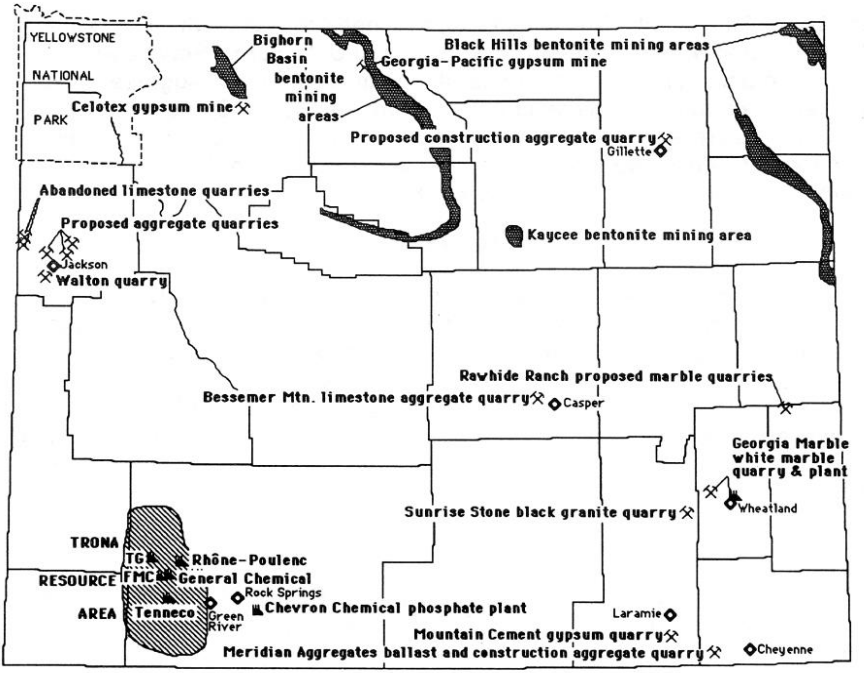


Figure 17. Industrial mineral and construction material activities in Wyoming in the first quarter of 1992.

acquire a small mining permit (for operations under 40 acres) from the Wyoming Department of Environmental Quality.

The Wyoming Board of Land Commissioners denied a permit for a construction aggregate quarry north of Gillette (Figure 17), citing proximity to existing homes as a reason for denial.

In Yellowstone National Park, the National Park Service has decided to reclaim three aggregate quarries that had been used for in-park construction. Park officials have asked the Wyoming Abandoned Mined Lands (AML) Reclamation Program, which is administered by the Wyoming Department of Environmental Quality, to fund the reclamation work.

The U.S. Army Corps of Engineers announced plans to upgrade the 24-mile-long Snake River Levee System in the Jackson area. From 5,000 to 10,000 cubic yards of aggregate are required annually to maintain the levee system, which protects existing homes and other buildings. The current source for rock, the Walton Quarry, will be depleted in two years, according to the Corps of Engineers. Three new sites are under consideration to replace the Walton Quarry. These are

the Curtis Canyon, Flat Creek, and Phillips Ridge sites, all of which are within the Bridger-Teton National Forest (Figure 17). The U. S. Forest Service will begin a scoping process on the proposed sites this summer. Although aggregate sources farther away from the levees are much more costly, the Geological Survey of Wyoming has received inquiries about rock sources outside of Jackson Hole, and has recommended two abandoned limestone quarries on the west side of the Teton Mountains in Wyoming (Figure 17).

Bentonite

Wyoming remained the largest producer of bentonite in the Nation in 1991. Bentonite mining continues in the Bighorn Basin, Black Hills, and Kaycee bentonite mining areas (Figure 17). 1992 production may be slightly greater than in 1991, due to increased uses of bentonite for waste isolation (lining pits and disposal sites) and for binding of foundry sand. Bentonite and foundry sand are combined to make foundry casting molds. In 1991, for the first time, more bentonite was used as a binder for foundry sand than for any other use (Ampian, 1992). This reflects the decline in domestic oil and gas drilling.

Decorative Stone

Work continues at Sunrise Stone's "Wyoming Raven" black granite quarry in northern Albany County (*Wyoming Geo-notes No. 33*, p. 32, and *No. 32*, p. 31) (Figure 17). Recent improvements include construction of an access road and entrance to the quarry site. Quarried blocks are shipped by truck to Fagan Marble and Granite in Mena, Arkansas, for cutting and polishing into finished decorative pieces, including interior and exterior building facing.

In February, Georgia Marble requested some blocks of a black and a red marble described in Geological Survey of Wyoming Public Information Circular 31, *Decorative stones of Wyoming*. If the marble is satisfactory, it will be included in Georgia Marble's product line of cut and polished marble. As soon as all permits are obtained, these blocks will be quarried at two locations on the Rawhide Ranch in northwestern Goshen County (Figure 17). Georgia Marble also operates the white marble aggregate quarry and plant near Wheatland in Platte County (Figure 17).

Fertilizer

The planned sale of Chevron Chemical Company's fertilizer company southeast of Rock Springs (Figure 17) to FS Industries, a joint venture between Farmland Industries and J. R. Simplot, Inc., is not yet complete (*Wyoming Geo-notes 33*, p. 32-33). As of April 6, the Federal government had not yet approved the sale. This plant manufactures fertilizer from phosphate ore mined north of Vernal, Utah, and sulfur recovered from Wyoming natural gas.

Gypsum

In 1992, gypsum mining in Wyoming continues at two locations in the Bighorn Basin where Celotex and Georgia-Pacific manufacture wallboard, and south of

Laramie where gypsum is mined by Mountain Cement for an additive in cement (Figure 17). Gypsum production in Wyoming should not increase in 1992 since the plants are operating at near capacity levels. Nationally, the production of gypsum in recent months has been 10% greater than it was in 1990 and 1991.

Trona

The production of soda ash and related sodium compounds from mined trona continues to be the most important nonfuel mineral industry in Wyoming, and Wyoming still produces well over 90% of the soda ash produced in the United States. Five companies produce soda ash and sodium compounds from trona mined from the Wilkins Peak Member of the Green River Formation in the "Trona Resource Area" west of Green River (Figure 17). One company in California produces soda ash from surficial and brine deposits. The U.S. Bureau of Mines estimates that production of mined trona in Wyoming for 1991 was down slightly from 1990 (Kostick, 1992a). The decrease was attributable to a 5 percent decrease in domestic consumption of soda ash, which is used primarily in the manufacture of glass and sodium chemicals. The decrease in domestic consumption was somewhat offset in 1991 by a 14 percent increase in exports (Kostick, 1992b), but this was not enough to reverse the minor decline in production.

Tenneco Minerals Co., one of the five soda ash producers in Wyoming, announced during the first quarter of 1992 that it was delaying an expansion project for one year. The project was the planned construction of a facility to produce "calcined trona", a lower-grade soda ash-type product (*Wyoming Geo-notes No. 31*, p. 30). The delay was said to be due to capitalization problems at Tenneco, and not due to a weakness in the sodium market. [In late April, however, Tenneco announced the sale of its 80 percent share in the mine and plant to Solvay S.A. of Brussels, Belgium.]

A Mexican company, Vitro, S.A., is also interested in acquiring a captive source for soda ash, and is apparently negotiating a purchasing agreement with a Wyoming producer. Although Vitro did not name a company, it is probably General Chemical. General is partly owned by an Australian company, which has been trying to sell its interest in General.

Uranium

The current NUEXCO spot market price for yellowcake is $8.00, down from $8.75 at the end of 1991.

In January, Pathfinder Mines (a wholly-owned subsidiary of COGEMA-France) announced that it is planning to close the Shirley Basin uranium mine in Carbon County in the spring of this year (Figure 18). This is the only active, conventional, uranium mine and mill in Wyoming. Following the closure of this mine, all production of uranium in Wyoming will be from Power Resources' Highland operations in Converse County (Figure 18), which produce uranium from several in-situ well fields.

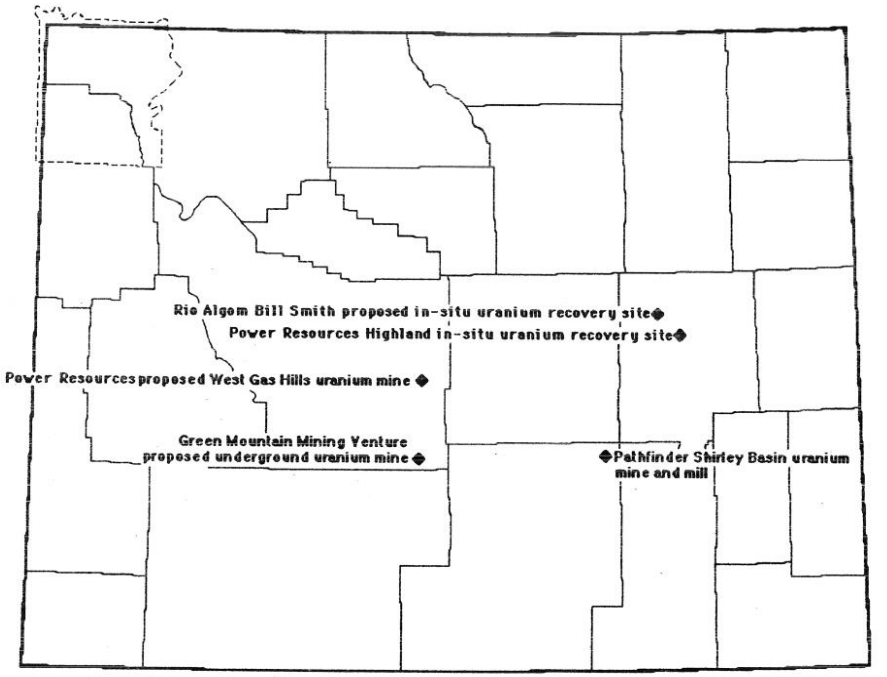


Figure 18. Uranium activities in Wyoming in the first quarter of 1992.

A few companies, however, are reportedly planning new operations. Rio Algom, which has been testing the Bill Smith property in the southern Powder River Basin, has received a license from the Nuclear Regulatory Commission to begin in-situ mining. In January, the *Casper Star-Tribune* reported that Power Resources, in a joint venture with Urangesellschaft , a German company with a long history of exploration in Wyoming, is planning to develop a mine in the western Gas Hills. Kennecott, a subsidiary of Rio Algom, in a joint venture with U.S. Energy-Crested Corp. (Green Mountain Mining Venture), continues to study the Green Mountain property south of Jeffrey City for a future underground uranium mine (Figure 18). Even though these mining plans have been made public, there are no plans to begin production soon. Rio Algom noted that the mid-1990s may be as early as they can start.

Fremont County received a $100,000 grant from the U. S. Department of Energy to study the feasibility of locating a monitored retrievable storage (MRS) facility in the county. An MRS is an above-ground storage facility for nuclear material such as spent fuel rods. At an MRS site, the stored radioactive materials are contained in several layers of shielding.

At the present time, there are many MRS sites around the United States. Most of these are located at nuclear power plants. These sites, however, are

becoming full. Yucca Mountain, Nevada, is being developed as a permanent site, but it is behind schedule and years from completion. New MRS locations like the one being studied by Fremont County would be used until a permanent repository is completed.

The United States does not reprocess spent fuel rods into usable fuel as is done in many other countries. France, for example, has several MRS sites where these materials are stored temporarily until they are reprocessed.

References cited

Ampian, S. G., 1992, Clays: U. S. Bureau of Mines Mineral Commodity Summaries 1992, p. 50-51.

Kostick, D. S., 1992a, Sodium compounds in 1991: U. S. Bureau of Mines Mineral Industry Surveys, p. 2-3.

Kostick, D. S., 1992b, Soda ash and sodium sulfate in January 1992: U. S. Bureau of Mines Mineral Industry Surveys, 9 p.

Tepordei, V. V., 1992a, Stone (crushed) in 1991: U. S. Bureau of Mines Mineral Industry Surveys, 3 p.

Tepordei, V. V., 1992b, Sand and gravel (construction) in 1991: U. S. Bureau of Mines Mineral Industry Surveys, 3 p.

METALS AND PRECIOUS STONES UPDATE

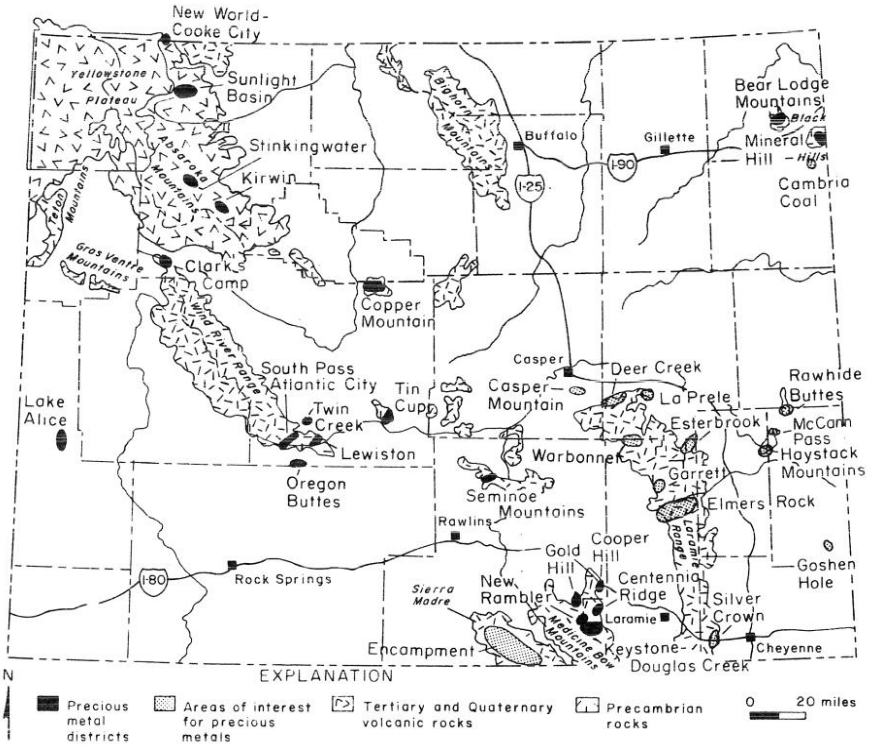
by W. Dan Hausel
Senior Economic Geologist, Geological Survey of Wyoming

Analytical results for many samples collected by the Geological Survey of Wyoming last field season became available during the winter. Many of the results are reported in the following discussions.

Encampment district, Sierra Madre

During the 1991 field season, reconnaissance field investigations in the Encampment District were conducted by the Geological Survey of Wyoming (Figure 19). Two investigated localities yielded interesting metal anomalies.

In the Purgatory Gulch area south of Encampment, selected samples of limonitic quartz collected from a quartz vein on the Golden Crown property (sec. 36, T14 N, R83W) were anomalous in gold. One sample (EN10-91) of quartz with limonite boxworks after pyrite assayed 1.3 ounces of gold per ton (40.63 ppm) and 0.1 ounce of silver per ton (3.62 ppm) (Hausel, 1992a). The vein at the sample site is from 2 to 4 feet wide.



Geological Survey of Wyoming, 1992

Figure 19. Principal metal districts and mineralized regions of Wyoming.

The historic Kurtz-Chatterton property (sec. 29, T14N, R84W) along Copper Creek, southwest of Encampment was sampled primarily to test for the the presence of gold and silver. Historic reports indicated the mine yielded highly anomalous copper values, but gave no specific data on precious metals.

Ten samples collected from various mine and prospect dumps on this property averaged 5.96 ppm (0.19 opt) Au, 2.1 ppm (0.07 opt) Ag, and 4.43% Cu (Hausel, 1992a). The samples varied from no detectable gold to 28.10 ppm (0.9 opt) Au, no silver to 7.24 ppm (0.23 opt) Ag, and 0.7% to 12.55 % Cu. The mineralized zone was traced along strike 2,500 feet and probably extends another 1,500 feet based on mineralized samples recovered from a mine dump farther to the east. The mineralized zone swells to as much as 800 to 1,000 feet at one point.

The encountered mineralization included sulfides, oxides, and carbonates in a sheared and silicified zone in granite. Locally, zones of secondary biotite, chlorite, and muscovite were noted.

Southern Wyoming

During the 1991 field season, the Geological Survey of Wyoming investigated a number of different geological environments for gold and other metals under a grant provided by Union Pacific Resources (Hausel and others, 1992). These included the historic Cooper Hill mining district, several sand and gravel and placer deposits, coal deposits, titaniferous black sandstones, sandstones, quartzites, conglomerates, and limestones.

Cooper Hill district, Medicine Bow Mountains: Field work began at the Cooper Hill mining district early in the summer (Figure 19). The district lies along the northeastern edge of the Medicine Bow Mountains in southeastern Wyoming, immediately south of I-80 and east of Arlington. According to historic reports, the district was active for a short period in the 1890s and early 1900s, and produced minor amounts of gold, copper, silver, and lead.

The stratigraphic succession of Cooper Hill is dominated by quartzite containing local quartz-pebble conglomerate underlain by metalimestone, mica schist, amphibolite, and more quartzite. The steep hillsides are scree covered with few rock exposures.

Based on some earlier studies, the hill is interpreted as a gravity slide originating from the west (King, 1964; Blackstone, 1973). Drilling data from nearby oil tests also provide support that Cooper Hill is an allochthonous block (Paul J. Graff, personal communication, 1991). It is still unclear whether Cooper Hill is a gravity slide or an overthrust salient.

A 1:12,000-scale map of the district was completed, and many of the mine dumps, veins, and placers along nearby Cooper Creek were sampled. Several mines and prospects were developed on veins and skarns. Although none of the mines were accessible during this study, historic accounts suggest that at least one mine may have had as much as 1,300 feet of development (Hausel, 1992b). Lode samples collected during this study were generally poorly mineralized with only a few exceptions. Probably the most interesting mineralization occurred at the Albion mine where galena-bearing quartz occurs with credits in gold and silver. Placers sampled along Cooper Creek were anomalous in gold. Essentially all of the panned concentrates collected along Cooper Creek yielded some visible gold (Hausel and others, 1992).

Aspen Mountain, south of Rock Springs: Quaking Asp Mountain, also known as Aspen Mountain, was investigated for possible disseminated gold. This hill rises 1,700 to 1,800 feet above the surrounding basin and is preserved due to intense and widespread silicification over a 20- to 30-square-mile region.

Exploration of this area for oil and gas began a few decades ago, and geologist E.R. Keller, with Mountain Fuel Supply Company, discovered an eight-foot-thick bed of alunite from drill cuttings of an oil and gas well on the south flank of Aspen Mountain in 1957. This zone was later trenched and investigated by the U.S. Geological Survey in 1958 and 1960 (Love and Blackmon, 1962). A core hole

was also drilled about a mile southwest of the trench and penetrated 6 feet of white claystone at 145 feet, suggesting the alunite may be relatively widespread. Nearly 200 feet southeast of this second core hole, a gas well cut through 3,704 feet of hard, silicified, Cretaceous sandstone and shale (Love and Blackmon, 1962).

Aspen Mountain is comprised of Cretaceous shales and sandstones. The hill is capped by highly silicified, fine- to medium-grained sandstone and quartzite of the Rock Springs Formation (Upper Cretaceous), which is underlain by highly silicified, gray, silty and sandy shale interbedded with gray siltstone and fine-grained sandstone of the Blair Formation (Upper Cretaceous).

Locally, both of these formations are unconformably overlain by sandstone facies of the Bishop Conglomerate (?) (Oligocene). The Bishop Conglomerate (?) is a gray, yellow-green, and white, subrounded to well-rounded, fine to coarse-grained tuffaceous to limy sandstone, yellowish-green mudstone, white, silty to sandy tuff, and tuffaceous conglomerate containing some angular gray siltstone, sandstone, and quartzite rock fragments. Love and Blackmon (1962) and others place the alunite-bearing claystone within the Bishop Conglomerate. The lower part of this unit includes gray silicified sandstone with some secondary chert. The alunite-bearing claystone appears to be stratified (Love and Blackmon, 1962).

Where the silicification is intense, the sandstones have been converted to hard quartzites containing some secondary kaolinite. In many places, the sandstones are so intensely silicified that they ring when struck by a hammer. Locally, zones of banded chert occur within the silicified zone.

Some other interesting features of the Aspen Mountain area include a hydrogen sulfide spring, small travertine deposits, and local occurrences of free sulfur in the silicified zone.

During the study, 94 rock chip, soil, and stream sediment samples were taken in and around the silicified zone on Aspen Mountain. In addition, the National Uranium Resource Evaluation (NURE) stream sediment sample data were examined for this region. None of the NURE samples contained detectable gold. Of the samples collected by the Geological Survey of Wyoming, 16 contained trace amounts to a maximum of only 0.115 ppm Au (only 8 of the samples contained measurable gold). All of these lie within the Aspen Mountain silicified zone.

Arlington gold placer, Medicine Bow Mountains: Sand and gravel deposits were sampled at several locations in southern Wyoming during the summer of 1991 (Hausel and others, 1992). Possibly, the most interesting sand and gravel deposits were those of the Arlington area on Rock Creek. Available historic reports indicate that within the early part of 1876, placer gold was discovered on Rock Creek along the old Overland Trail. In May, 1877, ditches were constructed to supply water for hydraulic mining operations for the area, but the camp was abandoned within a few years (*Wyoming Industrial Journal*, 1907, v. 9, no. 4, p. 4).

Twenty years later, in 1897, placer operations began again on Rock Creek, and three miles of ditches with 1,300 feet of flume were constructed running from Foote and Wagon Hound Creeks to Rock Creek. The placer gravel was reported to be 4 to 9 feet deep with widely dispersed and granular gold (*Engineering and Mining Journal*, 1897, v. 63, June 5, p. 583). Two hydraulic Giants were operated day and night washing 20,000 cubic yards of gravel in a 20-foot face on the east bank of Emigrant Gulch. The gravel reportedly averaged $0.75/yd^3 gold (1897 prices), and additional Giants were planned (*Engineering and Mining Journal*, 1897, v. 63, June 26, p. 673).

The Geological Survey of Wyoming collected samples in the Arlington sand and gravel pit. Panned concentrates contained visible gold. Farther upstream in Rock Creek, placer samples also panned visible gold. Concentrates from both of these sample sites were assayed and yielded more than 100 ppm gold. Several other sand and gravel samples collected in southern Wyoming also yielded anomalous gold (Hausel and others, 1992).

Titaniferous black sandstones, Rock Springs uplift: Several Cretaceous age titaniferous black sandstones from the Rock Springs Formation along the flank of the uplift were sampled for gold, iron, titanium, zirconium, and rare earth elements. A few samples yielded trace gold (none to 0.100 ppm), anomalous iron (16.56% to 33.58% Fe), anomalous titanium (7.95% to 40.74% TiO_2), trace zirconium (<0.2% to 1.41% ZrO_2), and anomalous rare earth elements (2,784.2 ppm to 6,115.6 ppm total rare earths).

Rawlins hematitic conglomerate: Samples of hematite-cemented Flathead conglomerate (Cambrian) and arkosic conglomerate (Cambrian ?) were collected for analyses from the Rawlins uplift. Chip and composite chip samples of the hematitic conglomerate yielded 1.51 to 47.9% iron and no detectable gold. One sample was crushed and concentrated and yielded detectable gold (2.4 ppm). The arkosic conglomerate contained no detectable gold and 520 to 690 ppm total rare earth elements (4 to 5 times average crustal abundance).

Coal: Coal deposits were sampled by Gordon Marlatt at a few localities in southern Wyoming and tested for gold (Hausel and others, 1992). In particular, coal from Walcott Junction and from the Black Buttes coal mine were tested. Samples from Walcott Junction yielded no gold to a high of 0.11 ppm gold (most samples yielded no detectable gold). Coal and carbonaceous shale samples from the Black Butte mine yielded similar results (none to 0.1 ppm Au), however, a relatively large number (42%) of these samples yielded anomalous gold values.

Limestone: Fossiliferous limestone from Delany Ridge near Wamsutter contained anomalous gold. Samples collected in this region yielded none to 0.18 ppm gold (Hausel and others, 1992).

Ultramafic schist

Ultramafic schists are assumed to be important source rocks for a variety of metal resources. A few years ago, an investigation of these rocks (which occur

in many Wyoming supracrustal belts) was initiated by the Geological Survey of Wyoming. Recently, samples were collected on Casper Mountain, South Pass, and the Seminoe Mountains for analysis (Figure 19). Some results from South Pass and the Seminoe Mountains were recently published, and new data from Casper Mountain and South Pass supracrustal belts are now available.

Casper Mountain: Samples of ultramafic schist and serpentinite collected on Casper Mountain yielded 19.65% to 35.7% MgO (21.2% to 40.5% MgO volatile-free-basis), 225 ppm to 1,456 ppm Ni, 0.42% to 17.01% Cr_2O_3, and <0.005 ppm to 0.006 ppm Au. Anomalous chromium-bearing samples were collected in an area where the U.S. Bureau of Mines reported chromite deposits in 1949.

South Pass: A group of cumulate-textured serpentinite samples collected in 1991 near the Atlantic City iron ore mine were analyzed. These samples yielded, 18.25% to 30.41% MgO (19.34% to 34.4% MgO volatile-free-basis), 704 ppm to 1,092 ppm Ni, 0.20% to 3.46% Cr2O3, and <0.005 ppm to 0.148 ppm Au. Anomalous chromium was first noted in this area by Hausel (1991), and the 3.46% Cr_2O_3 is the highest value reported to date.

References cited

Blackstone, D.L., Jr, 1973, Structural geology of the eastern half of the Morgan Quadrangle, the Strouss Hill Quadrangle, and the James Lake Quadrangle, Albany and Carbon Counties, Wyoming: Geological Survey of Wyoming Preliminary Report 13, 45 p.

Hausel, W.D., 1991, Economic geology of the South Pass granite-greenstone belt, southern Wind River Range, western Wyoming: Geological Survey of Wyoming Report of Investigations 44, 129 p.

Hausel, W.D., 1992a, Geology and mineralization of the Copper Creek area and nearby prospects, Encampment mining district, Sierra Madre, Wyoming: Geological Survey of Wyoming Mineral Report 92-2 (unpublished), 3 p.

Hausel, W.D., 1992b, Economic geology of the Cooper Hill mining district, Medicine Bow Mountains, Wyoming: Wyoming Geological Association 43rd Annual Field Conference Guidebook, in press.

Hausel, W.D., Marlatt, G.G., Nielsen, E., and Gregory, R., 1992, Preliminary study of precious metals and stones along the Union Pacific right-of-way of southern Wyoming: Geological Survey of Wyoming Mineral Report 92-1 (unpublished), 63 p.

King, J. S., 1964, Cooper Hill- a gravity slide in the northeastern Medicine Bow Mountains, Wyoming: University of Wyoming Contributions to Geology, v. 3, no. 1, p. 33-37.

Love, J. D., and Blackmon, P. D., 1962, Alunite on Aspen Mountain, southwestern Wyoming: U.S. Geological Survey Professional Paper 450 D, p. 11-15.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1991)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.7	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.3	billion barrels
Remaining Reserve Base (January 1, 1991)		
Measured reserves (Proved reserves) (Includes 0.79 billion barrels of oil, 0.66 billion barrels of gas liquids, and 0.10 billion barrels of condensate)	1.55	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.35	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1991)		
Discovered (Includes 21 trillion cubic feet (TCF) of methane[1] and 122.1 TCF of CO_2[3])	143.1	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,850.3	trillion cubic feet
Remaining Reserve Base (January 1, 1991)		
Measured reserves (Proved reserves) (Includes 10.4 TCF of methane[2] and 60.7 TCF of CO_2[3])	71.1	trillion cubic feet

COAL

Remaining Resources (January 1, 1991)		
Identified and Hypothetical (Discovered)	1,428.6	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,460.1	billion tons
Remaining Reserve Base (January 1, 1991)		
Demonstrated strippable (Measured and indicated reserve base)	27.0	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	69.5	billion tons

TRONA

Original Resources (1990 estimate)		
Trona	81.0	billion tons[8]
Mixed trona and halite	52.7	billion tons[8]
Total	133.7	billion tons

URANIUM

Remaining Resource (December 31, 1989)	1.99	billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1989)		
Uranium oxide recoverable at $30.00 per pound	66	million pounds[9]

OIL SHALE

Original Resources (January 1, 1981)		
Identified (Discovered)	320	billion barrels of shale oil[10]

[1] Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.
[2] Modified from Energy Information Administration, 1991, U.S. crude oil, natural gas, and natural gas liquids reserves: 1990 Annual Report, September.
[3] De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.
[4] Jones, R.W., and De Bruin, R.H., 1990, Coalbed methane in Wyoming: Geological Survey of Wyoming Public Information Circular 30, 15 p.
[5] Law, B.E., and others, 1989, Estimates of gas resources in overpressured low-permeability Cretaceous and Tertiary sandstone reservoirs, Greater Green River Basin, Wyoming, Colorado, and Utah: Wyoming Geological Association, 40th Annual Field Conference Guidebook, Casper, Wyoming p. 39-61.
[6] Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000 scale (color) and 44 p. pamphlet.
[7] Geological Survey of Wyoming, January, 1992. (Modified from Berryhill, H.L., Jr. and others, 1950), Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.
[8] Modified from Culbertson, W.C., 1983, Genesis and distribution of trona deposits in Wyoming (abstract) in Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19, p. 34.
[9] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.
[10] Knutson, 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.

GEOLOGIC MAPPING AND STRATIGRAPHY

by Alan J. Ver Ploeg
Staff Geologist - Geologic Mapping, Geological Survey of Wyoming

SUMMER MEETING TO EMPHASIZE MESOZOIC OF THE WESTERN INTERIOR

The Society of Economic Paleontologists and Mineralogists (SEPM) will sponsor a theme meeting on the Mesozoic of the Western Interior, August 17-19, 1992, in Fort Collins, Colorado, on the campus of Colorado State University. The meeting will include technical sessions, special symposia, poster sessions, and pre- and post-meeting field trips focusing on the stratigraphy and sedimentation, geologic history, and economic geology of the Western Interior Basin.

Specifically, there will be a technical session and a poster session devoted to Western Interior Cretaceous Projects (WIK), an ongoing series of projects to compile a data base from which to reconstruct and interpret the depositional history within the Western Interior Cretaceous Basin. WIK is described in more detail in *Wyoming Geo-notes No. 28*, p. 41-42 and *Wyoming Geo-notes No. 25*, p. 39.

For more information on the meeting and topics to be discussed, contact Dr. Frank G. Ethridge at the following address:

Dr. Frank G. Ethridge
Department of Earth Resources
Colorado State University
Fort Collins, CO 80523
(303) 491-5661

NEW ARTICLES ON WYOMING GEOLOGY PUBLISHED

Four new articles on Wyoming geology and hydrology were recently published in scientific journals. Various workers discussed research done in the Wamsutter Arch area, the Wind River Basin, and the Bighorn Basin.

Gerald K. Arp, of ARCO Oil and Gas Company, recently published a paper describing the vegetative anomaly over Patrick Draw Field (Figure 20). The paper is titled: "An integrated interpretation for the origin of the Patrick Draw oil field sage anomaly". The Patrick Draw Field has been the site of research into surface and remote sensing methods for hydrocarbon exploration for nearly ten years. The oil field has a conspicuous tonal anomaly within the sage overlying the field's gas cap, especially visible on Landsat images. This article (Arp, 1992) attempts to resolve the controversy over whether the anomaly is related to oil field factors or to other independent factors. Arp concludes that the anomaly does indeed result from upward migration of gases and reservoir formation waters injected as part of the reservoir pressure maintenance program for the field. There appears to be no evidence of climatic involvement in the development of the anomaly. Also, Arp feels the lag time between reservoir injection and the effects of massive seepage

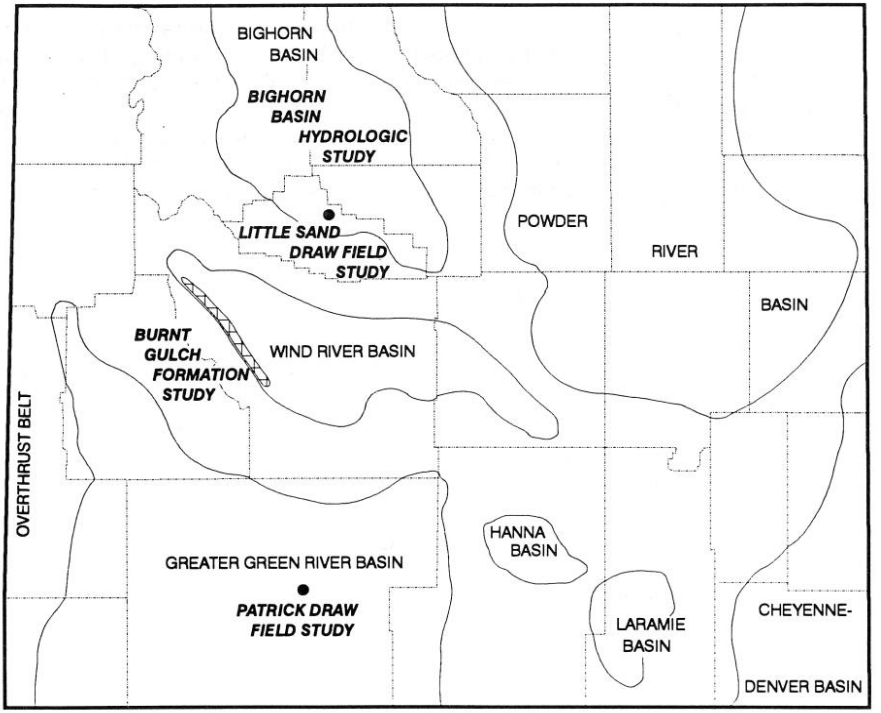


Figure 20. Index of recent geologic research in Wyoming.

at the surface, and the continued effects at the surface after injection ceased, have been overlooked and may have led to misinterpretation by previous workers.

T.R. Garfield, N.F. Hurley, and D.A. Budd recently completed a research project on the porosity and permeability characteristics of Little Sand Draw Field in the Bighorn Basin (Figure 20). Their paper is titled: "Little Sand Draw Field, Bighorn Basin, Wyoming: A hybrid dual-porosity and single-porosity reservoir in the Phosphoria Formation" (Garfield et al, 1992). The authors examined porosity and permeability characteristics exhibited by well core from 14 wells within the field, relating this data to rock type and depositional environment. The field, which appears to be compartmentalized with respect to the type of predominating porosity and permeability, exhibits three basic compartments. Studies indicate two types of single-porosity and one type of dual-porosity flow behavior occur within this reservoir. The authors feel this compartmentalization is probably present within other fields in the Bighorn Basin, which produce from the same reservoir.

J.D. Bredehoeft, K. Belitz, and S. Sharp-Hansen have completed a research project on the hydrodynamics of the Bighorn Basin (Figure 20). Their article is entitled: "The hydrodynamics of the Bighorn Basin: A study of the role of faults"

(Bredehoeft et al, 1992). The authors used a three-dimensional mathematical model to simulate groundwater flow in the Bighorn Basin of Wyoming. The model tests whether faults within the basin serve as horizontal barriers to water flow or as vertical conduits to flow. Previous workers have either ignored the faults in the basin or treated them as barriers to horizontal flow. Bredehoeft et al feel that the faulting actually serves as vertical conduits for flow. Although the model suggests that both interpretations are plausible, the actual measured hydraulic heads for portions of the basin best fit the vertical conduit interpretation.

W.D. Martin, R.G. McWilliams, and M. Kochan published the results of their work on the Burnt Gulch Formation of the Wind River Basin (Figure 20). Their paper is titled: "Occurrence and significance of the Burnt Gulch Formation: A Pliocene-Pleistocene fanglomerate, Wind River Basin, Wyoming" (Martin et al, 1992). The authors examined the Burnt Gulch Formation in eight localities along the northeast flank of the Wind River Range. Some previous workers concluded that the Burnt Gulch Formation represents a coarse grained facies of the lower Eocene Wind River Formation. Martin et al present evidence that the formation is a Pliocene-Pleistocene fanglomerate.

References cited

Arp, G.K., 1992, An integrated interpretation for the origin of the Patrick Draw oil field sage anomaly: American Association of Petroleum Geologists Bulletin, v. 76, no. 3, p. 301-306.

Bredehoeft, J.D., Belitz, K., and Sharp-Hansen, S., 1992, The hydrodynamics of the Big Horn [sic] Basin: A study of the role of faults: American Association of Petroleum Geologists Bulletin, v. 76, no. 4, p. 530-546.

Garfield, T.R., Hurley, N.F., and Budd, D.A., 1992, Little Sand Draw Field, Big Horn [sic] Basin, Wyoming: a hybrid dual-porosity and single-porosity reservoir in the Phosphoria Formation: American Association of Petroleum Geologists Bulletin, v. 76, no. 3, p. 371-391.

Martin, W.D., McWilliams, R.G., and Kochan, M., 1992, Occurrence and significance of the Burnt Gulch Formation: A Pliocene-Pleistocene fanglomerate, Wind River Basin, Wyoming: The Mountain Geologist, v. 29, no. 1, p. 29-40.

GEOLOGIC HAZARDS IN WYOMING

by James C. Case,
Staff Geologist-Geologic Hazards, Geological Survey of Wyoming

LANDSLIDE AT LANDER

An active landslide, classified as a slump/debris block slide complex, has caused some concern in the town of Lander. The landslide, which is located in SE SE sec. 18, T33N, R99W, southeast of the Popo Agie River and south of the

intersection of Highways 287 and 789, has a head scarp located within ten feet of Buena Vista Drive in Lander.

Buena Vista Drive was constructed on relatively flat-lying terrace deposits and colluvium located on top of the Cretaceous Cody Shale. The landslide formed in colluvium and slope wash deposited on top of an erosional scarp that formed along the edge of the terrace. Those hillslope materials are also located on top of the Cody Shale.

Although a detailed study has not been conducted, it is probable that last year's heavy precipitation led to the destabilization of the slope. Many types of landslides can be formed as a result of increases in precipitation, especially in semi-arid areas such as Wyoming. Since many areas of the State did have greater than normal amounts of precipitation last year, there may be more landslides than usual this year. Any unusual cracks or deformation in surficial materials or bedrock could be indicative of a landslide forming. If any unusual features are noticed, please call Jim Case at the Geological Survey of Wyoming (307-766-2286).

RADON

The Geological Survey of Wyoming's (GSW's) Radon Sampling Program has been underway since January, 1992. Twelve sample sites have been selected in the Laramie Basin, and those sites are monitored on a weekly basis. Each of the sites is on a distinct soil type and geomorphic feature. The primary purpose of the program is to determine if relative radon relationships that are observed among the sites during one sample period are repeatable. If the relationships are repeatable, then the sampling and measurement techniques may make it possible to rapidly characterize large areas with some degree of confidence. This will be of importance not only for homeowners concerned about radon, but also for future uranium investigations in the State.

Soil permeability, soil moisture, soil temperature, and barometric pressure can all have an effect on radon release and migration. Soil moisture, however, may be the most significant variable. A variety of techniques for determining soil moisture were examined to find the best method for the Laramie Basin. A fiberglass and metal resistivity-type moisture cell was selected for this project as the cells do not dissolve and can be buried for a long period of time (Colman and Hendrix, 1949).

A few techniques require that a permanent borehole be installed at the site. Those techniques were not chosen due to concerns that the borehole, even with casing in it, may serve to slowly degas the site. Other techniques require that a soil sample be extracted and analyzed in a laboratory for each moisture determination. Those techniques were not chosen as the many boreholes would result in a rapid degassing of the site. Another technique, using buried gypsum blocks, was not used because the blocks have a tendency to dissolve over a long period of time.

For three months, the GSW tried to calibrate the moisture cells. Each cell has to be calibrated to the soil in which it will be placed. It has become apparent that salts and carbonates present in the soils can hamper the accurate calibration of the cells.

Soil-gas radon samples have been collected at the twelve sites in the Laramie Basin. Radon levels to date have varied from 122 picocuries per liter of air to over 1,100 picocuries per liter. Soil-gas radon samples in this range are not abnormal. This range of radon levels will allow for a good comparative study. Updates on this project will be presented in future issues of *Wyoming Geo-notes*.

Reference cited

Colman, E.A., and Hendrix, T.M., 1949, The fiberglas [sic] electrical soil-moisture instrument: Soil Science, v. 67, p. 425-438.

1991 MINERALS EXPLORATION SUMMARY FOR WYOMING

by W. Dan Hausel, Ray E. Harris, and Richard W. Jones
Geological Survey of Wyoming

METALS AND PRECIOUS STONES

During 1991, companies and prospectors conducted some exploration for gold, base metals, and diamonds in Wyoming. No significant discoveries were reported.

Arlington, Medicine Bow Mountains

Panned concentrates collected by the Geological Survey of Wyoming (GSW) from a sand and gravel deposit at Arlington, Wyoming, yielded anomalous gold (>100 ppm). Some colors were also recovered from the concentrates. This area drains Proterozoic metasedimentary rocks (including quartz pebble conglomerates) in the northern Medicine Bow Mountains (Figure 19).

A review of the historic mining literature for this area revealed that it was initially included in the Herman mining district and that the area was hydraulically mined for gold in the 1870s and 1890s. Currently, the sand and gravel is mined for road metal.

Cooper Hill district, Medicine Bow Mountains

In 1991, the Cooper Hill mining district was investigated and mapped at 1:12,000 by the GSW (Figure 19). Little is known about the district although minor amounts of copper, gold, silver, and lead were mined in the late 1800s. The district occurs in a folded miogeoclinal succession of Proterozoic age metamorphic rock along the northeastern edge of the Medicine Bow Mountains.

Samples collected from veins, skarns, various mine dumps, and nearby placers were analyzed for metal content (Hausel and others, 1992). Possibly the most interesting metal values were obtained from nearby placers and sand and gravel deposits. Samples collected at several locations on nearby Cooper Creek contained visible gold.

Diamond exploration

An Australian company reportedly explored for diamondiferous kimberlite in the Colorado-Wyoming State Line district. The company is currently seeking permits in Colorado and Wyoming to conduct tests on the Kelsey Lake intrusives. To date, more than 100,000 diamonds have been recovered by mining companies in the State Line district (McCallum and Waldman, 1991).

A major mining firm reportedly conducted reconnaissance exploration for diamondiferous lamproite in the Leucite Hills north of Rock Springs. No discoveries have been reported. The GSW's preliminary testing of olivine-bearing lamproite in this same area has been negative.

Encampment district, Sierra Madre

The GSW investigated the historic Kurtz-Chatterton copper mine in the Encampment district for precious metals (Figure 19). The mine produced high-grade copper near the turn of the century. Additional production occurred during World War I and II when the mine dumps were high-graded for the war effort (Duane Cruz, personal communication, 1992).

A brief reconnaissance survey of the property found numerous prospect pits with mineralized rock. Ore specimens collected from the property were taken over a strike length of 2,500 feet (the mineralized zone could extend another 1,000 to 1,500 feet based on mineralized samples collected from a mine dump farther to the east). The width of the mineralized zone swells from a relatively narrow width to possibly 800 to 1,000 feet at one point. Selected samples were collected to test for precious metal content of the copper ore since no data are available on the precious metal values of the ore. The samples yielded 0.7% to 12.55% Cu, none to 28.1 ppm AU, none to 7.34 ppm Ag, and none to 0.8% TiO_2.

Much of the mineralization appears to be localized in quartz veins and veinlets, and in rehealed and sheared Sierra Madre granite. Some localized zones of secondary biotite, chlorite, and muscovite are associated with mineralized rock.

Hartville uplift

The 1991 field season began with a claim staking rush in the Hartville uplift in eastern Wyoming. Three to four companies, including two majors, were involved in the rush. The activity was centered around metasedimentary-hosted massive sulfide targets (Houston and others, 1992).

The Hartville uplift is interpreted as an Archean eugeoclinal terrane form of a succession of hematite schist, metadolomite, metabasalt, and pelitic schist unconformably overlain by Paleozoic carbonates. The district has had a past history of copper, silver, uranium, and iron mining. Past iron ore production amounted to more than 45 million tons.

Porphyry copper-silver, Absaroka Mountains

The Absaroka Mountains in northwestern Wyoming represent a deeply dissected Tertiary volcanic plateau (Figure 19). Two porphyry copper-silver deposits lie outside the wilderness and have been receiving interest by private industry. These are the Kirwin and Sunlight Basin porphyries south of Cooke City, Montana.

Quaking Asp Mountain, Rock Springs

The GSW investigated an enigmatic silicified zone south of the town of Rock Springs during 1991. The silicified zone covers an area of about 20 to 30 mi^2 and continues to a depth of 3,700 feet based on past drilling in the area for oil and gas.

The area was initially investigated by the U.S. Geological Survey in 1962 because of the discovery of alunite along the southeastern margin of the silicified zone. More recently, the U.S. Geological Survey identified some travertine deposits along the western edge of the silicified zone.

Most of the seventy-nine samples collected in the area contained no detectable gold. However, a few chip samples yielded a trace to a maximum of 0.115 ppm Au (Hausel and others, 1992). Further investigations are planned.

South Pass (Wind River Range)

Private industry conducted reconnaissance exploration for lode gold in the South Pass region along the southern tip of the Wind River Range in western Wyoming, although no major developments occurred (Figure 19). South Pass is interpreted as an Archean greenstone belt with greenschist to amphibolite facies metavolcanic, metasedimentary, and plutonic rocks folded into a regional synclinorium. The greenstone terrane is exposed over a region of 200 to 250 mi^2, and continues to the south under a thin Tertiary cover. Two historic mining districts lie in the greenstone terrane and extensive paleoplacers lie along the southern and northeastern margins of the belt. Gold occurs in shear zones, quartz veins, quartz-copper-carbonate veins, and in Tertiary paleoplacers and modern placers.

Exploration and testing of a previously untested gold paleoplacer were reported by the Goldstake-Sawatch Gold Placers, Inc. joint venture south of Atlantic City. Placer gold was also recovered at the Stout placer mine on Rock Creek. The Gyorvary Mining Company continued work at the Mary Ellen gold mine also in the South Pass-Atlantic City district. Gyorvary received a mine permit from the State at the beginning of the season.

INDUSTRIAL MINERALS

There was continued exploration for industrial minerals and construction materials in Wyoming in 1991. Many companies producing industrial minerals expanded their operations during the year and some companies were exploring for resources for new commodities.

The five producers of soda ash from mined trona in Wyoming were constructing expanded or new facilities. In addition, two non-producers were exploring for new deposits. BWAB, Inc., a Denver Company, announced in late 1990 that it planned to explore by drilling for black trona water near Farson, Wyoming, north of the existing trona mining area, and continued to test this area in 1991 (Figure 17). Evergreen Enterprises, of Casper, Wyoming, applied for a permit to explore for trona on its leases east of and adjacent to Rhône-Poulenc's property northwest of Green River.

Developmental exploration for bentonite continued in the Bighorn Basin district, in the Kaycee district in Johnson County, and in the Black Hills bentonite district (Figure 17). Wyoming continues as the largest producer of bentonite in the Nation.

Exploration for construction aggregate, including railroad ballast, continued in Wyoming in 1991. Dolomite from near Guernsey in east-central Wyoming was used by the state of Nebraska for highway road base and sub-base material. There was a great increase in exploration for construction aggregate in the Green River Basin in southwestern Wyoming, in an effort to locate sources close to the new construction projects at the soda ash plants.

In regard to railroad ballast, Lamb Construction, of Torrington, Wyoming, located a source of gneissic granite south of Lusk in Niobrara County and produced 750,000 tons for the Chicago North Western Railroad. In a related development, Meridian Aggregates, located at Granite, 20 miles west of Cheyenne, diversified their product line and now sells sized granitic aggregate for construction purposes as well as railroad ballast (Figure 17).

Decorative aggregate was shipped from Wyoming in 1991, and several companies explored for some of the many colored rocks found in the state. With the assistance of the Geological Survey of Wyoming (GSW), sources of rose quartz, green serpentine, and pink feldspar were developed for landscape rock and other uses.

In June, 1991, Sunrise Stone shipped the first block of black granite (amphibolite) from a quarry in northeastern Albany County, which was located with the help of the GSW (Figure 17). The black granite is known as "Wyoming Raven", and is shipped to a fabricating plant in Mena, Arkansas. This stone may be the blackest rock in production in the world. Sunrise Stone and the GSW also explored a dark purple rock locality and a dark brownish-black rock locality in the Medicine Bow Mountains in southwestern Albany County.

At least two other stone producing companies were interested in samples of decorative rock from Wyoming. Rocky Mountain Stone, of Longmont, Colorado, explored for and leased sources of buff and white sandstone. Rocky Mountain Stone was in the process of constructing a fabricating plant at Longmont at year's end.

In 1991, the publication of the Geological Survey of Wyoming's Public Information Circular 31, *Decorative stones of Wyoming* caused several stone suppliers and producers to request samples of granite and marble from Wyoming, and, in early 1992, Georgia Marble requested blocks of black-and-gold and dark red marble for possible inclusion in their product line.

Mountain Cement, which operates a cement plant at Laramie, explored for gypsum, shale, and limestone to add to its reserves of these materials. A new gypsum source was located south of Laramie, and is now being used as the source of gypsum for the plant (Figure 17). The plant also uses a siliceous shale in its cement process, as well as small amounts of iron oxide and other minor additives. A new siliceous shale locality was explored for and developed southwest of the plant.

Limestone was the target for exploration by two companies in Wyoming in 1991. Pete Lien, Inc., of Rapid City, South Dakota, explored for and located another deposit of high-purity limestone 11 miles northeast of Laramie. The company decided that a location discovered in 1990 was uneconomical due to mining restrictions related to its proximity to a housing development. At year's end, the company's plans to construct a lime plant at the site were on hold pending renewed strength in the lime market. Dakota Coal, Inc., which originally announced plans to construct a lime plant near Guernsey, in eastern Wyoming, decided instead to construct the plant at Frannie, in northwestern Wyoming. The limestone used as a source for the lime will initially come from the Warren Quarry in Montana. The company has plans to explore for limestone sources in Wyoming, east of Frannie. Lime from this plant will be used as a stack-gas scrubbing agent in coal-fired power plants.

In 1991, a Dallas, Texas, company, Greenbelt Earth Sciences, Inc. conducted exploration for leonardite, a naturally occurring oxidation product of coal. Greenbelt located a source in Wyoming and established a processing and packaging facility in Casper. Leonardite is used in drilling fluids, wood stain, and, in the case of Greenbelt's product, as a soil conditioner-fertilizer. Greenbelt continues to explore for new sources of leonardite.

In late 1991, the GSW and a private company sent some samples of mineral pigments including iron oxides, colored clay, and colored marble to an Arizona company, Swansea Minerals, for testing for their mineral pigment product line. With the exception of iron oxides, these potential pigments represent new uses for some colored rocks. In Wyoming, Georgia Marble produces white marble aggregate and sells the finely ground marble as pigment (Figure 17).

The GSW and the Wyoming Division of Economic and Community Development continue to assist several companies in plans to develop silica resources in Wyoming. These resources are being examined for their use in the manufacture of glass in Wyoming.

Other commodities that were the subject of exploration efforts in 1991 included zeolites, abrasives, mica, and common clay.

Uranium

There was very little exploration for uranium in Wyoming in 1991. Early in 1992, Pathfinder Mines announced that it was closing its Shirley Basin operations, the last conventional mine and mill in Wyoming (Figure 18). Power Resources continued to conduct developmental drilling for expansion of an in-situ well field on their North Morton Ranch ore body, part of their Highland in-situ operations. Rio Algom continued developmental drilling and construction of an in-situ well field near the former Bill Smith shaft in the southern Powder River Basin. Pathfinder acquired property in the Pumpkin Buttes area of the Powder River Basin in Campbell and Johnson Counties for testing the feasibility of in-situ recovery of uranium, and Kennecott Minerals continued developmental exploration on Green Mountain, south of Jeffrey City, as part of a joint venture called the Green Mountain Mining Venture, with Crested Corp. — U. S. Energy Corp.

COAL

Coal exploration in Wyoming occurred in areas proposed for new coal mines, in tracts adjacent to existing mining operations, and in currently active mine properties. The exploration not only concentrated on proving up reserves and determining coal quality but also supported environmental analyses and baseline studies in the new areas. Although many coal companies operating in Wyoming have emphasized production of existing reserves in recent years (in response to low coal prices, a relatively soft coal market, and a large productive overcapacity), much of the easily accessible or available coal reserves have been mined or committed to contracts. Because of this, some coal companies began exploring for reserves in new areas and assessing coal reserves adjacent to their current operations.

The passage of the Clean Air Act Amendments of 1990 has increased the interest in Wyoming coal. The impending new regulations on power plant emissions forced some coal-burning utility companies to acquire low-sulfur Wyoming coal for the first time in 1991. The large number of coal sales to new users (primarily those utility companies testing the coal) as well as increased

usage by traditional Wyoming coal purchasers pushed Wyoming coal production to 193.9 million short tons in 1991. This was an increase of over five percent from 1990 and set another state production record. Wyoming continued as the Nation's leading coal producing state for the fourth consecutive year and accounted for about 19 percent of the total coal produced in the U.S. in 1991.

In 1991, seven Federal coal exploration licenses in Campbell County were active in Wyoming. Shell Mining Company explored two tracts of Federal coal totalling 8,095.24 acres, Cordero Mining Company explored 40 acres on two tracts, Antelope Coal Company explored on a 449.8-acre tract, Amax Coal Company explored a 1,279.4-acre tract, and Northwestern Resources Company explored a 20-acre tract. With the exception of Northwestern Resources Company, all these exploration programs for Federal coal were near the licensee's active mine property. A total of 9,884.4 acres of Federal coal in the Powder River Coal Field were under exploration license in 1991.

Coal leasing activities in the Powder River, Green River, and Bighorn Coal Fields continued in 1991. Following the decertification of Regional Coal Teams (RCTs), the Federal government went to a lease-by-application system. This replaced the previous system of regional lease sales in response to industry expressions of interest. Through 1991, the Bureau of Land Management had received coal lease applications for 9 tracts under the new system. Coal reserves in those tracts totalled about 1,061 million tons. Six of the lease applications are in the Powder River Coal Field and include about 1,035 million tons; two of the applications are in the Green River Coal Field; and one application is in the Bighorn Coal Field.

While there are no specific figures available, exploration drilling in 1991 was probably greater than in previous years because of the increased interest in new leasing, lease modifications and bypasses, and in development of additional coal reserves elsewhere. Most of the drilling activity was in the Powder River Coal Field, in Campbell and Converse counties; a minor amount of drilling occurred in southern Wyoming.

References cited

Hausel, W.D., Marlatt, G.G., Nielsen, E.L., and Gregory, R.W., 1992, Preliminary study of precious metals and stones along the Union Pacific right-of-way of southern Wyoming: Geological Survey of Wyoming Mineral Report 92-1 (unpublished), 63 p.

Houston, R.S., Hausel, W.D., Woodfill, R.D., and Graff, P.J., 1992, Metallogenic map of volcanogenic massive sulfide occurrences in Wyoming: U.S. Geological Survey Map MF-1835-F, scale 1:1,000,000.

McCallum, M.E., and Waldman, M.A., 1991, The diamond resources of the Colorado-Wyoming State Line district: kimberlite indicator mineral chemistry as a guide to economic potential: Wyoming Geological Association 42nd Annual Field Conference Guidebook, p. 77-90.

NEW PUBLICATIONS

*Publications available from the Geological Survey of Wyoming, free.

*Organization, mission, goals, and authorities of the Geological Survey of Wyoming, Information Pamphlet No. 4, free.

Index to U.S. Geological Survey topographic maps of Wyoming, 1:1,000,000, 1992, $2.00 folded.

*Geologic map of the Miners Delight Quadrangle, Fremont County, Wyoming: Map Series 38, 1992, 1:24,000 (color) - $5.00 folded.

Preliminary geologic map of the Packsaddle Canyon Quadrangle, Johnson County, Wyoming, by Alan J. Ver Ploeg and P.L. Greer: Open File Report 92-1, 1:24,000, $3.50.

Wyoming's carbon dioxide reserves, by R.H. De Bruin: Open File Report 91-6, 1991, $4.00.

Wyoming State Fossil, *Knightia*, postcard, 1992, $.25.

---

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

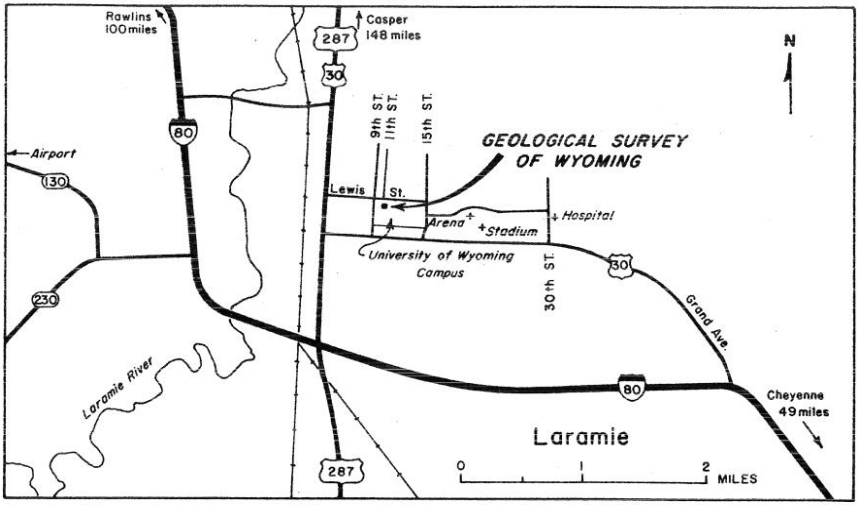
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

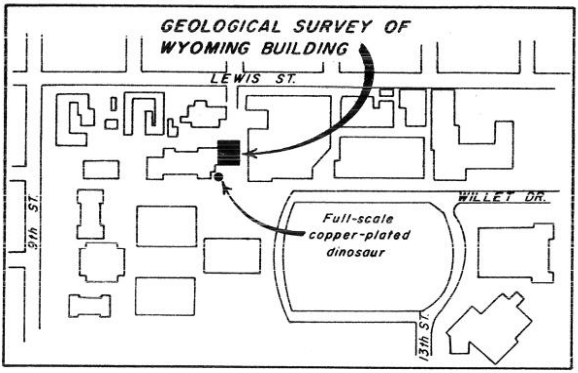
No first class postage charge for prepaid orders, unless otherwise marked.

— WYOMING GEOLOGICAL ASSOCIATION—

By special arrangement with the Wyoming Geological Association (WGA), the Geological Survey of Wyoming now sells all of WGA's Annual Field Trip Guidebooks as well as its Symposium Volumes. These publications are available over-the-counter at the Survey's offices on the University campus in Laramie. Although they can be purchased by mail, prepayment is required. Call the Survey for book prices and postage costs. WGA sale prices will be honored also.

GEOLOGICAL SURVEY OF WYOMING
LOCATION MAPS





ORDER FORM

Send this order and make checks payable to:

The Geological Survey of Wyoming
Box 3008, University Station
Laramie, Wyoming 82071-3008

Your name, address, zip:

_____

_____

_____

_____

_____

Larger orders sent U.P.S. which requires a street address.

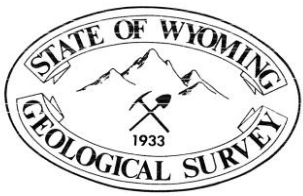
No postage charged on prepaid orders unless otherwise specified.

Quantity	Publication Number	Publication Title	Price	Total Price

Tubes for rolled maps ($1.50 each tube)	
WYOMING RESIDENTS ADD 5% SALES TAX (or furnish proof of exempt status)	
TOTAL ENCLOSED	

Prices are subject to change.

(4/92)


STATE OF WYOMING
1933
GEOLOGICAL SURVEY