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

WYOMING GEO-NOTES
NO. 29

LARAMIE, WYOMING
January, 1991

WYOMING GEO-NOTES

This quarterly digest on the State's geology and mineral resources and activities of the Geological Survey is available by subscription (four issues for $5.00) or as single copies at $1.50 each. Two-year subscriptions are accepted.

Cover: Jay T. Roberts inside the Comstock mine, Silver Crown District, Wyoming, during a mapping study by the Geological Survey of Wyoming. Sketch by his field partner W. Dan Hausel. Jay Roberts recently announced his resignation from the Survey to accept a position as an engineer with Honeywell in Phoenix. Jay began working for the State over 11 years ago as a part-time geologic assistant in the Coal Division. Later, Jay was promoted to the head of the Laboratory Section, where he has done a variety of tasks including geochemical analyses, sample processing, x-ray analyses, sample collection, and field mapping of historic metal mines. Jay has been an outstanding and dedicated employee and will be missed by all.

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

Table of Contents

- Please note -

PHONE NUMBER CHANGE

The Geological Survey of Wyoming
now has only one phone number:

(307) 766-2286

Several lines are accessed by this
single number, so you should
experience fewer busy signals.

We hope this change will be more
convenient for everyone.

MINERALS UPDATE

OVERVIEW

by Gary B. Glass, State Geologist

In the fourth quarter of 1990 as the world braced for the war which is now a reality, average posted prices for Wyoming crude oil fell from a high of almost $35 in October, to about $32 in November, to just above $25 in December. Even with oil prices declining $10 in the last quarter, prices were markedly better than at least the previous three years where the average monthly posted prices never exceeded $22 and often went below $18 a barrel (Figure 1). Before the war started on January 16th, January oil prices had started to increase, but early indications after war started were confusing at best. Currently, there are just too many "ifs" in this situation for any meaningful answers to these questions.

Natural gas prices still look like they bottomed out in 1989-1990 and are poised to increase in 1991. By December, the spot market gas price at Opal, Wyoming, was about the same as the estimated contract price for natural gas in 1990, but this might only be a seasonal aberration (Table 1 and Figure 2).

Based only on the average annual rig count, higher oil prices and more stable gas prices apparently have made little difference in the State's oil and gas drilling activities (Figure 4). A closer look at drilling activities, however, suggests that drilling has shifted away from truly exploratory wells to a greater number of infill or development wells for both oil and gas. Notable exceptions are the current horizontal drilling plays (mostly in the Niobrara Formation of southeastern Wyoming) and the coalbed methane plays scattered across the State. The higher oil prices are also having an effect on enhanced oil recovery projects, especially projects slated to use the huff n' puff carbon dioxide process. The **OIL AND GAS UPDATE** below provides more details on these activities in the oil patch.

The big news relative to natural gas involves the proposed gas pipelines to southern California. Kern River Gas Transmission Co. started construction of their pipeline just after the fourth quarter of 1990 while WyCal apparently scrubbed theirs. Governor Sullivan also endorsed a $250 million loan to Kern River, but with certain stipulations. Kern River had not made any decision on the stipulations by mid-January.

Coal production continued strong with spot sales accounting for 16 percent of total coal deliveries at the start of the third quarter of 1990. This continued the trend toward more and more spot or short-term sales. The **COAL UPDATE** in this issue discusses almost 30 new contracts, sales, or test-burns of Wyoming coal, including sales to Spain. Prices paid for spot sales, however, did not increase.

In regard to other minerals, trona production set a new record in 1990 while uranium prices fell in the fourth quarter, putting a damper on some of the guarded optimism of the third quarter. Interest in gold, copper, aggregate, decorative stone, and limestone continued along with some renewed interest in diamonds.

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	20.00	1.64	8.29	44.00	19.00
1991	23.00	1.80	7.94	45.00	20.00
1992	23.00	1.98	7.59	46.00	21.00
1993	23.00	2.18	7.24	46.00	21.50
1994	23.00	2.40	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).

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	—	0.63
*1985	131.0	597.9	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	563.2	23.8	0.15	136.3	13.3	0.3	—	0.66
*1987	115.9	619.0	114.2	0.86	146.5	13.6	0.2	0.06	1.19
*1988	114.3	701.6	110.0	0.83	163.6	14.9	0.3	1.40	0.96
*1989	109.1	739.0	126.1	0.94	171.1	16.2	0.1	1.07	1.07
1990	104.4	777.0	127.0	0.95	179.2	16.9	0.45	1.0	1.10
1991	102.3	795.0	127.0	0.95	187.6	17.5	0.45	1.5	1.10
1992	100.3	894.0	127.0	0.95	196.4	18.5	0.45	4.0	1.10
1993	98.3	1,015.0	127.0	0.95	205.0	20.0	0.45	4.0	1.10
1994	96.3	1,034.0	127.0	0.95	214.0	20.0	0.45	6.0	1.10

*Actual values for comparison; [1]Geological Survey of Wyoming, January, 1991; [2]millions of barrels; [3]billions of cubic feet; [4]billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [5]millions of tons; [6]millions of tons of uranium ore (not yellowcake); [7]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).

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

	1981	1982	1983	1984	1985	1986	1987	1988	1989
Ballast [2,3]	1.72	0.81	0.99	2.43	0.67	0.61	1.09	0.80 [8]	1.28 [7]
Bentonite [2]	4.81	2.35	2.18	3.08	2.59	1.82	2.16	2.32	2.22 [7]
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 [8]	0.06 [7]
Dolomite [2]	0.87	0.61	0.66	0.86	0.87	0.81	0.46	0.19 [7]	0.15 [7]
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 [8]	0.20 [7]
Iron Ore [2]	4.67	3.28	2.48	----	----	----	----	----	
minor [9]									
Limestone [2,5]	0.72	0.59	0.56	0.65	0.32	0.34	0.42	0.64	0.60 [7]
Sand and Gravel [2]	5.21	4.74	5.00	4.76	4.71	3.53	2.57	2.16	4.62 [7]
Scoria [2,6]	0.08	0.08	0.07	0.23	0.13	0.04	----	0.20 [7]	0.37 [7]
Shale [4]	----	----	----	20.3	14.7	9.88	49.0	50.2 [7]	1.8[1]
Sodium Sulfate [4]	3.20	3.17	3.19	3.25	2.71	2.03	----	2.10 [7]	3.2[1]

Sources: [1]Ad Valorem Tax Division. [2] Millions of short tons. [3] Includes granite, scoria and other rock. [4] Thousands of short tons. [5] Includes limestone used for cement rock, sugar beet refining, and other uses. [6] Baked and fused rock, also called clinker. [7] Wyoming State Inspector of Mines. [8] Estimated by Geological Survey of Wyoming. [9] Less than 1,000 tons of iron ore were sold for pigment. Prepared by Geological Survey of Wyoming, January, 1991.

OIL AND GAS UPDATE

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

The uncertainty over what will happen in the Middle East caused considerable fluctuation in crude oil prices during the fourth quarter of 1990 (Figure 1). The average posted price for Wyoming sweet crude peaked in October, 1990, at $35 per barrel but dropped in November and December. December's average posted price was just slightly over $25 per barrel. Most of the drops in price were attributed to at least fleeting optimism that the Middle East crisis might be settled peacefully, to Iraq's release of the American hostages, and to the announcement that OPEC and other countries have more than made up the amount of production that was lost when the United Nations placed an embargo on oil production from Iraq and Kuwait.

In 1990, the average prices paid for spot sales of natural gas were mostly higher than for corresponding months in 1989 (Figure 2). The demand for natural gas is finally catching up with supply and prices should rise slightly in 1991. Another factor that will help Wyoming gas producers after 1991 is the Kern River pipeline from southwestern Wyoming to southern California.

The Wyoming rig count did not respond to the higher oil prices as the average monthly count during the fourth quarter of 1990 was lower than in 1989 (Figure 3). The average yearly count was only slightly higher than 1989 and has essentially been the same for the past five years (Figure 4). There is still too much volatility in prices for companies to invest heavily in ventures where production is several years away.

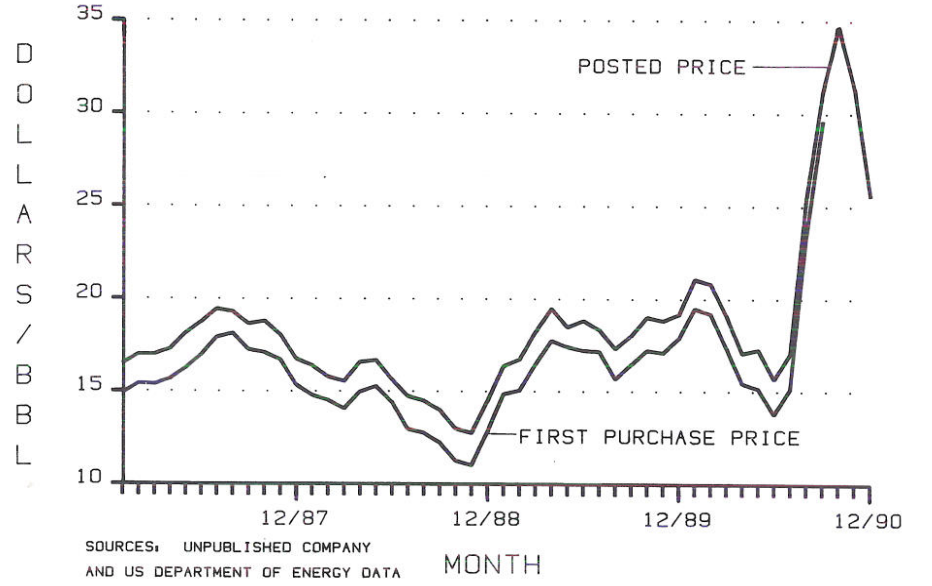


Figure 1. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987 TO PRESENT).

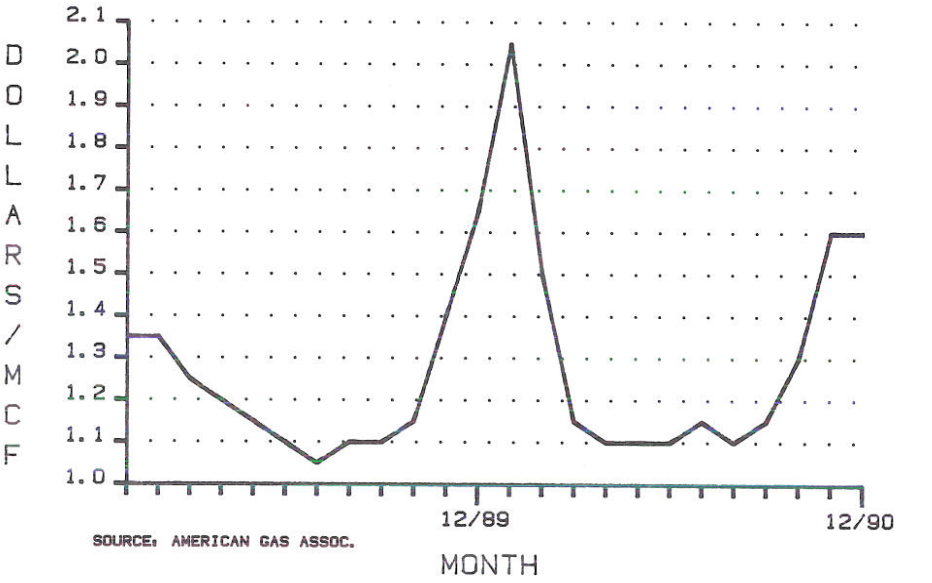


Figure 2. SPOT GAS PRICES AT OPAL, WYOMING, AVERAGED BY MONTH (1989 TO PRESENT).

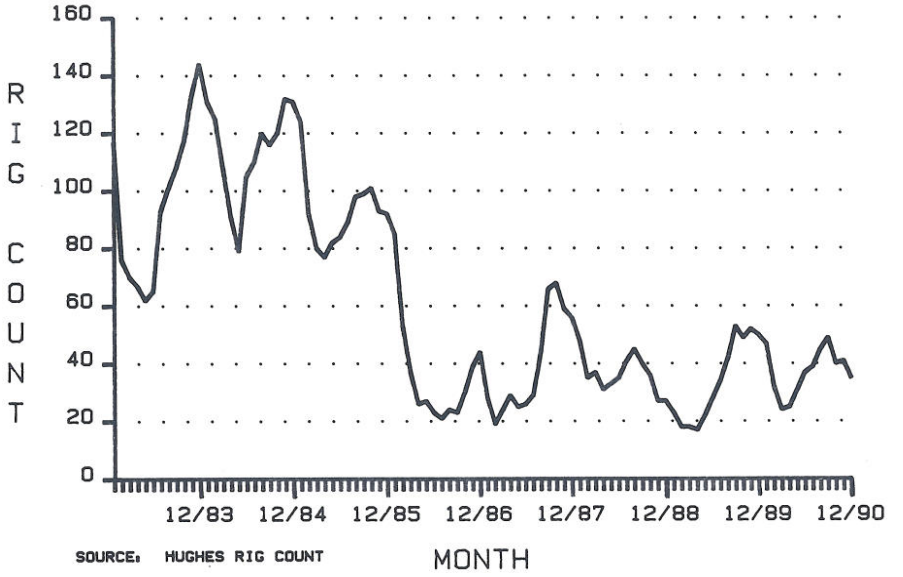


Figure 3. WYOMING RIG COUNT AVERAGED BY MONTH (1983 TO PRESENT).

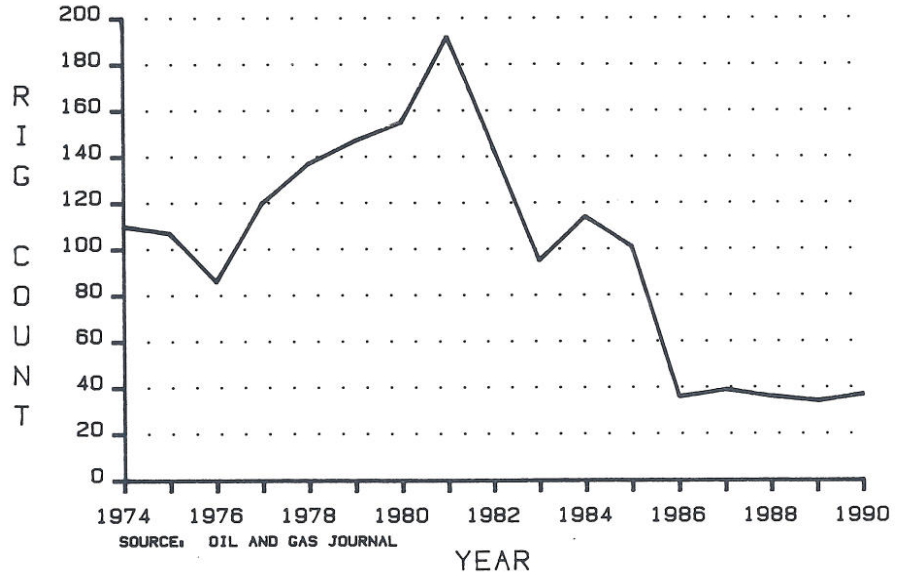


Figure 4. WYOMING RIG COUNT AVERAGED BY YEAR (1974 TO 1990).

The speculation on who might build the gas pipeline from southwestern Wyoming to southern California is over. On January 3, 1991, Kern River Gas Transmission Co. began construction of sections five and six of their pipeline. Both of these sections are in southeastern Utah. The Kern River pipeline will consist of eight sections that are from 61 to 112 miles in length. The entire pipeline will be 904 miles long and is scheduled for completion by late 1991 or early 1992. About two weeks before Kern River began construction, WyCal, the other company in the running to build a pipeline from Wyoming to southern California, announced that their line would not be built.

In a related item, Governor Mike Sullivan endorsed a $250 million State loan to build a pipeline to southern California. Governor Sullivan, however, seeks several additional provisions to make the loan acceptable: 1) An acceleration provision that contains a grace period; 2) Provision for an accelerated repayment call by the State Treasurer at the request of the Governor and the Attorney General; 3) Parental guarantee by Williams and Tenneco, joint owners of the Kern River Gas Transmission Company; 4) Provision for payment of breakup fees if the loan is committed, but not accepted; and 5) The establishment of a reasonable time for negotiations of the loan. The loan is expected to lower transportation costs thereby making the gas in Kern River's pipeline more competitive. While the initial capacity of the pipeline is 700 million cubic feet per day, it could be expanded to 1.2 billion cubic feet.

In other pipeline news, the capacity of Northwest Pipeline Corp.'s system will be expanded by 534 million cubic feet of gas per day. The main pipeline begins in northwestern New Mexico and ends at the Canadian border north of Seattle, Washington. The pipeline passes through southwest Wyoming and transmits gas processed at a Northwest gas plant near Opal, Wyoming.

In other industry news, Coastal Chem Inc. has signed a $72 million contract with Davy McKee Corp. for a methyl butyl ether (MTBE) complex near Cheyenne. The complex is designed to produce 4,000 barrels per day of MTBE. MTBE is used as an additive in gasoline to reduce air pollution.

The recently enacted Budget Act for Fiscal Year 1991 includes an estimated $2.5 billion worth of energy incentive provisions over the next five years. The Budget Act extends the drilling and production tax credits for nonconventional fuels to January 1, 2003, providing a project begins before January 1, 1993. Nonconventional fuels include coalbed methane; oil produced from shale or tar sands; gas produced from geopressured brine, Devonian shale, or biomass; and liquid, gaseous, or solid synthetic fuels produced from coal. The Act also reinstates production from tight gas sands as a qualifying nonconventional fuel.

Another provision of the Budget Act includes a 15 percent credit for qualified enhanced oil recovery costs. The Act also increases the net income limitation on oil and gas percentage depletion from 50 to 100 percent of net income from the property and now allows percentage depletion claims on proven oil and gas properties which are transferred after October 17, 1990. The Act provides that percentage depletion rates will increase by one percent for each whole dollar that the average domestic

wellhead price of crude oil, for the preceding year, is less than $20 per barrel. This figure is not adjusted for inflation and the maximum increase is limited to 10 percent. This provision only applies to interests in marginal wells that are held by independent producers or royalty owners. The Act also modifies the definition of marginal production to include oil or gas produced from a stripper well as well as production of heavy oil. In the Act, a stripper well is one which produces an average of 15 or less equivalent barrels of oil per day.

The new law provides oil and gas producers a special deduction from the alternative minimum tax. This deduction cannot exceed 40 percent of the alternative taxable income and cannot be carried forward. The deduction is phased out in taxable years when the price of crude oil exceeds $28 per barrel and is eliminated if the average price of oil exceeds $34 per barrel.

The Budget Act should help slow the abandonment of stripper wells within the United States and Wyoming. According to the annual stripper well survey conducted by the Interstate Oil Compact Commission, 16,107 stripper wells were abandoned in the U.S. in 1989. Two hundred sixty-three of these were abandoned in Wyoming. Wyoming still has 2,982 stripper wells which produce an average of 4.95 barrels of oil per day. For comparison, the United States has 452,589 stripper wells which produce an average of 2.34 barrels of oil per day.

Provisions of the Budget Act should also help stimulate exploration and production of coalbed methane and gas from formations designated as tight gas sands in various areas of the State (see section on Coalbed Methane, p. 15). Since enhanced oil recovery projects will also benefit from the Budget Act, the use of the carbon dioxide huff n' puff process may increase in Wyoming. The University of Wyoming's Enhanced Oil Recovery Institute has begun a multi-well test series of the huff n' puff process funded by a legislative appropriation of $500,000. Wells have already been treated in Crooks Gap, Lost Soldier, Wertz, Salt Creek, Beaver Creek, and Little Buffalo Basin Fields (Figure 5).

Amoco already has plans to use the huff n' puff process on as many as 4,000 wells in Elk Basin, Little Buffalo Basin, Winkleman, Lander, Beaver Creek, Lost Soldier, Wertz, and Salt Creek Fields (Figure 5). In a December docket before the Wyoming Oil and Gas Conservation Commission, Conoco announced plans to use the huff n' puff procedure on a total of six wells in Bonanza, Gebo, Glenrock South, Sunshine North, and Sussex West Fields (Figure 5).

The Budget Act also reduces Wyoming's share of Federal mineral royalties. The deductions are to help pay for the Minerals Management Service's costs for administering the Federal royalty management program. In FY91-92, these administrative costs are estimated at $6.4 million and $7.7 million, respectively.

Lease sales in the State continue to do well. The U.S. Bureau of Land Management's (BLM) October sale had a high per-acre bid of $200 made by Gerrity Oil and Gas for a 40-acre tract covering NE NE section 10, T15N, R65W (Table 4). The lease is on the southwestern flank of Silo Field and is less than a mile west of

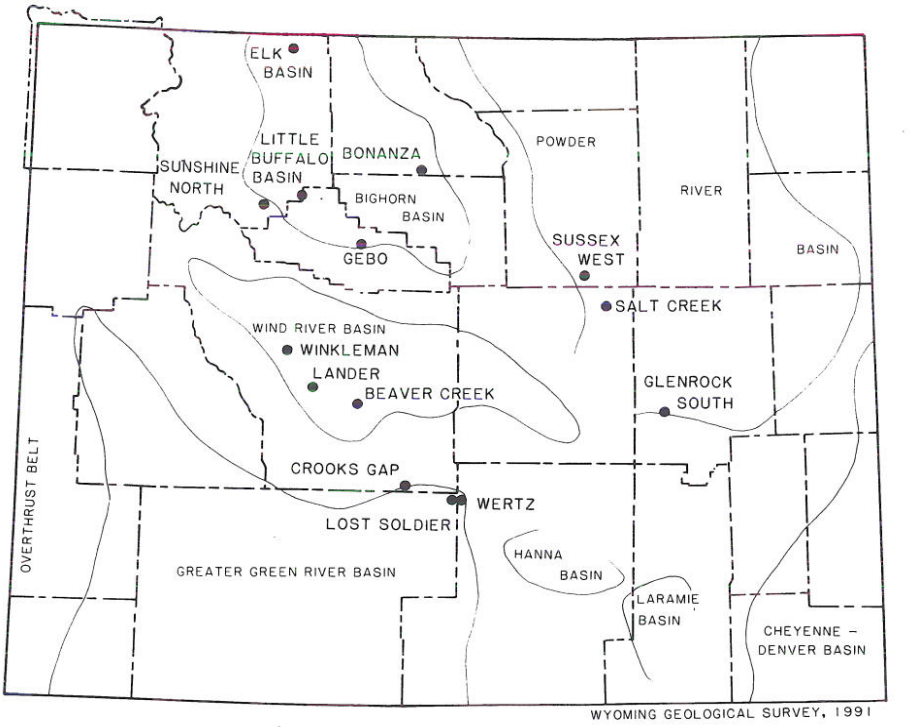


Figure 5. ANNOUNCED ENHANCED OIL RECOVERY PROJECTS USING THE HUFF N' PUFF CARBON DIOXIDE PROCESS.

Cowan Oil's 1 Warren well, the first horizontally-drilled Niobrara well in the State (see section on Horizontal Drilling, p. 13). The 1 Warren well produced over 11,000 barrels of oil in June and July, 1990, before it was shut in due to mechanical problems.

The highest overall bid at this sale ($206,800) was made by Tom Brown Inc. for a 1,880-acre parcel in portions of sections 24, 29, 30, 31, 32, 33, and 34, T37N, R91W. The lease is between four and seven miles southwest of Lance gas production at Kanson Draw Field and is about six miles northeast of Fort Union oil and gas production at Fuller Reservoir Field.

The high per-acre bid at the December BLM sale was $260 made by Wells Petroleum for a 161.9-acre lease covering parts of sections 12 and 21, T48N, R70W. The portion of the lease in section 12 is less than a mile from Minnelusa oil production at Fish Field and the portion of the lease in section 21 is less than a mile from Minnelusa oil production at Railroad Bend Field.

Table 4. FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES IN WYOMING.

Month	BLM SALES Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	STATE SALES 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

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

The highest overall bid at the December sale ($117,900) was made by Maurice Brown for a 1,178.93-acre parcel in portions of sections 10, 22, 27, 28, 29, 32, and 33, T54N, R68W. The lease is near Minnelusa oil production at Lilly Field and near Muddy oil production at VI Bar Ranch Field.

The State Land and Farm Loan Office's November sale also did well (Table 4). The high per-acre bid of $265 was made by James Clark Oil Properties for a 40-acre tract that covers SE NW section 8, T40N, R76W. The parcel is two miles east of GLG Inc.'s Federal exploratory unit established for horizontal drilling of the Niobrara Formation. Frontier and Shannon production at Finley Draw Field is about two miles east of this parcel.

The highest overall bid ($86,400) at the November sale was made by W.C.S. Oil and Gas for a 640-acre parcel that covers section 36, T17N, R64W. The lease is about four miles northeast of a horizontally-drilled Niobrara well at Silo Field.

Based on company data and on information compiled and published by Petroleum Information, the following significant exploration and development events occurred in Wyoming during the fourth quarter of 1990. The letters preceding the discussions below refer to locations on Figure 6.

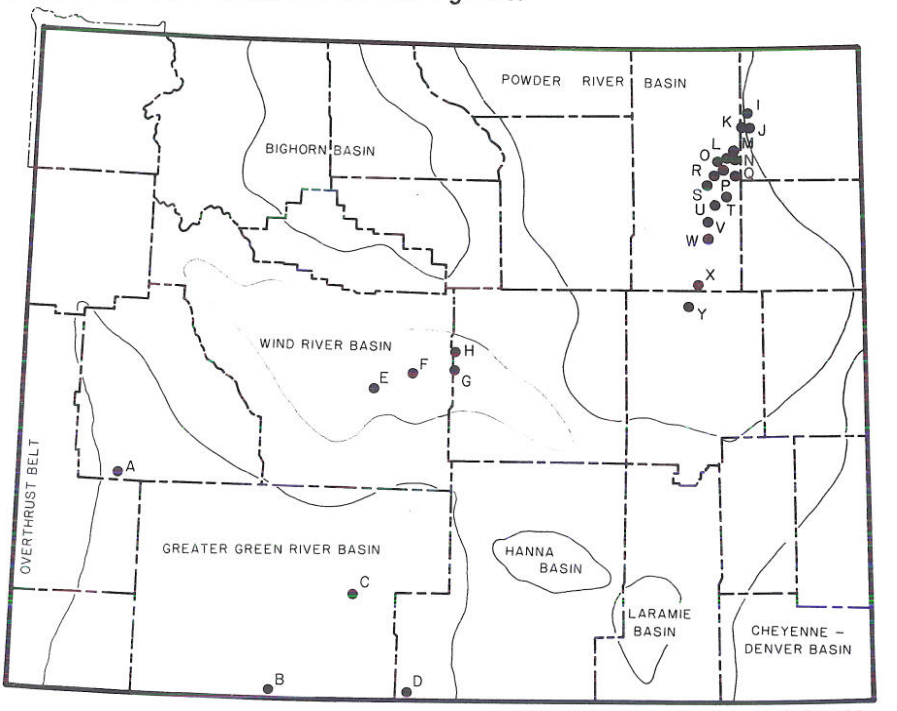


Figure 6. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING DURING THE FOURTH QUARTER OF 1990.

A. Chevron USA completed its 112 Birch Creek Unit well in SW SE section 26, T27N, R113W, in the Frontier Formation. The well flowed 8.3 million cubic feet of gas, 68 barrels of condensate, and 60 barrels of water per day. Chevron also completed the 116 Birch Creek Unit well in NW SW section 22, T27N, R113W, in the Frontier for an initial flowing potential of 4.4 million cubic feet of gas, 19 barrels of condensate, and 19 barrels of water per day.

B. Exxon Corp. began drilling an 18,000-foot Madison test on the southwestern flank of the northeast-trending Canyon Creek anticline. The 34 Canyon Creek Dome Unit well is being drilled in NW NE section 9, T12N, R101W. Celsius Energy and Exxon recently signed an agreement to jointly explore this area.

C. Union Pacific Resources completed a wildcat discovery on the north side of the Washakie Basin. The 1 UPRR 4-27 well in C SW section 27, T20N, R97W, flowed 10.2 million cubic feet of gas daily on a test of the Ericson Sandstone.

D. Celsius Energy completed a wildcat discovery in the Almond Formation for an initial potential of 246,000 cubic feet of gas and 282 barrels of water per day. The 1 Anthill Unit was drilled in NW NW section 8, T12N, R93W.

E. TCF Inc. tested another well in Fuller Reservoir Field in several zones in the Fort Union Formation. The 4 Esther Fuller well in NE SE section 26, T36N, R94W, flowed 10.0 million cubic feet of gas per day.

F. The 1 Moneta Hills Unit well in NW NE section 11, T37N, R91W, drilled by Wagner & Brown, encountered eight productive zones in the Fort Union Formation. Only one of these zones was tested and it flowed 1.2 million cubic feet of gas, 25 barrels of condensate, and two barrels of water per day.

G. General Atlantic Resources has an apparent gas discovery in the Fort Union at their 35-1 Merlot well in N/2 NW section 35, T37N, R89W. General Atlantic set production casing at the prospect.

H. W.A. Moncrief, Jr. began drilling a 24,500-foot Madison test in October, 1990. The 1 Badwater Creek well is expected to take over a year to drill and is in SW NE section 12, T38N, R89W. Cost of a dry hole is about $17 million and a producer will be an additional $4-5 million. It is hoped the well will extend the productive Madison interval found in two other deep tests on Madden anticline.

I. Fancher Oil completed a new Minnelusa well in Texas Trail Field, the 14-10 Zimmerschied-Hahn, in NW SE section 14, T53N, R68W. The well was completed pumping 364 barrels of oil per day.

J. Western Interior Resources drilled the second producing well in Trava Field. The 3 Trava-State well in SW SW section 16, T52N, R67W pumped 25 barrels of oil per day and no water from the Minnelusa Formation.

K. Presidio Exploration completed two new Minnelusa oil producers in Heath

Field. The 2-5 Miramar-Federal in NE SE section 5, T52N, R68W, pumped 438 barrels of oil per day. The 44-5 Miramar-Federal in SE SE section 5, T52N, R68W, pumped 407 barrels of oil per day. Slawson Exploration also completed a new Minnelusa well in Heath Field. The 2-4 Miramar-Federal pumped 508 barrels of oil per day.

L. Double Shield Field has a new Minnelusa producer. Yates Petroleum completed the 1 Elvira well in NW NE section 22, T51N, R70W, pumping 103 barrels of oil and eight barrels of water per day.

M. Apache Corp. completed a new Minnelusa oil producer in Lone Cedar Field. The 8 Lone Cedar Unit well in NW SE section 8, T51N, R69W, pumped 480 barrels of oil per day.

N. Phillips Petroleum completed a wildcat nearly a mile north of the inactive Garner Lake Field. The 1 Garner Lake well in SW SE section 21, T51N, R69W, pumped 410 barrels of oil per day from the Minnelusa Formation.

O. A new field, designated Springen North, was discovered by CNG Producing's 23-30 Federal well in SE NW section 20, T51N, R71W. The well pumped 158 barrels of oil daily from the Muddy Sandstone.

P. Caza Exploration discovered oil in the Minnelusa at their 2 Tigers Tail well in SW NE section 23, T50N, R71W. The well produced an average of 140 barrels of oil and 250 barrels of water per day during eight days in August.

Q. Robert E. Hudson added a Minnelusa oil producer to Rozet Field. The 41-28 Miller well in NE NE section 28, T50N, R69W, was completed pumping 180 barrels of oil per day.

R. Raymond T. Duncan Inc. has an apparent Minnelusa discovery at their 33-13 Record well in NW SE section 13, T50N, R71W. A drillstem test recovered 1,580 feet of gas and 5,193 feet of gas-cut oil.

S. Nicor Exploration and Production discovered oil in the Minnelusa at their 13-34 Mallard-Federal well in NW SW section 34, T49N, R72W. This well was completed for 295 barrels of oil per day. The well is about one-half mile southwest of Minnelusa production at McCreery Field.

T. During 24 days in August, Caza Exploration produced an average of 16 barrels of oil and 65 barrels of water per day from the Minnelusa at their 1 Ripcord-State well in SW NW section 16, T47N, R70W.

U. Raymond T. Duncan Inc. and Apache Corp. completed a new Minnelusa producer less than a mile from Minnelusa production at Maysdorf and Haight Fields. The 1 L.A. Sims well in NE SE section 30, T47N, R71W, was completed for an initial pumping potential of 435 barrels of oil per day.

V. Santa Fe Energy Operating Partners L.P. staked the first location of a

proposed 26-well Minnelusa joint exploration program with Celsius Energy Co. The 1-7 Fire-Federal well will be drilled in SE NE section 7, T46N, R72W, about three miles south of Minnelusa production at Hawk Point Field.

W. Nicor Exploration and Production completed a Minnelusa well for 334 barrels of oil per day. The 41-1 Dawn-Federal well in NE NE section 1, T46N, R71W, is within a mile of Minnelusa, Dakota, and Muddy production at Am-Kirk Field.

X. Kerr-McGee Corp. completed a new Dakota producer in Buck Draw North Field. The 14-6 NBDU in SE SW section 6, T41N, R73W flowed 1,481 barrels of oil and 3.0 million cubic feet of gas per day. The operator of Buck Draw North Field currently injects hydrocarbon gas into the Dakota to maintain pressure and enhance production. During September, 1990, the last month for which production figures are available, the field averaged a total of 9,093 barrels of oil and 2.7 million cubic feet of gas per day from only 12 producing wells.

Y. In nearby Powell Field, Woods Petroleum completed a new Frontier producer. The 27-2 Powell Unit well in SW SW section 27, T40N, R74W, pumped 787 barrels of oil and 2.2 million cubic feet of gas per day.

Horizontal Drilling

During the fourth quarter of 1990, the following significant activities related to horizontal drilling occurred. The letters preceding the discussions below refer to locations on Figure 7. The discussions are based on company data and on information compiled and published by Petroleum Information.

A. Horizontal drilling activity in and around Silo Field is accelerating since Cowan Oil drilled the first horizontal Niobrara well earlier in 1990. The 1 Warren well in NW NE section 11, T15N, R65W, produced over 11,000 barrels of oil in June and July before it was shut in. Since Cowan's discovery, three additional Niobrara wells were completed and tested. Union Pacific Resources' 1H Antelope 9-11 well in NW SE section 11, T15N, R64W, was completed for an initial pumping potential of 400 barrels of oil and 300,000 cubic feet of gas per day after an earlier 21-hour flow test yielded 1,462 barrels of oil. Their 1 McGahan 21-5H well in NE NW section 5, T15N, R64W, flow-tested 767 barrels of oil and 326,000 cubic feet of gas during a 24-hour period. At the 2-H Willett well in E/2 SE section 22, T16N, R64W, Snyder Oil completed a Niobrara producer for an initial pumping potential of 216 barrels of oil per day. This well had approximately 3,700 feet of horizontal displacement in the Niobrara. Union Pacific Resources has reached total depth at their 1H Goertz 5-12 well in NE NW section 12, T15N, R65W, but no test results are available yet. Snyder Oil started work on the location for their 10-21H Hutton well in SW NW section 21, T16N, R64W, and should begin drilling soon. Additionally, Cowan Oil has locations staked for a well in SW SE section 29, T16N, R64W, a well in E/2 NE section 22, T16N, R64W, and a well in W/2 SW section 21, T16N, R64W. Union Pacific Resources had locations staked for a well in SW SW section 11, T15N, R64W, a well in SW SW section 3, T15N, R64W, and a well in SW SW section 7, T15N, R63W. Union Pacific Resources plans to drill up to 10 wells in the Silo area in 1991. Exxon also plans to drill at least one well. Gerrity Oil and Gas staked a location for a well in NE NE section 10, T15N, R64W.

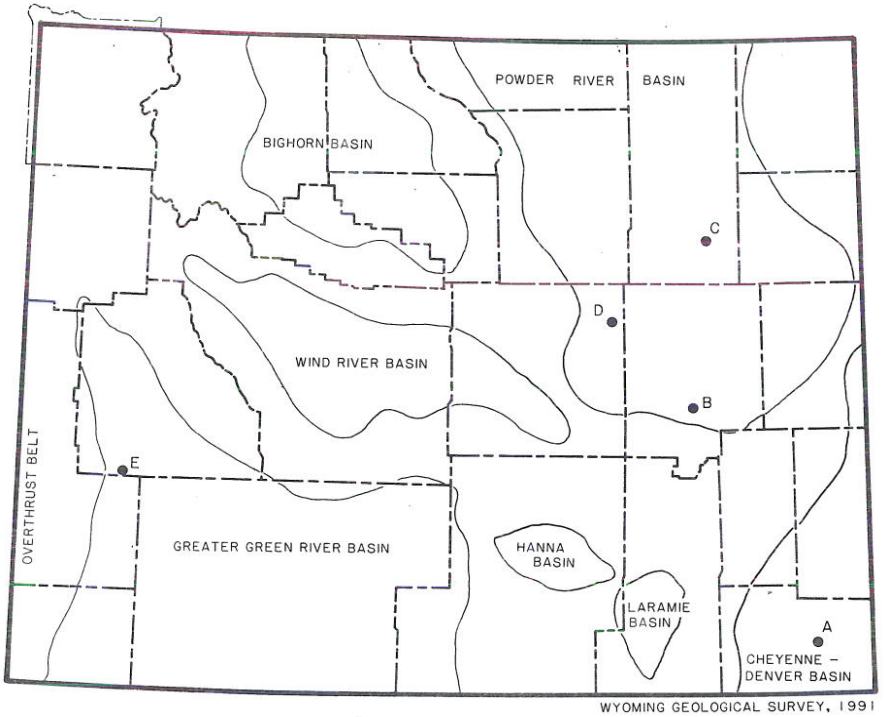


Figure 7. HORIZONTAL DRILLING ACTIVITY IN WYOMING.

B. Amoco Production Co. staked a location for a horizontal test of the Frontier at their 1-25 Morton Ranch well in NE SW section 25, T33N, R72W. Amoco plans to drill a vertical pilot hole to 11,400 feet, run logs, plug back to 10,300 feet, and kick off an 8°/100 feet curved bore hole. Amoco will evaluate Niobrara in the curved part of the hole and Frontier in the horizontal part of the hole. The well will be just over a mile south of Orpha Field which produces from the Frontier.

C. Harvey E. Yates Co. is drilling its 1H-19-22 Stuart Ranch Deep Unit well in SW NW section 19, T44N, R71W, to horizontally test the Niobrara. The well is a reentry of a dry hole completed in 1988 by Chevron USA and is less than a mile east of a shut-in Niobrara well that produced over 32,000 barrels of oil. The company also staked a location for another horizontal Niobrara test with a surface location in NE SW section 19, T44N, R71W.

D. GLG Energy reached total depth at their horizontal Niobrara test, the 32-6H Si Tanka well in SW NE section 6, T38N, R77W. GLG also staked a location for a second horizontal Niobrara test in SE SE section 36, T39N, R78W. GLG will drill at least four horizontal wells on the Si Tanka Federal Exploratory Unit that was approved in 1990.

E. Texaco Inc. completed an Almy (Fort Union) oil producer that pumped 37 barrels of oil and three barrels of water per day. The G634Y La Barge Unit well in NE SW section 34, T27N, R113W, was drilled vertically to 520 feet and was plugged back to 492 feet. From a vertical depth of 440 feet, horizontal legs were drilled to the north, the southeast, and the southwest. Most Almy wells in the area produce less than 5 barrels of oil per day.

Coalbed Methane

The names on Figure 8 refer to companies that are or have been active in coalbed methane exploration and(or) production in the State. The two areas of shallow Fort Union gas production in the Powder River Basin are areas where some 15 different companies are active. The exploration in these two areas is concentrated on shallow sandstone units in the Fort Union Formation. The source for the gas produced from these sandstones is most likely the thick Fort Union Formation coals in the area; however, the gas is not "coalbed methane" because the wells are not completed in coal beds. Only a few wells within these areas are producing gas from coal beds. Betop's wells are some that are producing coalbed methane.

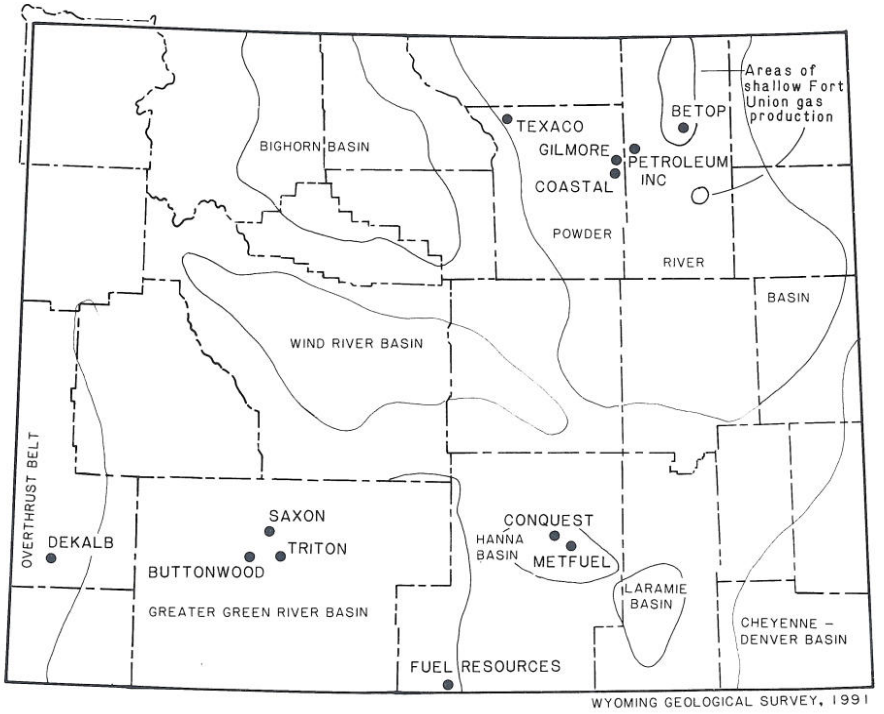


Figure 8. COALBED METHANE ACTIVITY IN WYOMING.

The most active area of coalbed methane exploration in the fourth quarter was in the southern part of the State. Fuel Resources drilled four new wells in sections 1, 2, and 12, T12N, R90W. No information is yet available on these wells. Fuel Resources drilled five wells earlier this year and has locations staked for 36 other coalbed methane wells in the area. The objective in all the wells is the Upper Cretaceous Almond Formation at a depth that ranges from 500 to 3,000 feet.

Saxon Exploration drilled two coalbed methane tests of Mesaverde coals in the fourth quarter. The wells were drilled in section 7, T25N, R102W, and in section 23, T25N, R103W. No other details are yet available on these wells. Saxon plans to drill an additional 50 to 100 wells in the area.

In an adjacent area, Triton Oil and Gas Corp.'s plans are still on hold. Triton wants to drill 93 coalbed methane wells in the Mesaverde coals and to construct up to 23 evaporation ponds and a gas processing plant with a capacity of 71 million cubic feet per day. Triton's plans are waiting on decisions by the U.S. Bureau of Land Management.

Gilmore Oil and Gas set production casing at their 1 Artesian Unit well in SE NE section 1, T49N, R77W. The well was drilled to test the coalbed methane potential of coal beds in the Fort Union Formation. Gilmore has also begun work on another well location in the same section. This activity is about 10 miles north of Coastal Oil and Gas' apparently unsuccessful coalbed methane exploration program (in the Fort Union) at their Sasquatch Unit.

Texaco Inc. drilled their 1 Texaco-Lott-Fee well in SE SE section 13, T52N, R83W, to test the coalbed methane potential of coal beds in the Wasatch Formation. No further details on this well are yet available. Texaco staked a location for a second well in the same section.

COAL UPDATE

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

1990 coal production from Wyoming will almost certainly set another record. Although final production figures will not be available until at least mid-February, 1991, coal deliveries through September, 1990, were 8.4 million tons more than for the same period in 1989 (Table 5). In fact, if coal deliveries for the last three months of 1990 were only equal to those for the same period in 1989 and if unreported tonnage for 1990 equals that of 1989, our projected production of 179.2 million tons would be exceeded by 0.3 million tons (Table 6).

It is also notable that coal deliveries to electric utility companies in August exceeded 16 million tons, the highest amount of coal ever recorded as delivered in a single month (Figure 9). Delivered tonnages in July, August, and September of 1990 were also among the highest monthly totals recorded.

The amount and percentage of spot coal delivered to electric utility companies also increased during the third quarter of 1990 (the last quarter for which we have data). For example, in August, spot coal deliveries accounted for almost 14 percent of the total coal delivered and in September it accounted for nearly 16 percent of total coal deliveries. This trend supports our contention that the percentage of low-priced coal continues to increase, (Table 6 and *Wyoming Geo-notes No. 28,* November, 1990, p. 17). The large number of coal purchasing transactions reported in the Powder River Coal Field during the last quarter of 1990 (see Coal Contracts-Powder River Coal Field below), along with published coal prices, indicates the influence of the spot market on Wyoming coal production and prices.

Significant increases in deliveries to Georgia, Indiana, Iowa, Michigan, Nebraska, and Illinois power plants more than offset slight decreases in deliveries to Arkansas, Louisiana, and Texas power plants. There appears to be a slight eastward shift in Wyoming spot coal markets as some utility companies whose plants do not have scrubbers and (or) whose plants use high-sulfur eastern coals attempt to deal with amendments to the Clean Air Act, which further restrict sulfur dioxide emissions. Many utility companies are now assessing the economics of: 1) burning low-Btu, low-sulfur coal; 2) installing and using scrubbers, 3) burning natural gas, or 4) purchasing power elsewhere.

Transportation of coal will play an important role in developing more distant markets for Wyoming coal. According to some transportation analysts, there is only about 30 million tons of uncommitted rail capacity out of the Powder River Coal Field. If this is true, by as early as 1994 this additional rail capacity could be consumed in just the Wyoming portion of the coal field (see Campbell and Converse Counties on Table 6). If Montana coal production increases, the uncommitted rail capacity will be gone even before 1994.

Although there are no announced plans for increasing rail capacity out of Wyoming, one suggested solution is "double tracking" the existing rail lines. Some

Table 5. 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		
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		
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		
TOTAL TONNAGE REPORTED	134,522,160		142,399,520		157,093,930		165,308,270			
TOTAL TONNAGE NOT REPORTED	1,782,896		4,089,128		6,494,270		5,831,734			
TOTAL TONNAGE PRODUCED[2]	136,305,056		146,488,648		163,588,200		171,140,004			

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

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

Table 6. COAL PRODUCTION AND FORECAST TO 1995 (MILLIONS OF TONS).

	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1988[1]	1989[1]	1990	1991	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	150.0	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	7.5	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	4.6	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	12.0	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	5.0	5.1	5.3	5.5	5.6	5.8
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming[3]	112.2	130.7	140.7	135.7	146.5	163.6	171.1	179.2	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%	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, September, 1990. [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.

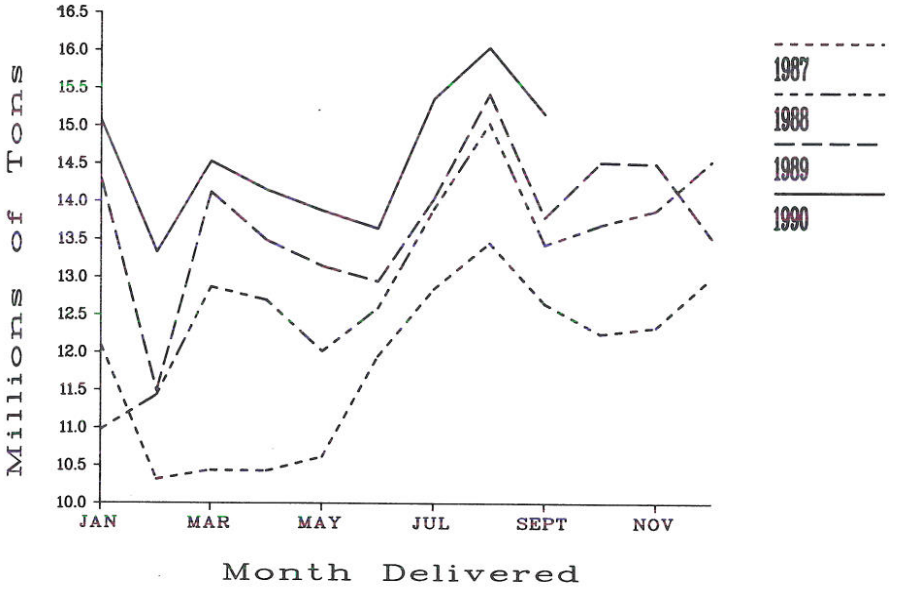


Figure 9. REPORTED DELIVERIES FROM WYOMING COAL MINES (FROM COALDAT MARKETING REPORT BY RESOURCE DATA INTERNATIONAL, INC., COMPILED FROM FERC FORM 423 FILED MONTHLY BY ELECTRIC UTILITIES).

industry analysts fear that increased transportation costs of coal (brought about by the financing of construction costs or even through increased fuel costs caused by rising oil prices) may offset the economic advantages that currently make low-sulfur coal from Wyoming so attractive to utility companies.

By the same reasoning as above, any significant increases in the delivered price of Wyoming coal (or other low-sulfur western coal) could also create barriers and limits to the growth potential of western coal. There are also some coal industry analysts who believe that the demand for low-sulfur western coal will be short-lived because technological advances (supported in-part by programs such as the Clean Coal Technology Program), conservation, and alternative energy sources will soon reduce the need for low-sulfur western coals. This view, however, seems very improbable given the long lead times needed to phase in new technologies or alternative energy sources.

The Clean Air Act Amendments of 1990 were signed into law by President Bush on November 14, 1990. Congress has been debating various aspects of the legislation for the last 13 years. The 10-pound, 700-page bill addresses many issues and programs outside the coal industry (such as auto emissions, nitrous oxide

emissions from all sources, industrial boiler emissions, and numerous related subjects), but the acid rain control measures addressed in Title V of the bill are those that affect the coal industry the most. The sulfur dioxide (SO_2) reduction program addressed in the bill consists of two phases. Phase I requires the 111 highest SO_2-emitting power plants in some 22 states to reduce their total annual emissions to 2.51 pounds of SO_2 per million Btu (multiplied by baseline fuel consumption) starting on January 1, 1995. Phase II requires all SO_2-emitting utility units with nameplate generating capacity equal to or greater than 75 megawatts to reduce total annual emissions to no more than 1.2 pounds of SO_2 per million Btu (multiplied by baseline fuel consumption) beginning on January 1, 2000. Phase II also limits total annual SO_2 emissions from all U.S. power plants to 8.9 million tons of SO_2 by the year 2000.

Another provision of the new act includes a system of marketable allowances that enables tonnages of emitted SO_2 to be "traded". Utility companies that reduce SO_2 emissions below the required level can accumulate tradable, saleable pollution "credits". A company unable to make on-site reductions in SO_2 emissions can purchase pollution "credits" and apply these tonnages of SO_2 towards the limits of SO_2 emissions required by law. Beginning in the year 2000, no new plant could go on line until it had obtained the necessary pollution credits to cover the entire amount of its expected annual SO_2 emissions.

Developments in western and southwestern Wyoming

Operator of the Intermountain Power Project (IPP) in western Utah announced in November that the 1,600-megawatt plant would begin testing bituminous coal from underground mines in western Colorado and southern Wyoming. The $5 billion Intermountain power plant uses 4 to 5 million tons of coal a year from Utah's underground coal mines and supplies about one-third of the electricity for Los Angeles, California. Twenty percent of the plant's coal needs are met from spot coal purchases and the plant is capable of burning bituminous coal with a heating value greater than 10,500 Btu/pound. Although no specific Wyoming coal mines have been mentioned as possible sources for the coal, Arch Mineral Corporation's newly-opened Pilot Butte underground mine north of Rock Springs is a likely candidate. The Governor of the State of Utah has threatened legal action against IPP if coals other than those from Utah are burned in the plant.

Arch Mineral Corporation's Pilot Butte underground mine is supplying coal to the Jim Bridger power plant (no. 2, Figure 10). About 75 percent (300,000 tons) of the 400,000 tons that Arch expected to produce from the mine in 1990 were sold to Pacific Power and Light Company's Jim Bridger power plant. The full productive capacity of the mine is about 750,000 tons per year and the mine contains about 63 million tons of reserves.

Developments in the Hanna Coal Field

Fourth quarter coal purchases from coal producers in this field are worth noting. Cyprus-Shoshone Coal Company furnished 9,000 tons of coal for testing in Nebraska Public Power District's (NPPD's) Sheldon, Nebraska, power plant (no. 11, Figure 10). The coal was used in late November and early December and followed

a successful earlier test burn of 200 tons. NPPD is blending this coal from the Shoshone No. 1 underground mine near Hanna with contract coal from the Black Thunder surface mine in Campbell County.

Arch of Wyoming and Cyprus-Shoshone Coal Company each furnished 18,000 tons of coal for test burns at Missouri Public Service Company's (MPS) Sibley, Missouri, power plant (no. 17, Figure 10). The coal was from the Medicine Bow and the Shoshone No. 1 mines (see *Wyoming Geo-notes, No. 27*, July, 1990, p. 24). By mid-1992, MPS expects to switch from Illinois Basin coal to western coal; the test burns from the Hanna Coal Field are part of MPS's western coal evaluation program.

As reported in *Wyoming Geo-notes No. 26* (April, 1990, p. 17) Pacific Power and Light Company (PP&L) announced the purchase of three 100,000-ton increments of coal from Arch of Wyoming's Medicine Bow mine for testing at the Jim Bridger power plant east of Rock Springs (No. 2, Figure 10). The test burns, which were originally scheduled for the third and fourth quarters of 1990, have been delayed until 1991.

Several publicly-owned utility companies recently released F.O.B. mine prices from several coal contract solicitations. Among the bids received were three from producers in the Hanna Coal Field. For a coal supply contract of 580,000 tons with San Antonio City Public Service Board's J.T. Deely, Texas, plant (see item 21 below under Coal Contracts-Powder River Coal Field), Arch of Wyoming submitted a bid of $14.25 per ton for 10,000 Btu/pound coal from the Medicine Bow mine. This equates to 71.25 cents per million Btu, as compared to the winning bid of 21.76 cents per million Btu which was made by Amax Coal Company's Belle Ayr mine in the Powder River Coal Field. For a contract solicitation by Fremont (Nebraska)

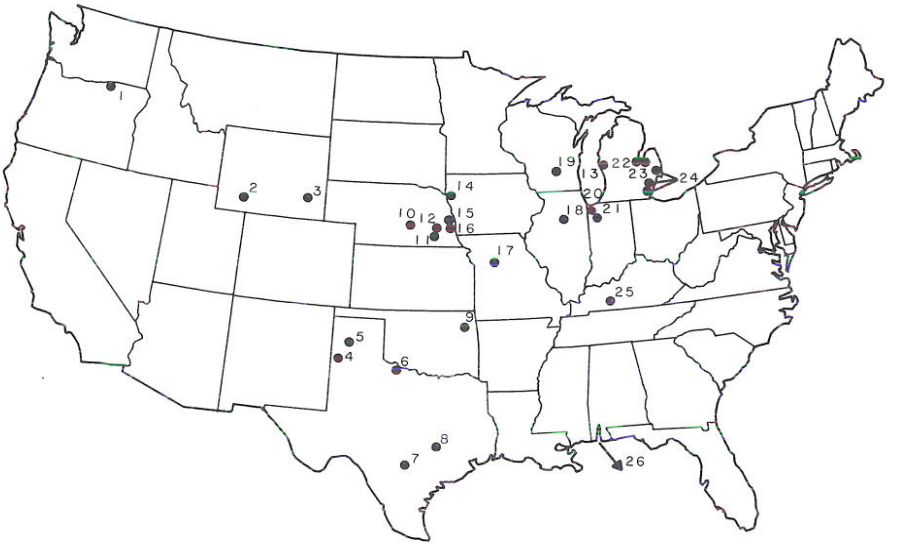


Figure 10. INDEX MAP OF COAL CONTRACT AND SALES ACTIVITIES INVOLVING WYOMING COAL MINES, NOTED DURING THE FOURTH QUARTER OF 1990.

Department of Utilities (see *Wyoming Geo-notes No. 27*, July, 1990, page 27), Arch of Wyoming submitted a bid of $14.00 per ton (67.31 cents per million Btu) for 10,400 Btu/pound coal from the Medicine Bow mine. Cyprus-Shoshone Coal Company submitted a bid of $17.50 per ton (77.43 cents per million Btu) for 11,300 Btu/pound coal from the Shoshone No. 1 underground mine. The winning bid for this contract was $4.05 per ton (23.55 cents per million Btu) for 8,600 Btu/pound coal from a producer in the Powder River Coal Field.

Developments in the Powder River Coal Field

There has been some progress toward the construction of a $65 million, commercial-size, K-Fuels plant. K-Fuels Partnership and Enserv, a subsidiary of Wisconsin Power and Light Company (WPL), reached an agreement in December in which Enserv will acquire majority interest in EA-K Energy. K-Fuels Partnership had been the major owner of EA-K Energy, a company holding the rights to license the K-Fuels technology in North America. Before the agreement, K-Fuels Partnership and its subsidiary, Energy Brothers, were delinquent on an $800,000 loan payment due the State of Wyoming for an $11.7 million clean coal technology loan given to Energy Brothers for construction of a K-Fuels demonstration plant near Gillette. The agreement with Enserv enables Energy Brothers to pay off the overdue loan payment and to proceed with planned construction of the commercial-sized plant in the spring of 1991.

WPL will purchase up to one million tons of the high-Btu, low-sulfur K-Fuels pellets, 400,000 tons of which are to be delivered to WPL by January 1, 1993. When completed, the K-Fuels plant will produce about 530,000 tons of finished fuel pellets from coal mined at the adjacent Fort Union coal mine. Apparently three other utility companies are involved in the financing and ownership of the new plant, but an investment firm owned by Iowa-Illinois Electric Company was the only company identified by name. The commercial plant should benefit from the recently enacted extension to the Federal Alternative Fuels Tax Credit Program. A tax credit of $20 per ton is expected.

A new long-term coal transportation contract was recently signed by Savage Industries, Inc. of Salt Lake City, Utah, and Black Hills Power and Light Company (BHPL). Savage will haul coal by truck from Wyodak Resources Development Corporation's Wyodak mine (east of Gillette) to BHPL's Osage plant at Osage, Wyoming, and to the Kirk plant near Lead, South Dakota. The length of the contract and the tonnages of coal involved were not disclosed.

The Tennessee Valley Authority (TVA) has recently purchased spot coal from five coal producers in the Powder River Coal Field. The coal is for TVA's Paradise, Kentucky, plant (see item 23 below). TVA has been given until July 1, 1991, to find a solution to the opacity emission problems at both Units 1 and 2 (which have scrubbers) and at Unit 3 (which lacks a scrubber). TVA announced that if they can't solve the problems at Paradise without having to burn western coal, they may be forced to fire all three units with up to 9 million tons of coal per year from the Powder River Coal Field.

In September, 1990, the Wyoming Environmental Quality Council approved new air quality rules that exempt coal mines in the Powder River Coal Field from some of the air quality regulations that apply to other areas of the State. The U.S. Environmental Protection Agency (EPA), whose rules and regulations at coal mines are enforced by the State of Wyoming, approved the new rules. It was ruled that standards developed for prevention of significant deterioration were based on a Federal pollution model that was incorrectly applied to the mines in the Powder River Coal Field. Fugitive dust emissions, which are the major pollutants from the mines, threatened to curtail coal production in this part of the State.

Coal Contracts - Powder River Coal Field

Purchasing activities in this coal field were numerous during the last quarter of 1990 as many utility companies finalized their coal purchases for the year and announced future purchases for the start of 1991. Along with the numerous spot sales, several longer-term contracts were also announced. Purchase of coal for conducting test burns and blending with other coals was down somewhat from previous quarters.

New coal contracts/sales are summarized below:

1) Sun Coal Company's subsidiary, Cordero Mining Company is supplying 150,000 tons of spot coal to Grand Island Electric Department's Platte, Nebraska, power plant (no. 10, Figure 10). Coal deliveries from the Cordero mine began in November, 1990, and will continue through February, 1991.

2) Amax Coal Company, Mobil Coal Producing, Inc., and Carter Mining Company are supplying a total of 1.35 million tons of coal to Portland General Electric Company's (PGE) Boardman, Oregon, plant (no. 1, Figure 10). About 550,000 tons were delivered during the last quarter of 1990 and the remaining 800,000 tons will be delivered through June, 1991. Although neither the mine names nor the specific tonnages from each company were released, the coal purchase is part of a renegotiated contract PGE recently signed with Amax Coal Company (see Wyoming Geo-not*es No. 28*, November, 1990, p. 27). This contract allows PGE to substitute or supplement coal purchased from Amax Coal Company in the event that Amax is unable to meet a competitor's bid price.

3) Mobil Coal Producing, Inc.'s Caballo Rojo mine provided 100,000 tons of spot coal for Northern Indiana Public Service Company's (NIPSCO's) Dean H. Mitchell, Indiana, power plant (no. 20, Figure 10) during November and December. The coal is supplied through an "as-needed, as-available" purchase agreement.

4) Amax Coal Company's Belle Ayr mine also supplied 120,000 tons of spot coal to NIPSCO's Mitchell, Indiana, plant (no. 20, Figure 10) during November and December under a similar "as-needed, as-available" purchase agreement.

5) Thunder Basin Coal Company (a subsidiary of Arco Coal Company) will supply Southwestern Public Service Company's (SWPSC's) Ray Tolk, Texas,

power station (no. 4, Figure 10) with 300,000 to 500,000 tons of coal during 1991. The coal, which will originate on the Burlington Northern Railroad (BN) at either the Coal Creek or Black Thunder mines, will continue from Denver via the Atchison, Topeka, and Santa Fe Railway Company.

6) Thunder Basin Coal Company and Rochelle Coal Company (a subsidiary of Peabody Development Company) will each supply half of the 800,000 to 1.2 million tons of coal needed in 1991 by SWPSC's Harrington, Texas, power station (no. 5, Figure 10). The coal, which will originate at either the Coal Creek or Black Thunder mines and at the Rochelle mine, respectively, will be transported by BN.

7) Cordero Mining Company's Cordero mine, Thunder Basin Coal Company's Black Thunder mine, and Rochelle Coal Company's Rochelle mine will collectively supply 500,000 to 1 million tons of coal per year for two years to Detroit Edison's River Rouge, Monroe, or St. Clair, Michigan, power plants (no. 24, Figure 10). The contracts provide for the purchase of an additional 1 million tons of coal per year if needed. The contracts also provide for possible extensions of deliveries for another 10 years. Neither the specific amounts of coal from each mine nor the transportation details were announced.

8) Mobil Coal Producing, Inc. and West Texas Utilities (WTU) signed a coal supply contract in late October, 1990, but no terms were announced. Carter Mining Company currently supplies WTU's Oklaunion, Texas, power plant (no. 6, Figure 10) under a long-term contract that will expire in July, 2006. Coal under the new contract would be from Mobil's Caballo Rojo mine and presumably would supplement coal that Carter Mining Company sells to the Oklaunion plant.

9) Mobil Coal Producing, Inc. and Grand River Dam Authority (GRDA) recently renegotiated the price on a coal supply contract for the Grand River Dam power station at Chouteau, Oklahoma (no. 9, Figure 10). The F.O.B. mine price of the coal was reportedly reduced from $6.70 per ton to slightly more than $4.00 per ton; at the same time, the heating value guarantee was also raised.

10) Carter Mining Company (a subsidiary of Exxon Coal USA, Inc.) will furnish Iowa Public Service Company's (IPS's) George Neal Unit No. 3 near Sioux City, Iowa, (no. 14, Figure 10) with 850,000 tons of coal per year for four years, starting in January of this year. The coal from Carter Mining's Caballo mine will be transported by Western Rail Properties, Inc. (WRPI), Union Pacific Railroad Company (UP), and Chicago and North Western Transportation Company (C&NW). The coal contract also contains an option for an additional two years of deliveries.

11) Cordero Mining Company's Cordero mine will also supply IPS's George Neal Unit No. 3 with up to 1 million tons of spot coal in 1991. The Cordero mine supplied spot coal to this same unit as well as Unit No. 4 in 1990 (see *Wyoming Geo-notes No. 27*, July, 1990, p. 28 and *Wyoming Geo-notes No. 28*, November, 1990, p. 26, respectively).

12) Rochelle Coal Company furnished 75,000 tons of coal from its Rochelle mine in southern Campbell County to Archer-Daniels-Midland Company's Lincoln,

Nebraska, manufacturing plant (no. 12, Figure 10). This coal was delivered in the fourth quarter of 1990.

13) Cordero Mining Company will furnish 1 million tons of coal to Wisconsin Power and Light Company's (WPL's) Columbia No. 2 unit near Portage, Wisconsin, (no. 19, Figure 10) in the first part of 1991. The coal will be mined at the Cordero mine and transported to Wisconsin by WRPI, C&NW, and UP rail lines.

14) Carter Mining Company will also supply 200,000 tons of spot coal from the Caballo mine to WPL's Columbia No. 2 unit during the first part of 1991.

15) Triton Coal Company (a division of Shell Mining Company) will furnish up to 500,000 tons of spot coal to Basin Electric Power Cooperative's Laramie River power station north of Wheatland, Wyoming (no. 3, Figure 10). The coal, which will be mined at the Buckskin mine north of Gillette, will be delivered in 1991. Triton's Buckskin mine currently supplies 220,000 tons of coal a year to the Laramie River plant under a term contract.

16) Amax Coal Company's recent contract with Omaha Public Power District (OPPD) to supply 250,000 tons of blended coal (15 percent dried product and 85 percent run-of-mine) (see *Wyoming Geo-notes No. 28*, November, 1990, p. 27) was recently modified. The blended coal was to be burned at OPPD's North Omaha and Nebraska City, Nebraska, power plants (nos. 15 and 16, respectively, Figure 10). OPPD will still purchase 250,000 tons of coal from the Belle Ayr mine, but it will be run-of-mine coal instead of the blended product.

17) Amax Coal Company will supply 700,000 tons of coal from either the Belle Ayr or Eagle Butte mine to OPPD's North Omaha, Nebraska, power plant (no. 15, Figure 10). The coal will be delivered during the last three quarters of 1991; an additional 100,000 tons of coal will be optional. The coal will originate on BN with final delivery by UP. The reported F.O.B. mine price of the coal was less than $4.00 per ton.

18) Triton Coal Company's Buckskin mine will supply 500,000 tons of spot coal to OPPD's North Omaha, Nebraska, power plant during the first four months of 1991.

19) Cordero Mining Company and Lower Colorado River Authority (LCRA) have signed a one-year contract for 200,000 tons of spot coal. The Cordero mine will supply this coal to the Fayette Power Project Unit No. 3 in 1991 to augment long-term contract coal also supplied by Cordero (see *Wyoming Geo-notes No. 26*, April, 1990, p. 21). The Fayette Power Project Unit No. 3 (no. 8, Figure 10) is also fueled by Texas lignite, which is mined near the plant.

20) Carter Mining Company will supply LCRA's Fayette Power Project Units 1 and 2 with 195,000 tons of spot coal from the Caballo mine in 1991. The published F.O.B. mine price was $3.95 per ton for coal with a heating value of 8,540 Btu/pound; delivered price to the Texas utility was $20.80 or 121.8¢ per million Btu. Using these figures, transportation charges for the coal are $16.85 per ton, or about 81 percent

of the delivered price. Of the six bids considered for this contract solicitation, the highest priced coal was $5.15 per ton for coal with a heating value of 8,775 Btu/pound. The average F.O.B. mine price for the bids was $4.29 per ton and the average delivered price was $20.98 per ton.

21) Amax Coal Company recently signed an agreement with San Antonio City Public Service Board to supply 580,000 tons of spot coal from the Belle Ayr mine to the J.T. Deely power plant at San Antonio, Texas (no. 7, Figure 10). The coal will be delivered in 1991 via Union Pacific Railroad. The published F.O.B. mine price for the coal was $3.70 per ton. The average F.O.B. mine price for nine bids from mines in the Powder River Coal Field was $4.26 per ton and transportation charges accounted for over 80 percent of the delivered price.

22) Some 23,000 tons of spot coal from undisclosed coal mines in the Powder River Coal Field were also purchased by Consumers Power Company in November and December, 1990. Part of this coal was burned at Units 7 and 8 of the J.C. Weadock power station, Michigan (no. 23, Figure 10). The remainder of the coal was used for testing (see below).

23) Five coal producers from the Powder River Coal Field have signed contracts with Tennessee Valley Authority (TVA) to supply a total of 250,000 to 500,000 tons of coal to the Paradise, Kentucky, power plant (no. 25, Figure 10). Cordero Mining Company's Cordero mine, Amax Coal Company's Belle Ayr mine, Thunder Basin Coal Company's Black Thunder mine, Triton Coal Company's Buckskin mine, and Nerco Coal Company's Antelope mine will each supply 50,000 tons with options for an additional 50,000 tons of coal (each). Although all transportation arrangements have not been completed, initial transportation out of Wyoming would be by rail with final delivery to Paradise by barge. The coal from each mine will be used separately and blended in varying amounts with coal from western Kentucky. Deliveries were scheduled to begin in January, 1991.

24) In December, 44,080 tons (40,000 metric tons) of coal from Kerr-McGee Coal Corporation's Jacobs Ranch mine were shipped to power plants operated by Endesa, Spain's national utility company. BN hauled the coal directly to the Port of Mobile, Alabama (no. 26, Figure 10) where it was loaded onto a ship to Spain. Carbotex, an international coal trading company, which arranged this sale and three previous coal sales between Wyoming producers and Spain, is apparently arranging a fifth coal sale to Endesa from Amax Coal Company. The shipment from Kerr-McGee is the first to exit the United States through Mobile, Alabama. The previous Spanish coal sales exited through the Port of New Orleans after traveling down the Mississippi River by barge.

Coal purchased for test burns is summarized below:

1) Consumers Power Company's purchase of 23,000 tons of spot coal from undisclosed coal mines (see item 22, above) includes coal that will be test burned in Unit No. 2 of the D.E. Karn power plant, Michigan (no. 22, Figure 10).

2) Rochelle Coal Company supplied 50,000 tons of coal from the Rochelle mine to Illinois Power Company's (IPC's) Hennepin, Illinois, power plant (no. 18, Figure 10). The test burn at the facility's plant, which does not have a scrubber, was quite successful in that the plant reached 100 percent capacity on 100 percent Rochelle coal. The Hennepin plant normally burns high-sulfur coal from the Illinois Basin. BN hauled the coal to St. Louis where it was barged up the Illinois River to the plant.

3) Pacific Power and Light Company's (PP&L's) plans to test burn coal from Amax Coal Company's Belle Ayr mine, Rochelle Coal Company's Rochelle mine, and Nerco Coal Company's Antelope mine during the third and fourth quarters of 1990 were delayed until the first half of 1991. The test burn was scheduled for the Jim Bridger plant at Point of Rocks, Wyoming (no. 2, Figure 10). The only coal from the Powder River Coal Field burned at Bridger so far has been from the Rochelle mine. The above three mines have furnished coal to PP&L's Dave Johnston, Wyoming, and Centralia, Washington, power plants.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

Construction Aggregate

Construction aggregate is a sized rock material produced from gravel deposits or from crushed rock or gravel deposits. Production of construction aggregate in Wyoming declines during the winter months due to the seasonal downturn in construction projects in cold weather. During the third quarter of 1990, the production of construction aggregate in the United States was about 1.3% below the 1989 figure. This decline may foreshadow recessionary effects on the national construction industry. The relationship of this decline to the construction industry in Wyoming, however, remains to be seen since 1991 production of construction aggregate is not expected to decline.

Rissler-McMurray has received a mining permit for a new construction aggregate quarry on Bessemer Mountain west of Casper. The quarry, which is in the Triassic Alcova Limestone, is slated to begin operation as soon as February.

Bentonite

Wyoming continues to lead the Nation in bentonite production. Bentonite production remained relatively constant through 1990 and is not expected to

increase significantly in 1991 unless there is a major increase in domestic drilling for oil and gas.

Decorative Aggregate and Stone

Decorative aggregate is sized rock produced for its color or other aesthetic qualities. It must have certain physical characteristics as well (strength, resistance to acid, etc.). Decorative aggregate is used in colored, prestressed concrete; roofing granules; landscape rock; building faces; etc. Decorative aggregate is produced in Wyoming by Georgia Marble, which operates Basins, Inc.'s white marble plant at Wheatland. The quarry is about 20 miles west of Wheatland. This material is known as "Wyoming White", and is used nationwide. All of the production from Wheatland is aggregate.

There may soon be other decorative aggregate production in Wyoming. During late 1990, several samples of colored rock were tested by an Iowa-based epoxy tile manufacturer. In this use, colored rock is crushed and mixed with epoxy, then polished to produce sheets measuring 12' X 8' and smaller. Both salmon-colored and gray quartz from Platte County, as well as black granite from northern Albany County, were shipped to the producer for testing. Larger test shipments are expected in early 1991.

No decorative stone (uncrushed rock) is produced in Wyoming at the present time. However, at least four companies are investigating the possibility of locating decorative stone quarries in the State. Initially, 4' x 4' x 8' stone blocks will be quarried and shipped elsewhere for cutting and polishing. If warranted by demand and economics, stone processing plants could be located in Wyoming. Granite, quartzite, and marble in many colors are found in Wyoming, and one industry expert called a collection of colored stone samples from Wyoming, "a better collection than all the stones from the rest of the world". This collection is on display at the Geological Survey of Wyoming building in Laramie.

Limestone

In Wyoming, limestone is now used as construction aggregate and in the production of cement. Other past uses of Wyoming limestone include sugar beet refining and the production of lime (CaO), a product with a wide variety of industrial uses.

In response to an 11% increase in national demand for lime, in the latter part of 1990 Pete Lien, Inc. announced that it intended to open a limestone quarry and construct a lime plant near Laramie. The quarry, which is located three miles east of Laramie, is on a high-calcium limestone in the Permian-Pennsylvanian Casper Formation. An older quarry in the same area provided limestone for the cement plant in Laramie. A spokesman for Pete Lien estimated the quarry and lime plant would employ about 50 persons. The U.S. Bureau of Land Management is currently holding public hearings on the planned quarry and State and local permits must still be acquired before the quarry and plant are constructed.

Fertilizer

Chevron Chemical Co. produces fertilizer in Rock Springs, Wyoming, from phosphate mined in Utah and from by-product sulfur produced in Wyoming. Phosphate is transported to the plant from a mine north of Vernal, Utah, by slurry pipeline. In November, 1990, Chevron annouced that the plant was for sale. No buyer has been announced to date; and Chevron is apparently not planning to shut the plant down. The plant is the newest and most efficient fertilizer plant in the country. Phosphate-based fertilizer products are in demand, but there is overproduction of phosphate fertilizer nationwide.

Trona

Wyoming's five trona mining companies, which produce a variety of sodium compounds from mined trona (See *Wyoming Geo-notes No. 28* for an extended summary of current operations and plans) continue to enjoy increased production and prices. 1990 was a record production year, and 1991 may be yet another record as new production lines and new plants are completed. In regard to State revenues, trona is the leading nonfuel mineral resource produced in Wyoming.

Uranium

After experiencing a price increase earlier in the year, Wyoming uranium prices fell in the fourth quarter of 1990. The earlier price rise was a result of increased demand for uranium by utilities. However, as demand increased and prices rose, foreign uranium stockpiles were dumped into the market at extremely low prices. Much of this uranium came from the Soviet Union. Lower prices have almost erased the 25% gain earlier in 1990. The year-end price for U_3O_8 was $9.80 per pound, compared with a high of about $12.00 per pound at mid-year, up from $8.10 per pound near the end of 1989. Uranium prices are no longer likely to reach the projected $20.00 price range (*Wyoming Geo-notes No. 28*, p. 33). It is more likely that they will remain at $10.00 or less through 1991.

In Wyoming, Uranerz USA is applying for a uranium mining permit for a solution-mining (in-situ) operation located south of the Pumpkin Buttes. Although this mine is mostly in Johnson County, parts of the permit area are located in Campbell and Converse counties. Uranerz has not announced a date for beginning mine construction, but it is planning to wait for more favorable uranium marketing conditions.

Umetco Minerals Corp., formerly Union Carbide, owns uranium properties in the Gas Hills area in Wyoming. The company announced in December that it was closing all of its uranium mining and milling activities. This will not cause any changes in its Wyoming operations since they are all inactive or being reclaimed.

The American Nuclear Corporation, located in Casper, Wyoming, announced that it will accept low-level radioactive waste materials from other sites for disposal at an inactive uranium mine in the Gas Hills.

Pathfinder Mines has begun mining and milling uranium from a new ore body in the Shirley Basin. Pathfinder closed its mill early last year while stripping overburden from the new ore body. This is the only surface uranium mine and conventional mill operating in Wyoming. Power Resources is currently the only other uranium producer. It produces uranium from an in-situ operation north of Douglas in Converse County.

In October, President Bush signed legislation providing compensation to underground uranium miners or their families for health problems resulting from working in underground uranium mines in the 1940's, 1950's, and early 1960's. The bill as originally drafted did not compensate Wyoming miners. However, the bill was modified when it became known that there had been underground uranium mines in Wyoming.

METALS AND PRECIOUS STONES UPDATE

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

Mining companies conducted reconnaissance studies of some mineral deposits (principally gold and copper) this past field season. And a group of South Dakota mining companies, upset with unfair treatment in that state, contacted the Metals and Precious Stones Division for information and assistance in locating potentially commercial gold deposits in the Cowboy State. These latter companies plan to invest exploration dollars in Wyoming in order to find minable gold deposits.

The author traveled to the Northwestern Mining Association conference in December and presented a paper on the exploration activity and geology of metal deposits in Wyoming (Hausel, 1990a). Since the presentation, there has been increased interest in some of the State's gold deposits as well as significant interest in the State's copper deposits. The mining industry's increased interest in copper suggests that the market for base metals may remain relatively strong in the near future. Contact W. Dan Hausel or the Publications Division of the Survey for copies of the paper titled, "Precious and base metal deposits in Wyoming".

Deposits attracting the greatest amount of interest are the giant porphyry copper-silver deposits (with associated gold, lead, zinc, and molybdenum) in the Absaroka Mountains (in particular, Kirwin and Sunlight Basin), the red bed copper-silver-zinc-lead deposits of the Lake Alice district in the Overthrust Belt, and the Ferris-Haggarty stratabound quartzite-hosted copper deposit in the Sierra Madre (Figure 11).

Bear Lodge district (Black Hills)

Gold properties in the Bear Lodge Mountains in the northwestern Black Hills of northeastern Wyoming have been receiving considerable exploration interest over

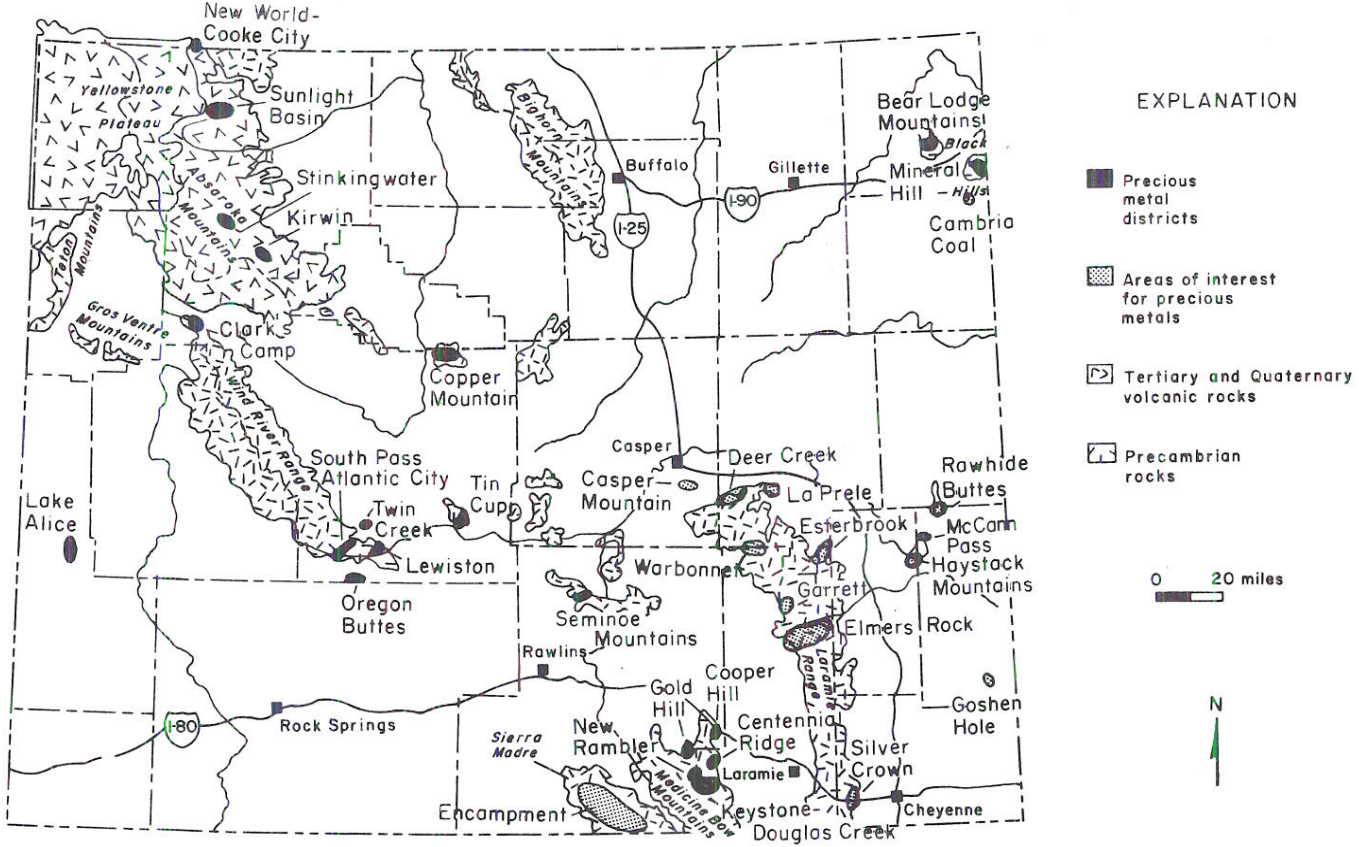


Figure 11. PRINCIPAL METAL DISTRICTS AND MINERALIZED REGIONS OF WYOMING.

the past several years. Mineralization in the district occurs as disseminated gold in feldspathic breccia. Some historic reports also described gold in fluorite veins although fluorite samples recently collected by the Geological Survey of Wyoming contained no detectable gold. Exploration in this region has been conducted by Molycorp, FMC Gold, Hecla Mining, International Curator Resources, and Coca Mines.

The most recent interest in the district is from Coca Mines, which reportedly leased 1,480 acres of unpatented mining claims on their Sundance project. According to the Engineering and Mining Journal, October, 1990, p. 43, the company planned to drill 36 additional holes during the third quarter of 1990 to confirm the extent of the mineralization. Initial drilling showed gold mineralization to vary from 30 to 195 feet thick with an average grade of 0.025 ounce per ton. The Sundance property is apparently the same deposit drilled by International Curator Resources. In their 1988 Annual Report, International Curator reported the discovery of a 2,000 by 120-foot wide intrusive breccia grading from 0.01 to 0.05 ounce per ton gold.

Seminoe Mountains

The Geological Survey of Wyoming continued field studies in the Seminoe Mountains greenstone belt throughout the summer and fall. Many samples were collected for laboratory work (Table 7) and detailed mapping of lithologies and structures continued. A new map of the western portion of the Seminoe Mountains greenstone belt (Bradley Peak Quadrangle) will soon be completed and available as an open file report. Mapping on the Seminoe Dam Quadrangle will begin next summer.

The available sample analyses show the presence of ultramafic rocks with relatively high chromium and nickel (Table 7). Also of interest, are the numerous weak precious metal anomalies detected in banded iron formation (Table 7). The Geological Survey of Wyoming initiated a long-term project last summer to test for precious metals in banded iron formation throughout the State. 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, such a project is considered high priority.

Geologically, the Seminoe Mountains represent a relatively young (2.7 to 2.9 billion-year-old) greenstone belt with a lower, mafic to ultramafic metavolcanic unit having an apparent thickness of nearly 10,000 feet. This lower unit is overlain by an ultramafic unit with nearly 1,000 feet of serpentinites and spinifex-textured basaltic and peridotitic komatiites, which in turn is overlain by several hundred feet of banded iron formation, clastic metasediments, felsic metavolcanics, and metagabbro. Gold in the greenstone belt occurs in veins associated with pervasive chloritic alteration, sulfides, quartz, and calcite.

South Pass

Goldstake Exploration continued exploring and testing their property in the South Pass greenstone belt this past summer. No results are available at this time.

Table 7. SELECTED ANALYSES OF ROCK SAMPLES FROM THE SEMINOE GOLD DISTRICT..

Sample #	Description	Fe (%)	Au (ppm)	Ag (ppm)	MgO (%)	Cr (ppm)	Ni (ppm)	Cu (%)	Pb (ppm)	Zn (%)
SM7-90	Banded iron formation (BIF) w/crosscutting quartz veinlet	20.4	nd*	1.1	-	-	-	-	-	-
SM8-90	Sheared BIF	-	nd	2.9	-	-	-	0.05	-	-
SM16-90	BIF breccia	-	nd	1.8	-	-	-	-	-	-
SM19-90	BIF with quartz vein	-	nd	1.5	-	-	-	-	-	-
SM22-90	Carbonate facies BIF	-	nd	1.2	-	-	-	-	-	-
SM23-90	Chlorite schist with 30-ft-wide quartz stockwork	-	1.3	4.0	-	-	-	0.14	-	-
SM29-90	Iron-stained milky quartz	-	nd	2.1	-	-	-	-	-	-
SM32-90	Fault breccia-carbonate cemented	-	nd	1.1	-	-	-	-	-	-
SM36-90	One-foot channel cut across shear, Sunday Morning prospect	-	0.07	45.4	-	-	-	1.8	-	-
SM37-90	Grab sample of copper-stained quartz, Sunday Morning prospect	-	2.1	26.9	-	-	-	5.8	1,970	-
SM47-90	10-foot composite chip sample, sheared mafic schist, Junk Creek prospect	-	nd	1.7	-	-	-	0.78	-	-
SM48-90	Copper-stained quartz, Junk Creek prospect	-	0.05	1.4	-	-	-	1.2	-	-
SM52-90	Copper-stained quartz, Junk Creek prospect	-	0.15	2.7	-	-	-	3.7	66	0.3
SM34-90	Copper-stained felsite schist	-	-	-	-	-	-	4.4	-	-
SM3-90	Fine-grained metabasalt	-	-	-	10.8	1,800	-	-	-	-
SM24-90	Spinifex-textured basaltic komatiite	-	-	-	13.4	1,700	166	-	-	-
SM33-90	Spinifex-textured basaltic komatiite	-	-	-	21.2	3,800	813	-	-	-
SM40-90	Serpentinite	-	-	-	29.2	7,800	1,217	-	-	-
SM43-90	Serpentinite	-	-	-	33.8	5,400	1,632	-	-	-
SM44-90	Chlorite-actinolite schist	-	-	-	21.0	4,600	873	-	-	-

* nd = not detected

A final report on the Geological Survey of Wyoming's six-year study of this greenstone belt will describe numerous gold and iron deposits and anomalies, and some silver, copper, tungsten, tin, and chromium anomalies. The results suggest the greenstone belt contains several possibly commercial mineral deposits, a high potential for the discovery of near-surface hidden gold deposits, and the potential for some hidden giant gold deposits. This report should be available in the first quarter of 1991.

Union Pacific Resources (Minerals) provided the Geological Survey of Wyoming with a $20,000 grant for 1991 to conduct applied research related to the distribution and occurrence of gold and diamond along the railroad land grant in southern Wyoming. This grant will provide the Survey with an opportunity to look for gold, diamonds, and other valuable minerals in a variety of unusual geological environments that have been overlooked in the past. Since 1980, the Survey has been accumulating data on precious metals and stones (see Albert, 1986; Hausel and others, 1988; Hausel, 1989) and it has become apparent that there are numerous anomalies in some atypical environments.

Some areas slated for study in the Greater Green River Basin of Carbon, Sweetwater, and Uinta counties include the potential for gold, diamonds, or other valuable metals and minerals in lamproites in the Leucite Hills, in Cretaceous titaniferous black sandstones, in coal, in oil shale, in uraniferous sandstones, in sand and gravel deposits, and in an extensive alunite-silica deposit. In Albany, Carbon, and Laramie counties, the Survey will investigate a large disseminated gold-copper deposit, some vein deposits, a titaniferous black sandstone, and some sand and gravel deposits.

These areas were considered for this study because: (1) similar titaniferous black sandstones have been gold-bearing elsewhere, (2) the Leucite Hills' lamproites are mineralogically and chemically similar to diamondiferous lamproite in Arkansas and Western Australia, (3) gold anomalies have been reported in coal at three other locations in Wyoming, (4) in 1922, the U.S. Bureau of Mines reported anomalous gold in oil shale near Rock Springs and Green River, and no known follow-up studies have occurred, (5) anomalous gold has been reported in uranium roll fronts elsewhere in Wyoming (Gordon Marlatt, personal communication, 1988), (6) sand and gravel deposits often carry gold, (7) an extensive zone of silicification and alunite in the Green River Basin is mineralogically similar to hydrothermal alteration associated with extensive disseminated gold deposits in Nevada, and (8) the disseminated gold-copper deposit and the vein deposits are similar to commercial deposits mined elsewhere in the world.

This reconnaissance study is scheduled for completion by the end of 1991, but it could be continued if favorable results are obtained.

Diamonds

The Geological Survey of Wyoming resumed its exploration for diamond deposits this past summer under a grant from the University of Wyoming's Mining and Mineral Resource Research Institute. To date the project has revealed

numerous heavy mineral anomalies in the Laramie Mountains (Hausel and others, 1988). The project apparently has attracted the interest of diamond exploration firms in that the Survey has recently been contacted by a consulting firm looking at the feasibility of testing diamondiferous kimberlite in the State Line district south of Laramie. There are also reports that a major international diamond mining company has been exploring both the Bighorn and Gros Ventre Mountains over the past few years.

Joint WGA-UW-WGS Field Conference

In 1991, the Wyoming Geological Association (WGA), the University of Wyoming's Department of Geology and Geophysics (UW), and the Geological Survey of Wyoming (WGS) will jointly host the WGA's annual field conference, which will be held in Laramie, Sept. 14-18. The theme of the conference is mineral resources of Wyoming. Tentatively, the conference will start with pre-conference field trips to the Seminoe and South Pass gold and iron districts, followed by one day of papers and(or) talks on gold, copper, coal, diamond, petroleum, rare earths, industrial minerals, construction materials, titaniferous magnetite, uranium, vanadium, platinum, and palladium. Tours of the Anaconda Collection in the Archive of Economic Geology of the American Heritage Center are also planned. The conference will end with two days of post-conference field trips. The post-conference trips currently include (1) the Hanna Coal Field, (2) industrial mineral deposits in southeastern Wyoming, and (3) the anorthosite complex and associated titaniferous magnetite deposits, diamond deposits in the State Line district, and the geology of the Medicine Bow Mountains.

References Cited

Albert, K.G., 1986, Reported gold concentrations in sediment samples from U.S. Department of Energy's National Uranium Resource Evaluation (NURE) reports: Geological Survey of Wyoming Open File Report 86-4, scale 1:500,000.

Hausel, W.D., 1989, The geology of Wyoming's precious metal lode and placer deposits: Geological Survey of Wyoming Bulletin 68, 248 p.

Hausel, W.D., 1990a, Precious and base metal deposits in Wyoming: Paper presented to the 96th Annual Northwest Mining Association Convention, Spokane, Washington, Dec. 5-7, 22 p.

Hausel, W.D., 1990b, Precious metals of Wyoming, *in* Gold '90: Society of Mining, Metallurgy, and Exploration of AIME, Littleton, CO, p. 53-63.

Hausel, W.D., Sutherland, W.M., and Gregory, E.B., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 11 p.

Table 8. 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, 1990)		
Identified and Hypothetical (Discovered)	1,431.2	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,462.7	billion tons
Remaining Reserve Base (January 1, 1990)		
Demonstrated strippable (Measured and indicated reserve base)	26.7	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	38.3	billion tons[7]
Total	64.9	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, 1985)	1.99	billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1985)		
Uranium oxide recoverable at $30.00 per pound	83	million pounds[9]

OIL SHALE

Original Resources (January 1, 1983)		
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] DeBruin, R.H., and Jones, R.W., 1989, Coalbed methane in Wyoming: Wyoming Geological Association 40th Annual Field Conference Guidebook, Casper, Wyoming, p. 97-103.
[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] 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, October, 1990. (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, 1985, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(85) 142 p.
[10] Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

GEOLOGIC MAPPING AND STRATIGRAPHY

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

Fieldwork completed on Monument Hill Quadrangle

The Stratigraphy Division completed its field examination of the Monument Hill Quadrangle (Figure 12) in October. The quadrangle contains outcrops of sedimentary rocks ranging from Cambrian Gros Ventre Formation to Triassic/Permian Goose Egg Formation, with an interspersed capping of Tertiary White River Formation. Geologic mapping shows two prominent monoclines, which merge near the western

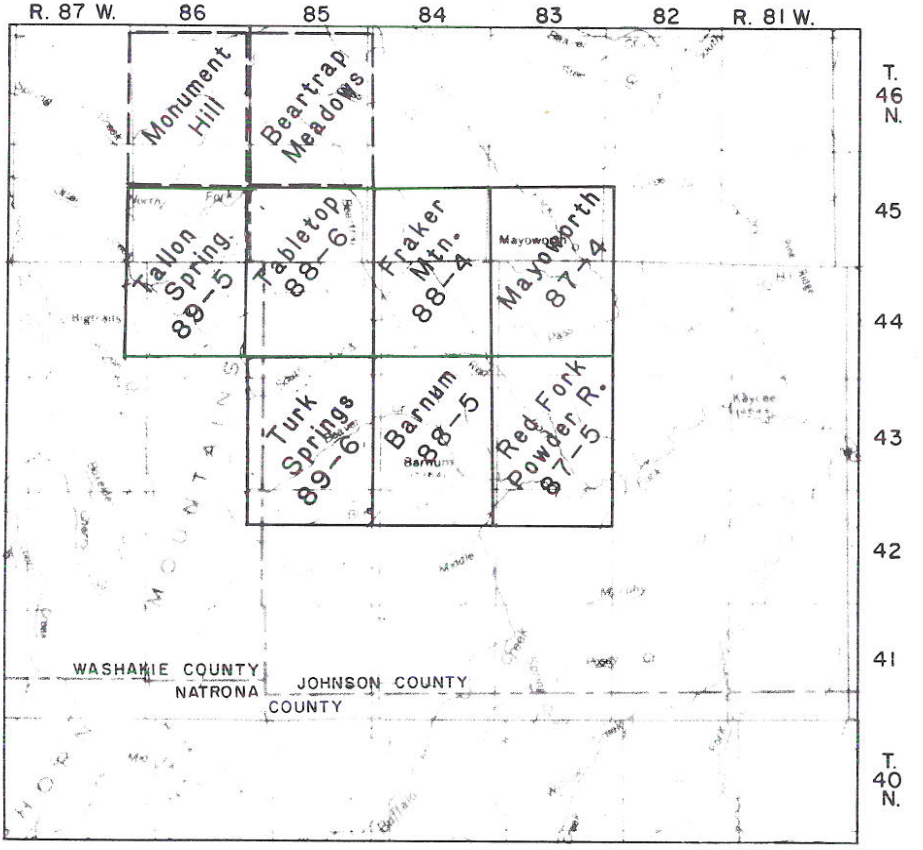


Figure 12. INDEX MAP TO STATE SURVEY MAPPING IN THE SOUTHERN BIGHORN MOUNTAINS.

side of the map, probably representing basement faulting. In addition, the Big Trails fault system is mapped on the southeastern corner of the map. Regional dip is westward into the Bighorn Basin.

Field mapping of the quadrangle uncovered some interesting features. For example, a resistant ridge of silicified fault gouge was discovered on the portion of the Big Trails fault mapped in the southeast corner of the map. This gouge zone was 15-20 feet thick and contained high-angle fractures dipping 76°E toward the main fault trace. These fractures give an indication of the dip on this portion of the fault.

Several outcrops of probable Oligocene White River Formation were found within the map area. These outcrops consisted of interbedded tuffaceous claystone, unconsolidated gravel lenses (consisting of igneous, metamorphic, and Paleozoic rocks), and rare occurrences of cemented conglomerate. Although no dating of the outcrops has been attempted at this time, the description of these deposits is similar to the White River Formation described by other workers in the Bighorn Mountains. Many of the White River occurrences are found in or near present day drainages indicating a probable Oligocene paleodrainage system which had an obvious effect on the location of the present drainage system.

The Monument Hill Quadrangle and the Beartrap Meadows Quadrangle (discussed in *Wyoming Geo-notes No. 28*) will be available as open file maps sometime in 1991. When these two maps are completed, there will be open file maps for nine quadrangles in this part of the southern Bighorn Mountains (Figure 12).

New dinosaur finds at Como Bluffs

In July of this year, paleontologists from the University of Colorado, led by Dr. Robert Bakker, unearthed the remains of two more dinosaurs near Como Bluffs, Wyoming. Both the specimens represent the last known members of their respective family of dinosaurs. The one discovery is an example of the largest and last member of the cetiosaur family. The other specimen is the youngest brontosaur found to date. While Bakker believes that these two discoveries point toward a "stepwise" pattern of extinction for the dinosaurs rather than extinction by a cataclysmic disaster, it will be a long time before the jury is in on which of these theories is the most correct. While the cetiosaurs died out near the end of the Jurassic Period, about 138 million years ago, the brontosaur discovered by the group extends the brontosaur family into the Cretaceous Period, which occurred 63-137 million years ago.

The discovered cetiosaur probably weighed 30 tons as compared to the "average" plant-eating cetiosaur, which ranged from 12 to 15 tons. It was 70 feet long and 25 feet tall. The discovered brontosaur was also immense. It was 75 feet long and weighed 20 to 25 tons. Both dinosaurs seem to follow the rule that the last member of the species generally was the largest.

In November, Dr. Bakker spoke to an enthusiastic group of dinosaur fans on the University of Wyoming campus. His presentation titled *Wyoming dinosaurs: the untold story* was sponsored by the Friends of the Dinosaurs, a support group for the University of Wyoming's Geological Museum (see *Wyoming Geo-notes No. 28*, p. 42). Dr. Bakker discussed many of his revolutionary ideas concerning dinosaurs and their behavior. In addition, he sketched several different dinosaur species and gave the copies to children who correctly identified them. The Friends of the Dinosaurs are planning other paleontology lectures.

GeoRef data now available on CD-ROM

The University of Wyoming's Geology Library acquired the CD-ROM version of GeoRef this fall. GeoRef has references to North American geology dating as far back as 1785. It also includes geologic information about the rest of the world dating back to 1933. The database contains 1.5 million records including journal articles, books, maps, reports, and theses. As of early 1990, the GeoRef system included 9,433 entries for Wyoming. The CD format and easy-to-use software allows for quick, efficient data searches by subject, author, title, publication year, key words or phrases, etc. The database is updated quarterly with approximately 15,000 to 20,000 records.

In addition, the Geology Library has subscribed to a separate database of U.S. Geological Survey publications, also on CD ROM. This separate CD includes more than 70,500 references to U.S. Geological Survey publications, including reports and maps published from 1880 to 1988, non-Survey publications with Survey authors from 1983 to 1989, and references to reports produced by the Hayden, King, Powell, and Wheeler Surveys. The database consists of complete bibliographic references and GeoRef index terms for topics and locations. The sheet size, scale, and latitude and longitude are given for maps. This database is updated on a yearly basis each March 1st. The Library also has two CDs containing data from the Deep Sea Drilling Project.

To facilitate the development of small customized bibliographies and to aid in answering inquiries, the Stratigraphy Division is currently working on a cooperative program with the Geology Library.

HISTORIC EARTHQUAKES IN SOUTHEAST WYOMING

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

The earthquake risk in the western portions of Wyoming, from Yellowstone National Park in the north through the Evanston area in the south, has been well publicized in recent years. Numerous earthquakes, however, have been located in other portions of the State. Southeastern Wyoming has had a number of events, with a few causing damage to homes, schools, businesses, or pipelines. Before the events are described, a discussion of the two measures of an earthquake is necessary.

One method utilizes seismographs to measure or determine various aspects of seismic waves, including the source area, wave form, and the amount of energy released. This instrumentally determined measure of the size of an earthquake and the total energy released is called magnitude. The Richter scale is a scale of earthquake magnitudes. Each one step increase in magnitude roughly equates to a 32-fold increase in released seismic energy.

Another method of measuring an earthquake utilizes a compilation of personal observations of the effects an earthquake has on the Earth's surface or on specific types of structures at a given locality. This measure is called the intensity. The intensity scale ranges from I to XII, with an intensity I earthquake only being felt by a very few persons under especially favorable circumstances. With an intensity XII event, damage is total. Reported earthquakes in southeastern Wyoming range from intensity II to intensity VII. For a single earthquake, intensities can vary depending upon the distance from an epicenter. The magnitude, however, remains constant. Both intensity and magnitude figures are used to describe the southeast Wyoming earthquakes described below. Instrumentally determined magnitudes in Wyoming were not common until the late 1950's. Most descriptions of earthquakes prior to that time are described in terms of intensities. Only the most significant events are described below. For a more complete presentation of earthquake epicenters, refer to Geological Survey of Wyoming Open File Report 90-10, *Earthquake epicenters and suspected active faults with surficial expression in Wyoming.*

Northern Laramie Range

There have been a series of earthquakes recorded in the Douglas, Esterbrook, and northern Albany County areas. On April 14, 1947, an intensity V event was felt near La Prele Creek southwest of Douglas. The earthquake was felt by all in a ranch house, and by a few outdoors. Windows were rattled, chairs were moved, and buildings shook (Murphy, 1950). On August 22, 1952, an intensity IV earthquake was reported near Esterbrook. It was felt by several people in the area, and was reportedly felt 40 miles to the southwest (Murphy et al, 1954). In October, 1952, another small event was reported in the area, with no damage occurring (Murphy et al, 1954).

In the 1980s, there were a series of relatively significant earthquakes in northern Albany County. On February 13, 1983, a magnitude 4.0, intensity IV event was recorded. The event was felt in Laramie, Casper, Wheatland, and Medicine Bow (*Laramie Daily Boomerang*, February 15, 1983; *The Wyoming Eagle*, February 14, 1983). No damage was reported. On October 18, 1984, a magnitude 5.5, intensity VI earthquake occurred. The earthquake, with an epicenter located approximately 21 miles south of Esterbrook, was felt in Wyoming, South Dakota, Nebraska, Colorado, Utah, Montana, and Kansas. Stover (1985) reports that cracks were found in the exterior brick walls of the Douglas City Hall and a public school in Medicine Bow. Chimneys were cracked at Casper, Douglas, Guernsey, Lusk, and Rock River, and broken underground pipes were reported from Casper and Shirley Basin. Foundations and exterior walls were cracked at Casper, Guernsey, Hanna, Lusk, McFadden, Rock River, and Shirley Basin. There were a number of aftershocks to the main event, with none causing any significant damage. The earthquake was one of the largest felt in eastern Wyoming.

Hartville Uplift Area

On February 25, 1942, an intensity V event, with an epicenter south of Lusk, did not cause any damage (*Casper Tribune-Herald*, February 27, 1942). On October 3, 1954, an intensity IV earthquake was reported near Guernsey. Although the event was felt from Douglas to Wheatland, no damage was reported. Train traffic between Douglas and Wheatland was halted until it was determined that the tracks were not damaged (*Laramie Republican-Boomerang*, October 4, 1954). On March 28, 1964, there was an intensity V event with an epicenter southeast of Lusk, near the Nebraska state line. That earthquake was primarily felt in western Nebraska, with no significant damage reported (*Casper Star-Tribune*, March 29, 1964). On October 22, 1964, there was a magnitude 4.5, intensity V, earthquake recorded with an epicenter northwest of Lusk. Much of the town was attending a concert in the town's new high school building, and when the attendees felt the tremor they thought that the furnace had blown up (Wyoming State Tribune, August 23, 1964). No significant damage was reported.

Laramie Basin and Vicinity

A number of earthquakes have occurred in the Laramie Basin although none have caused significant damage. The earliest reported event was on January 1, 1898, and it occurred in the Laramie area. The intensity IV event shook buildings and rattled dishes, windows, and loose objects. A number of people were awakened by the earthquake (*The Daily Boomerang*, January 14, 1898). On September 21, 1931, an intensity IV earthquake was felt in the Laramie area. Windows and dishes rattled, and a few residents ran from their homes (*The Laramie Republican-Boomerang*, September 21, 1931). Another intensity IV event was reported on November 10, 1935. This earthquake, which rattled dishes in Laramie, was also felt in Rock River and Rawlins (*The Laramie Republican-Boomerang*, November 11, 1935).

On January 20, 1954, an intensity V event was reported, with an epicenter thought to be located approximately 12 miles north-northeast of Laramie. Furnishings shifted and windows were rattled at Albany. Small objects were shifted at Jelm, and there were reports of dishes being shaken off tables in Laramie (Murphy et al, 1956). The earthquake was also felt in Centennial, Tie Siding, and Ryan Park. A few days later, on January 23, 1954, an estimated intensity IV event was reported at Jelm. A strong but brief shock was felt in Jelm, but no damage was reported (Murphy et al, 1956).

On May 22, 1955, an intensity IV earthquake occurred near Jelm and Woods Landing. Reflecting the fears of the time, one person thought that an atomic bomb had dropped on Denver. A group of fisherman camping near Woods Landing reported that they were rolled around in their tent. Dishes and windows were rattled in many cabins in the Woods Landing area (The Laramie *Republican - Boomerang*, May 23, 1955). On August 6, 1958, an intensity IV earthquake was felt in the same area. Windows and dishes were rattled in Foxpark. The earthquake was also felt in Laramie, where no damage occurred (The Laramie *Daily Boomerang*, August 7, 1958). On December 25, 1959, an intensity V earthquake, with an epicenter near Foxpark, was felt in Foxpark and Laramie. Concrete block buildings were cracked slightly at Foxpark (Coffman et al, 1982).

Summary

In conclusion, earthquakes have been felt or reported in all counties in southeastern Wyoming. Algermissen and others (1982) have estimated that the maximum random earthquake that should be expected in southeastern Wyoming is of magnitude 6.1. In historical times, an earthquake of that magnitude has not yet occurred. For further information on earthquakes in Wyoming, contact the author at the Geological Survey of Wyoming.

References

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L., and Bender, B.L., 1982, Probabilistic estimates of maximum acceleration and velocity in rock in the contiguous United States: U.S. Geological Survey Open File Report 83-1033, 99 p., scale 1:7,500,000.

Case, J.C., 1986, Earthquakes and related geologic hazards in Wyoming: Geological Survey of Wyoming Public Information Circular No. 26, 22 p., scale 1:1,000,000.

Coffman, J.L., von Hake, C.A., and Stover, C.W., 1982, Earthquake history of the United States: National Oceanic and Atmospheric Administration and U.S. Geological Survey Publication 41-1 (revised edition, through 1970), Reprinted 1982 (with supplement, 1971-1980), 258 p.

Humphreys, W.J., 1917, Section V. - seismology, *in* Abbe, C., editor, Monthly Weather Review: U.S. Department of Agriculture, Weather Bureau Monthly Weather Review, v. 45, No. 3, p. 130.

Murphy, L.M., 1950, United States earthquakes 1947: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 730, 61 p.

Murphy L.M., and Cloud, W.K., 1954, United States earthquakes 1952: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 773, 112 p.

Murphy, L.M., and Cloud, W.K., 1956, United States earthquakes 1954: U.S. Department of Commerce, Coast and Geodetic Survey Serial No. 793, 110 p.

Stover, C.W., 1985, Preliminary isoseismal map and intensity distribution for the Laramie Mountains, Wyoming, earthquake of October 18, 1984: U.S. Geological Survey Open File Report 85-137, 9 p.

NEW PUBLICATIONS BY THE GEOLOGICAL SURVEY OF WYOMING

*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: MS-9R, 1990, 1:1,000,000 - $2.50.

Metallic and radioactive minerals and lapidary materials of the Powder River Basin and adjacent uplifts, by W.D. Hausel, R.E. Harris, J.K. King, and W.M. Sutherland: Map Series 32, 1990, scale 1:500,000 (color) - $4.00.

Coal map of the Powder River Basin and adjacent areas, Wyoming, by R.W. Jones: Map Series 33, 1990, scale 1:500,000 (color) - $4.00.

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.

Geology of the Cheyenne belt, by E.L. Duebendorfer: Open File Report 90-8, 1990, Plate 1 (scale 1:24,000), Plate 2 (scale 1:50,000) - $8.00.

*Gemstones, lapidary materials and geologic collectables in Wyoming, by W.M. Sutherland: Open File Report 90-9, 1990, 53 p. and 2 maps, scale 1:1,000,000 - $12.00.

*Earthquake epicenters and suspected active faults with surficial expression in Wyoming, by J.C. Case, L.L. Larsen, C.S. Boyd, and J.C. Cannia: Open File Report 90-10, 1990, 1:1,000,000 - $4.00.

*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, 1991, 1:1,000,000 - $4.00.

Coalbed methane in Wyoming, by R.W. Jones and R.H. De Bruin: Public Information Circular 30, 1990 - $4.00.

Results of coal drilling projects in the Bighorn Basin, Wyoming, by P.J. Taucher, R.W. Gregory, and G.B. Glass: Report of Investigations 43, 1990 - $12.00.

*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.

---

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

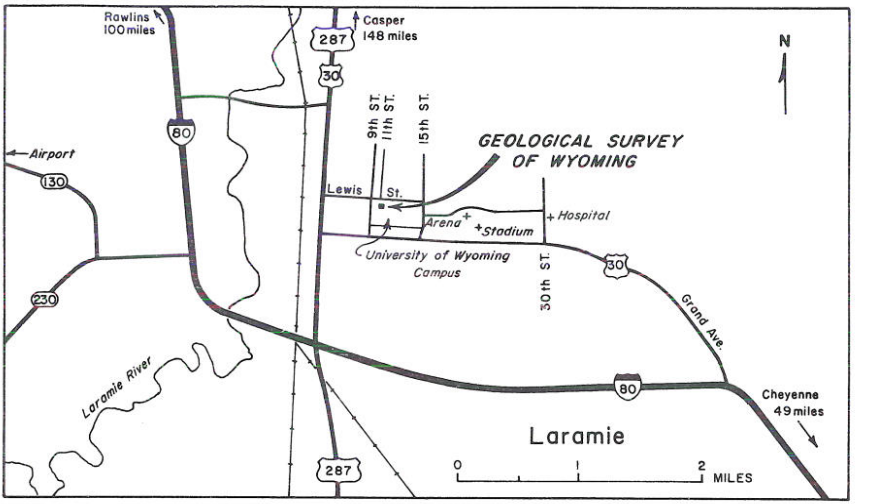
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

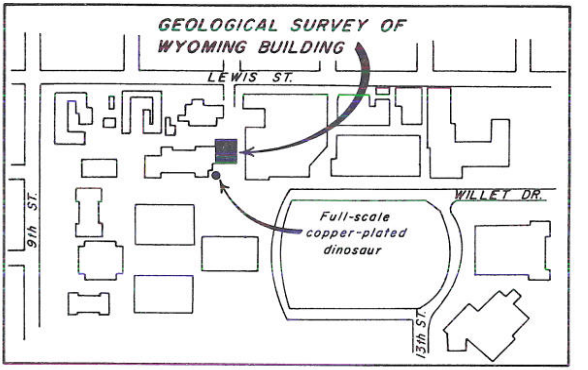
No first class postage charge for prepaid orders, unless otherwise marked.

— 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





Order Form

Send this order to:

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

Your name, address, zip:

_____

_____

_____

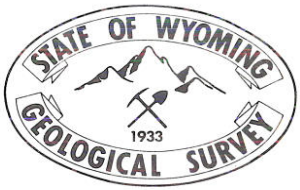
_____

_____

No postage charged on prepaid orders
unless otherwise specified

Quantity	Title	Price	Total Price

ROLLED CHARGES	
WYOMING RESIDENTS ADD 5% SALES TAX (or furnish proof of exempt status)	
FIRST CLASS POSTAGE	
TOTAL	


STATE OF WYOMING
1933
GEOLOGICAL SURVEY