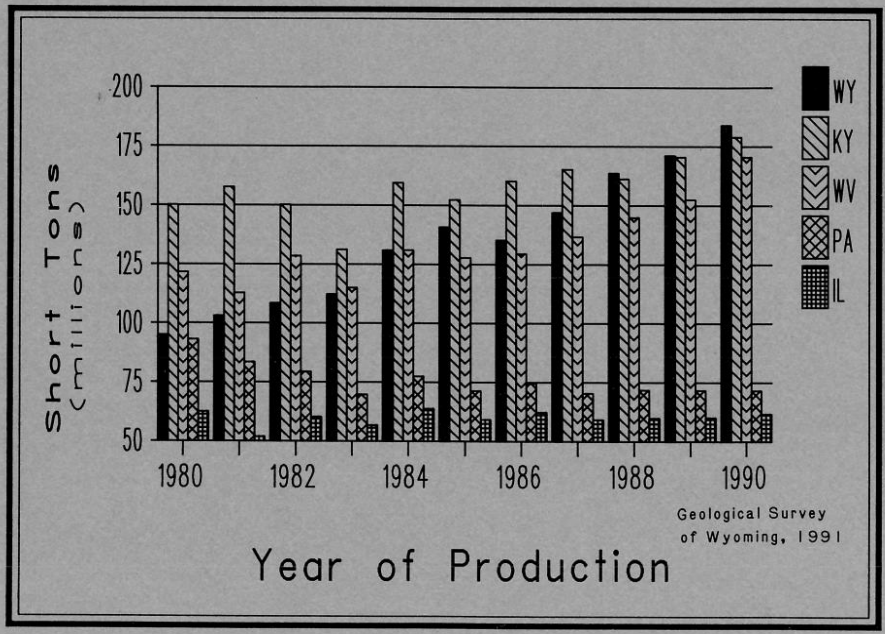
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES
NO. 30



LARAMIE, WYOMING
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WYOMING GEO-NOTES
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Cover: A decade of coal production from the five largest coal-producing states shows Wyoming's advance to the number one position in 1988.

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MINERALS UPDATE

OVERVIEW

by Gary B. Glass, State Geologist

At the end of the fourth quarter of 1990, the world was braced for the impending war in Iraq. Before the end of the first quarter of 1991, the war had started and ended. And as a result of these events, the average posted price of Wyoming crude oil fell every month since its October high of $35. By March, 1991, the average posted price for Wyoming sweet was under $20 per barrel. This translates into a first purchase price below $18, which is less than the average first purchase price in 1990. The $21 in 1990 was the highest average price since 1985 (Table 1). For the near-term, posted oil prices now look like they may stay down in the high teens and low 20s, which is not that much different from what they were before Iraq's invasion of Kuwait. There is still a downside risk of even lower prices in 1991.

Petroleum Information's preliminary estimate of 1990 oil production from Wyoming is 103.8 million barrels, which is slightly below our estimate of 104.4 million barrels (Table 2). As expected, production declined about five percent from 1989 production.

Table 1. AVERAGE PRICE PAID FOR WYOMING OIL, NATURAL GAS, COAL, TRONA, AND URANIUM, FORECAST TO 1994[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	21.05[7]	1.38	8.29	44.00	19.00
1991	17.00	1.35	7.94	45.00	20.00
1992	17.00	1.48	7.59	46.00	21.00
1993	17.00	1.63	7.24	46.00	21.50
1994	17.00	1.80	6.99	47.00	22.00

* Actual value for comparison.

1 Modified from Consensus Revenue Estimating Group, Wyoming State Government Revenue Forecast FY91-FY95, October, 1990, 18 p.

2 First purchase price in dollars per barrel.

3 Wellhead price in dollars per MCF (includes carbon dioxide).

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

5 Dollars per ton of trona.

6 Uranium prices are all estimated by the Geological Survey of Wyoming (January, 1991); in dollars per pound of yellowcake (weighted average price for in-situ and surface-mined uranium).

7 Estimated price from EIA.

Table 2. WYOMING MINERAL PRODUCTION, FORECAST TO 1994[1].

Calendar Year	Oil[2]	Methane[3]	Carbon Dioxide[3]	Helium[4]	Coal[5]	Trona[5]	Mined Uranium[6]	In-situ Uranium[7]	Sulfur[8]
*1981	122.1	455.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	465.1	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	539.7	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	600.1	—	—	130.7	11.0	1.6	—	0.71
*1985	131.0	597.9	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	563.2	23.8	0.15	136.3	11.9	0.2	—	0.76
*1987	115.9	619.0	114.2	0.86	146.5	12.4	0.2	0.06	1.19
*1988	114.3	701.6	110.0	0.83	163.6	14.9	0.3	1.40	1.06
*1989	109.1	739.0	126.1	0.94	171.1	16.2	0.1	1.07	1.17
1990	104.4	817.0	127.0	0.95	*184.0	16.9	0.45	1.0	1.17
1991	102.3	841.5	127.0	0.95	187.6	17.5	0.45	1.5	1.17
1992	100.3	894.0	127.0	0.95	196.4	18.5	0.45	4.0	1.17
1993	98.3	1,015.0	127.0	0.95	205.0	20.0	0.45	4.0	1.17
1994	96.3	1,034.0	127.0	0.95	214.0	20.0	0.45	6.0	1.17

*Actual values for comparison; [1]Geological Survey of Wyoming, April, 1991; [2]millions of barrels; [3]billions of cubic feet (includes rented CO_2); [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]millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1989-1994 are based on company information); [8]millions of tons (prior to 1989, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission).

Contracted natural gas prices, which had given every indication of starting back up, have also apparently fallen in the first quarter of 1991. And the spot market price at Opal, Wyoming, dipped below $1.10, which is the lowest it has gone since July of 1989. While no one talks about a gas bubble anymore, it is apparent that there is more than an adequate supply of natural gas to meet current market demands.

Development drilling for natural gas in southwestern Wyoming, however, has not been slowed by lower prices. With the Kern River pipeline to southern California already under construction and plans proceeding on the Altamont line from Canada, there are new markets coming open and apparently everyone wants to be ready. Meanwhile, Kern River Transmission Co. has still not made any decision in regard to the State's stipulations on a proposed $250 million loan to the company. The State extended the deadline for Kern River's decision into the second quarter of 1991.

Petroleum Information's preliminary estimate of 1990 natural gas production from Wyoming is 897.8 billion cubic feet. Because their estimate includes all natural gases, our estimates of methane, carbon dioxide, and helium in Table 2 must be added together to get a comparable estimate. Our estimate is 950 billion cubic feet. In either case, 1990 production should be more than 30 percent higher than production in 1989.

As expected, in 1990, coal production from Wyoming mines set another record. The 184 million tons produced in Wyoming exceeded our earlier estimate

of 179.2 million tons. Wyoming also remained the top coal-producing state in the Nation. With no tonnage estimates available for the first quarter of 1991, it is really too early to tell if our forecast of 187.6 million tons for 1991 is low (Table 2).

In the first quarter of 1991, there were no surprises in regard to coal prices. Prices announced during the quarter were under $4.00 per ton. The **COAL UPDATE** in this issue describes 16 new sales of Wyoming coal.

A potential concern for the coal industry was the threatened national railroad strike. A prolonged railroad strike could have had serious consequences for the coal mines in Wyoming since 92 percent of the coal produced in the State is transported by rail. In a year, it takes more than 15,000 unit trains, each with a capacity of 11,000 tons, just to haul this amount of coal to its destinations and another 15,000 trains come back empty. This number equates to more than 82 unit trains a day, coming and going. Because not all coal haulage is by unit train, it actually takes even more trains. An extended strike would have also affected the trona mining companies since most of their products are also shipped by rail.

During the 1991 Session, the Wyoming Legislature extended the two percent severance tax break to the uranium industry for four more years. Although this tax incentive will help, the outlook for the State's uranium industry did not improve in the first quarter. While Wyoming still has the second-largest resource of uranium in the Nation and two active uranium-mining operations, it looks like the future of uranium mining in Wyoming is very much dependent on the fate of import restrictions as well as on the possible sale of Federal uranium stockpiles (see p. 42).

In the first quarter, there was also interest in aggregate, decorative stone, limestone, silica, black trona water, base and precious metals, and diamond.

Table 3. PRODUCTION HISTORY OF SELECTED WYOMING MINERAL COMMODITIES[1].

	1981	1982	1983	1984	1985	1986	1987	1988	1989
Bentonite [2]	4.81	2.35	2.18	3.08	2.59	1.82	2.16	2.32	2.22 [6]
Clay [4]	23.2	15.7	36.4	59.6	35.9	23.2	1.31	61.1	23.6 [1]
Decorative Stone [2]	0.05	0.05	0.07	0.08	0.09	0.07	0.06	0.07 [7]	0.06 [6]
Dolomite [2]	0.87	0.61	0.66	0.86	0.87	0.81	0.46	0.19 [6]	0.15 [6]
Feldspar [4]	0.03	0.17	----	----	----	----	----	----	2.0 [1]
Gypsum [2]	0.28	0.26	0.33	0.33	0.35	0.41	0.35	0.40 [7]	0.20 [6]
Iron Ore [2]	4.67	3.28	2.48	----	----	----	----	----	minor [8]
Limestone [2, 5]	0.72	0.59	0.56	0.65	0.32	0.33	0.32	0.64	0.60 [6]
Sand and Gravel [2, 3]	7.88	6.24	6.72	8.31	6.40	5.01	4.12	3.15	6.46 [6]
Shale [4]	----	----	----	20.3	14.7	9.88	49.0	50.2 [6]	1.8 [1]
Sodium Sulfate [4]	3.20	3.17	3.19	3.25	2.71	2.03	----	2.10 [6]	3.2 [1]

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, April, 1991.

OIL AND GAS UPDATE

by Rodney H. De Bruin, Oil and Gas Division Head, Geological Survey of Wyoming

Crude oil prices continued their decline during the first quarter of 1991 (Figure 1). The average posted price for Wyoming sweet crude oil was $35 per barrel in October, 1990, but has dropped every month since then. By March, 1991, the posted price was under $20 per barrel. The average first purchase price for Wyoming crude oil was just over $21 per barrel for 1990. This price is an improvement over the past four years and is the highest average price since 1985 (Table 1).

Oil producers were more than able to make up the lost production from Kuwait and Iraq during the war. Even with most of Kuwait's oil wells on fire and not expected to produce significant oil for world markets in the next few years, it appears that crude oil supplies will be adequate. If OPEC does not cut production over the next few months, however, crude prices could decline further.

Spot prices for natural gas also declined during the first quarter of 1991 (Figure 2). Because January and February temperatures were above normal, supplies of natural gas were more than adequate to meet winter demand. While prices are normally lower from March through September, the March spot price in 1991 is already lower than it normally is during the low-demand months of June, July, and August.

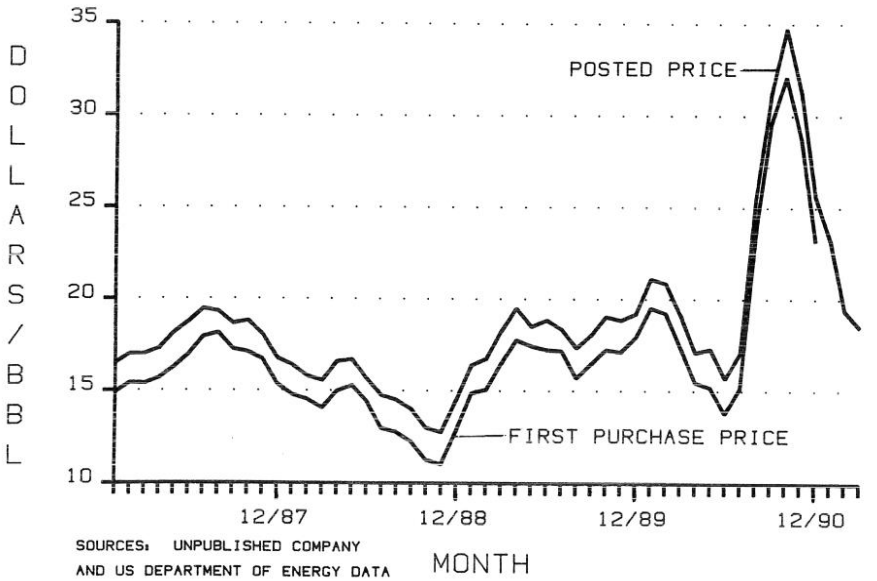

Figure 1. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987 TO PRESENT).

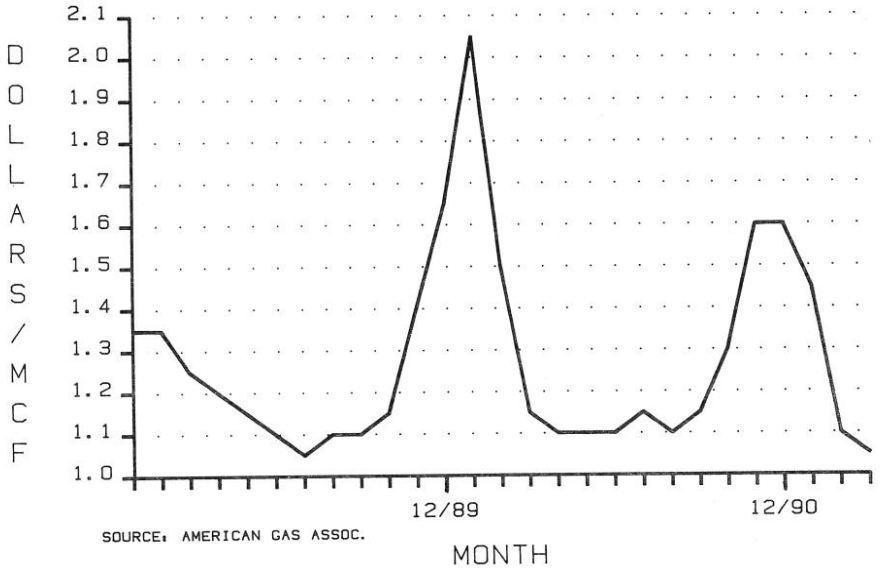

Figure 2. SPOT GAS PRICES AT OPAL, WYOMING, AVERAGED BY MONTH (1989 TO PRESENT).

The average rig count for Wyoming during the first quarter was very slightly higher than it was during the first quarter of 1990 (Figure 3). Activity in horizontal drilling and in gas exploration and development apparently accounted for most of the increase. Figure 4 shows that the average annual rig count has been about the same for the last five years.

A preliminary estimate of oil production for 1990 from Petroleum Information (1991b) shows that Wyoming produced 103,855,349 barrels, which should rank Wyoming in fifth place nationally (Table 4). Wyoming's 1990 production, however, is a decline of nearly 5.2 million barrels (4.8 percent) from 1989 production (Figure 5). It is unlikely that this rate of decline will change much in the next few years. Petroleum Information's estimated production is about 0.5 percent below our estimate of 104.4 million barrels (Table 2). The official 1990 production is still not available.

A preliminary estimate of natural gas production for Wyoming (Petroleum Information, 1991b) shows that production reached an all-time high of 897.8 billion cubic feet in 1990 (an increase of 31.8 billion cubic feet over 1989 production). This estimate includes methane, helium, and carbon dioxide production and is about 0.8 percent lower than our estimate of 905 billion cubic feet (Table 2). Based on total gas production, Wyoming should be the fourth largest natural gas-producing state in 1990 (Table 4). Again, there are no official production figures available yet.

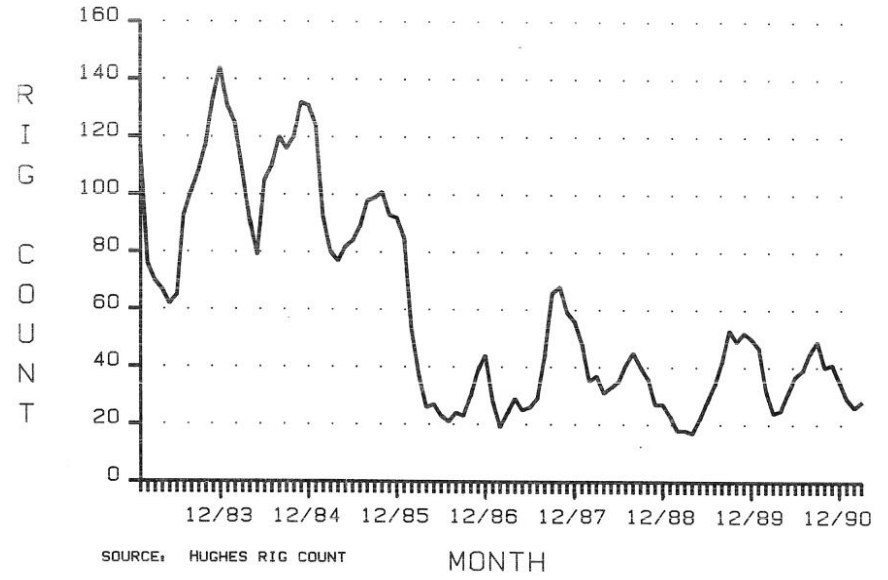

Figure 3. WYOMING RIG COUNT AVERAGED BY MONTH (1983 TO PRESENT).

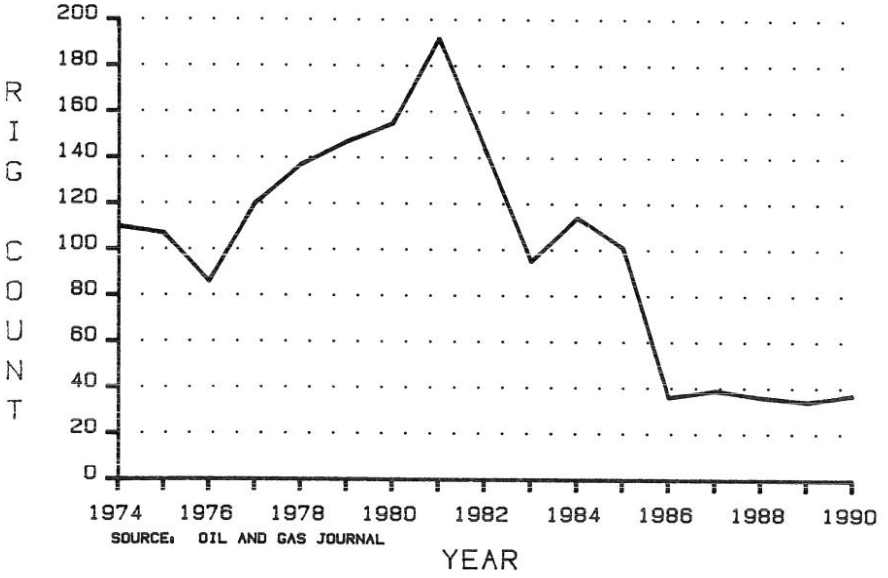

Figure 4. WYOMING RIG COUNT AVERAGED BY YEAR (1974 TO 1990).

Table 4. TOP TEN OIL AND GAS PRODUCING STATES IN 1990 (ESTIMATED).

	OIL		NATURAL GAS
1.	Alaska	1.	Texas
2.	Texas	2.	Louisiana
3.	California	3.	Oklahoma
4.	Louisiana	4.	Wyoming
5.	Wyoming	5.	New Mexico
6.	Oklahoma	6.	Kansas
7.	New Mexico	7.	California
8.	Kansas	8.	Colorado
9.	North Dakota	9.	Mississippi
10.	Colorado	10.	West Virginia

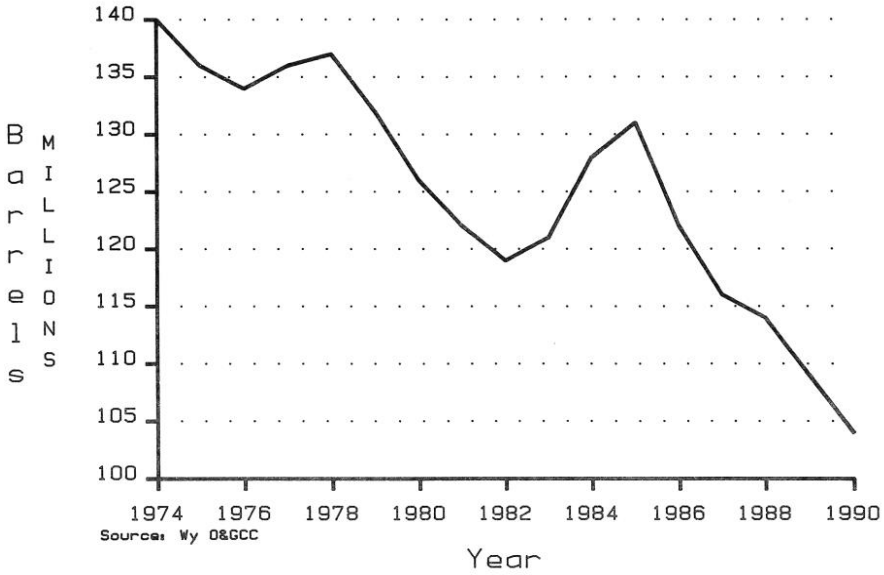

Figure 5. ANNUAL OIL PRODUCTION FROM WYOMING (1974 TO 1990).

Wyoming's annual gas production has increased over 300 billion cubic feet since 1986 (Figure 6), a 50 percent increase. Natural gas production in the State will continue to increase for years to come (Table 2) as increased gas usage accelerates development of the State's large gas resources (Table 5).

Construction of the Kern River pipeline from Wyoming to California began in the first quarter of 1990. Kern River secured bank financing for the pipeline but

is still negotiating a $250 million low-interest State loan. This pipeline is the largest pipeline built since 1981, and its construction is spurring other pipeline activity in southwestern Wyoming.

Northwest Pipeline recently completed a new 22.5-mile, 20-inch-diameter gathering line that can deliver gas production from fields on the Moxa arch to the company's gas processing plant at Opal, Wyoming. The capacity of the new gathering line is 200 million cubic feet of gas per day. Gas from the plant can be delivered to Colorado Interstate Gas, Northwest Pipeline, and to Kern River when it is completed. Northwest has signed long-term gathering and processing contracts with most of the major gas producers in the area and may expand their processing plant at Opal.

Northwest also plans to expand their pipeline system which passes through southwestern Wyoming. According to a Northwest Pipeline spokesman, the 534 million cubic feet per day expansion will benefit Wyoming gas producers since roughly 30 percent (160 million cubic feet per day) will come from Wyoming gas fields on the Moxa arch. This production will add nearly 60 billion cubic feet of gas to the State's annual production. If the Federal Energy Regulatory Commission (FERC) grants Northwest a timely construction certificate, Northwest Pipeline's expansion could be completed by 1992.

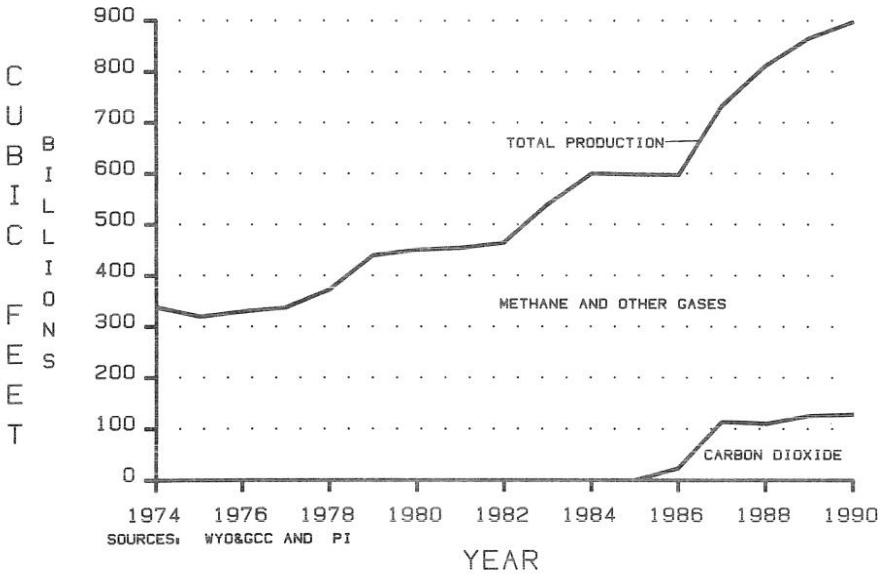

Figure 6. ANNUAL PRODUCTION OF NATURAL GAS FROM WYOMING (1974 TO 1990).

Table 5. MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING.

PETROLEUM

Remaining Resources (January 1, 1990)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.8	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.4	billion barrels
Remaining Reserve Base (January 1, 1990)		
Measured reserves (Proved reserves) (Includes 0.815 billion barrels of oil and 0.805 billion barrels of gas liquids)	1.51	billion barrels[2]
Indicated and inferred reserves	2.8	billion barrels[1]
Total	4.31	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1990)		
Discovered (Includes 23 trillion cubic feet (TCF) of methane[1] and 12 TCF of CO_2 and He^3)	34.1	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 103 TCF of CO_2 and He^3)	3,779.0	trillion cubic feet
Total	3,813.1	trillion cubic feet
Remaining Reserve Base (January 1, 1990)		
Measured reserves (Proved reserves) (Includes 10.9 TCF of methane[2] and 11.8 TCF of CO_2 and He^3)	21.6	trillion cubic feet

COAL

Remaining Resources (January 1, 1991)		
Identified and Hypothetical (Discovered)	1,431.0	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,462.5	billion tons
Remaining Reserve Base (January 1, 1991)		
Demonstrated strippable (Measured and indicated reserve base)	26.4	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	38.3	billion tons[7]
Total	64.7	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, 1982)		
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, 1989, U.S. crude oil, natural gas, and natural gas liquids reserves: 1988 Annual Report, October.

[3] Derived from Exxon information.

[4] De Bruin, R.H., and Jones, R.W., 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, April, 1991. (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.

FERC has given initial approval for construction of Altamont Gas Transmission Company's proposed pipeline. If Altamont's plans go as expected, they will transport Canadian gas through Montana and Wyoming and hook into the Kern River pipeline where it originates in southwestern Wyoming.

There were 146 more well completions in Wyoming in 1990 than in 1989 (Petroleum Information, 1991a). Both oil completions and gas completions increased substantially. Gas completions were at their highest level in the last six years (Table 6). Increased gas completions were a direct result of increased drilling in the Greater Green River Basin and of continued exploration for coalbed methane. Construction of the Kern River pipeline and its anticipated completion in early 1992 should keep gas completions high in 1991 as well.

Table 6. WYOMING WELL COMPLETION SUMMARY[1]

Year	Oil	Gas	Dry	Total
1990	191	151	224	566
1989	121	93	206	420
1988	272	70	361	703
1987	345	62	369	776
1986	359	50	428	837
1985	735	76	676	1,487

[1] Modified from Petroleum Information, 1991b.

Successful wildcat wells in Wyoming that are drilled between January 1, 1991, and December 31, 1994, will be eligible for a four percent reduction in the severance tax rate for a period of four years from the date of first production. The current severance tax rate for the majority of production is six percent.

Phillips Petroleum is closing their Casper exploration and production office. The closing will affect 15 people who were offered jobs at other locations. Over the past few years, Amoco, Chevron, Marathon, and Gulf Oil companies have all closed their Casper offices.

Lease sales in the State did very well in the first quarter of this year. The State Land and Farm Loan Office's January sale had a high per-acre bid of $401 made by Kenneth Berry for a 160-acre parcel covering NW section 16, T50N, R71W (Table 7). The lease is a mile west of Minnelusa oil production at Superhornet Field.

Chesapeake Operating picked up 59 parcels in southeastern Wyoming in Laramie and Goshen counties. These parcels are in and around the recent horizontal-drilling play in the Niobrara (see **Horizontal Drilling**, p. 16). Yates Petroleum was the high bidder on 61 parcels that are spread across the State.

Table 7. 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
				1987								1987			
TOTAL	$15,724,159	727	646	197,422	177,960	$ 88.36	$6,555.00	TOTAL	$2,526,567	1,200	579	511,638	244,740	$10.32	$2,300.00
				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			
February	$2,418,295	800	230	857,475	187,012	$12.93	$1,225.00	January	$331,145	200	112	73,322	39,650	$8.35	$110.00
April	$2,334,604	732	227	557,643	145,055	$16.09	$390.00	March	$493,179	200	129	74,512	47,886	$10.30	$140.00
June	$1,673,150	758	163	962,929	138,691	$12.06	$160.00	May	$512,736	199	129	76,396	51,919	$9.88	$155.00
August	$3,469,570	656	197	577,518	141,841	$24.46	$285.00	July	$684,374	200	154	82,760	65,034	$10.52	$190.00
October	$3,247,334	788	296	657,918	178,013	$18.24	$3,000.00	September	$474,104	200	134	77,889	50,749	$9.34	$540.00
December	$2,689,152	552	247	415,266	181,791	$14.79	$340.00	November	$628,446	200	134	76,973	56,036	$11.22	$170.00
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	$5,015,813	1,199	732	475,896	380,382	$13.19	$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
								March	$642,191	197	170	$69,652	62,226	$10.32	$110.00

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

The high per-acre bid at the State Land and Farm Loan Office's March sale was $110 by Brown Operating for a 640-acre parcel that covers section 36, T51N, R71W. The parcel is near Minnelusa oil production at Dutch Field and shut-in Minnelusa oil production at Springen Ranch Field.

In regard to total revenue, the U.S. Bureau of Land Management's (BLM) February sale was the best in several years (Table 7). The sale's top bid of $16,000 per acre was made by Kerr-McGee Corp. for a 160-acre parcel that covers SW section 24, T36N, R76W. The parcel is just north of Derrick Draw Field where Kerr-McGee is producing oil and gas from the Muddy Sandstone and from an interval that includes the Carlile, Frontier, and Belle Fourche formations. The total bonus on this parcel was $2.56 million.

Scientists at the University of Wyoming are investigating a relatively new idea for hydrocarbon traps (pressure chambers) and have found evidence that this type of trap exists in the Powder River Basin. In 1975, two Amoco scientists first hypothesized the existence of pressure chambers, which are buried units of porous rock sealed within impermeable layers of other rock. These pressure chambers have the potential to hold significant amounts of oil and natural gas. Dr. Ronald C. Surdam, a University of Wyoming geology professor, is the project director. The research is funded by a $1,562,619 grant from the Gas Research Institute, and involves faculty from the geology/geophysics, petroleum engineering, chemical engineering, and mathematics departments.

A new 1:500,000-scale oil and gas map of Wyoming was published by the Geological Survey of Wyoming during the first quarter of 1991 (p. 64). The large color map shows the locations of over 1,000 fields as well as pipelines, refineries, and gas processing plants. Fields are color-coded to the age of the predominant reservoir rocks. Pipelines are color-coded to the type of products that they transport. The pipelines are also annotated with the name of the operator, their diameter, and the direction of flow.

The Geological Survey of Wyoming (GSW) recently completed work on a $24,000 grant for the U.S. Department of Energy (DOE) through the Geoscience Institute for Oil and Gas Recovery Research. The Institute is a consortium of 24 universities and state geological surveys and is located at the University of Texas at Austin. The reservoir heterogeneity of over 160 of the main oil-producing reservoirs in the State were classified according to depositional environment, diagenetic overprint, and structural compartmentalization. In a cooperative effort with the Utah, Colorado, and Montana geological surveys, the GSW also coordinated the classification of heterogeneity of Utah, Colorado, and Montana reservoirs. DOE will use the heterogeneity classifications of reservoirs from all oil-producing states to help determine where additional research on enhanced oil recovery techniques might be the most successful.

The Texas Bureau of Economic Geology (TBEG) and the Geological Survey of Wyoming (GSW) are collaborating on a study of tight gas sands in the Frontier Formation of southwestern Wyoming. Completion data for more than 600 Frontier wells were compiled and provided to TBEG. In addition, the GSW prepared a

detailed map of oil and gas fields in the Greater Green River Basin and Overthrust Belt of Wyoming. This map will be published later this year. The GSW's portion of the project is funded by a $48,000 grant from TBEG. The study is being done for the Gas Research Institute.

In the second quarter of 1991, the Geological Survey of Wyoming anticipates starting work on the Wyoming portion of an atlas of Rocky Mountain gas reservoirs. This project is also for the Gas Research Institute. The atlas will contain descriptions and maps of the major gas plays in Wyoming and will include geologic, engineering, and production parameters of individual reservoirs in each play.

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 1991. Activities related to horizontal drilling and coalbed methane are discussed in separate sections. The letters preceding the discussions below refer to locations on Figure 7.

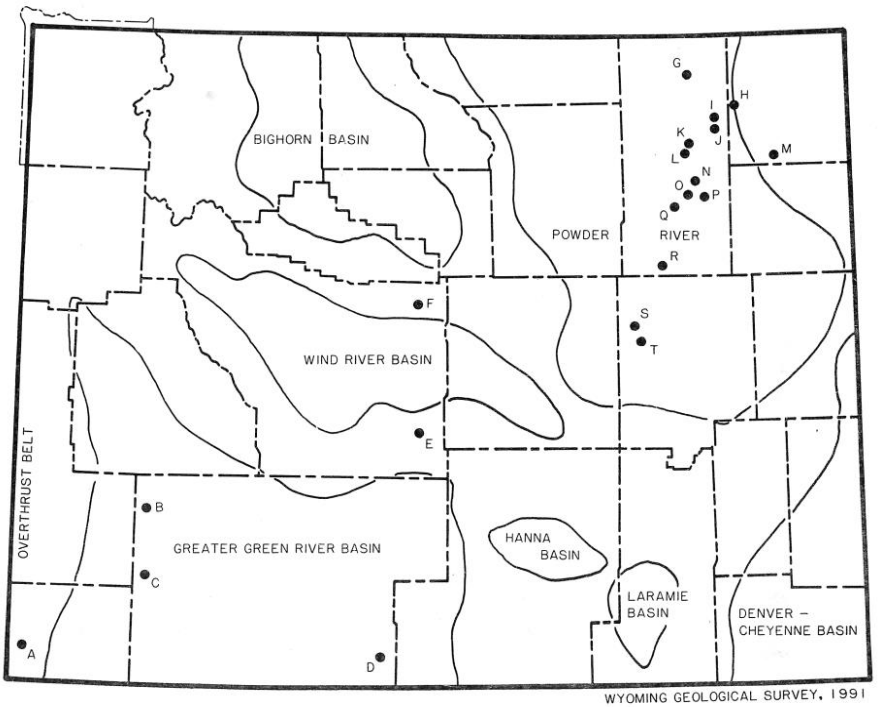

Figure 7. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING DURING THE FIRST QUARTER OF 1991.

A. Chevron USA began drilling their 1-11 Chevron-UPRC well in SE SW section 11, T14N, R120W in the Overthrust Belt. The well is about a mile southeast of Nugget Sandstone oil and gas production at Glasscock Hollow Field and is scheduled as a 17,000-ft Nugget test.

B. Presidio Exploration completed their 30-36 Golden-State well in NE SW section 36, T24N, R111W. The well is in Mesa Field and it flowed 1.8 million cubic feet of gas per day from the Frontier.

C. Presidio Oil Co. completed their 20-1 Whiskey Buttes well as a new discovery in the Dakota. The well, in SW NE section 1, T21N, R111W, flowed 1,147 barrels of oil and 1.9 million cubic feet of gas per day and is over a mile southwest of Dakota production at Sugarloaf Butte Field.

D. Union Pacific Resources extended Dripping Rock Field with their 9-1 Oxy-Federal well in SE NW section 9, T14N, R94W. The well flowed 4.0 million cubic feet of gas per day from the Almond Formation. Celsius Energy extended the field to the south with the completion of their 20-1 Celsius Federal well in NW SE section 20, T14N, R94W. The well flowed 2.6 million cubic feet of gas per day from the Almond.

E. BWAB Inc. has discovered a new, deeper gas pool in Castle Garden Field. The 13-23X Federal well in NE SW section 13, T34N, R91W, produced an average of 628,000 cubic feet of gas per day during 20 days of production in December, 1990. This new pool is in the Frontier Formation. Castle Garden was discovered in 1958 and has produced gas from the Shannon.

F. Louisiana Land and Exploration began drilling a 25,000-ft Madison test on the Madden anticline. The 3-36 Big Horn well in SE SE section 36, T39N, R91W will take over a year to drill. This will be the fourth Madison test on the anticline. Two earlier wells tested high flow rates from the Madison and a third well is currently drilling below 19,000 feet. Production from the Madison at Madden will probably begin in 1992 when a gas plant is scheduled for completion. The $50 million plant initially will process gas from the two completed wells. The plant may be enlarged if the two wells that are currently drilling find economical gas volumes. In addition to methane, the plant will produce three railroad cars of sulfur a day and carbon dioxide that could be used in enhanced oil recovery projects proposed for oil fields in the Wind River and Bighorn basins.

G. Continental Trend Resources set production casing to evaluate Cretaceous sandstones at their 1-1 Whitetail Federal well in SE SW section 1, T55N, R71W. The nearest production from Cretaceous reservoirs is from the Muddy Sandstone at White Field. White Field is over four miles southwest of this well.

H. Plains Petroleum Co. completed their 23-28 Plains-Federal well in NE SW section 28, T53N, R68W, in the Minnelusa Formation. The well pumped 352 barrels of oil per day and was drilled as a stepout to Cambridge Field.

I. Maxus Exploration recovered oil on a drillstem test of the Minnelusa at their 1 Alpha Unit well in SW SW section 1, T51N, R69W. Pipe recovery was 2,650 feet of oil and 400 feet of water.

J. Flying J Exploration and Production Co. discovered oil in the Minnelusa at their 10-25 Thompson well in NW SE section 25, T51N, R69W. The well pumped 631 barrels of oil per day and is a mile north of Minnelusa oil production at Stewart East Field.

K. Raymond T. Duncan, Inc. completed a new Minnelusa discovery. The 33-13 Record well in NW SE section 13, T50N, R71W, pumped 584 barrels of oil and one barrel of water per day. The new discovery is less than a mile from Minnelusa oil production at FD Field.

L. Caza Exploration is testing their 3 Tigers Tail well in SE NE Section 23, T50N, R71W. An earlier drillstem test of the Minnelusa recovered 1,105 feet of gas-cut oil and 180 feet of oil-cut mud. The well offsets Caza's 2 Tigers Tail well in SW NE section 23, T50N, R71W, which is producing oil from the Minnelusa.

M. L&W Group discovered oil and gas at their 1 Federal well in SW NW section 32, T49N, R66W. A drillstem test of the Lakota recovered 1,140 feet of gas-cut oil and 200 feet of oil and gas-cut mud. The nearest Lakota production is nearly three miles away at Wind Creek Field.

N. Raymond T. Duncan, Inc. completed a new Minnelusa well in Maysdorf Field. The 44-17 Hayden well in SE SE section 17, T47N, R71W, pumped 359 barrels of oil per day.

O. Duncan Energy found oil in the Minnelusa at their 2 L.A. Sims well in SE SE Section 30, T47N, R71W. The well pumped 60 barrels of oil per day. Nearest Minnelusa oil production is less than a mile south at Haight Field.

P. Cramer Oil discovered oil in the Minnelusa at their 36-15 State well in SW SE Section 36, T47N, R71W. The well pumped 406 barrels of oil per day.

Q. Ampolex Inc. discovered oil and gas in the Muddy at their 21-18 Wilson well in NE SW section 28, T46N, R72W. The well pumped 72 barrels of oil and 70,000 cubic feet of gas per day. The new discovery well is in a shallower pool in Lea Springs Field. Ampolex discovered Minnelusa oil at Springs Field in 1990.

R. Kerr-McGee completed another Dakota producer in Buck Draw North Field. The 13-7 NBDU well in NW SW section 7, T41N, R73W, flowed 1,485 barrels of oil and 2.99 million cubic feet of gas per day.

S. Phillips Petroleum Co. discovered oil and gas at their 1 Pine Ridge-Federal well in NE SE section 10, T37N, R76W. The well flowed 156 barrels of oil and 153,000 cubic feet of gas per day from the Muddy Sandstone. The well is

three miles from Muddy, Frontier, and Dakota oil and gas production at Sand Dunes Field.

T. Kerr-McGee Group Corp. completed two producing wells in Derrick Draw Field. The 33-35 Derrick Draw-Federal well in NW SE section 35, T36N, R76W, pumped 377 barrels of oil, 287,000 cubic feet of gas, and three barrels of water per day from an open-hole interval in the Carlile, Frontier, and Belle Fourche formations. The 11-36 State-Derrick Draw well in NW NW section 36, T36N, R76W, flowed 2,116 barrels of oil and 1.8 million cubic feet of gas per day from the Muddy.

Horizontal Drilling

During the first quarter of 1991, the following significant activities related to horizontal drilling occurred. The letters preceding the discussions below refer to locations on Figure 8. The discussions are based on company data and on information compiled and published by Petroleum Information.

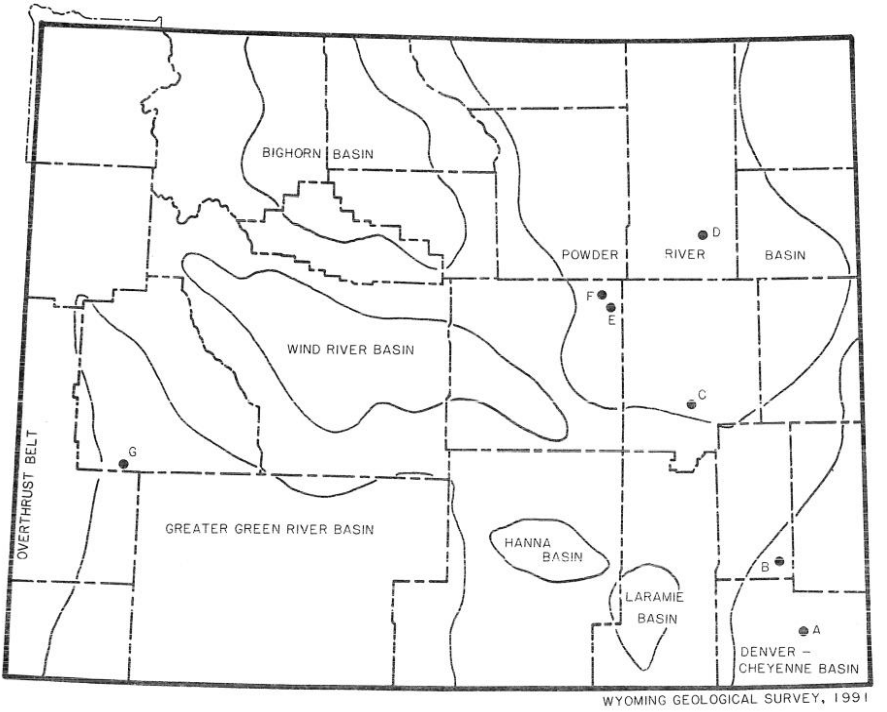

Figure 8. HORIZONTAL-DRILLING ACTIVITY IN WYOMING.

A. Horizontal drilling in the Niobrara Formation continues in and around Silo Field. Union Pacific Resources completed their 1H Goertz 5-12 well in NE NW section 12, T15N, R65W, for an initial pumping potential of 368 barrels of oil, 136,000 cubic feet of gas, and six barrels of water per day. Their 1H Epler 14-7 well in SW SW section 7, T15N, R63W, was completed for an initial pumping potential of 280 barrels of oil and 72,000 cubic feet of gas per day. Union Pacific Resources is drilling their 2H Leroy Goertz 14-3 well in SW SW section 3, T15N, R64W, and staked a location for a well in NE NE section 22, T16N, R65W. Snyder Oil reached total depth at their 10-21H Hutton well in SW NW section 21, T16N, R64W, but test results are not yet available. Two companies, not previously active in the Niobrara play, staked well locations: Exxon staked a location in SE SW section 6, T15N, R64W, and Cimarron Operating Co. staked a location in SW SW section 26, T16N, R64W. Gerrity Oil and Gas Company began drilling their 4-9H State well in NE SE section 4, T15N, R64W. The Niobrara in the Silo Field area is between 7,500 and 8,500 feet deep.

B. Union Pacific Resources (UPR) began drilling their 1 H Hellbaum 11-11 well in NW NW section 11, T21N, R66W. The well is about 12 miles south of Chugsprings Field, an abandoned Niobrara and Codell producer. UPR's well will test the Niobrara at a depth of about 8,500 feet.

C. Amoco has not started their 1-25 Morton Ranch well in NE SW section 25, T33N, R72W. Amoco staked the location last quarter and plans to evaluate the Niobrara in the curved part of the hole and Frontier in the horizontal part of the hole. The true vertical depth of this test is about 11,400 feet.

D. Harvey E. Yates Co. reached a true vertical depth of 9,010 feet at their 1 H-19-22 Stuart Ranch deep well in SE NW section 19, T44N, R71W. The well was drilled to test the Niobrara; however, test results are not yet available.

E. GLG Energy has not released any details on their 5,500-ft Niobrara test in SW NE section 6, T38N, R77W. The company staked another location for a 4,089-ft Niobrara test in NW NE section 3, T39N, R78W. Drilling has not yet started at a location staked last quarter (SE SE Section 36, T39N, R78W). The true vertical depth targeted for that well is 4,437 feet.

F. Amoco Production completed a relatively shallow horizontal well in two intervals in the Second Wall Creek at Salt Creek Field. The 40 WC2 NE25-H well in NW NW section 30, T40N, R78W, pumped 10 barrels of oil and 3,319 barrels of water per day from producing intervals at about 1,780 feet (true vertical depth).

G. Texaco, Inc.'s shallow Almy (Fort Union) well with three horizontal legs produced an average of 17 barrels of oil per day during November, 1990. The well was plugged back to a true vertical depth of 440 feet before the three horizontal legs were drilled.

Coalbed Methane

During the first quarter of 1991, the following significant activities related to coalbed methane occurred. The letters preceding the discussion below refer to locations on Figure 9. The discussions are primarily based on information supplied by company personnel. Some information comes from reports compiled and published by Petroleum Information. Nancy Doelger of the BLM provided useful information for Powder River Basin operations.

A. Betop and Martens and Peck Operating are producing natural gas from 10 Fort Union coalbed methane wells in Rawhide Butte Field in T51N, R72W. An additional well in the field, operated by National Coop Refining is presently shut-in. All these wells are less than 1,000 feet deep.

B. Petroleum Inc. is no longer producing their four, Fort Union, coalbed methane wells in Dead Horse Creek Field in T49N, R75W. Indications are that these 1,200-1,800 feet deep wells will be abandoned.

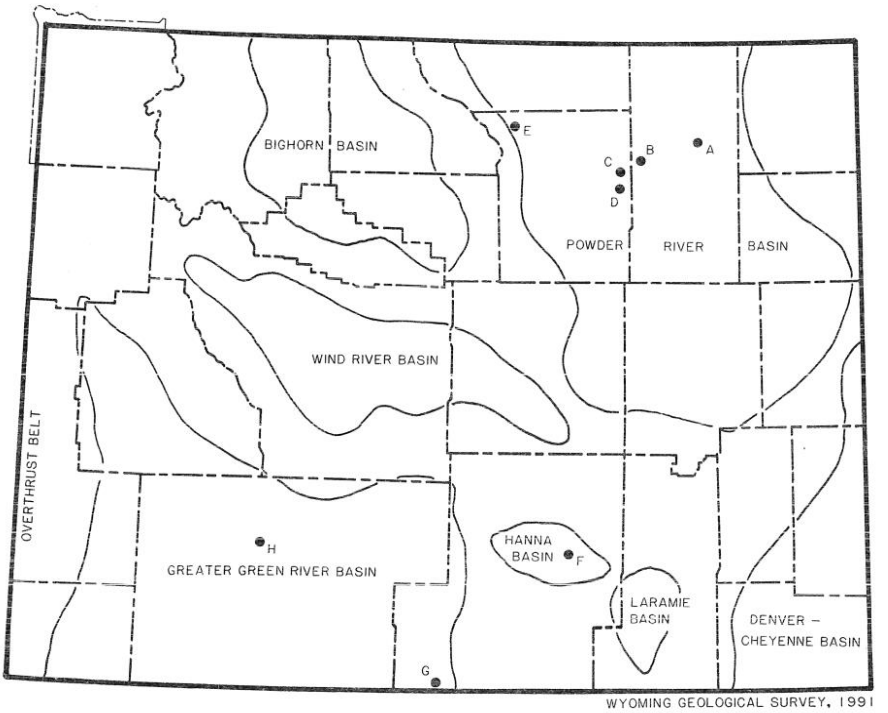

Figure 9. COALBED METHANE ACTIVITY IN WYOMING.

C. Gilmore Oil and Gas is dewatering their 1 Artesian Unit well in SE NE section 1, T49N, R77W. The 1 Artesian Unit well was a 2,418-ft test of coal beds in the Fort Union Formation. Gilmore still has plans to drill a second well in the same section.

D. Operations at Coastal's wells in the Sasquatch Unit were suspended. Another company has expressed interest in resuming operations in this area at a later date. Coastal's wells were drilled to test the Big George coal bed at depths between 1,000-1,500 feet. This coal bed is in the Fort Union Formation.

E. Texaco, Inc. plugged and abandoned their 1,500-ft 1 Texaco-Lott-Fee well in SE SE Section 13, T52N, R82W. The well was completed to test the coalbed methane potential of coal beds in the Wasatch Formation.

F. METFUEL is dewatering their 3-1 UPRR-Palm Livestock well in NE SE section 3, T23N, R81W and their 11-1 UPRR-Palm Livestock well in NE NW section 11, T23N, R81W. These wells are all completed in Hanna Formation coal beds at depths below 3,500 feet. METFUEL may drill additional wells this summer.

G. Fuel Resources Development is producing methane and water from 11 wells in the newly named Dixon Field. The field straddles the Wyoming-Colorado border and seven of the wells are in Wyoming. The wells are all producing from two steeply dipping coal beds in the Almond Formation and are all on fee land. The depths of production are between 900 and 2,300 feet. The company has tentative plans to drill more wells after they evaluate the 11 producing wells.

H. Triton Oil and Gas Corp.'s plans to develop coalbed methane in Mesaverde coals are still on hold. Triton tested several coal beds between 900 and 4,100 feet at two wells drilled in late 1989. Triton is awaiting a decision by the BLM on whether an environmental impact statement is necessary before development can begin. In an adjacent area, Saxon is testing two Mesaverde coalbed methane tests drilled in section 7, T25N, R102W and in section 23, T25N, R103W. Although Saxon's wells were drilled to 7,000 feet, the depth of the coal beds that they are testing has not been disclosed.

Huff n' Puff Carbon Dioxide Projects

A total of 31 carbon dioxide huff n' puff tests were performed on oil wells in Wyoming through the end of 1990 (Deans, 1990). The first test began in November, 1989, at Wold's Crooks Gap #4 well and an additional 30 tests were performed in 1990. At the present time, test results have not been reported for most of the projects, but more data will be available by the next issue of *Wyoming Geo-notes*. The first major presentation of results in scheduled for the Seventh Annual Enhanced Oil Recovery Institute (EORI) Symposium in Casper, May 1-2, 1991.

The letters preceding the discussion below refer to locations on Figure 10. The discussions are mainly a summary of where tests were performed by various companies and which formations were stimulated.

A. Enron tested the Mesaverde Formation at one well in Big Piney Field.

B. Wold Oil in cooperation with EORI injected the Dakota twice at the Crooks Gap #4 well in Crooks Gap Field. The production rate, after the second injection, stabilized at an estimated 20-40 barrels of oil per day.

C. Amoco performed three tests of the Darwin Sandstone and Madison Limestone interval, three tests of the Flathead Sandstone, and one test of the Tensleep Sandstone at Wertz and Lost Soldier Fields.

D. Stovall Oil tested the Sundance Formation at one well in Schrader Flats Field.

E. Stovall tested the Lakota at one well in Tipps Field.

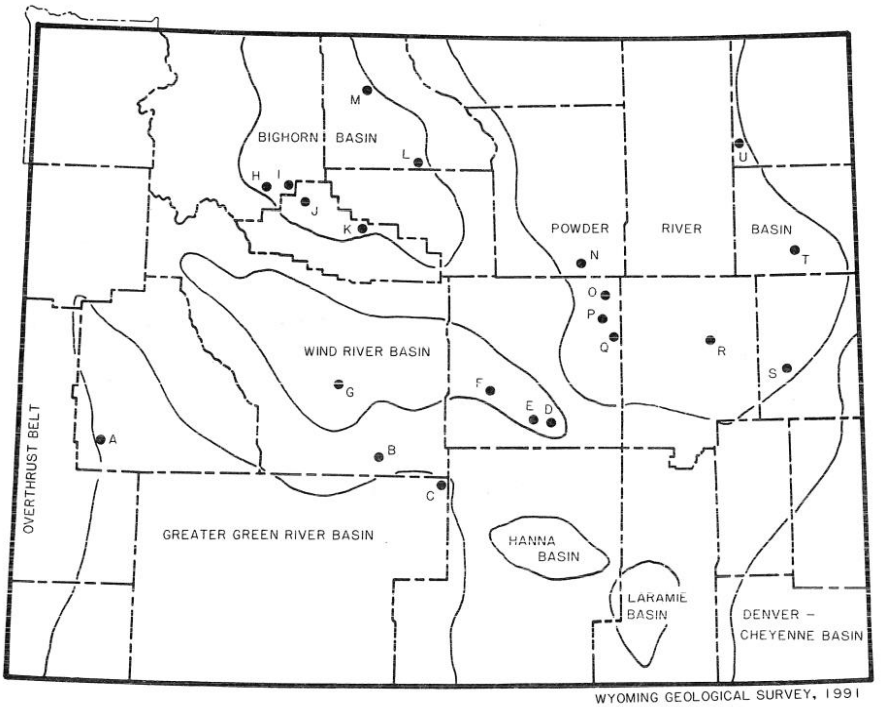

Figure 10. HUFF N' PUFF CARBON DIOXIDE PROJECTS.

F. Timberline tested the Muddy Sandstone in cooperation with EORI at one well in Grieve North Field.

G. Amoco cooperated with EORI on a one-well test of the Cody at Beaver Creek Field. Results of this test were reportedly discouraging.

H. Conoco tested the Tensleep Sandstone at one well in Sunshine North Field.

I. Amoco performed a test of the Tensleep and a test of the Embar (Phosphoria/Dinwoody) at Little Buffalo Basin Field.

J. Marathon cooperated with EORI on a one-well test of the Frontier Formation at Grass Creek Field. Test results were reported as discouraging.

K. Conoco tested the Embar (Phosphoria/Dinwoody) at one well in Gebo Field.

L. Conoco tested the Tensleep Sandstone at Bonanza Field.

M. Underwood tested the Phosphoria Formation at one well in Goose Egg Field.

N. Conoco tested the Shannon Sandstone at one well in Sussex West Field.

O. Amoco tested the Second Wall Creek Sand (Frontier) in three wells at Salt Creek Field. Amoco plans a flood at this field and used these tests to demonstrate that incremental oil is recoverable with carbon dioxide injection.

P. McMurry injected the Dakota at one well in Burke Ranch Field.

Q. G.G. Nicolaysen cooperated with EORI on a one-well test of fractured Dakota at Cole Creek Field. Mechanical problems delayed production at this test.

R. Underwood tested the Muddy Sandstone at Mikes Draw Field.

S. One well in the Muddy Sandstone was stimulated at Lightning Creek Field. Lightning Creek Oil Co. performed another test on an interval in the Mowry Shale.

T. Western Production injected carbon dioxide into a Turner interval at one well in Finn-Shurley Field.

U. Union Pacific Resources tested a Minnelusa interval in one well at Prong Creek Field.

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Deans, H.A., 1990, Progress through December 31, 1990, on single-well, cyclic, CO_2 stimulation (huff n' puff) of depleted wells in Wyoming: The Enhanced Oil Recovery Institute, University of Wyoming, Laramie, Wyoming, p. 1-26.

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Coal Update

by Richard W. Jones, Coal Division Head, Geological Survey of Wyoming

In 1990, coal production from Wyoming mines set another all-time record for the fourth consecutive year. This production ranked Wyoming as the top coal-producing state in the United States for the third straight year, surpassing second-place Kentucky's 179.0 million tons and third-place West Virginia's 170.5 million tons (Figure 11). The 184.0 million tons of coal reported by the Wyoming State Inspector of Mines represents a 7.5 percent, 12.9-million-ton increase over the 171.1 million tons produced in 1989 (Table 8). This production is also 4.5 million tons above our forecast made in October, 1990. Cumulative coal production from Wyoming mines between 1865 and 1990 exceeds 2.2 billion tons.

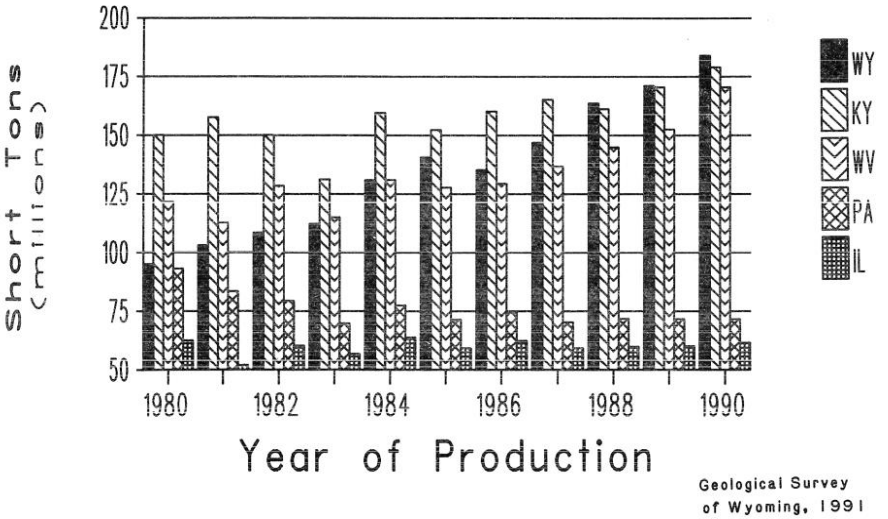

Figure 11. PRODUCTION FROM THE TOP 5 COAL-PRODUCING STATES IN THE U.S. (1980-1990).

Table 8. 1990 WYOMING COAL PRODUCTION BY COUNTY AND COAL FIELD.

County	Production	Percent of Total Production	Number of Mines	Number of Employees
POWDER RIVER COAL FIELD				
Campbell	154,696,691	84.1%	16	2,590
Converse	7,890,670	4.3%	2	272
Sheridan	134,104	0.1%	1	19
TOTAL	162,721,465	88.4%	19	2,881
GREEN RIVER COAL FIELD				
Sweetwater	11,936,525	6.5%	4	939
HAMS FORK COAL FIELD				
Lincoln	4,735,548	2.6%	2	466
HANNA COAL FIELD				
Carbon	4,511,202	2.5%	5	328
BIGHORN COAL FIELD				
Hot Springs	101,961	<0.1%	1	9
TOTAL WYOMING	184,006,701	100%	31	4,623

Source: Wyoming State Inspector of Mines, preliminary data for 1990.

National coal production in 1990 broke the 1-billion-ton mark for the first time, as 1.022 billion tons of coal were produced. This represents a 4.1 percent, 41-million-ton increase in national production over 1989. Wyoming accounted for about 18 percent of the national total and about 46 percent of the 401 million tons of coal produced in states west of the Mississippi River.

Most of the increase in Wyoming coal production for 1990 occurred in the Powder River Coal Field, which recorded a 12.7-million-ton, 8.4 percent increase over 1989 production (Table 8). The Powder River Coal Field accounted for 88.4 percent of Wyoming's coal production in 1990. In this field, Campbell County coal production alone increased from 143.8 million tons in 1989 to 154.7 million tons in 1990 (a 7.5 percent increase) and accounted for about 84 percent of the State's production (Table 8). Converse County experienced an increase in production of 29 percent in 1990 and accounted for 4.3 percent of the State's total production,

as compared to its 3.6 percent share in 1989. Figure 12 shows the dominance of production from the Powder River Coal Field.

The Hanna and Bighorn coal fields also recorded increased production. Production from the Green River and Hams Fork coal fields, however, was slightly less in 1990 than in 1989.

A total of 31 coal mines reported production in 1990, as compared with 27 mines in 1989 (Table 9). All but four of the State's mines were surface mines. Two additional coal mines in Campbell County, Dry Fork Coal Company's Dry Fork mine and Shell Mining Company's North Rochelle mine, reported some production in 1990. An additional mine in the Green River Coal Field (Sweetwater County) was active in 1990 as Arch of Wyoming's Pilot Butte underground mine (formerly Bitter Creek Resources' Stansbury mine) resumed production. The fourth new mine was Wyoming and West Virginia, Inc.'s remotely-controlled underground mine in the Hanna Coal Field (see **Developments in the Hanna Coal Field**, p. 32).

In 1990, coal production from Wyoming's four underground coal mines increased by 0.2 million tons (or 13 percent) over 1989 production (Table 9). A slight decrease in coal production at Cyprus-Shoshone Coal Company's Shoshone No. 1 mine in the Hanna Coal Field was more than offset by increased production at Lion Coal Company's Swanson mine, resumption of production at Arch of Wyoming's Pilot Butte mine (which was closed for renovation in 1989), and

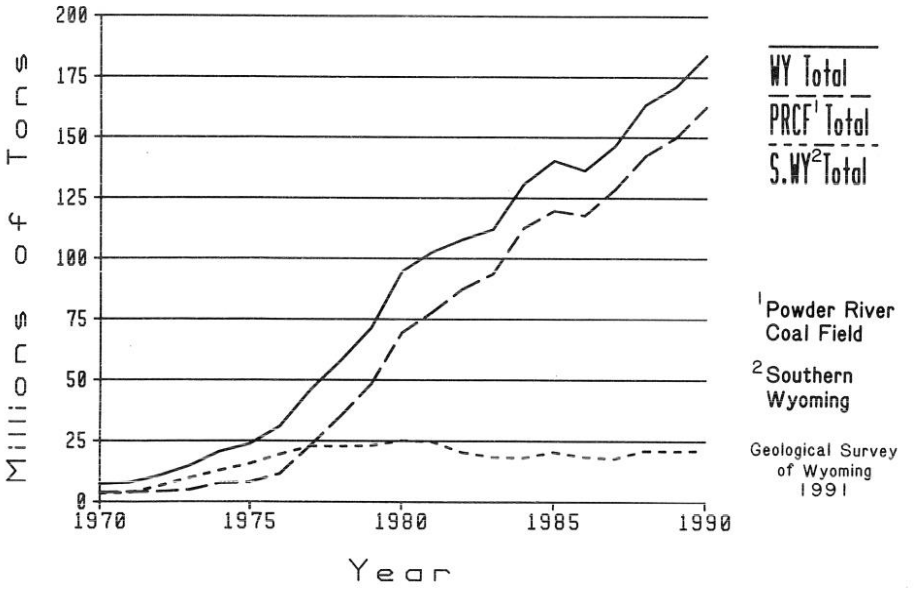

Figure 12. WYOMING COAL PRODUCTION (1970 TO 1990).

Table 9. 1989 AND 1990 WYOMING COAL INDUSTRY EMPLOYEES AND COAL PRODUCTION BY COAL FIELD AND MINE.

Company	Mine Name	1989 Employees	1989 Production (short tons)	1990 Employees	1990 Production (short tons)
POWDER RIVER COAL FIELD					
Amax Coal Co.	Belle Ayr (surface)	273	13,600,000	235	15,529,327
	Eagle Butte (surface)	253	13,567,000	205	15,396,412
Antelope Coal Co.	Antelope (surface)	52	3,541,184	99	5,211,642
Ash Creek Mining Co.	PSO No. 1 (surface)	1	—	1	—
Big Horn Coal Co.	Big Horn (surface)	26	106,147	18	134,104
Carter Mining Co.	Caballo (surface)	233	12,856,387	218	14,312,971
	Rawhide (surface)	173	10,628,737	173	11,442,355
Cordero Mining Co.	Cordero (surface)	224	12,602,336	226	12,922,653
Dry Fork Coal Co.	Dry Fork (surface)	3	under construction	37	815,056
Fort Union Coal Co.	Fort Union (surface)	9	42,092	4	38,528
Glenrock Coal Co.	Dave Johnston (surface)	178	2,575,184	173	2,679,028
Kerr-McGee Coal Corp.	Jacobs Ranch (surface)	366	14,662,159	367	16,724,780
Mobil Coal Prod., Inc.	Caballo Rojo (surface)	144	8,368,787	153	8,566,831
North Antelope Coal Co.	North Antelope (surface)	122	6,909,325	128	8,242,231
Rochelle Coal Co.	Rochelle (surface)	155	10,892,567	161	12,030,237
Shell Mining Co.	North Rochelle (surface)	2	under construction	1	13,000[2]
Thunder Basin Coal Co.	Black Thunder (surface)	495	29,536,578	488	27,919,411
	Coal Creek (surface)	6	139,116	6	140,250
Triton Coal Co.	Buckskin (surface)	116	7,693,929	131	7,695,009
Wyodak Res. Dev. Corp.	Wyodak (surface)	56	2,348,085	57	2,907,640
TOTAL		2,887	150,069,613	2,881	162,721,465
HANNA COAL FIELD					
Wyoming & W.V., Inc.	Blue Sky No. (deep)[3]	—	—	9	100,746
Arch of Wyoming	Seminoe No. 2 (surface)	27	344,942	29	—
	Medicine Bow (surface)	92	2,305,147	91	2,813,212
Cyprus-Shoshone Coal Co.	Shoshone No. 1 (deep)	186	1,544,661	183	1,420,980
Rosebud Coal Sales	Rosebud (surface)	21	72,408	16	176,264
TOTAL		326	4,267,158	328	4,511,202
GREEN RIVER COAL FIELD					
Arch of Wyoming	Pilot Butte (deep)	13	under construction	31	189,824
Black Butte Coal Co.	Black Butte (surface)	386	5,885,947	449	5,797,238
Bridger Coal Co.	Jim Bridger (surface)	420	6,023,607	406	5,842,017
Prospect Point Coal Co.[1]	Leucite Hills (surface)	—	—	—	—
Lion Coal Co.	Swanson (deep)	47	65,235	53	107,446
TOTAL		866	11,974,789	939	11,936,525
HAMS FORK COAL FIELD					
FMC Wyoming Corp.	Skull Point (surface)	102	896,000	101	950,000
Pittsburg and Midway	Kemmerer (surface)	365	3,880,294	365	3,785,548
TOTAL		467	4,776,294	466	4,735,548
BIGHORN COAL FIELD					
Northwestern Res. Co.	Grass Creek (surface)	14	52,150	9	101,961
TOTAL		14	52,150	9	101,961
TOTAL UNDERGROUND		246	1,609,896	276	1,818,996
TOTAL SURFACE		4,314	169,530,108	4,347	182,187,705
GRAND TOTAL		4,560	171,140,004	4,623	184,006,701

Source: Annual report of the Wyoming State Inspector of Mines, 1989 and preliminary data for 1990.

[1]Production and employment reported as part of the Black Butte mine.

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

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

production from Wyoming and West Virginia, Inc.'s Blue Sky No. 1 mine. Coal production from underground mines accounts for less than one percent of the State's total coal production.

Employment at Wyoming coal mines increased by 63 employees in 1990, an increase of 1.4 percent over 1989 (Tables 8 and 9). This is the third year in a row that total employment in Wyoming coal mines has increased (Figure 13). Employment in southern Wyoming and the Bighorn Coal Field increased by 69 between 1989 and 1990 while employment in the Powder River Coal Field decreased by 6 during the same time period (Table 9). Campbell County coal mines experienced a loss of 40 employees, Converse County lost 42 employees, and Sweetwater County gained 73 employees. While total employment in underground coal mines increased by 30 between 1989 and 1990, total employment in surface coal mines increased by 33 during the same period.

Coal deliveries during the last quarter of 1990 were about one million tons a month more than the year before. Similarly, the amount of unreported deliveries was also higher than anticipated (Table 10 and Figure 14). Unreported deliveries of 7.5 million tons of coal in 1990 included coal used for industrial and commercial purposes, coal delivered in small amounts for test burns, and coal delivered to electric utility plants rated at less than 50 megawatts.

During the last quarter of 1990, the amount of spot coal and its percentage of the total coal delivered to electric utility companies continued increasing. For

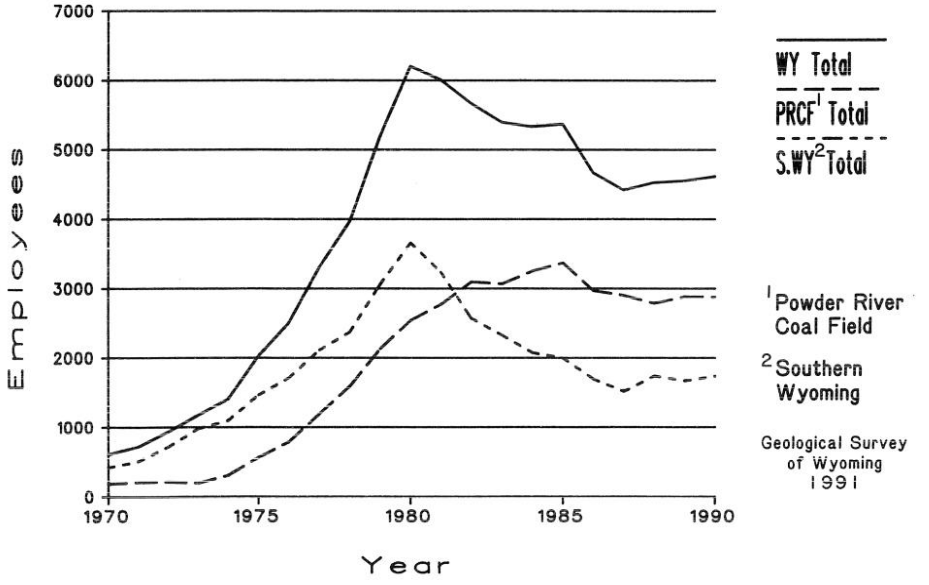

Figure 13. COAL EMPLOYMENT IN WYOMING (1970 TO 1990).

Table 10. COAL DELIVERIES BY MONTH FROM WYOMING MINES[1].

	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE	1990 MONTHLY	1990 CUMULATIVE
JANUARY	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020	15,059,530	15,059,530
FEBRUARY	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160	13,328,290	28,387,820
MARCH	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490	14,535,270	42,923,090
APRIL	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940	14,155,470	57,078,560
MAY	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110	13,882,590	70,961,150
JUNE	10,499,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970	12,948,350	79,482,460	13,649,070	84,610,220
JULY	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640	14,043,350	93,525,810	15,368,280	99,978,500
AUGUST	11,773,510	87,195,190	13,460,470	92,150,870	15,041,090	101,533,730	15,428,210	108,954,020	16,046,910	116,025,410
SEPTEMBER	11,474,820	98,670,010	12,651,550	104,802,420	13,433,610	114,967,340	13,795,760	122,749,780	15,166,020	131,191,430
OCTOBER	10,854,670	109,524,680	12,248,080	117,050,500	13,696,190	128,663,530	14,523,480	137,273,260	15,244,760	146,436,190
NOVEMBER	11,971,990	121,496,670	12,340,720	129,391,220	13,889,890	142,553,420	14,507,130	151,780,390	15,569,280	162,005,470
DECEMBER	13,025,490	134,522,160	13,008,300	142,399,520	14,540,510	157,093,930	13,527,880	165,308,270	14,479,970	176,485,440
TOTAL TONNAGE REPORTED	134,522,160		142,399,520		157,093,930		165,308,270		176,485,440	
TOTAL TONNAGE NOT REPORTED	1,782,896		4,089,128		6,494,270		5,831,734		7,521,261	
TOTAL TONNAGE PRODUCED[2]	136,305,056		146,488,648		163,588,200		171,140,004		184,006,701	

[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.

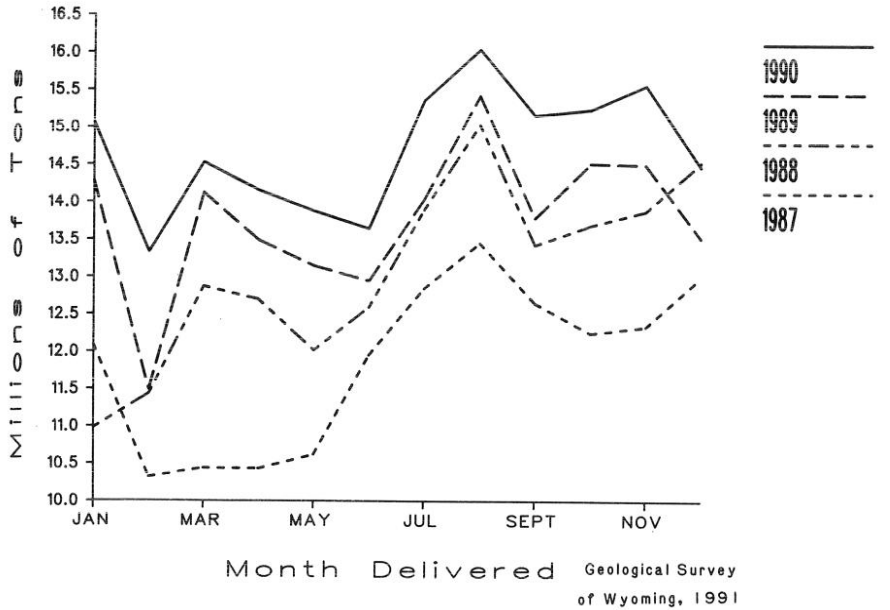

Figure 14. REPORTED DELIVERIES FROM WYOMING COAL MINES (FROM COALDAT MARKETING REPORT BY RESOURCE DATA INTERNATIONAL, INC., COMPILED FROM FERC FORM 423 FILED MONTHLY BY ELECTRIC UTILITIES.

example, almost 18 percent of all coal delivered to electric utilities in the last quarter of 1990 was spot coal. In December alone, spot coal accounted for 19 percent of all coal delivered to electric utility plants. During the first half of 1990, spot sales were only 13 percent of the total coal deliveries. For all of 1990, spot sales accounted for at least 25.8 million tons or 14.6 percent of all coal sold to electric utility 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, approximately 24 percent of the coal sold in 1990 were at prices below $5.00 (Table 11).

Wyoming coal was delivered to electric utilities in 22 states in 1990. Of these, only seven states (Texas, Arkansas, Illinois, Louisiana, Oklahoma, Colorado, and Washington) received less coal in 1990 than in 1989. Coal deliveries to Texas were 1.6 million tons less. Significant increases in coal deliveries were noted to Georgia (up 2.2 million tons), Indiana (up 4.0 million tons), Iowa (up 1.8 million tons), and Michigan (up 1.3 million tons).

Despite a 7.5 percent increase in coal production in 1990, we are still predicting only a five percent increase in coal production statewide for 1991 (Table 2 and Table 11). Coal production from the Powder River Coal Field should increase again in 1991, but there is still no evidence that markets for Wyoming coal have changed appreciably since last year. Additional utility companies will

Table 11. COAL PRODUCTION AND FORECAST TO 1995 (MILLIONS OF TONS).

	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1988[1]	1989[1]	1990[1]	1991	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	154.7	157.4	164.8	172.4	181.1	190.1
Converse County	2.7	3.3	3.6	4.8	5.1	5.7	6.1	7.9	8.0	9.0	10.0	10.5	11.0
Sheridan County	2.9	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.1	M[2]	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.5	4.3	4.1	3.8	3.5
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	12.0	11.9	12.5	13.0	13.0	13.0	13.0
Lincoln County	4.0	4.1	4.3	4.0	3.8	4.9	4.8	4.7	5.1	5.3	5.5	5.6	5.8
Hot Springs County	M	M	M	M	M	M	M	0.1	M	M	M	M	M
Total Wyoming[3]	112.2	130.7	140.7	135.7	146.5	163.6	171.1	184.0	187.6	196.4	205.0	214.0	223.4
Annual change	4%	16.5%	7.7%	-3.6%	8.0%	11.7%	4.6%	7.5%	5%	5%	4%	4%	4%
Low-priced coal[4]			6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%

[1] These are actual values for comparison. [2] M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, April, 1991. [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.

be testing low-sulfur Wyoming coal in 1991 as they assess their options for meeting the impending acid rain control regulations under the recently passed Clean Air Act Amendments of 1990. While the exact number of utilities that will switch to low-sulfur coals is not yet known, many of them will likely choose to burn Wyoming coal. This conversion will certainly contribute to the growth of Wyoming coal markets and coal production, but not necessarily on the short-term.

In the last **Coal Update** (see *Wyoming Geo-notes No. 29*, January, 1991, p. 17-18), the lack of uncommitted rail capacity was cited as a possible hindrance to the growth of Wyoming coal markets. Since that report, both the Union Pacific (UP) and the Burlington Northern railroads announced plans to improve their ability to haul coal out of the Powder River Coal Field and to decrease the cycle time for coal unit trains. In January, UP announced a 5-year, $250 million program to upgrade their major coal-hauling trackage in Nebraska, Kansas, Wyoming, Texas, Louisiana, and Missouri. This is part of a $620 million improvement plan. UP, in a joint venture with Western Railroad Properties, Inc., hauls coal out of the Powder River Coal Field to the Joyce siding, in eastern Nebraska. Eastward from Joyce, UP operates a major coal transportation route to midwestern U.S. markets.

Burlington Northern (BN) announced that they would spend upwards of $190 million per year over the next several years to improve their major coal unit train routes. The improvements announced by BN included upgrading trackage, using longer unit trains, using lighter aluminum coal hoppers, and using higher-powered locomotives. In their announcement, BN claimed that they would be able to handle an additional 50-60 million tons of coal a year by 2001.

Chicago and North Western Transportation Company (C&NW) also announced that they intended to do whatever was necessary for them to grow with the demand for additional capacity. The company has spent $55 million in the last two years for additional locomotives to haul coal unit trains.

The impending settlement of two lawsuits involving Wyoming coal were of interest in the first quarter of 1991. The first settlement involves 53.5 million tons of recoverable coal owned by Whitney Benefits, Inc., north of Sheridan. The coal is not minable, however, because it lies in the alluvial valley of the Tongue River. Under the Federal Surface Mining Control and Reclamation Act (SMCRA), Whitney Benefits is entitled to receive compensation for the coal because they have been denied access to it. At issue in this settlement were both the amount of recoverable coal that existed in the area and the value of the coal. A recent decision in the U.S. Court of Appeals upheld an earlier decision in the U.S. Claims Court that set the amount of coal at 53.5 million tons and the value of the coal at $60.3 million, plus interest accrued since August 3, 1977 (the date SMCRA went into effect). Using these numbers, the coal was valued at about $1.13 per ton.

In the other settlement, the State of Wyoming and a number of coal companies reached an agreement in a lawsuit that involved $25.5 million in protested State severance and ad valorem taxes. At issue in this settlement, were alleged ambiguities in the tax laws that caused coal companies to protest the system of valuation that the State of Wyoming had used in its calculation of ad

valorem and severance taxes in past years. The State of Wyoming filed suit in the 1st Judicial District Court for a declaratory judgment. Under terms of the judgment, the State of Wyoming will refund $7 million to the coal companies that filed suit; the remaining $19 million plus interest will be distributed to both the State of Wyoming and several counties. A number of other lawsuits, filed by individual coal companies against the State of Wyoming's valuation methods and tax audits, are still pending.

In the first quarter of this year, the Geological Survey of Wyoming (GSW) published the *Coal map of Wyoming*. This new color map contains the latest information on the extent of coal-bearing rocks, the outcrops of coal beds, and revised boundaries of many of the State's coal fields. The 1:500,000-scale wall map also shows locations of active, proposed, and abandoned coal mines; railroad routes and unit train loadouts; coal-consuming facilities; planned coal development projects; electrical generation plants; and electrical transmission lines. The map is the first color map of Wyoming at this scale devoted exclusively to coal deposits since 1950 (p. 64). This map complements a 1:500,000-scale coal map of the Powder River and Black Hills coal fields, which the GSW published in 1990.

The Geological Survey of Wyoming (GSW) and the U.S. Department of Energy's Energy Information Administration (EIA) recently entered into a one-year, $74,000 cooperative agreement to quantify the quality of Wyoming's coal reserves. With EIA's assistance, the GSW is characterizing the quality of Wyoming's remaining strippable coal, which is estimated at more than 26.7 billion tons. In addition, the GSW may do a similar characterization of the estimated 38.3 billion tons of coal reserves recoverable by underground mining methods. The EIA is providing $60,000 of the total funding for the project, plus some technical assistance and information. This agreement with the EIA is part of a nationwide effort to characterize the quality of coal reserves. Wyoming was chosen as an early participant because the EIA recognized that there was little analytical data available when Wyoming's reserves were originally calculated prior to the mid-1970s.

For this project, the GSW's Coal Division is preparing maps of the State's known coal reserves and plotting sulfur and heat values (Btu/pound) of the coal beds, which comprise the reserves. Once these reserve maps are prepared, the GSW investigators can report coal quality in pounds of sulfur per million Btu. By reporting the reserves this way, the study will document the amount of compliant coal remaining in Wyoming's coal deposits. While earlier reports indicate that Wyoming has at least 7.8 billion tons of compliant coal, State Geologist Gary Glass feels these estimates are low and that Wyoming probably has at least twice that much compliant coal. He went on to say that this report will prove him right or wrong on this prediction. "In either case," Glass said, "Wyoming has the largest reserves of compliant coal in the lower 48 states."

Compliant coal refers to coal that utility companies can burn in power plants without expensive scrubbers to remove sulfur dioxide emissions. By putting Wyoming's reserves into several different categories on the basis of pounds of

sulfur per million Btu, the completed study will indicate how much of Wyoming's coal reserves are complaint even if New Source Performance Standards (NSPS) change.

The head of the GSW's Coal Division is leading the study, which is now in its fourth month. Currently there are three people working on the project at the GSW's offices in Laramie.

Developments in western and southwestern Wyoming

This area of Wyoming includes the Bighorn, Green River, and Hams Fork coal fields. Coal production in the latter two coal fields in 1990 was slightly less than in 1989 while coal production in the Bighorn Coal Field in 1990 was almost double that of 1989. In the Green River Coal Field, two underground and two surface mines were active in 1990 (Table 9 and Figure 15). While both surface mines decreased production in 1990, both underground mines increased coal production. Coal production and employment data for the Black Butte mine now include data from what was previously known as the Leucite Hills mine.

Two surface mines in the Hams Fork Coal Field (Lincoln County) were active in 1990 (Figure 15). FMC Wyoming Corporation's Skull Point mine increased coal production in 1990 while Pittsburg and Midway Coal Mining Company's Kemmerer mine decreased production (Table 9). Both mines extract subbituminous coal from the Late Cretaceous Adaville Formation.

The Bighorn Coal Field had one active mine in 1990, Northwestern Resource Company's Grass Creek mine (Figure 15). This mine extracts bituminous coal from the Paleocene Fort Union Formation. Most of the production at this mine is used at nearby bentonite plants in the Bighorn Basin, which use it as a fuel in the drying of their products. Trucks haul coal from the mine. The 101,961 tons of coal produced from the Grass Creek mine in 1990 is the largest amount ever produced at the mine in one year. This surface mine has been operating since 1976.

In early March, the Wyoming Department of Environmental Quality notified Utah Power and Light Company (UP&L), a division of Pacificorp, that their 707-megawatt Naughton power plant at Kemmerer was exceeding Wyoming standards for sulfur dioxide emissions. Because the Naughton plant is not currently fitted with flue gas scrubbers, UP&L is discussing its compliance problem with Pittsburg and Midway Coal Mining Company, which supplies coal to the power plant.

Developments in the Hanna Coal Field

Coal production from the four active mines in this coal field was 4.5 million tons in 1990 (Figure 15 and Table 9). Although Arch of Wyoming's Seminoe No. 2 mine did not report any coal production in 1990, 29 workers are still actively employed at the mine doing reclamation work. The underground mining operation conducted by Wyoming and West Virginia, Inc., a subcontractor employed by

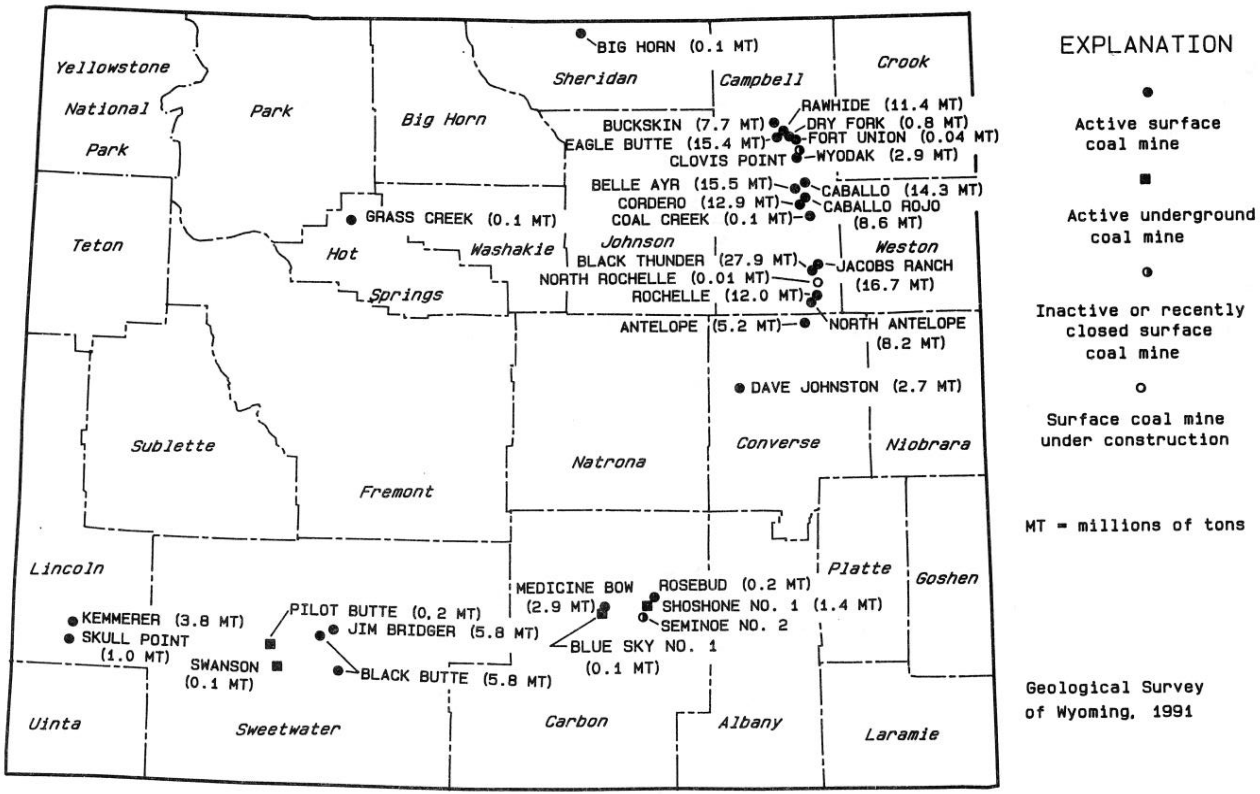

Figure 15. WYOMING COAL MINES AND PRODUCTION IN 1990 (184 MT FROM 31 MINES).

Arch of Wyoming, uses a remote-controlled, continuous miner to extract coal from beds considered too deep for strip mining. The continuous miner enters a coal bed where it is exposed at the base of the final highwall of the strip mine. Guided by video cameras mounted on the front of the continuous miner, coal is extracted downdip from the exposed coal face. A conveyer belt behind the continuous miner carries the mined coal to the surface where it is loaded onto coal haulers, which transport the coal to loadout facilities at the Medicine Bow mine.

A unit train of coal from Arch of Wyoming's Medicine Bow mine was apparently tested in December, 1990, at Arizona Electric Power Cooperative's Apache power plant in southeastern Arizona (no. 1, Figure 16). This power plant normally uses coal from the San Juan or Raton basins in New Mexico. The coal originated on the Union Pacific Railroad and terminated on the Southern Pacific. No other details on the spot sale were available.

Developments in the Powder River Coal Field

The nineteen active surface mines in the Powder River Coal Field collectively produced 12.7 million tons more coal in 1990 than in 1989 (Table 9). Only two mines in the coal field produced less coal in 1990 than they did in 1989. Neither the Fort Union mine, which produces coal for the K-Fuels project, nor Thunder Basin Coal Company's Black Thunder mine exceeded 1989 production. Despite a production drop of 1.6 million tons, the Black Thunder mine still produced 27.9 million tons of coal in 1990 and for the ninth straight year, led both the State and the Nation in coal production from a single mine. Eight surface mines, including

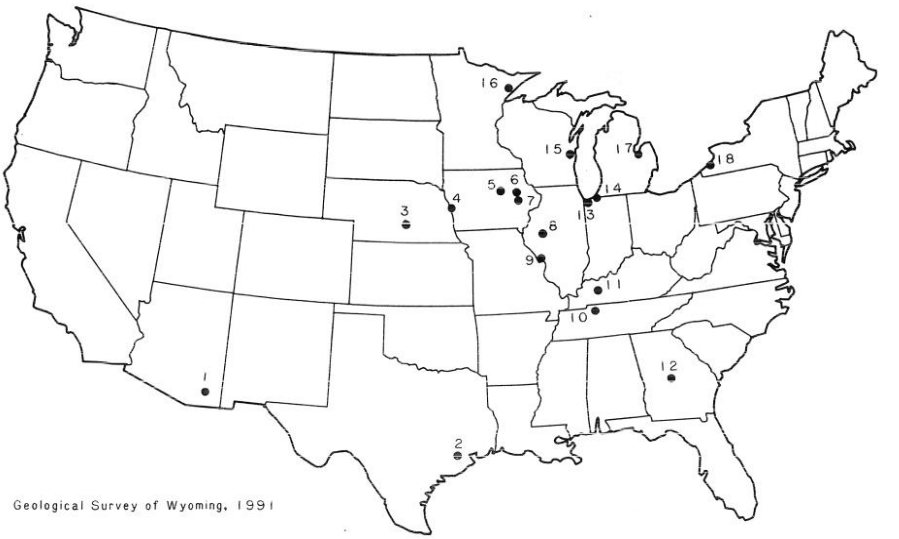

Figure 16. INDEX MAP OF COAL CONTRACT AND SALES ACTIVITIES INVOLVING WYOMING COAL MINES, NOTED DURING THE FIRST QUARTER OF 1991.

the Belle Ayr, Eagle Butte, Caballo, Rawhide, Cordero, Jacobs Ranch, Rochelle, and Black Thunder mines each produced in excess of 10 million tons in 1990 (Table 9).

In response to numerous requests, recent coal production from mines in both the Wyoming and Montana portions of the Powder River Coal Field is presented on Table 12. In 1990, almost 200 million tons of coal were produced from the 25 surface mines located in the Wyoming and Montana portions of the Powder River Coal Field. About 81 percent of that production was from Wyoming.

In another development in the Wyoming portion of the Powder River Coal Field, Cordero Mining Company, a subsidiary of Sun Coal Company, is cooperating with Carbontec Wyoming, Inc. of Bismarck, North Dakota, in a coal-drying project. Cordero will furnish subbituminous coal from their coal mine south of Gillette to Carbontec's 20-short ton-per-day demonstration plant in Bismarck. Carbontec received a $1.0 million loan from the Wyoming Investment Fund Committee in 1989 for testing Wyoming coal in the project (*Wyoming Geo-notes No. 21*, January, 1989, p. 21). Carbontec's process can upgrade a typical subbituminous coal with 30 percent moisture and a heat value of 8,500 Btu/pound to a product having 10 percent moisture and a heat value of 11,500 Btu/pound. If the demonstration plant is successful, a commercial coal-drying plant might be built at the Cordero mine.

Coal Contracts - Powder River Coal Field

During the first quarter of 1991, coal purchasing activities in this coal field were less numerous than the last quarter of 1990. Most of the coal purchased in the first quarter was on the spot market. There were, however, slight increases in the number of coal sales for test burns and for blending.

New coal contracts and sales are summarized below:

1) Thunder Basin Coal Company's Black Thunder mine and Nerco Coal Company's Antelope mine are supplying an undisclosed amount of coal to Cyprus Silver Power Group's 135-megawatt cogeneration plant in Silver Bay, Minnesota (no. 16, Figure 16). This plant, which started up in 1990, powers a nearby taconite pelletizing plant owned by Cyprus. Cyprus plans to sell any excess power that they generate. The plant could burn as much as 400,000 tons of coal each year at peak capacity. Transportation to the plant is via Burlington Northern.

2) Cordero Mining Company's Cordero mine is supplying 100,000-200,000 tons of coal to Grand Island Nebraska Electric Department (no. 3, Figure 16) between March 1 and October 31, 1991. The coal is transported by Union Pacific. Bids from four other producers in the Powder River Coal Field ranged from the $3.70 per ton bid submitted by Cordero to $5.40 per ton from Rochelle Coal Company's Rochelle mine. A bid of $3.50 per ton from Carter Mining Company's Rawhide mine was apparently not considered because the mine is only served by Burlington Northern.

Table 12. Coal production in the Powder River Coal Field, Montana and Wyoming (1980-1990).

Company	Mine name	1980 Production (short tons)	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)
	WYOMING MINES											
Amax Coal Co.	Belle Ayr	16,106,093	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
	Eagle Butte	8,440,000	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
Antelope Coal Co.	Antelope						66,344	1,709,787	2,554,333	3,141,088	3,541,184	5,211,642
Ash Creek Mining Co.	PSO No. 1			835	1,018	715	2,589	20				
Big Horn Coal Co.	Big Horn	4,327,594	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
Carter Mining Co.	Caballo	1,974,164	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
	Rawhide	4,472,530	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
Cordero Mining Co.	Cordero	6,562,802	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
Dry Fork Coal Co.	Dry Fork											815,056
Fort Union Coal Co.	Fort Union	22,046	34,887	206,650	302,032	298,119	532,716	219,313	394,004	508,263	42,092	38,528
Glenrock Coal Co.	Dave Johnston	3,803,932	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
Kerr-McGee Coal Corp.	Clovis Point	2,481,996	3,671,793	2,678,982	3,045,202	1,558,304	1,423,649	1,435,045	1,508,524			
	Jacobs Ranch	8,246,072	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
Mobil Coal Prod., Inc.	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
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
Rochelle Coal Co.	Rochelle						206,565	3,571,177	6,436,359	8,694,125	10,892,567	12,030,237
Shell Mining Co.	North Rochelle											13,000
Thunder Basin Coal Co.	Black Thunder	10,548,996	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
	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
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
Wyodak Res. Dev. Corp.	Wyodak	2,568,611	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
WYOMING SUBTOTAL		69,554,836	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
	MONTANA MINES											
Coal Creek Mining Co.	Coal Creek	63,996	64,142	16,608								
Decker Coal Co.	East Decker	5,577,607	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
	West Decker	5,541,112	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
Peabody Coal Co.	Big Sky	2,964,359	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
Spring Creek Coal Co.	Spring Creek	118,660	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
Western Energy Co.	Rosebud	10,401,972	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
Westmoreland Resources	Absaloka	4,905,262	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
MONTANA SUBTOTAL		29,572,968	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
GRAND TOTAL		99,127,804	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

3) In 1991, Amax Coal Company's Eagle Butte mine and Carter Mining Company's Rawhide mine will supply spot coal to Iowa Power, Inc.'s Council Bluffs, Iowa, power plant (no. 4, Figure 16). Although the volume of coal was not finalized at the time this article was written, the tonnage will probably be 0.5-1.0 million tons. Burlington Northern will transport the coal to the plant.

4) Mobil Coal Producing, Inc. will furnish 600,000 tons of spot coal from its Caballo Rojo mine to three Iowa Electric Light and Power Company generating plants in Iowa. About 300,000 tons of coal will go to the Sutherland, Iowa, plant (no. 5, Figure 16); the remaining 300,000 tons will go to both the Prairie Creek (no. 6, Figure 16) and the Sixth Street (no. 7, Figure 16) power plants near Cedar Rapids, Iowa. The coal contract is for 1991.

5) Powder River Coal Company (a subsidiary of Peabody Holding Company) will supply 320,000 tons of spot coal from its North Antelope mine in southern Campbell County to Wisconsin Power and Light Company's Edgewater, Wisconsin, power station (no. 15, Figure 16). The Edgewater Unit No. 5 will receive 150,000 tons of the coal; the remainder of the coal will be blended with other coals and used in Edgewater Units 3 and 4. The coal is scheduled for delivery during the first half of 1991.

6) Amax Coal Company's Belle Ayr mine supplied 160,000 tons of spot coal to Northern Indiana Public Service Company's (NIPSCO's) Mitchell, Indiana, power plant (no. 13, Figure 16) during January and February, 1991. The utility buys coal from Amax on an "as-needed, as-available" spot contract arrangement.

7) Mobil Coal Producing, Inc. also supplied 160,000 tons of spot coal from its Caballo Rojo mine to NIPSCO's Mitchell, Indiana, power plant (no. 13, Figure 16) during the first two months of 1991. NIPSCO has a similar "as-needed, as-available" contract with Mobil for spot coal supplies.

8) Amax Coal Company's Belle Ayr mine will furnish Houston Light and Power Company with 750,000 tons of spot coal for the W.A. Parish generating station in Texas (no. 2, Figure 16). The coal will be delivered throughout 1991 via two routes: Burlington Northern and Atchinson, Topeka & Santa Fe (AT&SF) railroads and via Chicago and North Western, Union Pacific, and AT&SF railroads.

9) During the first quarter, an undisclosed mine in the Powder River Coal Field furnished 1.0 million tons of spot coal to Georgia Power Company's Scherer generating plant near Macon, Georgia (no. 12, Figure 16). Southern Company Services, Inc. is the fuel buyer for Georgia Power.

10) Another undisclosed mine in the Powder River Coal Field furnished Consumers Power Company with 81,000 tons of spot coal during the first quarter of 1991. The coal was for the Weadock, Michigan, power plant (no. 17, Figure 16).

Coal furnished for test burns is summarized below:

1) Nerco Coal Company (a subsidiary of Pacificorp) sold an undisclosed amount of coal from its Antelope mine for test burning at Illinois Power Company's Wood River, Illinois, power station (no. 9, Figure 16).

2) Rochelle Coal Company (a subsidiary of Peabody Holding Company) furnished test coal from its Rochelle mine to Illinois Power Company's Havana, Illinois, power station (no. 8, Figure 16). The coal was blended with varying amounts of eastern coal as well as burned alone.

3) Mobil Coal Producing, Inc.'s Caballo Rojo mine will supply 11,000 tons of coal in April, 1991, to Niagara Mohawk Power Company's Dunkirk Unit No. 2 in western New York (no. 18, Figure 16). The coal will be blended with eastern coal in a 30/70 western/eastern ratio. Burlington Northern is the originating railroad; Bessemer and Lake Erie Railroad will transport the coal to a dock on Lake Erie where it will be blended with the eastern coal; and barges on Lake Erie will take the coal to the Dunkirk plant.

4) Five coal mines in the Powder River Coal Field, including the Cordero, Buckskin, Belle Ayr, Antelope, and Black Thunder mines, will each supply an additional 100,000 tons of spot coal to the Tennessee Valley Authority (TVA). Previous spot sales of 100,000 tons of coal from each mine (*Wyoming Geo-notes No. 29,* January, 1991, p. 23) were used at TVA's Paradise, Kentucky, generating plant. TVA will use up to 0.3 million tons of the additional coal in tests at their Cumberland, Tennessee, power plant (no. 10, Figure 16). The remainder of the additional coal will be used in tests at the Paradise plant (no. 11, Figure 16). Three of the above coal mines will ship coal directly to the Cumberland plant rather than to Paradise.

5) Amax Coal Company's Belle Ayr mine supplied 40,000 tons of test coal to NIPSCO's Michigan City, Indiana, power station (no. 14, Figure 16) in March, 1991.

INDUSTRIAL MINERALS AND URANIUM UPDATE

by Ray E. Harris, Industrial Minerals and Uranium Division Head, Geological Survey of Wyoming

Aggregate (Construction)

Rissler and McMurry Co., which was granted a mining permit to operate an aggregate quarry in the Alcova Limestone on Bessemer Mountain west of Casper, has proposed another quarry site located near Jackson Canyon. This site is nine miles southwest of Casper. If approved, this new site would replace the quarry on Bessemer Mountain. Residents near Bessemer Mountain oppose the Bessemer Mountain quarry location. The U.S. Bureau of Land Management has begun

a series of public hearings regarding this new quarry site. There is, however, already opposition to the new site, which is adjacent to an Area of Critical Environmental Concern (ACEC), but not in it.

Aggregate (Railroad Ballast)

Meridian Minerals, operator of the railroad ballast quarry west of Cheyenne, is still looking for a buyer for the facility. Meridian wants to sell all of its industrial minerals properties. The quarry continues to produce ballast for both the Burlington Northern Railroad (Meridian's parent company), and the Union Pacific Railroad.

The Geological Survey of Wyoming (GSW) is also looking for potential sources of railroad ballast. Railroad Stone Systems, Inc. provided a small unrestricted grant to aid in the GSW's field investigations.

Decorative Aggregate and Stone

The Geological Survey of Wyoming has been awarded a grant from Sunrise Stone, Inc. to help them locate sources of decorative stone and to evaluate quarry sites. As a result of this award, Sunrise Stone moved several large, gray, red, and pink marble blocks from deposits in northeastern Platte and northwestern Goshen counties to a staging area north of Guernsey. These blocks will be shipped to out-of-state stone-cutting facilities where they will be cut into slabs and displayed to potential buyers. If there is a demand for these marble products, several quarries could open in the area. Should market demand warrant it, there is also interest in constructing a stone-cutting and processing facility in the Guernsey area.

In late March, Sunrise Stone also opened a test quarry in black amphibolite in northern Albany County. If tests are successful, Sunrise will ship three 4' x 4' x 8' blocks to a stone-cutting facility in Denver in early April. A full-scale quarry could begin production later this spring. Sunrise Stone is also considering other black, blue, green, and red granites in Albany and Carbon counties for future development.

New occurrences of black and red granite and gray and brown marble were located by the Geological Survey of Wyoming in the first three months of 1991. Samples from these occurrences are on display at the Geological Survey of Wyoming building on the University of Wyoming campus.

In a cooperative effort with the Wyoming Department of Commerce's Division of Economic and Community Development, the Geological Survey of Wyoming is preparing an illustrated report, which will have color photographs of decorative stone that occurs in Wyoming. This report should be published in 1991.

Feldspar

In 1990, feldspar was mined in Wyoming for the first time since 1982. A Gillette-based company, Wyoming Red Rock, mined and sold feldspar from a

pegmatite deposit on Casper Mountain. Feldspar is used in ceramics, in specialty products such as dental materials, as an abrasive, and as decorative aggregate.

Fertilizer

Last year, Chevron Chemical Co. announced that its fertilizer plant southeast of Rock Springs was for sale. In mid-February of this year, Chevron reported that it had numerous inquiries from potential buyers, many of whom were producing fertilizer in other locations. The Rock Springs plant produces fertilizer from phosphate mined in Utah and from sulfur recovered from natural gas produced in Wyoming.

Gypsum

Both Celotex at Cody and Georgia-Pacific, south of Lovell, operated their gypsum mines at capacity in 1990 and in early 1991. Their capacities are 215,000 and 216,000 tons per year, respectively. These mines produce gypsum which is pressed into wallboard in nearby plants. According to the U.S. Bureau of Mines, the demand for gypsum nationally is strong and increasing due to increased construction. In 1991, it is likely that these plants will continue to produce wallboard at their capacities.

Mountain Cement mines gypsum south of Laramie for use in the manufacture of cement at its 300,000-ton-per-year Laramie plant. In 1991, gypsum production for Mountain Cement should continue at about the same level as 1990.

Limestone and Lime

Dakota Coal Company, a subsidiary of Basin Electric Power Cooperative, announced that it was planning to construct a lime plant 25 miles northeast of Guernsey. A subsidiary company, Wyoming Lime Producers, will operate the plant, which will use limestone from the Bass quarry in the Mississippian-Devonian Guernsey Formation near the plant location. The lime is for use in scrubbing sulfur dioxide from stack gas at the Laramie River Power Station near Wheatland, Wyoming, and at the Antelope Valley Power Station near Beulah, North Dakota. The plant construction costs are estimated at about $5 million, and the plant will employ about 40 people when completed. This plant should give a needed economic boost to the local area. Platte County lost a greater percent of its population between the 1980 and 1990 censuses than any other county in the Nation. Basin Electric officials report that there is already a long list of applicants for employment at this facility.

Pete Lien, Inc. still plans to develop a limestone quarry and construct a lime plant near Laramie. The company, which has expressed interest in mitigating any negative effects of its quarrying, is considering several quarry locations, both near Laramie and elsewhere. The proposed Laramie operation will employ about 50 people. The Pete Lien quarry will produce about 300,000 tons of limestone a year, which is about the same tonnage quarried each year at the Mountain Cement quarries near Laramie.

Nationally, the production of lime is increasing. The following table from the U.S. Bureau of Mines (1991) shows annual lime production for the last five years:

Year	Domestic Lime Production (short tons)
1986	14,474,000
1987	15,733,000
1988	17,052,000
1989	17,152,000
1990 (estimated)	17,400,000

Lime is used for steel making, stack gas desulfurization, paper and pulp manufacturing, water purification, and soil conditioning.

Perlite

The Harborlite perlite plant west of Green River expands perlite mined in Arizona and sells the product (expanded perlite) to the nearby soda ash plants for use as a filter aid. Production from this plant is expected to increase in 1991 as soda ash production increases.

Silica

Interest in silica deposits in Wyoming has continued. Silica (SiO_2) is the primary ingredient in glass. A California-based company announced plans to remodel the abandoned Atlantic City iron mine facilities and manufacture glass at that site southwest of Lander. The company is planning to use silica from Platte County and soda ash from the Wyoming trona basin in Sweetwater County. There could be a wrinkle in these plans, however, since it looks like all the buildings at the site of the Atlantic City iron mine will be destroyed or removed as a part of site reclamation (see discussion of South Pass on p. 49).

The Geological Survey of Wyoming (GSW) is assisting in the study of a silica sand deposit in John Blue canyon north of Lovell. This project is sponsored by the Town of Lovell, using grant funds from the Wyoming Department of Commerce, Division of Economic and Community Development (formerly called the EDS Board).

In addition, the GSW has received inquiries about silica deposits in Albany, Big Horn, and Platte counties.

Trona and Soda Ash

Trona is mined by five companies west of Green River in Sweetwater County. These companies process the trona into soda ash and other sodium-based products (*Wyoming Geo-notes No. 28*, p. 31) Wyoming is now the Nation's only producer of soda ash. The last non-Wyoming, domestic, soda ash producer ceased production in late 1990. It is not known if this closure is permanent. This plant is in southern California.

The market for soda ash looks like it will remain strong enough in 1991 to set another production record. There are two growing uses of soda ash that have contributed in a major way to increasing demand. Caustic soda, which was once almost exclusively manufactured by processes using chlorine, is now being made from processes that use soda ash instead of chlorine. Regulations governing the use of chlorine have increased chlorine processing costs to levels where a soda ash process is less expensive.

Somewhat ironically, the other growing market for soda ash is its use as a substitute for caustic soda. In some applications, soda ash works as well and is less expensive than caustic soda.

The increase in domestic consumption of soda ash masked a downturn in the export market. China, the largest importer of Wyoming-produced soda ash, cut its purchases significantly, and 500,000 fewer tons of soda ash were exported from the U.S. in 1990 than in 1989. There is some optimism for increased exports in the future since the European Community Commission repealed an anti-dumping duty on soda ash from the U.S. This encourages European countries to begin importing soda ash from the United States.

In Wyoming, Tg Soda Ash announced that construction on a proposed caustic soda plant may begin late in 1991. The $40 million project should employ 200 to 300 construction workers and take two years to build. The plant is a joint venture between Texasgulf and Atochem North American. Both joint venture partners are subsidiaries of Elf Aquitane, Inc., based in Paris, France.

In February, 1991, BWAB Inc., a Denver-based company, announced that it had received the necessary approvals from the U.S. Bureau of Land Management to conduct a test drilling program for black trona water in southwestern Wyoming. Black trona water is ground water that contains organic materials and is saturated with trona. The organic materials color the water black and make it smell like crude oil. If BWAB's test program near Farson is successful, they plan to produce soda ash from the trona that they recover from the black trona water. In addition, they may be able to produce organic-based fungicides, pesticides, and pigments from the by-product black water.

Uranium

The spot market price of U_3O_8 dropped from $9.80 to $9.50 per pound in the first quarter of 1991. Low-cost imported uranium has kept the market for U.S. uranium weak. And some international developments may drive the price even lower in the near future.

The Soviet Union (USSR) has apparently mined far more uranium than it could possibly have used during the past forty years. Some industry analysts say there are enormous stockpiles of uranium in the USSR. Recently, the USSR announced sales from their stockpile at extremely low prices. Some domestic utilities, including Yankee Atomic, contracted for uranium from the USSR for use

in nuclear power plants. Congress is looking into legislation to prevent low-cost purchases from the USSR stockpile. The U.S. Department of Energy is trying to determine how much uranium is stockpiled in the USSR.

South Africa is another major producer of uranium, and it produces uranium at far lower costs than domestic producers. There has been a sanction on imports from South Africa due to that country's racial policies. Because these sanctions may be lifted soon, the importation of South African uranium may also contribute to a further lowering of uranium prices.

Australia contains the world's largest uranium resources. Because of the high quality of the Australian deposits, their mining costs are far below U.S. mining costs. Although Australia enacted legislation a few years ago restricting production to only three mines, the Australian Labor Party is now reviewing this restriction. Australia is experiencing a major economic recession and may drop the three-mine limit. If it does, additional low-cost uranium will appear on the market.

To add to the woes of uranium producers, a recent story in the magazine *Nuclear Fuel* stated that the U.S. Department of Energy (DOE) planned to sell 7.5 million pounds of uranium on the open market. At current rates of production, this amount is approximately equivalent to eight years of uranium production from Wyoming. Very alarmed, the uranium producing industry went to DOE and to Congress to protest the sale. The DOE says the sale will happen sometime in the future, and that the uranium will be sold gradually, minimizing its effect on prices. Despite what DOE says, many observers predict that the price of U_3O_8 will decrease, just as the price of silver decreased when Federal stockpiles were sold.

In Wyoming, Pathfinder Mines, a subsidiary of COGEMA, is mining uranium in the Shirley Basin, and Power Resources, a British-owned company, produces uranium by in-situ solution mining methods from the Highland property and adjoining areas in the southern Powder River Basin. Pathfinder sold part of its property in the Crooks Gap area to U.S. Energy, a subsidiary of Crested Corporation. Pathfinder also purchased the Ruth property in Johnson County and the North Butte property in Campbell County. Both of these properties have mining permits, and Pathfinder plans to develop them for in-situ solution mining.

Families and individuals entitled to Federal compensation under the recently passed Underground Uranium Miners Compensation Act may begin receiving checks later this year. The compensation act provides benefit payments to miners or their families for health problems resulting from working in underground uranium mines prior to 1967. The U.S. Department of Justice is working out the regulations mandated by the legislation. Persons claiming benefits under this law have to wait until the regulations are completed before applying.

METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel, Deputy Director, Geological Survey of Wyoming

Mining companies are already planning reconnaissance exploration studies in Wyoming for the upcoming field season. Contacts and inquiries directed to the Geological Survey of Wyoming indicate that exploration in the State this summer and fall may surpass that of last year, even though the mining industry is in another recession. A modest increase in diamond exploration is expected. Some exploration for gold and possible property development is anticipated in South Pass and the Black Hills. Exploration for base and precious metals is also expected in the Absarokas, the Lake Alice district, the Hartville uplift, the Sierra Madre, and the Medicine Bow Mountains (Figure 17).

During February, the author attended the SME-CMA joint conference in Denver and presented a paper on precious metal deposits in Wyoming to the Colorado Mining Association (CMA) (Hausel, 1991a). A second paper on the mineral potential of the Wyoming Province was presented to the Society for Mining, Metallurgy, and Exploration (SME) (Hausel and others, 1991). A limited number of reprints of the CMA paper are available from the author. The other paper is available from SME as Preprint 91-72.

Diamond

The Geological Survey of Wyoming's (GSW's) exploration for diamondiferous kimberlite and lamproite will resume this summer under another grant from the University of Wyoming's Mining and Mineral Resource Research Institute. To date the project has revealed more than 100 heavy mineral anomalies in the Laramie Mountains in southeastern Wyoming. The project apparently has attracted the interest of diamond exploration firms around the world. For instance, the GSW has recently been contacted by both a consulting firm and a major mining company about exploration and testing of diamond deposits in the State Line district and elsewhere in Wyoming. Additionally, there are several reports of two other major international mining companies searching large areas in Wyoming for commercial diamond deposits.

The GSW will resume collecting stream-sediment sample concentrates in the Laramie and Medicine Bow Mountains this summer. As part of the research study, the GSW will also look for diamonds in lamproites in the Leucite Hills near Rock Springs.

Keystone district, Medicine Bow Mountains

The Keystone district in the central Medicine Bow Mountains, was examined by the Geological Survey of Wyoming (GSW) in 1989 and last fall (*Wyoming Geo-notes No. 25*, p. 35). The GSW's studies concentrated on the Keystone-Florence trend because the owner had requested assistance. The Keystone mine was also recently sampled by Homestake Mining Company.

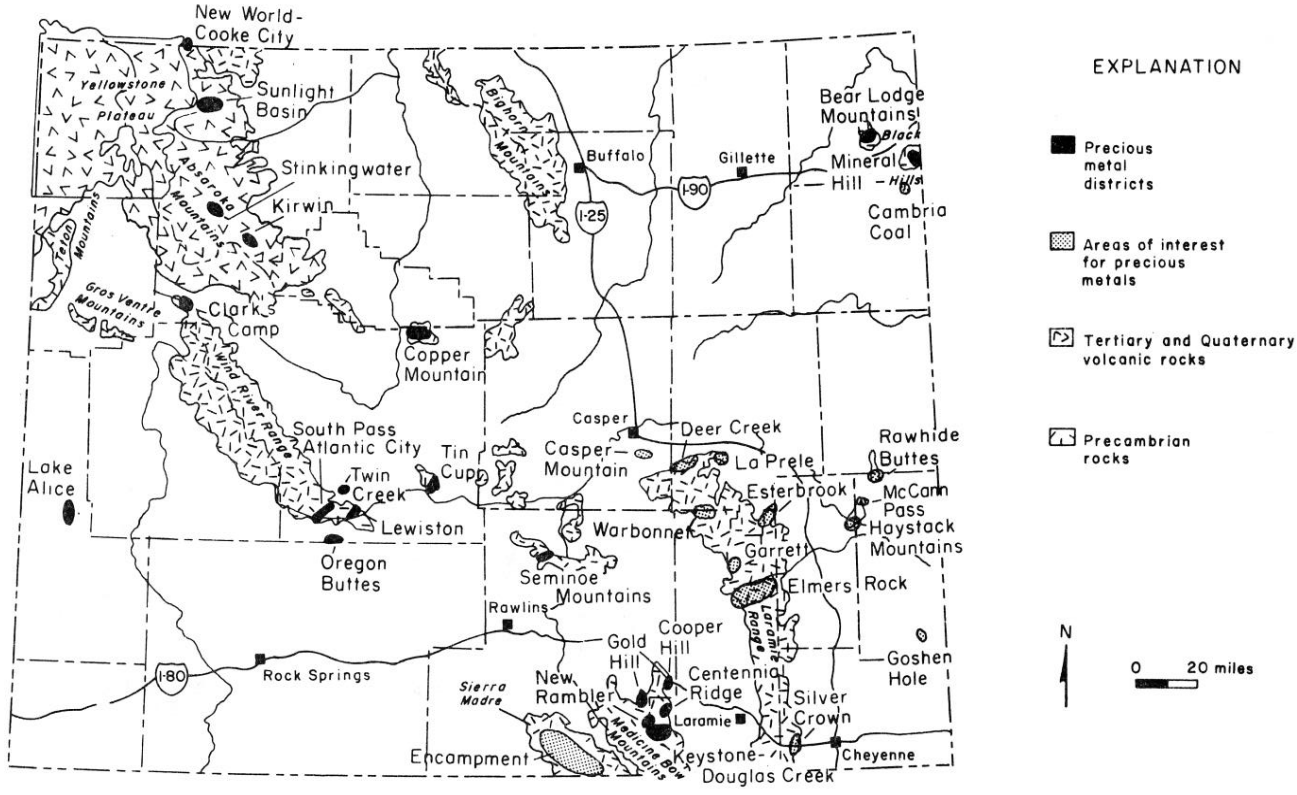

Figure 17. PRINCIPAL METAL DISTRICTS AND MINERALIZED REGIONS OF WYOMING.

The Keystone mine operated for a few years in the late 1800s and terminated operations for an unknown reason in 1893 with 6,000 tons of ore on the surface and 10,000 tons of ore still underground. The ore tenor reportedly averaged 1.2 ounces per ton gold (Currey, 1965). The mill was not dismantled until the early 1950s. Presumably, since very little ore remains on the site today, the material that was stockpiled on the surface was either milled or used in grading a nearby Forest Service road.

The Keystone-Florence trend is a mineralized shear zone traceable for approximately one mile on the surface. The shear cuts across the contact between Keystone Quartz Diorite and chlorite schist and is hosted by both rock types. The structure varies from 2-6 feet wide with local splays up to 300 feet long. Earlier information and recent sampling by the GSW indicate the shear is weakly mineralized along much of its trend with ore shoots at both ends (Table 13). While actual production from the Keystone and Florence mines is unknown, Currey (1965) estimated production of 5,000 ounces from the Keystone and 2,500 ounces from the Florence.

Table 13. GOLD, SILVER, COPPER, AND TUNGSTEN ANALYSES FOR SAMPLES FROM THE KEYSTONE-FLORENCE TREND, CENTRAL MEDICINE BOW MOUNTAINS. ANALYSES BY J.T. ROBERTS AND XRAL LABS.

Sample No.	Description	Au (ppm)	Ag (ppm)	Cu (%)	W (ppm)
FLORENCE MINE					
FL1-89	Six-inch wide chip sample of silicified quartz diorite	0.21	2.3	0.03	-
FL2-89	Limonite-stained quartz diorite	0.60	1.3	-	-
FL3-89	Quartz, minor limonite	0.54	-	-	-
FL4-89	Quartz, uncommon limonite, from mine dump	0.08	<0.5	-	-
FL5-89	Limonite after pyrrhotite and siderite in quartz diorite	0.92	-	-	-
FL1-90	Grab sample of milky quartz with limonite boxworks after pyrrhotite	0.71	0.6	-	-
FL2-90	Two-foot channel of milky quartz vein	0.15	<0.5	-	-
FL3-90	Wallrock sample of quartz diorite w/ minor disseminated sulfides	0.93	<0.5	-	-
FL4-90	Limonite-stained, 6-inch-wide quartz stringer	2.1	0.5	-	5
FL5-90	Chloritized quartz diorite wallrock	<0.01	<0.5	-	3
FL6-90	Selected sample of quartz diorite with primary pyrite and limonitic quartz stringer	45.0	1.6	-	10
FL7-90	Disseminated pyrite in chloritized quartz diorite	1.5	1.4	-	-
FL8-90	Argillized quartz diorite from Little Florence mine	<0.01	0.8	-	1
KEYSTONE MINE					
KS2-89	Milky quartz with minor pyrite and common limonite boxworks	22.0	2.6	-	-
KS3-89	Milky quartz with disseminated pyrite and siderite	2.1	-	-	-
KS4-89	Limonite-stained quartz-breccia vein	<0.05	<1.0	-	-
KS1-90	Milky quartz with siderite and limonite	0.11	1.0	-	12
KS2-90	Limonite-stained quartz in chlorite schist	0.28	0.6	-	19
KS3-90	Grab sample of limonite-stained quartz	0.92	0.8	-	-
KS4-90	One-foot channel sample of chlorite schist with some quartz	<0.01	<0.5	-	-
KS5-90	Chloritized, epidotized, iron-stained schist wallrock	<0.01	0.8	-	-

Samples from the Florence mine somewhat agree with the historic descriptions of the ore described in Currey (1965). The gold ore reportedly occurred in close association with massive pyrrhotite. Two samples collected a short distance northwest of the Florence shaft contained distinct limonite boxworks after pyrrhotite or pyrite. One of the samples was not assayed because it was specimen-grade and contained abundant visible gold (1 mm and smaller flakes). The second sample contained only a trace of visible gold and assayed 45 ppm (1.31 ounces per ton) gold (Table 13, FL6-90).

The Keystone dump and surrounding exposures have been so thoroughly picked over during the past years that they now show little evidence of ore on the surface. However, two specimens of ore were found on the dump, and they assayed 22 and 2.1 ppm (0.64 and 0.06 ounce per ton) gold, respectively (Table 13, KS2-89 and KS3-89).

Lake Alice district

The U.S. Forest Service is examining its management strategy in the Lake Alice district in the Overthrust Belt of western Wyoming. It is soliciting comments on the appropriate usage of the area to include the possibility of restricting access. The Lake Alice district hosts a large, red-bed, copper-silver-zinc-lead deposit of potentially enormous tonnage (Boberg, 1984). Boberg (1984) believes this area could easily host a 100-million-ton resource of copper and silver.

Seminoe Mountains

The Geological Survey of Wyoming (GSW) will continue field studies in the Seminoe Mountains this summer. A detailed map of the Precambrian rocks in the western portion of the Seminoe Mountains district was completed and published as an open file in March (Hausel, 1991b). This map supersedes an earlier map of the area compiled from previous workers (Hausel, 1989). Mapping on the Seminoe Dam Quadrangle to the east should begin early this summer.

The Seminoe Mountains includes a relatively thick belt (1,000-2,000 feet thick) of ultramafic rocks. These rocks are high in MgO, Cr, and Ni. Banded iron formation forms extensive outcrops in the Seminoe Mountains. Because of the affinity that gold has for iron, these rocks are being sampled for gold and silver (Table 14; and *Wyoming Geo-notes No. 29*, p. 34).

The GSW initiated a long-term, statewide project last summer to test banded iron formation for precious metals. Considering the importance of gold-bearing banded iron formation elsewhere (i.e., Jardine, Montana; Homestake, South Dakota; and numerous properties in Zimbabwe) and the abundance of iron formation in Wyoming, this project is considered high priority.

Geologically, the Seminoe Mountains represent a relatively young greenstone belt (2.7-2.9 billion years old), with a lower mafic to ultramafic metavolcanic unit having an apparent thickness of nearly 10,000 feet. The lower unit is overlain by an ultramafic unit with 1,000-2,000 feet of serpentinites and spinifex textured

basaltic and peridotitic komatiites. Several hundred feet of banded iron formation, clastic metasediments, felsic metavolcanics, and metagabbro overlie the middle unit. Gold in the greenstone belt occurs in veins associated with pervasive chloritic alteration, sulfides, quartz, and calcite.

Table 14. GOLD, SILVER, CHROMIUM, NICKEL, AND MAGNESIUM CONTENT OF ROCKS FOR THE SEMINOE MOUNTAINS AND SOUTH PASS REGION. ANALYSES BY XRAL LABS.

Sample No.	Description	Au (ppm)	Ag (ppm)	Cr (ppm)	Ni (ppm)	Mg (%)
SEMINOE MOUNTAINS						
SM94-90	Grab sample of quartz vein with common hematite-limonite boxworks from Sunday Morning mine dump	<0.01	<0.5	-	-	-
SM96-90	Asbestos-bearing serpentinite, Bradley Peak ultramafics	<0.01	<0.5	>4,000	1,700	-
SM97-90	Limonite pitted, talc-serpentine schist, Bradley Peak ultramafics	<0.01	<0.5	1,900	2,400	-
SM98090	Banded iron formation, limonite stained with minor cross-cutting quartz veinlet	<0.01	0.6	-	-	-
SM99-90	Isoclinally folded banded iron formation	<0.01	<0.5	-	-	-
SM100-90	Limonite-stained milky quartz in banded iron formation	<0.01	0.8	-	-	-
SOUTH PASS						
SP8-90	Copper-stained quartz vein in Lewiston district	<0.01	0.6	-	-	-
SP9-90	Wallrock of SP8-90 vein	4.8	2.3	-	-	-
SP1-90	Serpentinite	-	-	1,300	2,700	27.0
SP2-90	Serpentinite	-	-	120	870	14.0
SP3-90	Serpentinite	-	-	1,700	2,500	27.0
SP4-90	Serpentinite	-	-	1,400	2,000	27.0
SP5-90	Serpentinite	-	-	1,600	2,600	26.0
SP6-90	Serpentinite	-	-	1,300	2,400	25.0
SP7-90	Serpentinite	-	-	>4,000	1,400	24.0
JB-Ni	Serpentinite	-	-	2,300	2,400	28.0

Snowy Range, Medicine Bow Mountains

The Snowy Range is underlain by one of the more unique successions of Proterozoic rock in the world. According to Hutchison and Viljoen (1988), "only in the late Archean strata of Wyoming USA [*in reference to the Medicine Bow Mountains and the Sierra Madre*] are there believed to be paleoplacer occurrences of the same age as those in the Witwatersrand". Houston and others (1983) further point out that "the Magnolia Formation is of particular interest because it contains radioactive and fluvial conglomerates similar to the Witwatersrand of South Africa and the Blind River of Canada".

This analogy is important. For if the similarities hold, these rocks in the Snowy Range of the Medicine Bow Mountains could host significant mineral resources. It is reported that since the discovery of the Witwatersrand paleoplacers in 1886, they have produced 52% of the gold mined in all of human history. Total Witwatersrand gold production is estimated at about 44,650 short tons of gold.

The U.S. Forest Service has proposed the withdrawal of more than 12,000 acres in the Snowy Range from mineral entry. If this action is taken, it would lock up an area with tremendous mineral potential.

Within the area slated for withdrawal, significant gold mineralization was identified by geologists from the U.S. Forest Service and the Geological Survey of Wyoming. Sulfide samples collected from a 100-200 feet wide and 2,000 feet long, limonite-stained shear zone from the Lewis Lake prospect (S/2 S/2 section 8 and N/2 N/2 section 17, T16N, R79W) yielded assays from 0.063-4.8 ppm gold (0.002-0.14 ounce per ton). The average of four samples collected in this sulfide zone was 3.09 ppm (0.09 ounce per ton).

Southern Wyoming

The Geological Survey of Wyoming (GSW) has begun collecting information on occurrences of precious metals in southern Wyoming as a prelude to field studies, which are supported in part by a grant from Union Pacific Resources. Several individuals have already contacted the GSW about their precious metals discoveries along or adjacent to the Union Pacific land grant. Some of these discoveries include 1-2 mm rounded gold particles found in sands and sandstones in the middle of a basin and fine gold from sand and gravel deposits.

In order to more easily follow any discovered mineralized trends, the GSW contracted with a mobile-laboratory, which can process samples on site and on the same day they are collected. This procedure will eliminate the typical three to five months delay in obtaining assays through more conventional laboratories.

South Pass

The final report on the Geological Survey of Wyoming's six-year study of the South Pass greenstone belt was published in March (Hausel, 1991c). This 129-page report draws analogies to the gold-rich terranes in Western Australia and demonstrates similarities of lithology, age, structure, and mineralization between the two regions. The report includes a 1:48,000-scale map of the greenstone belt, a sample location map, more than 100 whole rock and single element analyses, and more than 24 mine maps (p. 65). Some of the mines were sampled in detail during the study.

Several important anomalies and significant mineral occurrences were recognized. Anomalous gold, copper, silver, chromium, arsenic, tin, and tungsten were identified. Some of the more interesting occurrences and deposits included channel and chip samples with gold values as high as 1-3 ounces per ton (opt),

a copper-silver stockwork, a hidden auriferous shear zone, and broad zones of low-grade gold mineralization.

The report concludes that the South Pass area contains several small, high-grade gold deposits; some large, low-grade gold deposits; extensive banded iron deposits; small gold placers; and some giant low-grade gold paleoplacers. There is also some potential for the discovery of a world-class gold deposit.

After the new South Pass report was published, samples of a serpentinite deposit located in the Lewiston Lakes granodiorite a short distance east of the South Pass greenstone belt were collected for x-ray diffraction studies and for chromium and nickel analyses. All of the tested samples were serpentinite containing no apparent nickel or chromium anomalies (Table 14; SP1-90 through JB-Ni). Two samples of a narrow quartz vein in metagreywacke north of the Lewiston district yielded anomalous gold and silver (Table 14, SP8-90 and SP9-90).

The Atlantic City iron mine located along the northern edge of the South Pass greenstone belt was the object of a recent judicial order. According to the Casper Star-Tribune (March 24, 1991, p. B1), a district judge ruled that the support buildings at the Atlantic City iron mine must be destroyed and removed as part of the mine's reclamation. This ruling is in favor of the Wyoming Department of Environmental Quality (DEQ), which is seeking to have the open pit mine reclaimed.

The Atlantic City iron mine, which was operated from 1962 to 1983 by U.S. Steel Corporation (now USMX), yielded more than 90 million tons of iron ore before mine operations were terminated. The iron ore operations ceased during an economic recession, and closure was apparently due to increased mining and milling costs and also to foreign competition. The mine property was eventually sold to Universal Equipment Company.

In 1968, Bayley reported that indicated iron reserves at the mine site were about 300 million tons (average content approximately 30% Fe). This suggests a substantial ore body remains unmined at the site. Recent mapping by Hausel (1987; 1988) supports Bayley. Because this is a relatively low-grade iron deposit, reclamation could make it economically impossible to recover the remaining reserves, even in the future.

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WYOMING MINERAL EXPLORATION SUMMARY - 1990

by Ray E. Harris, W. Dan Hausel, and Richard W. Jones

INDUSTRIAL MINERALS

In 1990, exploration for industrial minerals in Wyoming increased slightly over that in 1989. Several companies producing industrial minerals expanded their operations during the year and some companies explored for new commodities.

Even though exports of soda ash declined in 1990, soda ash production from mined trona in Wyoming increased as a result of growing domestic demand for soda ash and caustic soda produced from soda ash. By year's end all five soda ash producers had announced plans for expansion, and four were actively constructing expanded or new facilities.

In addition, BWAB, Inc., a Denver-based company, announced that it planned an exploration drilling project for black trona water near Farson, which is north of the existing trona mining area in Wyoming. Black trona water is ground water that contains both trona and organic materials. Trona can be recovered from black trona water, and fungicides, pesticides, and pigment can be produced from the organic material in the by-product water.

Bentonite producers continued to develop new resources. Companies must continually explore for and develop various grades of bentonite. These different grades are needed to satisfy widely differing user demands. Wyoming continues to be the largest producer of bentonite in the Nation.

Highway construction was the primary consumer of aggregate in the State in 1990. Exploration for construction aggregate, including railroad ballast, continued during the year. A source of granite for railroad ballast was located in Platte County as a result of a cooperative exploration program between Railroad Stone Systems, Inc., of Denver, Colorado, and the Geological Survey of Wyoming. An application to mine this source of granite was submitted by the end of the year.

Decorative aggregate was shipped from Wyoming in 1990, and several companies explored for green and red quartzite and various colors of granite and marble found in the State. White marble produced by Georgia Marble at Wheatland was the most significant decorative rock product produced in Wyoming last year. Under a contract with Wal-Mart Stores, Georgia Marble also shipped river rock from a quarry east of Guernsey. This rock was packaged and sold as landscape gravel. Red clinker (baked and fused shale), pink feldspar, and green serpentine were also shipped by other companies. A deposit of translucent gray quartz, which was located by the Geological Survey of Wyoming, was tested by a tile manufacturer. This rock was crushed and made into epoxy-based tile.

At least seven companies with interest in producing decorative stone explored for suitable material in Wyoming in 1990. With the assistance of the Geological Survey of Wyoming, Sunrise Stone, Inc. found and selected several blocks of gray, pink, red, black, and green-and-pink marble for market testing. Testing of a chocolate-brown marble, which was described in *Dimensional Stone* magazine (February, 1990), continued. Over 100 cut and polished decorative stone samples are on display at the Geological Survey of Wyoming building at Laramie.

Interest in silica deposits in Wyoming also continued. Two deposits of silica sand near Lovell, Wyoming, were explored. One was studied by the Geological Survey of Wyoming (GSW) using funds from the Town of Lovell through a community block grant from the Wyoming Department of Commerce's Division of Economic and Community Development. In early 1990, the GSW also provided geological and technical assistance to a company that conducted exploration drilling on a silica rock deposit near Glendo, in northern Platte County.

Mountain Cement, which operates a cement plant at Laramie, explored for gypsum and limestone to add to its reserves of these materials. A new limestone source was investigated south of Laramie. The company also looked for sources of iron oxide and other minor additives that are needed for its cement processing.

Limestone was the target for exploration by three other companies in Wyoming in 1990. Pete Lien, Inc., of Rapid City, South Dakota, explored for and located a deposit of high-purity limestone near Laramie. At year's end the company was planning to develop this deposit and construct a lime plant in or near Laramie. Dakota Coal, Inc., which expanded its reserves by drilling at the Bass quarry north of Guernsey during 1990, was developing plans to construct a lime plant at that locality. Lime from this plant would be used as a stack-gas-scrubbing agent in coal-fired power plants. Rissler-McMurry, Inc., of Casper, located a limestone quarry site on Bessemer Mountain near Casper. At year's end the company was completing the permitting process and expected to begin production of limestone aggregate in 1991.

Other commodities that were the subject of private exploration efforts in 1990 included zeolites, construction aggregate, gypsum for additions to the two wallboard manufacturers in northwestern Wyoming, mineral pigment, garnet, mica, and vermiculite.

URANIUM

There was very little exploration for uranium in Wyoming in 1990. The two active uranium producers (Pathfinder Mines in the Shirley Basin, and Power Resources in the Powder River Basin) continued testing their existing properties. Power Resources drilled an in-situ well field on their recently-acquired North Morton Ranch ore body, northwest of their Highland in-situ solution mine. Rio Algom began developmental drilling and the construction of an in-situ well field near the former Bill Smith shaft in the southern Powder River Basin.

METALS AND PRECIOUS STONES

During 1990, the Geological Survey of Wyoming was contacted by several mining companies seeking information and advice on gold, copper, zinc, diamond, and titanium deposits in the State. Most notable were companies from the Black Hills of South Dakota. Citing adversity toward the mining industry in that state, several companies initiated exploration programs in Wyoming to search for minable gold deposits. Exploration for diamond was also on the increase by private industry.

Geological Survey of Wyoming field projects in 1990 included (1) mapping and sampling of the Seminoe Mountains greenstone belt, (2) a study of the historic mining districts and geology along the Snowy Range highway in the Medicine Bow Mountains, (3) stream-sediment sampling for kimberlitic satellite minerals in the Laramie and Medicine Bow Mountains, and (4) a statewide study of the potential for precious metals to occur in banded iron formation (Figure 17, p. 45).

Exploration activities for gold and base metals were reported at a number of localities in the State in 1990 including the Black Hills of northeastern Wyoming, the Medicine Bow Mountains and Sierra Madre of southeastern Wyoming, the South Pass region of the Wind River Range in western Wyoming, the Rattlesnake Hills in the Granite Mountains of central Wyoming, and the Absaroka Mountains of northwestern Wyoming.

Bear Lodge Mountains, Black Hills. The Bear Lodge Mountains Tertiary alkalic complex in the western Black Hills of Wyoming has been receiving interest in regard to epithermal gold mineralization. In 1989, International Curator reported drilling an elongate intrusive breccia 120 feet wide by 2,000 feet long which contained 0.28-1.5 ppm gold (0.01-0.05 ounce per ton). In 1990, Coca Mines leased 1,480 acres of unpatented claims on the Sundance property, and planned to drill 36 holes to confirm the mineralization. The first five holes showed gold mineralization from 30-195 feet thick with an average grade of 0.858 ppm (0.025 ounce per ton).

Diamond exploration. Three major mining companies are reportedly conducting exploration programs and feasibility studies in Wyoming for diamonds in kimberlites and lamproites. Also, a new deposit of low-grade, good quality, diamonds was discovered by the Diamond Company NL (Ashton Mining Ltd., an Australian company)-Moonstone Diamond Corporation joint venture along the Colorado-Wyoming border. The diamondiferous kimberlites are called the Kelsey Lake intrusives. Additionally, a consulting firm from Texas continued to collect data on the Sloan 1 and 2 diamondiferous intrusives in the southern portion of the Colorado-Wyoming State Line district. In total, this district now contains more than 20 known diamondiferous intrusives.

Under a grant from the University of Wyoming's Mining and Mineral Resource Research Institute, the Geological Survey of Wyoming (GSW) continued looking for kimberlite satellite minerals in stream-sediment samples during the summer of 1990. To date the project has revealed more than 100 heavy mineral anomalies

in the Laramie Mountains in southeastern Wyoming. A few of the anomalies are impressive and warrant follow-up sampling and geophysical surveys to locate possible nearby kimberlite intrusives. If possible, the GSW will conduct follow-up sampling and surveying in 1991.

Iron formation. The Geological Survey of Wyoming initiated a long-term, statewide project last summer in which iron formation was tested for the occurrence of precious metals. Considering the importance of gold-bearing iron formation elsewhere (i.e., Jardine, Montana; Homestake, South Dakota; and numerous mines in Zimbabwe) and the abundance of iron formation in Wyoming, the project has more than a little merit. To date, weak gold and silver anomalies have been detected in iron formation in the South Pass-Atlantic City and Lewiston districts of the South Pass region and in the Seminoe Mountains district. Private industry has reported anomalous precious metals associated with iron formation in the Granite Mountains, Hartville uplift, and the Elmers Rock greenstone belt (central Laramie Mountains).

Lake Alice district, Overthrust Belt. Several companies inquired about the Lake Alice district in western Wyoming although it is not known if any exploration occurred in the district during the past year. The Lake Alice district hosts several red-bed, copper-silver-zinc-lead deposits along the contact between the Nugget Sandstone (Triassic-Jurassic) and overlying Twin Creek Limestone (Jurassic), including one large, structurally controlled deposit at the Griggs mine in the northern portion of the district. One consultant's estimate, based on drilling in the late 1970s, suggests this deposit could host a 100-million-ton resource of copper and silver. The U.S. Forest Service (Kemmerer district) began compiling data on an implementation plan for the Lake Alice district and is looking for comments on the usages of the area.

Medicine Bow Mountains, Keystone district. The owner of the Keystone and Florence mines offered the mines for sale. The mineralized shear was sampled by Homestake Mining Company and was also sampled and examined by geologists of the Geological Survey of Wyoming (GSW). The Keystone-Florence trend forms a one-mile-long shear zone with the Keystone and Florence mines located at either end of the structure. The shear varies from 2-6 feet wide with local splays up to 300 feet long. Available information and sampling by the GSW indicates the shear is weakly mineralized along much of its trend with ore shoots at both ends. Samples collected from the Keystone mine by the GSW assayed <0.01-22.0 ppm gold (<0.003-0.64 ounce per ton) and from the Florence mine, <0.01-45.0 ppm gold (<0.003-1.3 ounces per ton). One specimen-grade sample collected from the Florence mine was not assayed because it contained abundant visible gold (1 mm and smaller flakes).

Porphyry copper deposits, Absaroka Mountains. The Absaroka Mountains in northwestern Wyoming represent a deeply dissected Tertiary volcanic plateau. Two large porphyry copper deposits lie outside the Wilderness lands in this area and have been receiving interest by private industry. These are the Kirwin and Sunlight Basin porphyries.

Rattlesnake Hills. In 1982, the Geological Survey of Wyoming (GSW) identified significant gold mineralization in a sulfide-bearing Archean metachert in the Rattlesnake Hills. Composite chip samples yielded gold values of 4.5-7.5 ppm (0.13-0.22 ounce per ton). This discovery attracted several companies including American Copper & Nickel (AC&N), which initiated an exploration program in the area. AC&N's exploration not only extended the GSW's anomaly, but it also revealed widespread low-grade gold mineralization in the nearby Tertiary alkalic intrusives.

Seminoe Mountains. The Geological Survey of Wyoming continued field studies in the Seminoe Mountains gold and iron mining district last summer and produced a detailed geologic map of the western part of the district. Geologically, the Seminoe Mountains represent a 2.7-2.9 billion years old greenstone belt. Samples collected from veins, shear zones, and chloritized and carbonated wall rock yielded a trace to 98.4 ppm gold (2.87 ounces per ton). To date, samples from this area have yielded gold, silver, copper, zinc, and lead anomalies.

South Pass (Wind River Range). Reconnaissance exploration for lode gold was reported by private industry in the South Pass region along the southern tip of the Wind River Range in western Wyoming. 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 200-250 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.

Much of the activity in the greenstone belt was grassroots exploration. Sampling was conducted by a half dozen companies in both the South Pass-Atlantic City (SP-AC) and Lewiston mining districts. Between these two districts, exploration and testing of a previously untested and potentially large gold paleoplacer was reported by a Canadian-U.S. joint venture.

Hecla Mining Company suspended its drilling along the buried south flank of the South Pass greenstone belt. Hecla was searching for the source of gold in the Oregon Buttes Tertiary paleoplacer. The U.S. Geological Survey reported that this paleoplacer hosted at least 28.5 million ounces of gold.

Some placer gold was mined from the Stout placer on Rock Creek in the SP-AC district, and the Gyorvary Mining Company continued work at the Mary Ellen gold mine also in the SP-AC district. The Mary Ellen is an inclined shaft located on a dipping quartz vein in metatonalite porphyry. Available historic reports indicate ore from the Mary Ellen averaged 13.7 ppm (0.4 ounce per ton) gold.

The Geological Survey of Wyoming completed a six-year field mapping and sampling project in the South Pass region. During the study, some previously unreported gold occurrences and deposits were identified or discovered, and

several gold, copper, silver, and some tungsten, tin, and chromium anomalies were identified. Several gold-bearing structures were tested that varied from less than three feet to more than 100 feet wide and yielded grab, chip, and channel samples assaying from a trace to more than 104 ppm gold (3.05 ounces per ton). Ore shoots were identified at shear zone intersections, pinches and swells, and in fold closures.

Coal

Coal exploration in Wyoming was limited to those few coal companies that were proving up reserves and determining coal quality in tracts adjacent to current mining operations. Many coal companies operating in Wyoming have emphasized production of existing reserves in recent years. As has been the trend in the past few years, low coal prices, a relatively soft coal market, and a large productive over-capacity have all decreased incentives for extensive coal exploration programs. However, as discussed below, there are some indications that this situation may be starting to change.

The passage of the Clean Air Act Amendments of 1990 have apparently increased the interest in Wyoming coal. In anticipation of new regulations stemming from this legislation, many coal-burning utility companies started using low-sulfur Wyoming coal in 1990. As a result, coal production in Wyoming surged in 1990. The 184.0 million tons produced was 7.4% greater than in 1989 and set another State production record. Wyoming continued as the leading coal-producing state in the U.S. in 1990.

Four Federal coal exploration licenses in Campbell County and one exploration license in Sweetwater County were active in 1990. In Campbell County, Cordero Mining Company (a subsidiary of Sun Coal Company) explored a 486.95-acre tract, Thunder Basin Coal Company (an operating unit of Arco Coal Company) explored a 6,084.3-acre tract, Powder River Coal Company (a subsidiary of Peabody Holding Company) explored a 320.18-acre tract, and Carter Mining Company (an operating unit of Exxon Coal and Minerals Company) explored a 41.44-acre tract. In Sweetwater County, Bridger Coal Company (an operating unit of NERCO, Incorporated) explored a 5,118.2-acre tract. All of these Federal exploration programs were adjacent to or near the licensee's active mining operations. A total of 12,051.1 acres of Federal coal in the Powder River and Green River coal fields were under exploration license in 1990.

Coal leasing activities, especially in the Powder River Coal Field, increased in 1990. Following the decertification of the Powder River Regional Coal Team (RCT) in early 1990, the Federal government went to a lease-by-application system in this region. This replaced the system of regional lease sales in response to industry expressions of interest. In the latter part of 1990, four coal companies in this region of Wyoming applied for a total of 7,557 acres of Federal coal in five tracts under the new lease-by-application system. Coal reserves in those tracts totalled about 902 million tons. Two other coal companies applied for an additional 20 million tons of Federal coal in two lease modifications adjacent to

active Federal coal leases. Some of the exploration drilling under Federal exploration licenses were done in support of these leasing activities.

Coal exploration drilling by private industry is tracked by the Wyoming Department of Environmental Quality (DEQ) through their Abandoned Drill Hole Program. Data from 1989 drilling became available in late 1990, but because most of it was not yet entered into DEQ's computer system, only an estimate of the total 1989 drilling is possible at this time. The DEQ estimated that about 500 coal exploration holes were drilled in 1989, a decrease of about 256 drill holes from the previous year.

Nearly all the drilling was done on active coal mine permits; development drilling in advance of mining is not included in totals. Most of the drilling was in the Powder River Coal Field in Campbell and Converse counties. A minor amount of drilling occurred in southern Wyoming. If past trends continued into 1989, probably half of the holes were drilled on private lands. Most of the other holes were probably drilled on Federal lands; a few holes may have been drilled on State lands.

GEOLOGIC MAPPING AND STRATIGRAPHY

by Alan J. Ver Ploeg, Stratigraphy Division Head, Geological Survey of Wyoming

SOUTHERN BIGHORN MOUNTAINS PROJECT

The Geological Survey of Wyoming completed work on two new preliminary 1:24,000-scale geologic maps as part of the southern Bighorn Mountains mapping project. The maps are titled, *Preliminary geologic map of the Beartrap Meadows Quadrangle, Johnson County, Wyoming* and *Preliminary geologic map of the Monument Hill Quadrangle, Washakie and Johnson counties, Wyoming.* They are designated Open File Reports 91-4 and 91-5, respectively (p. 65). These two maps represent the eighth and ninth geologic quadrangle maps completed as part of this project (Figure 18). The mapped areas contain some interesting stratigraphic and structural features and are described in *Wyoming Geo-notes No. 28*, p. 41 and in *Wyoming Geo-notes No. 29*, p. 38-39.

STATEWIDE MAPPING PROJECT CONTINUES

The Geological Survey of Wyoming (GSW) recently began work on a second 1:100,000-scale, colored geologic map as part of a project to map the entire State at this scale. This map, the Kaycee Quadrangle, is located directly to the east of the recently completed Nowater Creek 30' x 60' Quadrangle. In order to fill gaps in the compilation of existing geologic mapping for the Kaycee Quadrangle, the

GSW will map the Packsaddle Canyon, Poker Butte, and Hole-in-the-Wall 1:24,000-scale quadrangles this summer field season (Figure 18).

Publication of the Nowater Creek Quadrangle is slated for late this year. The GSW should complete the Kaycee map in about one year.

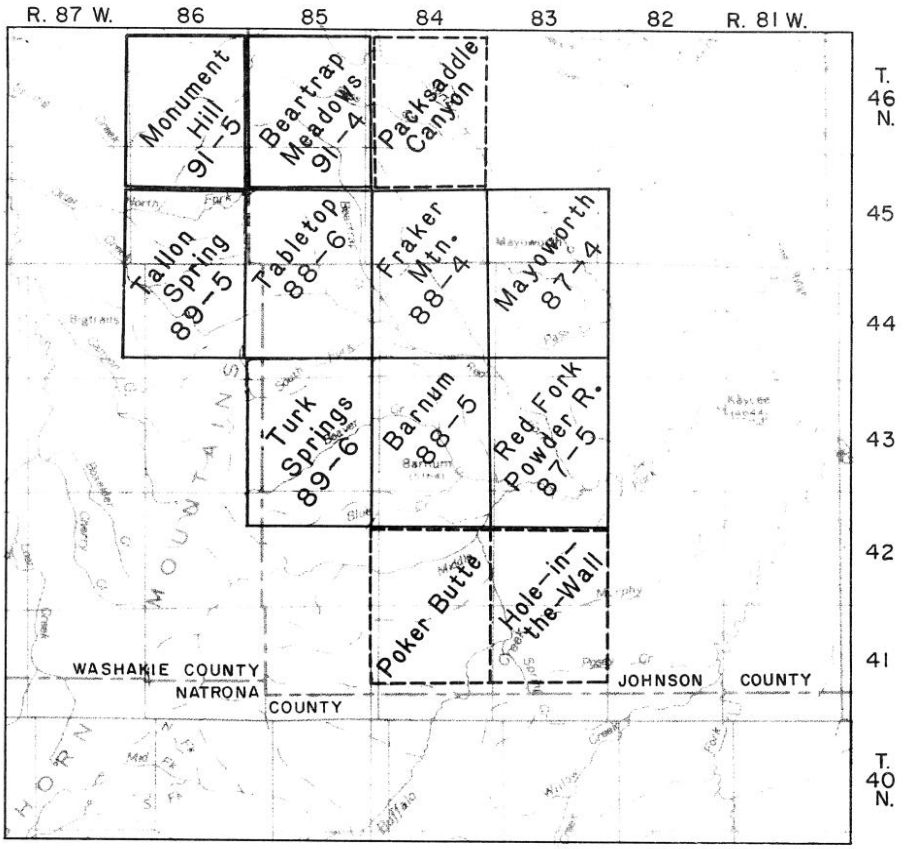

Figure 18. INDEX MAP TO MAPPING BY THE GEOLOGICAL SURVEY OF WYOMING IN THE SOUTHERN BIGHORN MOUNTAINS.

SIGNIFICANT FOSSIL FIND IN THE WIND RIVER BASIN

In the Wind River Basin, paleontologists from the Carnegie Museum of Natural History and the Denver Museum of Natural History recently discovered four fossilized skulls of primitive primates. This discovery may force rethinking of

the evolutionary tree. Dr. Richard Stucky of the Denver Museum of Natural History and Dr. Leonard Krishtalka and Dr. Christopher Beard of the Carnegie Museum of Natural History found skulls of an ancient tarsier, a goggle-eyed animal the size of a mouse. The group found these fossils in 50-million-year-old rocks of the Wind River Formation. The age of the find indicates that the primate family tree split into its three main branches (tarsiers, lemurs, and simians) earlier than previously thought. Prior evidence put this branching at 35-40 million years ago. These scientists named the species *Shoshonius cooperi* for the town of Shoshoni, near where these fossils were found. In addition, the fact that this discovery was made in North America challenges conventional thought that man evolved in Asia and Africa. This find creates a 15-million-year gap in the history of anthropoids and will provide a focal point for future studies.

NEW ARTICLES ON WYOMING STRATIGRAPHY PUBLISHED

Four significant articles on Wyoming stratigraphy and tectonics were recently published in scientific journals. Various workers discussed formations including the Lewis Shale, the Evanston Formation and Sublette Range Conglomerate, the Wall Creek Member of the Frontier Formation, and the Muddy Sandstone.

Roseanne Chambers Perman completed a study of the Lewis Shale based on research for a Ph.D. at the University of California, Berkeley. A paper describing the study is titled: *Depositional history of the Maastrichtian Lewis Shale in southcentral Wyoming: deltaic and interdeltaic, marginal marine through deep-water marine, environments* (Perman, 1990). The author used twenty-four stratigraphic sections, 180 borehole logs, and eight cores to determine the distribution of facies and paleogeography of the Lewis Shale in the study area. Data indicated shallow-water environments in the northern part of the area and deep-water environments to the south, supporting the conclusion that the Lewis Shale was deposited during a north to south progradation. Perman used biostratigraphic data to make regional correlations.

Todd S. Salat and James R. Steidtmann recently completed a study of the tectogenic sediments of the Cretaceous-Paloecene Evanston Formation in the Fossil Basin of southwestern Wyoming and the undated Sublette Range Conglomerate in the Bear Lake Plateau area of northeastern Utah. The title of their published paper is: *Provenance, dispersal, and tectonic significance of the Evanston Formation and Sublette Range Conglomerate, Idaho-Wyoming-Utah Thrust Belt* (Salat and Steidtmann, 1991). The paper is based on Salat's research for an M.S. degree at the University of Wyoming. Results of the study indicate the Sublette Range Conglomerate is a remnant of a proximal deposit which linked distal Evanston sediments in the Fossil Basin with their source area on the Paris and Willard plates. Early Eocene reactivation of the Crawford thrust resulted in the present elevated position of the Sublette Range Conglomerate.

Robert D. Winn, Jr., of Marathon Oil Company, recently published a paper describing his stratigraphic study of the Wall Creek Member of the Frontier Formation in the Powder River Basin. The paper is titled: *Storm deposition in*

marine sand sheets Wall Creek Member, Frontier Formation, Powder River Basin, Wyoming (Winn, 1991). Using cores, borehole logs, and outcrop data, Winn reconstucted the depositional history of the Wall Creek Member, which was deposited as a shelf sandstone on the western margin of the North American Cretaceous seaway. Various primary structures indicate that the most important form of sediment transport was storm-generated, rather than tide-generated. The paper contains an isopach map, cross sections, and paleocurrent diagrams for the Wall Creek Member as well as schematic diagrams of bedding styles derived from an examination of cores.

John Dolson, Dave Muller, M. J. Evetts, and J. A. Stein, with Amoco Production Company, completed work on a Muddy Sandstone study in the central and northern Rocky Mountains. Their paper is entitled: *Regional paleotopographic trends and production, Muddy Sandstone (Lower Cretaceous), Central and Northern Rocky Mountains* (Dolson and others, 1991). The authors used published subsurface maps, over 1,000 outcrop and core descriptions, a 900-well cross section gridwork, and a computerized regional formation-top file to reconstruct the depositional history and paleotopographic trends of the Muddy Sandstone. They constructed several cross sections, a Muddy Sandstone isopach map, and a paleodrainage and paleotopography map. Lithostratigraphic computer mapping served as the core of the paleotopographic reconstruction. Existing hydrocarbon production areas were superimposed on the paleotopography and categorized as to reservoir type. It appears that production was controlled principally by unconformities formed during a relatively low stand of sea level. Results of the study indicate petroleum reservoirs are found in paleohills of older marine sandstones, in younger valley fills and associated alluvial plain channel sandstones, and in transgressive marine deposits.

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GEOLOGIC HAZARDS

by James C. Case, Geologic Hazards Division Head, Geological Survey of Wyoming

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP)

The National Earthquake Hazards Reduction Program (NEHRP) was established by the U.S. Congress in 1977. The goal of the program is to provide an integrated national effort to reduce loss of life and property resulting from earthquakes. The Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS), the National Science Foundation, and the National Institute for Standards and Technology are responsible for leading, coordinating, and conducting earthquake research, hazard mitigation, and disaster preparedness activities at the Federal level. FEMA is the lead agency for the program.

To qualify for funding under NEHRP, States must have a demonstrated seismic risk, and they must formally apply for eligibility by preparing a documented report. In 1990, after the USGS classified Wyoming as a state with very high seismic risk, the Geological Survey of Wyoming (GSW) prepared and submitted a formal request for eligibility to FEMA. As a result of this 82-page application for eligibility, which was titled *Seismic history and future earthquake potential of Wyoming*, FEMA granted Wyoming eligibility in NEHRP in March, 1991.

Many states are now becoming eligible for NEHRP. As a result, FEMA is initiating a five-year plan of tasks and activities that participating states must accomplish. The Head of the Geologic Hazards Division at the GSW has been selected to assist FEMA in the development of a five-year plan for newly-eligible states in the National Earthquake Hazards Reduction Program. The five-year plan should be completed in mid-1991. For additional information on seismic risk in Wyoming or NEHRP, contact Jim Case at the Geological Survey of Wyoming (307-766-2286).

STATEWIDE LANDSLIDE MAPPING PROJECT

The Geological Survey of Wyoming (GSW) has completed the mapping of landslides on over 850 7 1/2-minute quadrangle maps. The project, which began in 1983, entailed the mapping or remapping of all landslide-prone areas in the State. All mapped landslides were classified as to type of movement. Most of the maps were generated from the interpretation of aerial photographs although limited field checking was done throughout the State. Because extensive and detailed field mapping is required to determine even the relative age of movement, landslides shown on the maps are a combination of active, inactive, and stable landslides.

Over 300 of the 7 1/2-minute quadrangle maps have been published as Preliminary Landslide Maps. A 1:1,000,000-scale landslide map, which provides

a statewide overview, has been published as Geological Survey of Wyoming Open File Report 91-1 (p. 65). Sixteen 1° x 2° quadrangles at a scale of 1:250,000 have just been published as Geological Survey of Wyoming Open File Reports 91-2A through 2P (p. 65). The 1:250,000-scale maps serve as regional overviews as well as indices for the 1:24,000-scale maps.

All counties in Wyoming have landslide activity at some scale. Goshen County has the lowest level of activity while Teton County has the highest. In fact, Teton County has one of the highest landslide densities in the United States. One of the largest landslide complexes in the country is in Park County. The northern, eastern, and southeastern flanks of Carter Mountain are primarily composed of landslide deposits. Landslides continuously cover more than 85 square miles of the surface around Carter Mountain.

Landslides result in road damage in some areas of the State nearly every year. Landslides can do more than damage roads, however. There are numerous documented cases of landslides damming streams or rivers. One of the most famous historical events is the Lower Gros Ventre landslide north of Jackson, Wyoming. In 1925, the landslide activated, damming the Gros Ventre River. Over 52,000,000 cubic yards of material were involved in that landslide which formed a dam about 230 feet high. In 1927, the landslide dam partially failed, resulting in the loss of life at Kelly, Wyoming. Landslide maps of Teton County provide evidence of much larger landslide dams than the Lower Gros Ventre slide. Many of the dams formed hundreds or thousands of years ago. The potential does exist for large landslide dams to form in the future, especially in an area with the potential for significant seismic activity like Teton County.

The Geological Survey of Wyoming (GSW) is presently coordinating with the U.S. Geological Survey, the U.S. Forest Service, and the U.S. Bureau of Land Management in regard to the assessment of future landslide risk. While the GSW's landslide mapping project resulted in the delineation and classification of most of the existing landslides in the State, much additional work is required to define areas that have the potential to move.

WYOMING REGISTRATION FOR PROFESSIONAL GEOLOGISTS

The 1991 Wyoming Legislature passed legislation providing the means for geologists to become registered as "Professional Geologists". Registration is only required for geologists who desire or need to use the title "Professional Geologist". An applicant for registration must meet all the following minimum requirements:

1. At least a bachelor's degree in geology or an associated science approved by the Registration Board;

2. A passing score on the Board's examination in the fundamentals of geology;

3. At least four years of active professional experience of a character acceptable to the Board; and

4. A passing score on the Board's professional examination.

During the first year of this act (July 1, 1991 through June 30, 1992), a grandfather clause will allow degreed geologists with at least four years of professional experience to apply for registration without taking any examination. The grandfather clause also allows a degreed geologist, who lacks the required experience, to apply for the status of Geologist-in-training. In this latter case, an applicant need not take the Board's examination in the fundamentals of geology.

Registration will be maintained by payment of an annual renewal fee and may require a continuing education requirement.

Rules governing this act will be ready for public comment by late summer. Additional information about proposed rules, fees, and application forms will be made available as soon as possible. Individuals wishing to receive applications, as they become available, should send their names and mailing addresses to:

Gary B. Glass, State Geologist
Geological Survey of Wyoming
Box 3008 University Station
Laramie, Wyoming 82071

NEW PUBLICATIONS

Index of geologic maps of Wyoming included in 1980-1989 graduate theses and dissertations from the University of Wyoming, compiled by J.K. King and A.J. Ver Ploeg: Map Series-9R, 1990, 1:1,000,000 - $2.50.

*Coal map of Wyoming, by R.W. Jones: Map Series 34, 1991, 1:500,000 (color) - $10.00 folded ($11.50 mailed rolled).

*Oil and gas map of Wyoming, by R.H. De Bruin and C.S. Boyd: Map Series 35, 1991, 1:500,000 (color) - $10.00 folded ($11.50 mailed rolled).

Preliminary landslide maps, by J.C. Case and others: call for the availability of particular 1:24,000- and 1:62,500-scale maps, 1990 - $3.00.

Landslide map of Wyoming, by J.C. Case, L.L. Larsen, L.A. Coombs, D.R. Gilmer, T.C. Nissen, J.A. Ford, J.C. Cannia, and W.B. Murray: Open File Report 91-1, 1:1,000,000 - $4.00.

*1° x 2° quadrangle landslide maps of Wyoming, by J.C. Case, L.L. Larsen, L.A. Coombs, D.R. Gilmer, T.C. Nissen, J.A. Ford, J.C. Cannia, and W.B. Murray (authorship on individual maps varies): Open File Report 91-2A through 91-2P, (sixteen maps) scale 1:250,000 - $4.00.

*Precambrian geology map of the Seminoe Mountains (iron-gold) mining district, Bradley Peak Quadrangle, Carbon County, Wyoming, by W.D. Hausel: Open File Report 91-3, scale 1:24,000 - $3.50.

*Preliminary geologic map of the Beartrap Meadows Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg and P.L. Greer: Open File Report 91-4, scale 1:24,000 - $3.50.

*Preliminary geologic map of the Monument Hill Quadrangle, Washakie and Johnson Counties, Wyoming, by A.J. Ver Ploeg and P.L. Greer: Open File Report 91-5, scale 1:24,000 - $3.50

*Geology and mineralization of the South Pass granite-greenstone belt, southern Wind River Range, Wyoming, by W.D. Hausel: Report of Investigations 44, 1991 - $20.00 (map is also available separately for $5.00).

Results of coal drilling projects in the Wind River Coal Field, Wyoming, by R.W. Gregory, R.W. Jones, and Gary B. Glass: Report of Investigations 46, 1991 - $5.00.

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

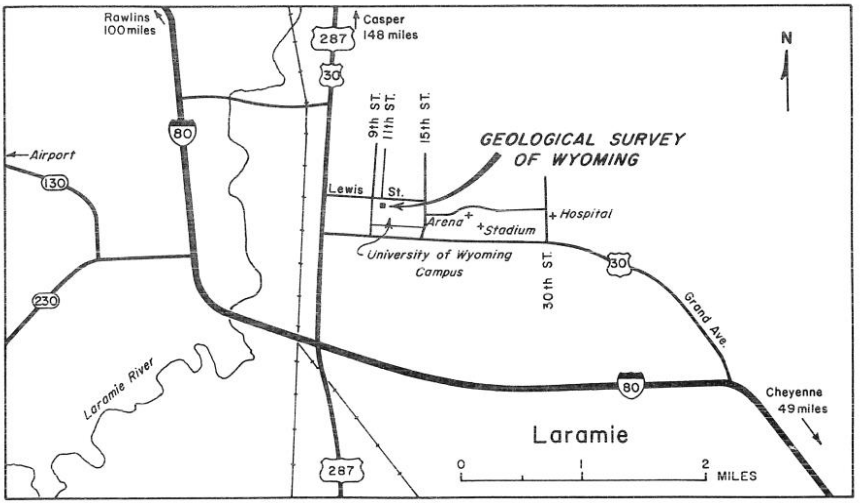
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

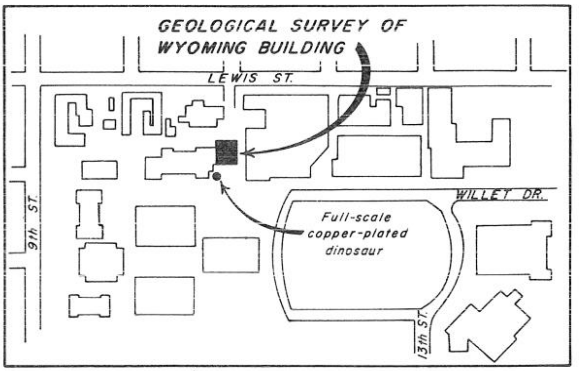
No first class postage charge for prepaid orders, unless otherwise marked.

— NEW SERVICE AVAILABLE —

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





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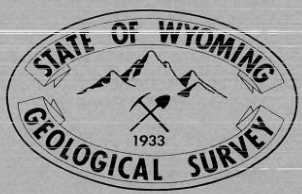
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