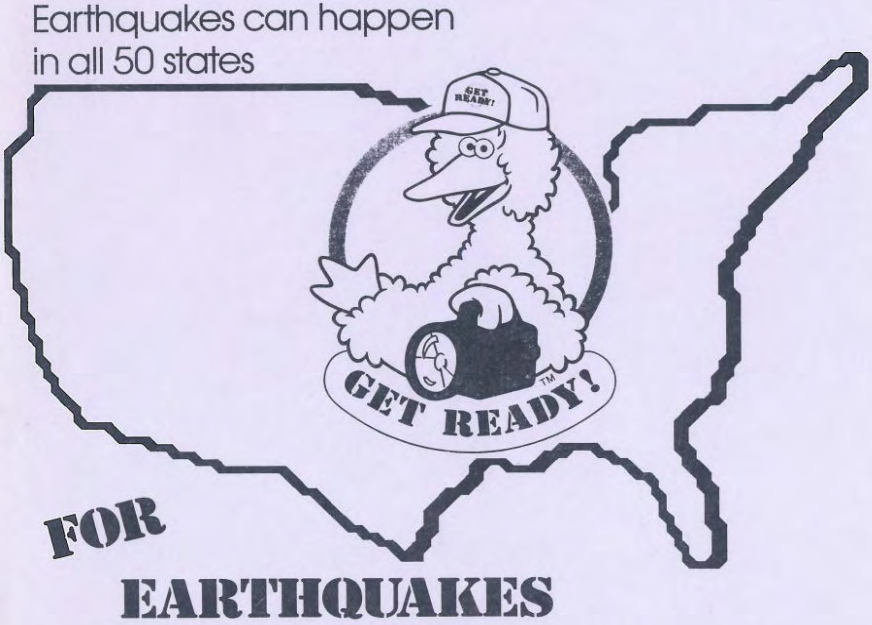
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES
NO. 26



LARAMIE, WYOMING
April, 1990

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: The Federal Emergency Management Agency (FEMA) has enlisted the aid of Sesame Street's Big Bird to help increase the awareness of earthquake hazards. The cover illustration appears on a board game called "Get Ready For Earthquakes". See pages 43 to 44 for a discussion of educational materials that are available on earthquakes.

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The Geological Survey of Wyoming
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Several lines are accessed by this
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We hope this change will be more convenient for everyone.

MINERALS UPDATE

OVERVIEW

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

The first quarter of 1990 brought some pleasant surprises in regard to energy and mineral production. Coal production in 1989 was 1.1 million tons higher than our estimate of October 1989. At 171.1 million tons, coal production set another record. Preliminary estimates of 1989 oil production look like they may be as much as 500,000 barrels more than our last forecast. Estimates of natural gas production in 1989 are 48 billion cubic feet or 6 percent higher than our October estimate. 1989 production of trona is also 1.2 million tons more than what was forecast in October.

Higher average posted oil prices in the first quarter of 1990 (up to $20.10 in January) also provided some optimism and relief although prices did decline overall in the quarter. OPEC actions in April, however, cast a new shadow over what may happen to prices in the second quarter of 1990. Natural gas prices, though volatile, seemed to average higher than 1989. The spot gas price at Opal was as high as $2.05 in January. Coal prices really showed little change over 1989 with spot sales still dipping under $4.00/ton. There was contract activity in both the Hanna and Powder River Basins in the first quarter, and there was some possibility of new contracts in both the Green River Basin and the Hams Fork Coal region.

Table 1. WYOMING MINERAL PRODUCTION FORECAST TO 1993[1].

Calendar Year	Oil Production[2]	Methane Production[3]	Carbon Dioxide Production[3]	Helium Production[4]	Coal Production[5]	Trona Production[5]	Mined Uranium Production[6]	In situ Uranium Production[7]	Sulfur Production[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	1.4	1.10
1989	108.5	736.7	127.0	0.95	*171.1	*16.2	*0.1	1.2	1.21
1990	103.6	758.6	127.0	0.95	177.1	18.0	0.1	1.0	1.21
1991	98.1	781.1	127.0	0.95	183.8	18.0	0.1	1.0	1.21
1992	92.9	804.4	127.0	0.95	189.2	18.0	0.1	1.0	1.21
1993	88.0	828.3	127.0	0.95	193.1	21.0	0.1	1.0	1.21

*Actual values for comparison; [1]Geological Survey of Wyoming, April 1990; [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 1989-1993 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).

Oil and gas drilling declined through the first quarter as it traditionally does although there was definitely more drilling than in 1988. Drilling activities were centered in the oil fields of the Powder River Basin and the gas fields of the Greater Green River Basin. While there is still no Wyoming to California pipeline under construction, the likelihood of one being built has only increased. In addition, two companies announced construction plans. Coastal Corporation plans to build a methyl tertiary butyl ether plant near Cheyenne and CO_2, Inc. is planning a carbon dioxide liquefaction plant north of Green River.

There is also major construction planned in the trona patch. Tenneco and Asahi Glass Co. have announced a $100 million expansion plan for Tenneco's soda ash plant near Green River. This project will expand Tenneco's operation an estimated 48 percent.

The uranium industry lost another mine in the first quarter of 1990. In this case, Malapai Resources ceased its *in situ* production in the Powder River Basin. While this left only one producing mine in Wyoming in March, Pathfinder still plans to reopen its Shirley Basin operation in 1990, and other companies are still evaluating their options.

Exploration activities for metals, precious stones, and industrial minerals are also anticipated as the weather improves. In particular, there is already announced exploration plans for gold, copper, diamond, dimension stone, aggregate, and silica sand.

Table 2. PRODUCTION HISTORY OF SELECTED WYOMING MINERAL COMMODITIES[1].

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Ballast[2,3]	1.65	1.72	0.81	0.99	2.43	0.67	0.61	1.09	0.80[8]
Bentonite[2]	3.58	4.81	2.35	2.18	3.08	2.59	1.82	2.16	2.32
Clay[4]	42.0	23.2	15.7	36.4	59.6	35.9	23.2	1.31	61.1
Decorative Stone[2]	0.05	0.05	0.05	0.07	0.08	0.09	0.07	0.06	0.07[8]
Dolomite[2]	1.67	0.87	0.61	0.66	0.86	0.87	0.81	0.46	0.19[7]
Feldspar[4]	0.20	0.03	0.17	----	----	----	----	----	----
Gypsum[2]	0.30	0.28	0.26	0.33	0.33	0.35	0.41	0.35	0.40[8]
Iron Ore[2]	4.88	4.67	3.28	2.48	----	----	----	----	----
Limestone[2,5]	0.50	0.72	0.59	0.56	0.65	0.32	0.34	0.42	0.64
Sand and Gravel[2]	5.06	5.21	4.74	5.00	4.76	4.71	3.53	2.57	2.16
Scoria[2,6]	0.03	0.08	0.08	0.07	0.23	0.13	0.04	----	0.20[7]
Shale[4]	----	----	----	----	20.3	14.7	9.88	49.0	50.2[7]
Sodium Sulfate[4]	----	3.20	3.17	3.19	3.25	2.71	2.03	----	2.10[7]

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. Prepared by Geological Survey of Wyoming, April, 1990.

OIL AND GAS UPDATE

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

Average posted prices for Wyoming Sweet crude oil in January, 1990, rose to their highest level in over three years. The average price was $21.10 per barrel. While the average posted price for February, 1990, was only slightly lower at $20.85 per barrel, the average posted price in March, 1990, dipped to $19.15 per barrel, which was still significantly higher than it was for March in the past three years. The average posted prices over the past 13 months have been higher and more stable for a longer period than for any comparable period over the past 39 months (Figure 1).

Increased demand for crude oil during January and February of 1990 was partly responsible for the high average posted prices in Wyoming. Refiners across the country bought extra crude oil to replenish their inventories which were very low following the high demand for heating oil and other products during the extremely cold weather in December, 1989. U.S. imports of crude oil and other petroleum products averaged over nine million barrels per day in January. This was the first month since 1977 that exports exceeded nine million barrels a day. Total petroleum imports accounted for a record 54 percent of domestic deliveries in January. Although high demand was partially responsible for the high import total, domestic crude oil production has declined by 1.7 million barrels per day since 1986.

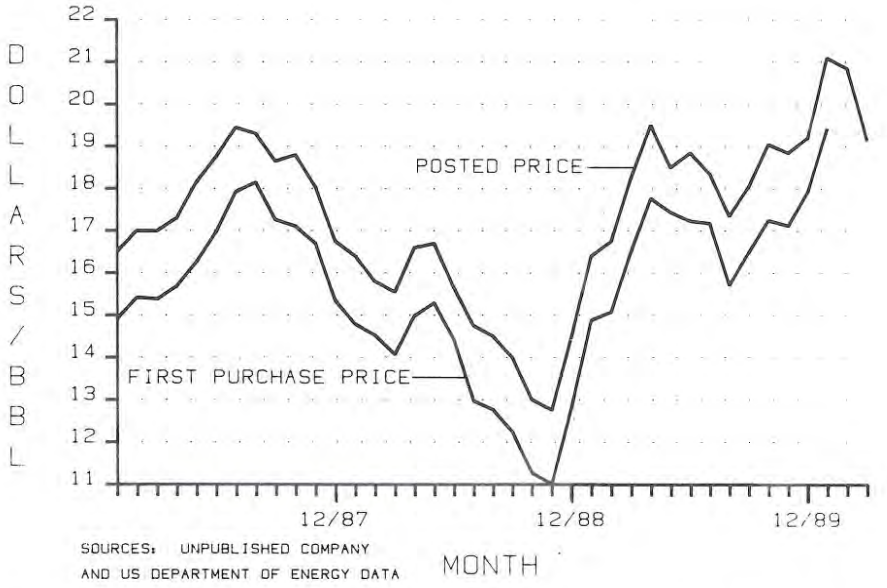

Figure 1. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987-PRESENT).

Wyoming's oil production also continued its decline (Figure 2). A preliminary estimate of oil production for 1989 from Petroleum Information (1990a) shows that Wyoming produced 108,541,829 barrels, which should keep Wyoming in sixth place nationally (Table 3). Wyoming's 1989 production, however, is a decline of nearly 5.8 million barrels (five percent) from 1988 production. It is unlikely that this decline rate will change dramatically in the next few years.

Table 3. TOP TEN OIL AND GAS PRODUCING STATES IN 1988.

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

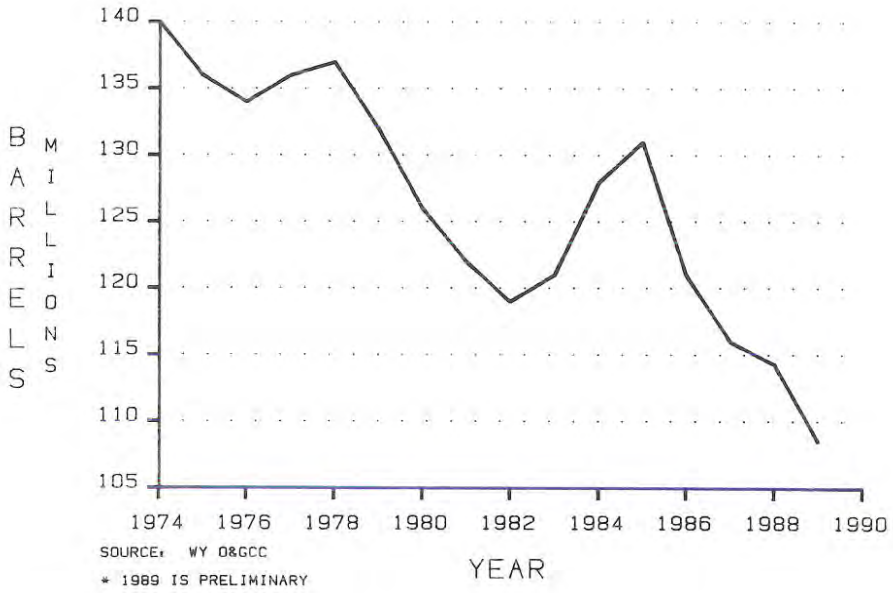

Figure 2. WYOMING OIL PRODUCTION (1974 TO 1989).

Even if crude oil prices stay in their current range and well completions increase, there is a lag time between well completions and production. Well completions in Wyoming in 1989 fell to 420 (Petroleum Information, 1990b). This figure will be adjusted upward somewhat when late reports arrive; however, the revised figure will still be much lower than the last four years (Table 4). When oil prices dropped in 1986, the rig count (Figure 3), well completions, and oil production also dropped. It will take several years of increased drilling and the implementation of major enhanced oil recovery projects to halt the oil production decline.

Table 4. WYOMING WELL COMPLETION SUMMARY[1]

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

[1] Modified from Petroleum Information, 1990b.

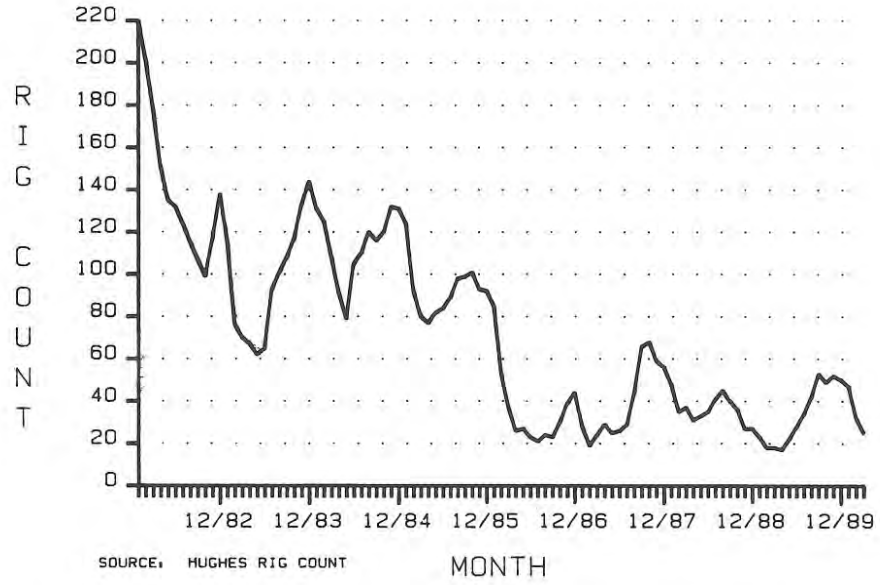

Figure 3. WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT).

One type of enhanced oil recovery project (new to Wyoming) that could at least help slow the State's oil production decline is the huff n' puff process (single-well, cyclic, carbon dioxide stimulation). The initial test well in Crooks Gap Field (*Wyoming Geo-notes No. 25*, pages 4-6) pumped about 1,600 barrels of oil during two months of production after stimulation. Although this first well produced significantly less oil than expected, in two to three months the well will be stimulated with carbon dioxide for a second time. Researchers speculate that the well may produce ten times as much oil in this second test. The 1990 Wyoming Legislature provided funds to the University of Wyoming's Enhanced Oil Recovery Institute to work on the huff n' puff process. Funding is also coming from private industry and the U.S. Department of Energy. Hopefully, this process will be economically feasible for use in other wells around the State and will help boost oil production.

A preliminary estimate of natural gas production for Wyoming (Petroleum Information, 1990a) shows that production reached an all-time high of 863.8 billion cubic feet in 1989 (an increase of 52.2 billion cubic feet over 1988 production). This preliminary estimate, which includes methane and carbon dioxide production, is six percent higher than our earlier estimate of 815 billion cubic feet. Nearly 30 billion cubic feet of the increase over 1988 production was from Fogarty Creek Field. Gas from this field contains approximately 66 percent carbon dioxide. Based on total gas production, Wyoming will probably maintain its fifth-place position as a natural gas-producing state in 1989 (Table 3).

Wyoming's annual gas production has increased over 260 billion cubic feet since 1986 (Figure 4) and will continue to increase for years to come as increased gas usage accelerates development of the State's large gas resources. The gas surplus in the United States is fast disappearing as evidenced by spot gas prices at Opal, Wyoming. The January, 1990, spot price was $2.05 per MCF (thousand cubic feet) while the January, 1989, spot price was $1.35 per MCF. Although the February, 1990, spot price declined to $1.50 per MCF, it was still higher than the $1.35 in February, 1989.

Both WyCal Pipeline Co. and Kern River Gas Transmission Co. claim they have enough letters of intent and signed agreements to proceed with plans to build a pipeline to deliver Wyoming gas to southern California. Although it is still uncertain which pipeline is ahead of the other, it is becoming more certain that a pipeline will be built. Both companies plan to start construction later this year and to begin delivery of gas by late 1991.

In a related item, Questar Pipeline Co., West Gas, and Rocky Mountain Natural Gas announced plans to construct a 300-mile, $100 million pipeline in Colorado. The TransColorado Pipeline could transport 250 to 300 million cubic feet of gas per day from western Colorado and other producing basins in Wyoming and Utah and connect with existing pipelines to ship gas to markets in the Midwest as well as markets in southern California.

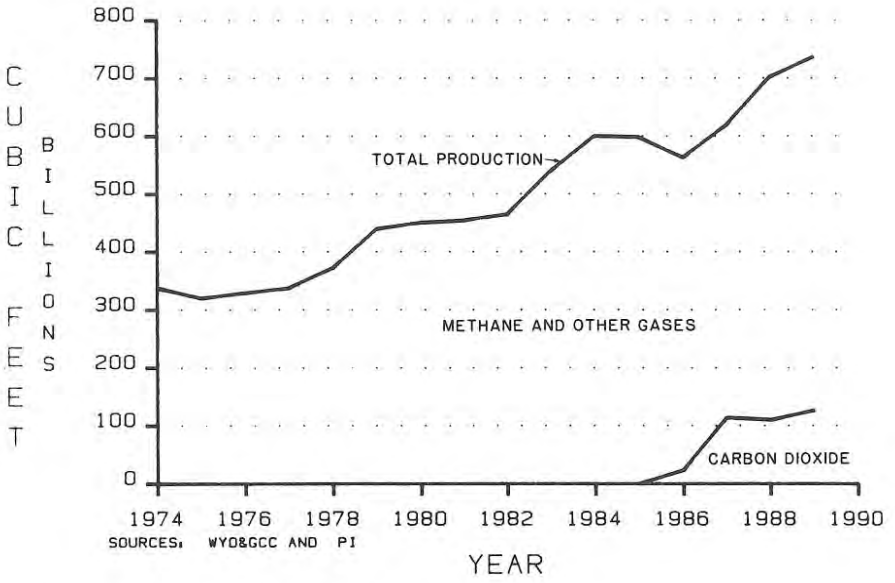

Figure 4. WYOMING NATURAL GAS PRODUCTION BY YEAR (1974 TO 1989).

The old Husky refinery in Cody could be reopened this summer if plans by a newly-formed Utah company are finalized. The refinery is slated to employ about 100 people within two years.

The Coastal Corporation announced plans to build a $65 million plant to produce methyl tertiary butyl ether (MTBE), a gasoline additive that helps reduce air pollution. The plant would employ about 25 people at the Coastal Chemical Inc. site near Cheyenne. Six weeks after the announcement; however, the U.S. Senate rejected an amendment that would favor the use of MTBE over ethanol. It is unknown whether this action will affect Coastal's plans to build their plant.

CO_2, Inc., a Texas company, announced plans to build a $500,000 carbon dioxide liquefaction plant in Sweetwater County. The proposed facility would be located near Exxon's Shute Creek plant north of Green River and would employ up to 30 people. The expected capacity of the plant is about 240 tons of carbon dioxide per day by late June. CO2, Inc. will market the liquefied carbon dioxide to enhanced oil recovery projects in and around Wyoming.

Although lease sales are still doing fairly well, the Wyoming Department of Public Land's January sale was disappointing. The March sale, however, was one of the two best sales in the last 15 months (Table 5). The high per-acre bid at the January sale was only $46 for a 640-acre tract covering all of section 36, T.22N.,

Table 5. FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES IN WYOMING

BLM SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1987				
TOTAL	$15,724,159	727	646	197,422	177,960	$ 88.36	$6,555.00
			1988				
March	$7,338,210	866	336	1,073,940	315,387	$23.27	$525.00
June	$7,564,135	820	375	755,242	293,050	$25.81	$575.00
August	$5,827,548	847	363	827,471	278,198	$20.95	$1,350.00
October	$3,913,765	820	257	994,618	282,145	$13.87	$6,500.00
December	$3,045,203	766	260	761,242	182,117	$16.72	$330.00
TOTAL	$27,688,861	4,119	1,591	4,412,513	1,350,897	$20.50	$6,500.00
			1989				
February	$2,418,295	800	230	857,475	187,012	$12.93	$1,225.00
April	$2,334,604	732	227	557,643	145,055	$16.09	$390.00
June	$1,673,150	758	163	962,929	138,691	$12.06	$160.00
August	$3,469,570	656	197	577,518	141,841	$24.46	$285.00
October	$3,247,334	788	296	657,918	178,013	$18.24	$3,000.00
December	$2,689,152	552	247	415,266	181,791	$14.79	$340.00
TOTAL	$15,832,105	4,286	1,360	4,028,750	972,403	$16.28	$3,000.00
			1990				
February	$3,301,479	524	259	335,275	141,555	$23.32	$340.00

STATE SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1987				
TOTAL	$2,526,567	1,200	579	511,638	244,740	$10.32	$2,300.00
			1988				
January	$826,698	200	142	76,953	56,430	$14.65	$200.00
March	$800,213	200	133	76,304	48,423	$16.53	$465.00
May	$1,649,974	200	182	75,987	69,285	$23.81	$290.00
July	$1,855,646	200	155	77,168	60,519	$30.66	$375.00
September	$751,646	200	142	68,456	55,168	$13.63	$180.00
November	$318,547	200	119	71,085	42,118	$7.56	$130.00
TOTAL	$6,202,724	1,200	873	445,953	331,943	$18.69	$1,640.00
			1989				
January	$331,145	200	112	73,322	39,650	$8.35	$110.00
March	$493,179	200	129	74,512	47,886	$10.30	$140.00
May	$512,736	199	129	76,396	51,919	$9.88	$155.00
July	$684,374	200	154	82,760	65,034	$10.52	$190.00
September	$474,104	200	134	77,889	50,749	$9.34	$540.00
November	$628,446	200	134	76,973	56,036	$11.22	$170.00
TOTAL	$3,123,984	1,199	792	461,852	311,274	$10.04	$540.00
			1990				
January	$190,921	200	100	74,987	38,884	$4.91	$46.00
March	$668,262	200	132	79,405	54,193	$12.33	$85.00

Sources: Wyoming Department of Public Lands, Petroleum Information Corporation - Rocky Mountain Region Report, and U.S. Bureau of Land Management.

R.110W. The lease is about five miles east of General Atlantic Resources' Sugarloaf Butte Field discovery of oil and gas from the Dakota. Yates Petroleum made the high per-acre bid of $85 at the March sale for a 320-acre tract covering N/2 section 36, T.49N., R.70W. The parcel is about 1/2 mile north of an abandoned Minnelusa oil well in Chalk Hills Field.

The high per-acre bid at the U.S. Bureau of Land Management's (BLM) February sale was $340 made by Wade Vick for a 2,360-acre parcel covering all or parts of sections 22, 23, 26, 27, 34, and 35, T.36N., R.94W., near Fort Union gas production in Fuller Reservoir Field. Only six parcels received bids of $100 or more per acre in this sale.

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 first quarter of 1990. The letters preceding the discussions below refer to locations on Figure 5:

A. Exxon Corp. has reached total depth at their 1 Rockslide Unit well in SW NE section 12, T.23N., R.118W. The well was drilled to 16,000 feet in the Bighorn

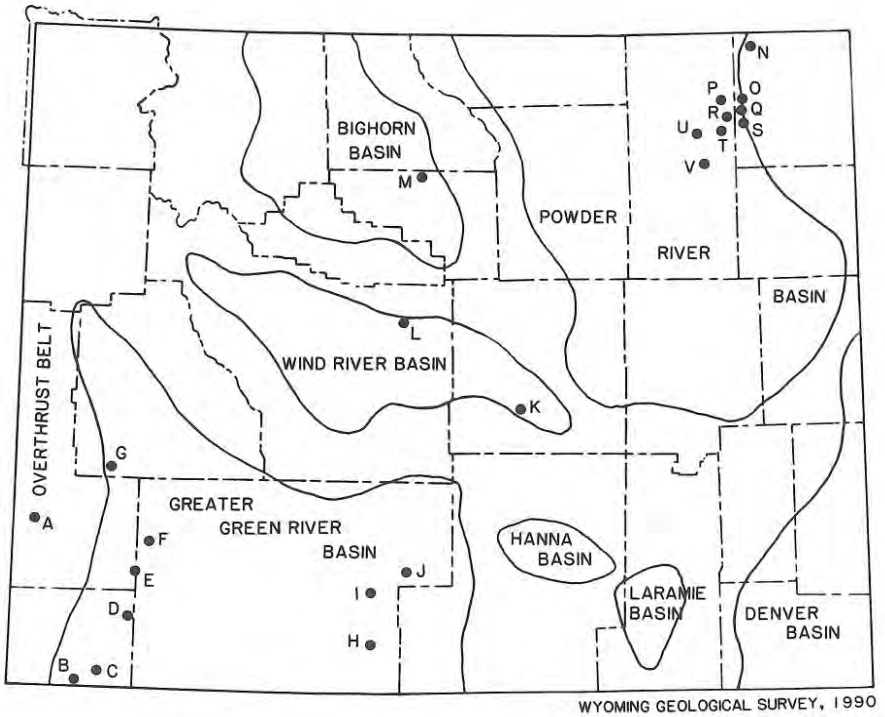

Figure 5. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING.

Dolomite and is 15 miles north of Exxon's 1989 Collett Creek Field discovery of oil and gas in the Bighorn.

B. Texaco Inc. set production casing at their 1 UPRR 13-Slab Park Unit well in SE NE section 13, T.12N., R.116W. The well is a 16,000-foot Dakota test located about four miles northwest of Dakota oil production in Graham Reservoir Field.

C. The Taylor Ranch Field area has two new Dakota wells. Anadarko Petroleum completed the 1-27 Taylor Ranch-Federal well in NW SW section 27, T.13N., R.114W., for 1.2 million cubic feet of gas, 120 barrels of condensate, and 40 barrels of water per day. Texaco Inc. completed the 4 TPI-Whiskey Springs well in SW SE section 32, T.13N., R.114W., flowing 1.8 million cubic feet of gas and 662 barrels of condensate per day.

D. Wexpro Co. completed four more producers in Church Buttes Field in the company's development drilling program with Union Pacific Resources. The 69 Church Buttes Unit well, completed in C SE section 17, T.16N., R.112W., flowed 1.07 million cubic feet of gas per day from the Dakota; the 65 Church Buttes Unit well in NE SE section 17, T.17N., R.112W., flowed 5.64 cubic feet of gas, 128 barrels of condensate, and 53 barrels of water per day from the Dakota; the 66 Church Buttes Unit well flowed 1.54 million cubic feet of gas, 41 barrels of condensate, and 22 barrels of water daily from the Frontier Formation; and the 73 Church Buttes Unit well in C SE section 33, T.17N., R.112W. flowed 3.20 million cubic feet of gas and 47 barrels of condensate per day from the Frontier.

E. Amoco Production completed seven new producers as part of their drilling program in Bruff and Fabian Ditch Fields. The 2-Champlin 285-Amoco C well in SW NE section 33, T.20N., R.112W., flowed 21 million cubic feet of gas, 121 barrels of condensate, and 20 barrels of water per day from the Dakota; the 2 Champlin 285-Amoco A well in SW NE section 27, T.20N., R.112W., flowed 21 million cubic feet of gas, 202 barrels of condensate, and 14 barrels of water per day from the Dakota; the 2 Champlin 285-Amoco well in NE NE section 35, T.20N., R.112W., flowed 1.8 million cubic feet of gas, 15 barrels of condensate, and five barrels of water daily from the Frontier; the 2 Champlin 149-Amoco D well in NE SE section 21, T.19N., R.112W., flowed 1.99 million cubic feet of gas and 18 barrels of condensate daily from the Frontier; the 2 Champlin 149-Amoco J well in NE SE section 11, T.19N., R.112W., flowed 2.41 million cubic feet of gas, one barrel of condensate, and one barrel of water per day from the Frontier; the 2 Champlin 149-Amoco L well in SE SW section 15, T.19N., R.112W., flowed 25 million cubic feet of gas and 114 barrels of condensate per day from the Dakota; and the 2 Champlin 358-Amoco F well in NE SE section 15, T.18N., R.112W., flowed 2.64 million cubic feet of gas daily from the Frontier. Together these seven wells had initial flowing potentials of over 75 million cubic feet of gas and 471 barrels of condensate per day.

F. General Atlantic Resources recently discovered Sugarloaf Butte Field. The discovery well, the 30-1 Whiskey Buttes-Federal in NW SW section 30, T.22N., R. 110W., flowed 1.46 million cubic feet of gas and 958 barrels of condensate daily

from the Dakota. General Atlantic is testing the Frontier at two other wells in the area, the 32-1 Whiskey Buttes-Federal in SW NW section 32, T.22N., R.110W., and the 1-36 Whiskey Buttes-Federal in SE NE section 36, T.22N., R.111W. In the same are, Presidio Exploration is testing the Frontier at the 34-7 Lombard Butte-Federal in NW SE section 7, T.22N., R.110W. The company will attempt to complete the 33-35 UPRR well in SE NE section 35, T.22N., R.111W. in the Dakota.

G. Chevron USA recently completed three development wells in the Birch Creek Field. The 106 BCU well in NW NE section 23, T.27N., R.113W., flowed 10 million cubic feet of gas and 33 barrels of water per day commingled from the Bear River and Frontier Formations; the 105 BCU well in SE SW section 24, T.27N., R.113W., flowed 3.96 million cubic feet of gas, six barrels of condensate, and 62 barrels of water per day commingled from the Bear River and Frontier; and the 107 BCU well in NW NE section 14, T.27N., R.113W., flowed 1.54 million cubic feet of gas and 60 barrels of water per day commingled from the Bear River and Frontier.

H. Celsius Energy and Union Pacific Resources completed a new discovery in the Almond Formation. The 1 Mulligan Draw Unit well in NE NW section 24, T.15N., R.95W., flowed 2.2 million cubic feet of gas daily. The discovery is about four miles northwest of Almond gas production at Dripping Rock Field and was an effort to evaluate the continuation of a depositional trend in the Almond at the Dripping Rock Field.

I. Amoco Production's Frewen Field discovery in the Lakota produced an average of 2.4 million cubic feet of gas daily during its first two months of production in November and December, 1989. The one well field produced a total of 147.7 million cubic feet of gas during these two months. Amoco began drilling a second well in W/2 SW section 7, T.19N., R.94W., and has a location staked for a third well in N/2 S/2 section 6, T.19N., R.94W.

J. Pacific Enterprises Oil Co. set production casing at their 12,000-foot Almond test well, the 10-1 NE Wamsutter in NE NW section 1, T.21N., R.93W. The well is about four miles from Mesaverde gas production at Monument Lake Field.

K. Amerada Hess Corp. discovered oil and gas in the Muddy Sandstone at their 27-32 Saddle Rock Unit well in NW NE section 27, T.33N., R.86W. The well flowed 67 barrels of water and 289,000 cubic feet of gas daily and is a mile south of Sun Ranch Field which produces oil and gas from the Muddy. The discovery was named Saddle Rock Field.

L. Thermal Exploration discovered Fort Union gas at their 32-28 Badwater II Unit well in SW NE section 28, T.38N., R.93W. The well is in the Shoshoni Field area. Shoshoni Field produced gas from the Fort Union but was abandoned in 1975. The new well flowed 884,000 cubic feet of gas and 40 barrels of water per day.

M. JN Exploration and Production staked a 10,300-foot Dakota test in SE SW section 23, T.48N., R.93W. The company has drilled one Dakota test in NE NE

section 14 and has another Dakota location staked in NE NE section 25, T.48N., R.93W.

N. Karlton Terry Oil Co. staked a horizontal test in Thompson Creek Field in NW SE section 2, T.57N., R.67W. in the Muddy Sandstone. The company's 10 Signal Hill well in NE NE section 10, T.57N., R.67W. was a horizontal well in the Muddy and produced an average of 108 barrels of oil per day during six days of production in December, 1989. Vertical wells in Thompson Creek Field are producing an average of seven to 20 barrels of oil per day.

O. McAdams, Roux, and Associates Inc. discovered oil in the Minnelusa. Their 31-28 Cambridge-Federal well in NW NE section 28, T.53N., R.68W., pumped 630 barrels of oil per day. The discovery was designated Cambridge Field.

P. Brown Operating discovered Jackelope Field with their 1 Jackelope-Federal well in SE NW section 23, T.53N., R.70W. The well pumped 104 barrels of oil daily from the Minnelusa Formation.

Q. Heath Field has a new producing well. Slawson Exploration's 1-4 Miramar-Federal in SW SW section 4, T.52N., R.68W., pumped 442 barrels of oil per day from the Minnelusa.

R. Fancher Oil completed a new Minnelusa producer in Breaks Field. The 26-8 Federal well in SE NE section 26, T.52N., R.69W., pumped 113 barrels of oil and 365 barrels of water per day.

S. Montex Exploration completed a new Minnelusa producer in Art Creek Field. The 8-7 Federal well in SE NE section 8, T.51N., R.67W., pumped 269 barrels of oil per day.

T. Pacific Enterprises Oil Co. completed two more Minnelusa producers in Indian Tree Field. The 43-33 Lois-Federal in NE SE section 33, T.51N., R.70W., pumped 575 barrels of oil per day and the 12-34 Simpson-Federal in SW NW section 34, T.51N., R.70W., pumped 120 barrels of oil and 40 barrels of water daily.

U. There is still a lot of activity in the Fort Union coalbed methane play around the Rawhide Butte Field, which was discovered by Betop Inc. last year. Betop drilled wells in NE SW and NW NW section 20, T.51N., R.72W. and staked locations for wells in section 17 and section 19, T.51N., R.72W. Betop's discovery well was adjacent to the Rawhide Village Subdivision, which was eventually evacuated because methane was discovered in basements and under the streets of the subdivision. National Cooperative Refinery Association drilled a well in NW SW section 28, T.51N., R.72W. and staked locations in section 28 and section 29, T.51N., R.72W. Martens and Peck Operating drilled wells in SE SE, in NE SE, and in SE NE section 30, T.51N., R.72W. The company also staked locations in sections 30 and 31, T.51N., R.72W.

V. Ampolex Inc. completed a new Minnelusa producer in WD Field. The 11-3 C-T well in NW NW section 3, T.48N., R.71W., pumped 42 barrels of oil and three barrels of water per day.

References cited

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COAL UPDATE

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

Preliminary production figures available from the Wyoming State Inspector of Mines indicate that Wyoming's coal mines set another all-time high production record in 1989. The 171.1 million short tons produced in 1989 are 7.6 million tons (or 4.6 percent) higher than the previous record of 163.6 million short tons set in 1988. Whether or not Wyoming repeated as the Nation's leading coal-producing state in 1989 will not be known until Kentucky's final coal production is released. Preliminary data indicate that Kentucky coal mines also produced in excess of 170 million short tons in 1989. An estimate of national coal production in 1989 was 974.7 million short tons of which an estimated 384 million short tons came from the western United States. Wyoming accounted for almost 18 percent of the estimated national coal production and about 45 percent of western production.

In 1989, most of the increase in coal production for Wyoming occurred in the Powder River Basin. The Hanna and Bighorn Basins also experienced a slight increase in coal production (see Table 6). In the Powder River Basin, about 7.7 million tons (or 5.4 percent) more coal was produced in 1989 than in 1988 and in Campbell County, 8.1 million tons (or 8.9 percent) more coal was produced. About 88 percent of the State's total production in 1989 was from coal mines in the Powder River Basin (see Table 7 and Figure 6). The Green River Basin and the Hams Fork Coal Region both experienced minor decreases in coal production from 1988 to 1989.

Coal production was reported from two of the three underground coal mines in Wyoming in 1989. Nearly 0.5 million tons more coal was produced in 1989 than in 1988 from underground mines, primarily due to increased coal production at Cyprus-Shoshone Coal Company's Shoshone No. 1 mine in the Hanna Basin. Underground coal production accounts for less than one percent of the State's total coal production.

Table 6. 1988 AND 1989 WYOMING COAL INDUSTRY EMPLOYEES AND COAL PRODUCTION BY COAL BASIN AND MINE[1]

Company	Mine Name	1988 Employees	1988 Production (short tons)	1989 Employees	1989 Production (short tons)
POWDER RIVER BASIN					
Amax Coal Co.	Belle Ayr (surface)	267	13,296,739	273	13,600,000
	Eagle Butte (surface)	252	12,915,476	253	13,567,000
Antelope Coal Co.	Antelope (surface)	41	3,141,088	52	3,541,184
Ash Creek Mining Co.	PSO No. 1 (surface)	1		1	
Big Horn Coal Co.	Big Horn (surface)	34	945,116	26	106,147
Carter Mining Co.	Caballo (surface)	222	12,779,942	233	12,856,387
	Rawhide (surface)	164	10,810,785	173	10,628,737
Cordero Mining Co.	Cordero (surface)	227	13,541,225	224	12,602,336
Dry Fork Coal Co.	Dry Fork (surface)			3	under construction
Fort Union Coal Co.	Fort Union (surface)	21	508,263	9	42,092
Glenrock Coal Co.	Dave Johnston (surface)	172	2,607,442	178	2,575,184
Kerr-McGee Coal Corp.	Jacobs Ranch (surface)	371	14,532,789	366	14,662,159
Mobil Coal Prod., Inc.	Caballo Rojo (surface)	141	7,126,693	144	8,368,787
North Antelope Coal Co.	North Antelope (surface)	114	6,088,207	122	6,909,325
Rochelle Coal Co.	Rochelle (surface)	113	8,694,125	155	10,892,567
Shell Mining Co.	North Rochelle (surface)			2	under construction
Thunder Basin Coal Co.	Black Thunder (surface)	464	24,862,429	495	29,536,578
	Coal Creek (surface)	21	684,322	6	139,116
Triton Coal Co.	Buckskin (surface)	107	7,174,718	116	7,693,929
Wyodak Res. Dev. Corp.	Wyodak (surface)	56	2,709,526	56	2,348,085
TOTAL		2,788	142,418,885	2,887	150,069,613
HANNA BASIN					
Amar	Seminoe No. 2 (auger)	11	61,323	6	
Arch of Wyoming	Seminoe No. 2 (surface)	100	1,599,591	21	344,942
	Medicine Bow (surface)	29	441,222	92	2,305,147
Cyprus-Shoshone Coal Co.	Shoshone No. 1 (deep)	153	1,067,305	186	1,544,661
Rosebud Coal Sales	Rosebud (surface)	62	886,483	21	72,408
TOTAL		355	4,055,924	326	4,267,158
GREEN RIVER BASIN					
Arch of Wyoming	Pilot Butte (deep)	22	17,478	13	under construction
Black Butte Coal Co.	Black Butte (surface)	384	5,325,380	386	5,885,947
Bridger Coal Co.	Jim Bridger (surface)	437	6,412,384	420	6,023,607
Prospect Point Coal Co.	Leucite Hills (surface)	53	381,280	—[1]	—[1]
Lion Coal Co.	Swanson (deep)	32	30,839	47	65,235
TOTAL		928	12,167,361	866	11,974,789
HAMS FORK REGION					
FMC Corp.	Skull Point (surface)	104	937,999	102	896,000
Pittsburg and Midway	Kemmerer (surface)	349	3,957,731	365	3,880,294
TOTAL		453	4,895,730	467	4,776,294
BIGHORN BASIN					
Northwestern Res. Co.	Grass Creek (surface)	9	50,300	14	52,150
TOTAL		9	50,300	14	52,150
TOTAL UNDERGROUND		207	1,115,622	246	1,609,896
TOTAL SURFACE		4,326	162,472,578	4,314	169,530,108
GRAND TOTAL		4,533	163,588,200	4,560	171,140,004

Source: Annual report of the Wyoming State Inspector of Mines, 1988 and preliminary data for 1989.
[1]Production and employment reported as part of the Black Butte mine.

Table 7. 1989 WYOMING COAL PRODUCTION BY COUNTY AND COAL BASIN.

County	Production	Percent of Total Production	Number of Producing Mines	Employees
		POWDER RIVER BASIN		
Campbell	143,847,098	84.1%	14	2,630
Converse	6,116,368	3.6%	2	230
Sheridan	106,147	0.1%	1	27
TOTAL	150,069,613	87.7%	17	2,887
		GREEN RIVER BASIN		
Sweetwater	11,974,789	7.0%	3	866
		HAMS FORK REGION		
Lincoln	4,776,294	2.8%	2	467
		HANNA BASIN		
Carbon	4,267,158	2.5%	4	326
		BIGHORN BASIN		
Hot Springs	52,150	<0.1%	1	14
TOTAL	171,140,004		27	4,560

Source: Wyoming State Inspector of Mines, preliminary data for 1989.

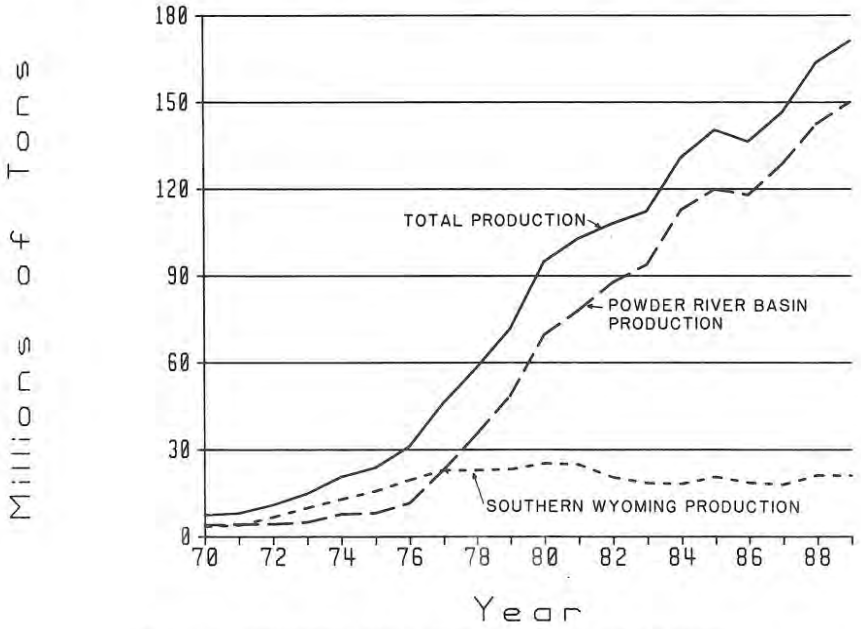

Figure 6. WYOMING COAL PRODUCTION (1970 TO 1989).

A total of 27 coal mines reported production in 1989, as compared with 29 mines in 1988. The number of coal mines in the Powder River Basin remained at 17; only the Green River Basin (Sweetwater County) had fewer producing coal mines in 1989 than in 1988. Coal production from the Leucite Hills mine is now reported as part of Black Butte's production (following Black Butte Coal Company's purchase of the Leucite Hills property in 1988). There was no reported production of coal at Arch of Wyoming's Pilot Butte underground mine (formerly Bitter Creek Resources' Stansbury mine) in 1989 because the sale of the mine was not consummated until July of 1989.

The Black Thunder, Jacobs Ranch, Belle Ayr, Eagle Butte, Caballo, Cordero, Rochelle, and Rawhide mines in Campbell County each produced in excess of 10 million tons in 1989. Thunder Basin Coal Company's Black Thunder mine led production with 29.5 million tons (Table 6). This mine also experienced the largest increase in production (4.7 million tons) between 1988 and 1989. Kerr-McGee Coal Corporation's Jacobs Ranch mine ranked second in production with 14.7 million tons. Seven coal mines in the Powder River Basin and six coal mines in the rest of Wyoming experienced a drop in production from 1988 to 1989 (Table 6).

Employment at Wyoming coal mines increased slightly in 1989, with a net gain of 27 employees (0.6 percent) over 1988 (see Tables 6 and 7). Employment in Powder River Basin coal mines increased by 99 employees (3.6 percent) in 1989, but employment in southern Wyoming decreased (see Figure 7). Statewide, employment in underground mines increased by 39 between 1988 and 1989 while employment in surface mines decreased by 12 during this same period.

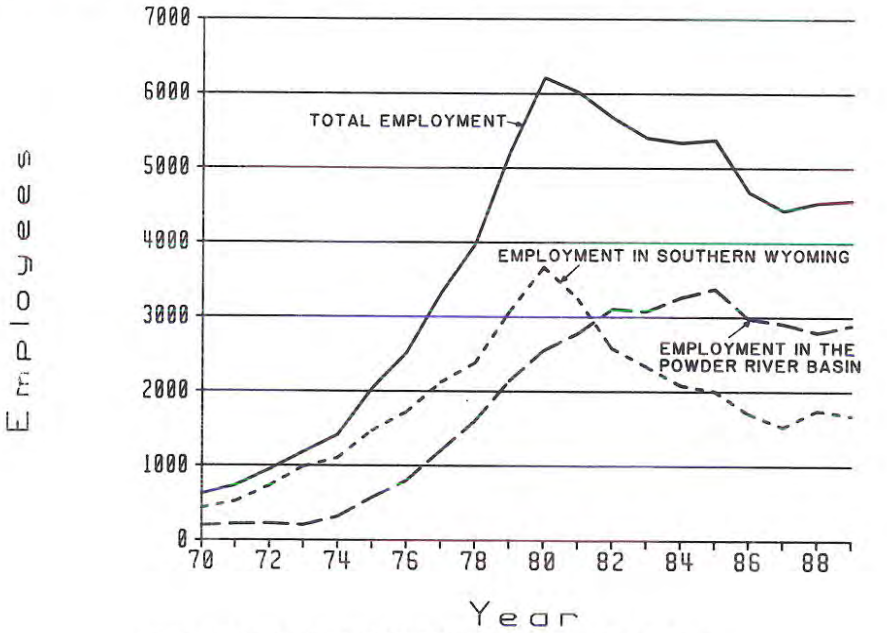

Figure 7. WYOMING COAL EMPLOYMENT (1970 TO 1989).

Deliveries of Wyoming coal to electric utility plants in the last quarter of 1989 were about the same as in the last quarter of 1988. Substantial gains in deliveries for the first two quarters of 1989 account for most of the increased coal production in 1989 (see Table 8 and Figure 8). Unreported deliveries of 5.8 million tons of coal in 1989 included coal used for industrial and commercial purposes, coal delivered in small amounts for test burns in advance of spot or contract sales, and coal delivered to electric utility plants rated at less than 50 megawatts. Spot sales during the last half of 1989 accounted for about 10 percent of the total coal deliveries. During the last quarter of 1989, however, spot sales accounted for over 15 percent of the total coal deliveries. Of the total coal delivered to electric utility companies in 20 states during 1989, only Illinois, Wyoming, and Arkansas used less Wyoming coal than in 1988. Significant increases in deliveries to electric utility plants in Texas, Indiana, Minnesota, Oklahoma, and Michigan were noted in 1989.

The owners of the Rawlins-based Coalbrik factory, which made compressed coal "bricks" for home heating, recently filed for bankruptcy after failing to raise sufficient private capital to continue in business. Coalbrik had received $1.25 million in loans from the State of Wyoming under the Amendment 4 economic development loan program in 1987 and had operated a factory in Rawlins that employed 28 people. The bankruptcy action officially places the $1.25 million loan in default. In October, 1989, the State of Wyoming took possession of the collateral used for the loan, including the Coalbrik building, equipment, and inventory after the firm fell behind in its loan payments. The employees at the factory were laid off earlier in the summer of 1989.

Developments in the Hanna Coal Field

On the positive side, Arch of Wyoming, Rosebud Coal Sales, and Cyprus-Shoshone Coal Company have all reported some new coal sales or other contract-related activity in late 1989 and early 1990. St. Joseph, Missouri Light and Power Company tested 5,000 tons of coal from the Rosebud mine in late 1989 at the utility's Lake Road power plant. Evidently, the utility will be in the market for purchasing coal sometime this spring. Los Angeles Department of Water and Power, coal buyers for their Intermountain Power Project (IPP) in Utah, have mentioned that they would purchase coal from Cyprus-Shoshone's Shoshone No. 1 mine at Hanna (if it is available) for test burning this summer. Even though the IPP is heavily committed to burning Utah coal, the utility is preparing for situations where additional coal may not be available from Utah coal mines because their production is sold out. Pacific Power and Light Company announced in early January, 1990, that they would be test burning 100,000-ton increments of Hanna Basin coal in the second half of 1990 at the Jim Bridger plant east of Rock Springs. A railcar unloading facility is under construction at Jim Bridger to accommodate unit train shipments of coal.

Several coal sales involving Arch of Wyoming occurred in the first quarter of 1990. In January, Arch sold a total of 100,000 tons of spot coal from their Medicine Bow mine to Illinois Power Company. The coal originated on Union Pacific Railroad with 50,000 tons shipped to the Havana, Illinois, power plant and 50,000 tons

Table 8. COAL DELIVERIES BY MONTH FROM WYOMING MINES[1]

	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE
JANUARY	11,601,200	11,601,200	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020
FEBRUARY	10,473,900	22,075,100	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160
MARCH	11,674,900	33,750,000	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490
APRIL	11,632,800	45,382,800	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940
MAY	11,497,900	56,880,700	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110
JUNE	11,692,200	68,572,900	10,499,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970	12,948,350	79,482,460
JULY	11,893,500	80,466,400	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640	14,043,350	93,525,810
AUGUST	12,107,100	92,573,500	11,773,510	87,195,190	13,460,470	92,150,870	15,041,090	101,533,730	15,428,210	108,954,020
SEPTEMBER	11,325,000	103,898,500	11,474,820	98,670,010	12,651,550	104,802,420	13,433,610	114,967,340	13,795,760	122,749,780
OCTOBER	11,048,500	114,947,000	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	10,589,700	125,536,700	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	11,459,300	136,996,000	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	136,996,000		134,522,160		142,399,520		157,093,930		165,308,270	
TOTAL TONNAGE NOT REPORTED	3,784,154		1,782,896		4,089,128		6,494,270		5,831,734	
TOTAL TONNAGE PRODUCED[2]	140,780,154		136,305,056		146,488,648		163,588,200		171,140,004	

[1] Source: National Marketing Reports by Coal Marketronix and COALDAT Marketing Report by DRI, Inc., compiled from FERC Form 423 filed monthly by electric utilities.

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

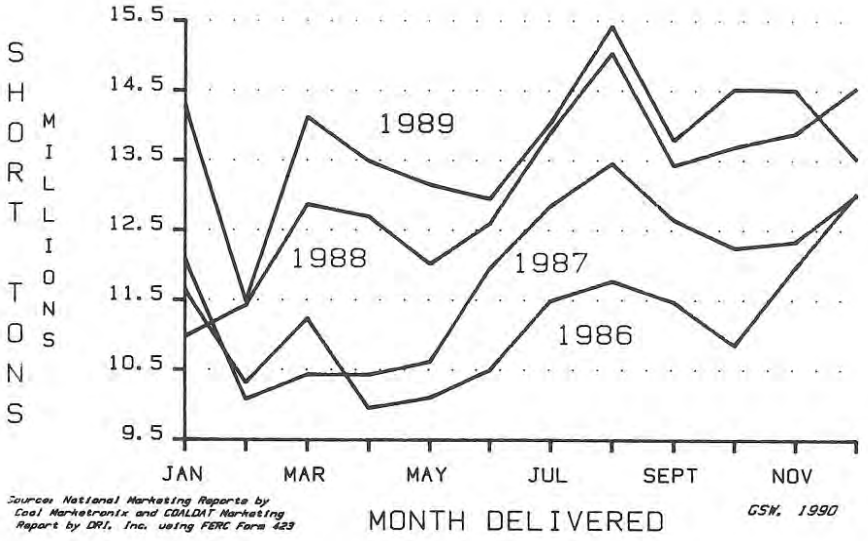

Figure 8. REPORTED DELIVERIES FROM WYOMING COAL MINES.

shipped to the Wood River, Illinois, power plant. In February, Arch sold another 50,000 tons of spot coal from their Medicine Bow mine to Central Illinois Public Service Company's Newton Unit No. 2 power plant.

In January, 1990, a new contract between Arch of Wyoming and Kansas Power and Light Company (KP&L) went into effect. The two-year contract calls for Arch to deliver 2.5 million tons of coal from the Medicine Bow mine to KP&L's Lawrence, Kansas, power plant. As much as 150,000 tons of coal per month could be shipped to the Kansas plant on an as(if) needed, as(if) available basis (McGraw-Hill, Inc., 1990a) until 2.5 million tons of coal are sold. The coal shipments will originate on Union Pacific Railroad and terminate on Santa Fe Railroad.

Developments in western and southwestern Wyoming

Los Angeles Department of Water and Power announced that they would also be test burning coal from Arch of Wyoming's new Pilot Butte underground coal mine (north of Rock Springs) at the Intermountain Power Project this summer. Although no coal was produced at the Pilot Butte mine in 1989 and no contracts or sales agreements have been announced yet, Arch plans to produce coal this summer.

Owners of a proposed $4 billion coal-fired power generating complex in northeastern Nevada, the Thousand Springs power plant, have apparently decided on coal sources for the 2,000-megawatt, eight-unit facility. If the plant is built, coal from both Utah and southwestern Wyoming will be used. Although no coal supply

contracts have been announced, the Wyoming coal would most likely come from Pittsburg and Midway Coal Mining Company's Kemmerer mine west of Kemmerer, Wyoming.

Developments in the Powder River Basin Coal Field

Powder River Basin coal appeared to be making inroads into additional distant markets during the first quarter of 1990. In late February, Alabama Power Company (APC) reported that it was testing 200,000 tons of coal from Wyoming's Powder River Basin. Although they did not identify the suppliers, the coal was tested in APC's Miller power plant near Birmingham, Alabama. The coal is shipped by rail to a single unit at the plant; deliveries are expected to continue through May of this year. This is the first western coal burned by Alabama Power.

During the second half of 1990, Niagara Mohawk Power Corporation's (NMPC's) Dunkirk and(or) Tonawanda, New York, plants expect to test coal from the Powder River Basin and(or) the Hanna Basin. Evidently, the utility will blend the western coal with eastern coal to test the feasibility of using blended coals in the event that clean air legislation forces the utility to decrease emissions. NMPC did not announce any details on coal suppliers, transportation methods, or the amounts of coal involved.

Nerco and Arco Coal Companies and a Spanish coal importer, Sociedad Espanola de Carbon Exterior SA (Carbotex), are considering the shipment of Powder River Basin coal to Spain. Test shipments of coal from Nerco and Arco mines in both Montana and Wyoming were scheduled for the first half of 1990. The coal would be test burned in power plants operated by Endesa, Spain's national utility company, as a possible fuel source to replace Spanish lignite, which is currently burned at the plants. The coal would be shipped by rail to the Mississippi River, barged to a terminal on the lower Mississippi, and then loaded on a ship bound for Spain. Maclean Hunter Publishing Company (1990) reports that the F.O.B. price for the coal at the port will be about $24.50 per ton. If the test burns are successful, Endesa could purchase from 1 to 3 million tons of Powder River Basin coal per year after 1992.

In January, the U.S. Bureau of Land Management (BLM) announced that the Powder River Coal Production Region of Wyoming and Montana was decertified. This means that BLM's coal activity planning process (operating through the Powder River Basin Regional Coal Team) and the past system of government-initiated coal leasing are replaced by an industry-initiated, lease-by-application process. The Powder River Coal Production Region is the last coal production region in the United States to decertify. Under what has been called a "partial decertification", the Regional Coal Team (RCT) remains intact and active by guiding the lease-by-application process, reviewing applications for leases, and preparing operating guidelines for the leasing process. The BLM pointed out that environmental reviews, public hearings, and competitive bidding on proposed lease tracts will still occur and that if industry-initiated leasing increases greatly, the RCT could recertify, if necessary. The leasing-by-application process is restricted to maintenance tracts that

would continue or extend the life of a mine. Applications for leases involving new mines or expansions of existing mine facilities would be considered by the RCT on a case-by-case basis.

A damage claim against the Federal government by Whitney Benefits appears nearly settled, pending the Government's appeal motions for reconsideration of the decision by a Federal claims judge. The judge's decision awarded Whitney Benefits and Peter Kiewit Sons, the coal owner and coal lessee, respectively, a total of $120 million in damages resulting from the Surface Mining Control and Reclamation Act of 1978 (SMCRA). The plaintiffs in the damage suit claimed that the passage of SMCRA denied them access to and production and revenues from a 1,327-acre, 143-million-ton tract of private coal along the Tongue River north of Sheridan in the Powder River Basin. Because of SMCRA, the coal tract cannot be mined because it is located within an alluvial valley floor. Although the Federal government had offered Whitney Benefits some Federal coal in exchange for the private coal, both Whitney Benefits and Peter Kiewit Sons decided that the Federal coal offered to them was unsatisfactory. The award consisted of $60 million in damages and $60 million in attorney's fees and 12 years of accrued interest.

A second item of interest involves a proposed exchange of a scenic easement in Grand Teton National Park for Federal coal in an area north of Sheridan, Wyoming. The U.S. Department of the Interior placed the proposed exchange on hold in February, 1990, pending an Interior Department review. The controversial exchange proposes that a 1,000-acre scenic easement on the JY Ranch property (owned by Laurence Rockefeller) be exchanged for a 200-million-ton tract of Federal coal in the eastern Powder River Basin. The scenic easement, which Rockefeller donated to the Sloan-Kettering Memorial Institute (a cancer research center/hospital in New York City), lies along the shores of Phelps Lake and is surrounded by Grand Teton National Park. If the exchange were made, the National Park Service would receive the scenic easement (which insures that the land would never be developed), but neither the public or the National Park Service would have access to the property. The Sloan-Kettering Institute would then take possession of the Federal coal, which would pass to private ownership, and the Institute would have the right to mine or lease the coal. The proposed exchange is still under review after several groups, including the State of Wyoming, protested the exchange.

Coal contracts - Powder River Basin

In January, Cordero Mining Company was awarded a contract to supply up to 7.5 million tons of coal to the Lower Colorado River Authority's (LCRA) Fayette Power Project Unit No. 3 (near Austin, Texas) for a conditional period of 5 years. Deliveries from the Cordero mine began in February, 1990, with a $4.00 per ton F.O.B. mine price. Twenty percent of the $4.00 per ton base price was set at a fixed rate, but the remainder of the price is subject to escalators based on fluctuations in mining costs (McGraw-Hill, Inc., 1990b). The contract allows LCRA to only buy the coal it needs. LCRA can end the contract after one year or five years, or it can extend the contract an additional five years.

In late February, LCRA opened bids on a solicitation for 223,000 tons of spot coal for Units 1 and 2 of the Fayette Power Project. Published F.O.B. mine bids on the coal ranged from a low of $3.30 per ton (22.75¢ per million Btu's) submitted by Cordero Mining Company to a high of $5.15 per ton (29.34¢ per million Btu's). Award of the contract is expected in April with deliveries scheduled between May 1 and December 31, 1990.

Rochelle Coal Company's Rochelle mine in southern Campbell County will furnish from 0.4 to 0.7 million tons of spot coal to Grand River Dam Authority's (GRDA) Units 1 and 2 near Chouteau, Oklahoma. The contract calls for deliveries from March through December, 1990, via Burlington Northern and Union Pacific Railroads.

Amax Coal Company will sell 175,000 tons of spot coal from their Belle Ayr mine to Wisconsin Power and Light Company's (WP&L) Columbia, Wisconsin, power plant. The coal will originate on Chicago and North Western Transportation Company's (C&NW) railroad and continue on Union Pacific (UP) Railroad and the Soo Line. Another 55,000 tons of spot coal will be delivered to WP&L's Edgewater, Wisconsin, power plant from Rochelle Coal Company's Rochelle mine. This coal will be shipped via C&NW and UP railroads.

During 1990, Thunder Basin Coal Company, a subsidiary of Arco Coal Company, will furnish spot coal to two of Southwestern Public Service Company's (SWPSC) Texas power plants. The Roy Tolk plant northwest of Lubbock, Texas, will receive from 0.1 to 0.4 million tons of coal from either the Black Thunder or Coal Creek mine. The coal will be transported by BN and the Atchison, Topeka, and Santa Fe Railway Company. The Harrington, Texas, power plant near Amarillo will receive from 0.4 to 1.2 million tons of coal from the Black Thunder mine with deliveries via Burlington Northern Railroad.

Cordero Mining Company's Cordero mine will furnish 330,000 tons of spot coal to Dairyland Electric Power Cooperative's Genoa and Alma, Wisconsin, power plants during 1990. Delivery of the coal will be by Burlington Northern Railroad and by barge from St. Paul, Minnesota.

Carter Mining Company, a coal-producing subsidiary of Exxon Coal, USA, has signed a contract with Iowa Public Service to supply up to 1.5 million tons of coal to the George Neal No. 3 unit near Sioux City, Iowa. The 1.5 million tons of coal will be mined at the Caballo mine and is expected to furnish all of the unit's coal requirements for 1990. The coal will be shipped by C&NW railroad.

Kerr-McGee Coal Corporation's Jacobs Ranch mine will supply 30,000 tons of spot coal to Fremont, Nebraska Department of Utilities. This is additional coal to that supplied to the utility in 1989 (see *Wyoming Geo-notes No. 24*, October, 1989, p. 20). The utility department is currently considering a five-year, 100,000 to 125,000 ton-per-year purchase for the near future (McGraw-Hill, 1990c).

Amax Coal Company's Belle Ayr mine delivered 6 unit trains (about 66,000 tons) of spot coal to Northern Indiana Public Service Company (NIPSCO) in March, 1990. No specific power plant was mentioned for the purchase, however.

During the months of April, May, and June, 1990, an unspecified amount of coal from the Powder River Basin, Wyoming, will be sold to Georgia Power Company (through their coal buyer Southern Company Services). The utility contracted for a total of 492,000 tons of spot coal for this period, with at least one of the 9 issued purchase orders going to an unidentified Wyoming mine. The remaining purchase orders were for eastern coal. The Wyoming coal will be delivered to the Pride, Alabama, transloader (via railroad to the Mississippi River and by barge down the Mississippi) where it will be placed back on rail cars for final delivery to possibly 6 power plants in Georgia.

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INDUSTRIAL MINERALS UPDATE

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

Aggregate (Construction)

While production of construction aggregate (sand, gravel, crushed rock, and railroad ballast) is expected to increase in 1990, Meridian Minerals' railroad ballast quarry west of Cheyenne at Granite is apparently decreasing production and several people have been laid off. While it is not clear why Meridian is scaling back its production, pricing competition is a more likely reason than aggregate quality or depletion of reserves. Both the Union Pacific and Burlington Northern Railroads have been acquiring ballast from other, out-of-state locations.

Cement

Cement is produced at Laramie by Mountain Cement. Their plant was expanded and converted to a dry process in 1988. Currently the plant is using limestone from the Permian-Pennsylvanian Casper Formation (east of the plant), gypsum from a quarry in the Triassic Chugwater Formation (south of the plant site), and shale from a quarry southwest of the plant site. The currently operating shale pit is located in the basal Thermopolis Formation near the center of Sec. 22, T.14N., R.74W. A recently-used shale source is from a pit in the Frontier Formation in the SE 1/4, Sec. 21, T.14N., R.74W. The cement plant has used shale from several rock units in the Laramie area including the Cretaceous Niobrara, Frontier, and Thermopolis Formations.

Dimension Stone

Currently, the Nation's dimension stone industry is centered primarily in the eastern part of the country. Changing economics of the stone industry, however, makes the feasibility of locating a dimension stone industry in a more centrally-located, less populated state such as Wyoming more likely. This may explain why the State Geological Survey has recently responded to several inquiries regarding dimension stone resources in Wyoming.

Dimension stone was produced in Wyoming in the past at several localities. The most famous Wyoming stone is a greyish-brown sandstone of uniform color and texture quarried south of the new State Penitentiary, south of Rawlins. Recently, small amounts of this material were removed for use in restoring the Frontier Prison in Rawlins, now a historical landmark. This stone was used in the Wyoming State Capitol building, the Union Pacific depot in Ogden, Utah, and in several buildings in Denver, Colorado. Other notable stone sources are a grey granite quarried from Teton Canyon, west of Grand Teton National Park; onyx, marble, and granite from the Hartville uplift and other areas, which were processed at a finishing plant in Jay Em, Wyoming; and a sandy limestone quarried six miles north of Laramie in the Casper Formation, which was used in buildings on the University of Wyoming campus.

Statewide, Wyoming has an amazing variety of stone of all types including granite of all colors; pink, grey, brown, and white marble; quartzite (classified as "sandstone" by the stone industry) of all colors including purple, several shades of green, and several shades of red; and other types of rock such as limestone and onyx. One Wyoming rock, a brown "marble" from the Bighorn Basin was featured in the February, 1990, issue of *Dimensional Stone.*

As part of an ongoing project, the Industrial Minerals Division of the Geological Survey of Wyoming has prepared over seventy cut and polished samples of decorative rock from Wyoming, some suitable for dimension stone. These samples are available for inspection in the Geological Survey building in Laramie. Interested persons should call Ray E. Harris at (307) 766-2286.

Gypsum

According to figures released by the U. S. Bureau of Mines, U.S. production of gypsum in 1990 is ahead of first quarter production in 1989. In Wyoming, gypsum is produced at two plants in the Bighorn Basin (near Cody and at Himes, between Lovell and Greybull). Production at these plants is continuing at levels near capacity. Because there are no expansion plans for these plants, gypsum production in Wyoming should increase only slightly or remain constant in 1990. These plants produce wallboard that is marketed regionally and in the Pacific Northwest. Gypsum is also mined near Laramie by Mountain Cement for use in producing cement (see Cement).

Limestone

Crushed limestone is the preferred rock for use as road-surfacing aggregate and sub-base material on Wyoming highways. Nebraska also uses Wyoming limestone on some roads in the western part of that state. Limestone from the present Fisher Industries (formerly Summit Materials) quarries east of Newcastle has been used on highways as far away as Wyoming Highway 59 between Wright and Bill. Seasonal increases in the production of limestone aggregate will soon begin as the weather warms and the snow melts.

Limestone used in the refining of sugar beets is known as sugar rock. A few readers have asked just how the limestone is used. The following discussion (Great Western Sugar Company, undated) is a simplified explanation:

> The sugar rock (limestone, $CaCO_3$) is heated in kilns (with or without coke, depending on the kiln) at the sugar beet refining plants to produce lime (CaO) (also called burned lime by sugar processors) and carbon dioxide gas (CO_2). Beet juice produced from raw, washed sugar beets is filtered and mixed with burned lime to produce a substance called milk of lime. This material is piped to another tank where carbon dioxide gas from the kiln is added to give the beet juice the proper alkalinity (CO_2 increases the pH and buffers the solution). This results in the precipitation of a limy material containing impurities. The resulting juice is sent to a processing vat where the limy precipitate containing impurities is removed from the juice. The precipitate is washed once to remove any sugar, and the washed sludge, which consists of a mixture of limy and organic materials, is dried and stored in a yard at the plant. More carbon dioxide gas from the kiln is added to the clarified beet juice, a limy impure material is again precipitated, and the sludge goes to the yard. The remaining clarified juice is then processed using several steps to sugar.

The limy material that is stored at several regional sugar beet plants may have some use as a source of lime. If the material is heated, the organic impurities are burned off, producing a fairly pure lime. This lime could be mixed with another waste product, such as fly ash from coal-fired power plants, to produce concrete.

Other lime used in Wyoming is purchased from commercial lime producers in neighboring states. Wyoming does not currently produce any commercial lime.

Phosphate and Phosphate-based Fertilizer

While no phosphate is produced in Wyoming, phosphate from a mine north of Vernal, Utah, is transported by slurry pipeline to Chevron Chemical Company's fertilizer plant near Rock Springs. The phosphate is combined with sulfur from Wyoming to produce fertilizer. Chevron's slurry pipeline is currently the only phosphate slurry pipeline in the United States. Recently, however, J. R. Simplot Co. announced plans to construct a phosphate slurry pipeline from a mine north of Soda Springs, Idaho, to their fertilizer plant north of Pocatello.

Silica raw materials

Exploration of a silica rock deposit near Cassa, in Platte County, continues. This exploration began after publication of a Geological Survey of Wyoming Report of Investigations (Harris, 1988). The company currently developing the deposit cored over 1,500 feet of rock in December, 1989, and January, 1990, and has increased the reserves of high-silica rock to over 100 million tons. The company is still investigating power sources, water availability, and markets for anticipated silica products.

In addition, the Town of Lovell, with geological assistance from the State Geological Survey and financial assistance from the Wyoming Economic Development and Stabilization Board, has begun an investigation of a deposit of very fine-grained, high-purity silica north of Lovell in Big Horn County.

Sulfur

Sulfur is produced in Wyoming as a by-product of the processing of sour natural gas and some oils. In the U.S., Wyoming is now a substantial producer of sulfur, as evidenced by Table 9, which shows Wyoming as the second or third largest producing state in 1989, depending on the type of production.

Table 9. PRELIMINARY ESTIMATE OF 1989 U.S. PRODUCTION OF SULFUR (SHORT TONS)[1]

State	"Unrecovered" sulfur production [2]	"Recovered" sulfur production[3]	Total produced sulfur
Texas	2,690,000	1,763,000	4,453,000
Louisiana	1,463,000	674,000	2,137,000
Wyoming		**1,214,000**	**1,214,000**
Mississippi		773,000	773,000
California		748,00	748,000
Others	minor	minor	minor
	4,153,000	5,172,000	9,325,000

[1]Source: U.S. Bureau of Mines.
[2]Sulfur mined underground using the Frasch process.
[3]Sulfur recovered from the processing of sour natural gas and (or) oil.

Although the demand for sulfur is still increasing nationally, the price has leveled off. Increases in sulfur production in Wyoming depend on increased throughput in the State's sour gas processing plants. Since there are no significant increases in sour gas throughput anticipated in 1990, annual sulfur production in Wyoming should remain at about 1.21 million tons.

Trona

First quarter demand for Wyoming soda ash, which is produced from mined trona, indicates another record year is in the making. The increases in demand are related to the manufacture of sodium cyanide for use in gold refining, the substitution of soda ash for caustic soda in many industrial processes, and growth in export markets. The best potential for even greater demand still lies in exports.

Other related news in the first quarter of 1990 includes a joint venture agreement between Tenneco and Asahi Glass Co. of Japan. This agreement will result in new construction and additional production capacity (about 48 percent) at Tenneco's soda ash plant near Green River. In addition, the agreement should result in the creation of 100 new jobs. The permitting processes for the new expansion are expected to take about six weeks.

There is another area of the world in which there are bedded trona deposits similar to those in Wyoming. In Turkey, at Beypazari, near Ankara, trona occurs in bedded deposits over 75 feet thick. Since the host rock is the Miocene Hirka Formation, these deposits are somewhat younger than the Wyoming deposits.

The Turkish deposits have the potential to compete with the producers of synthetic soda ash that currently serve markets in western Europe, in the Middle East, and in northern Africa. Several of these producers of synthetic soda ash may have canceled expansion plans, anticipating future development of this resource in Turkey. The development of the Turkish deposits will affect Wyoming only in that the markets in western Europe, the Middle East, and northern Africa are now a less likely future expansion for Wyoming soda ash (Dundar, 1988).

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URANIUM UPDATE

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

The order of rank for uranium-producing states has changed considerably in recent years. Wyoming and New Mexico, which held the number one and two positions for many years, have dropped to fourth and fifth, respectively (Table 10). It also appears that New Mexico's only uranium mine may have closed in 1990.

Table 10. Domestic uranium mill production in 1989 in millions of pounds of yellowcake (U_3O_8)[1].

Mill locations	U_3O_8 from conventionally mined ore	U_3O_8 from solution mined ore (*in situ*)	U_3O_8 from other ore	Total U_3O_8
Texas	1.5	5.4	—	6.9
Utah	2.5	—	1.5[2]	4.0[3]
Florida	—	—	2.2[4]	2.2
New Mexico	2.0	—	—	2.0
Wyoming	**0.5**	**1.2**	—	**1.7**
Louisiana	—	—	1.1[4]	1.1
TOTAL	6.5	6.6	4.8	17.9

[1]Modified from White, 1990.
[2]By-product of vanadium mining in Utah and Colorado.
[3]All production is from the Blanding mill, which processes ore from Utah, Colorado, and Arizona.
[4]By-product of phosphoric acid production.

While there were two *in situ* producers of uranium in Wyoming during the last quarter of 1989, only one remains in the first quarter of 1990. Power Resources (London Central Energy), which purchased the Highland *in situ* operations from Sparkling City Uranium (formerly Everest Minerals) is still operating. Malapai, despite last quarter's optimism, ceased production at Irigary Ranch - Christiansen Ranch in January of 1990.

Kennecott, which is owned by RTZ, of Great Britain, is taking a $1 million look at the properties of U. S. Energy-Crested Corp. south of Jeffrey City, beneath Green Mountain. Rio Algom (a subsidiary of Kennecott) and Uranerz, U.S.A. are still evaluating solution mining near the Bill Smith property in the southern Powder River Basin. Rio Algom, incidentally, is a major Canadian uranium producer. Pathfinder (COGEMA) is stripping overburden from a new ore body in the Shirley Basin and plans to resume production this summer.

What is the future of the uranium mining and milling industry in the United States and Wyoming? These topics were discussed at a uranium workshop held by the U. S. Geological Survey in Denver in March. The general consensus was that the industry is in bad shape and getting worse. Representatives from the U. S. Department of Energy did point out that because the domestic uranium stockpile is getting smaller, nuclear power plants will soon begin ordering new uranium. However, several industry people (including a representative from NUEXCO) noted that there is no incentive (including price) for utilities to buy domestic uranium. With the U. S. - Canada Free Trade Agreement in effect, it is probable that uranium producers will buy Canadian uranium. Subsidized or not, Canadian deposits are higher grade and larger than those discovered to date in the U. S., and their mining costs are much less than for a typical U. S. deposit. Also, due to the present demise of the domestic industry, there is no exploration for large, high-grade deposits in the United States. In Wyoming, for example, there are several uranium occurrences, similar to the Canadian deposits, none of which have been explored by drilling.

There was another alarming note at the uranium workshop. The Soviet Union, which has been stockpiling uranium mined in the USSR and formerly communist eastern Europe since the early 1950s, has begun selling it on the world market. The fear is that they may need cash badly enough to sell their uranium far below the prices needed by other uranium producers. There is also a fear that the Soviet Union may have stockpiled enough uranium to supply the world's nuclear power plants for decades.

It is most likely that the price of uranium (which is already below $9.00 per pound of U_3O_8) will continue to fall. In this case, many of the remaining U. S. producers will go out of business. Particularly susceptible are the conventional and *in situ* producers with no foreign commitment for production. In Wyoming, the recent closure of Malapai Resources' *in situ* operation is an example.

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METALS AND PRECIOUS STONES UPDATE

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

Weather generally precludes much field activity in metals and precious stones in the winter and early spring of any year, and 1990 was no exception. The Metals and Precious Stones Division of the State Geological Survey, however, did respond to inquiries from mining companies during the first quarter. As a result, several companies indicated their intent to fund exploration projects for both gold and copper in Wyoming. Thus, barring any major setbacks in the world's economy and metal prices, Wyoming should see a moderate increase in exploration activity this year.

Precious Stones

Exploration for diamond deposits is expected to resume this summer. The Geological Survey of Wyoming is planning to continue its search in the Laramie Mountains for indications of diamondiferous kimberlite and lamproite. Examinations of samples collected last year continued over the winter months. The project will be expanded to the Medicine Bow Mountains if funding is available. Diamond exploration by a mining company is also expected to resume in the Bighorn Mountains.

Seminoe Mountains

The Geological Survey of Wyoming is still evaluating the mineral resources of the Seminoe Mountains. Laboratory work on samples collected in 1989 continued through the first quarter and field work should resume late in the second quarter of the year. This will be the second year of this project. A progress report on the Seminoe Mountains project is found on pages 36 and 37 of this issue of *Wyoming Geo-notes*.

South Pass

Wyoming's greatest source of gold and iron ore has been the South Pass greenstone belt located at the southern tip of the Wind River Range of western Wyoming. This belt of greater than 2.8-billion-year-old metamorphosed volcanic, plutonic, and sedimentary rock was investigated by the Geological Survey of Wyoming between 1984 and 1989. During this time, the State Geological Survey identified many dozens of gold anomalies and occurrences; some copper, silver, tin, tungsten, chromium, and nickel anomalies; and some iron deposits. Eight 1:24,000-scale maps completed by the State Geological Survey were recently compiled into a full-color, 1:48,000-scale geologic map, which shows mines and gold-bearing shear zones (Hausel, 1990a). A final report on the district is nearing completion.

Gold has been of highest interest in the region. For example, gold anomalies ranging from a trace to 105 ppm (3.05 ounces/ton) were identified in narrow shear zones. Some wide, low-grade, mineralized deposits were also located. A 97-foot-

wide zone of mineralized wallrock at the Carissa mine averaged 0.8 ppm (0.02 ounce/ton) gold. This 97-foot-zone encloses a 3- to 6-foot shear zone which assays 5.1 to 10.2 ppm gold (Hausel. 1989). See later discussion on pages 37 and 38 of this issue of *Wyoming Geo-notes.*

Mineral Hill district, Black Hills

The Tertiary intrusive complex at Mineral Hill, Wyoming, was sampled by the Geological Survey of Wyoming last fall (see *Wyoming Geo-notes No. 25*, p.33). Samples from the Treadwell open cut along the northwestern flank of Mineral Hill were anomalous indicating the presence of two, parallel, horizontal, gold- and silver-bearing quartz veins in trachyte country rock. Assays for these veins were reported to contain 0.360 ppm to > 10 ppm gold and no silver to > 300 ppm. Follow-up analyses for sample TW4-89 (a limonitic quartz vein) contained 130 ppm gold (3.79 oz/ton) and 330 ppm (9.62 oz/ton) silver (Hausel, 1990b). For additional information, see pages 35 and 36 of this issue of *Wyoming Geo-notes.*

Alkaline and ultramafic alkaline rocks

At the turn of the year, the Geological Survey of Wyoming released a study of alkalic and ultramafic-alkalic igneous rocks found in the North American, Russian, and Siberian platforms (Erlich and others, 1989). The study was initiated in the Soviet Union by E.I Erlich and I.A. Zagruzina, and later completed as a cooperative study with members of the Geological Survey of Wyoming. The report contains isotopic information on numerous alkalic complexes in each of the three platforms.

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Table 11. MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1989)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.9 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	20.5 billion barrels
Remaining Reserve Base (January 1, 1989)	
Measured reserves (Proved reserves) (Includes 0.815 billion barrels of oil and 0.805 billion barrels of gas liquids)	1.62 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[1]
Total	4.42 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1989)	
Discovered (Includes 23 trillion cubic feet (TCF) of methane[1] and 12 TCF of CO_2 and He^3)	35.0 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	3,814.0 trillion cubic feet
Remaining Reserve Base (January 1, 1989)	
Measured reserves (Proved reserves) (Includes 10.9 TCF of methane[2] and 11.8 TCF of CO_2 and He^3)	22.7 trillion cubic feet

COAL

Remaining Resources (January 1, 1989)	
Identified and Hypothetical (Discovered)	1,431.4 billion tons[6]
Speculative (Undiscovered)	31.5 billion tons[6]
Total	1,462.9 billion tons
Remaining Reserve Base (January 1, 1989)	
Demonstrated strippable (Measured and indicated reserve base)	26.8 billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	38.3 billion tons[7]
Total	65.1 billion tons

TRONA

Original Resources (1983 estimate)	
Trona	81.7 billion tons[8]
Mixed trona and halite	52.7 billion tons[8]
Total	134.4 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 Doeiger, 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.

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GEOLOGICAL SURVEY OF WYOMING UPDATES MINERAL RESOURCE INFORMATION OF WYOMING

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

Geological Survey of Wyoming Bulletin 50, published in 1966, provides the most complete discussion of Wyoming's mineral resources ever published under one cover. It was the state-of-our-knowledge when it was published, and it has withstood the test of time. However, since it is a quarter of a century old, it is in need of revision.

For several years now, the Geological Survey of Wyoming has been updating Bulletin 50. But rather than waiting until research on all the State's mineral resources are completed, information on individual minerals has been released in Open File Reports or in other publications of the State Geological Survey. The following is a list of the minerals or mineral commodities that have been researched and the reports that have been made available. Persons interested in the following mineral resources (listed alphabetically) should not use the information in Bulletin 50, but should use the information in the references listed here:

Mineral Commodities	Publications
Alum	Open File Report 86-24
Anorthosite	Open File Report 90-1
Ballast	Open File Report 86-22
Chromium	Open File Report 87-7
Clay (non-bentonitic)	Open File Report 87-3
Cobalt	Open File Report 87-7
Columbium	Open File Report 87-6
Copper	Bulletin 68
	Report of Investigations 37
	Reprint 40
Diamond	Report of Investigations 31
Diatomite	Open File Report 86-16
Epsomite	Open File Report 87-2
Fluorite	Open File Report 88-10
Gold	Report of Investigations 23
	Bulletin 68
Graphite	Open File Report 89-11
Lead	Bulletin 68
Manganese	Open File Report 87-7
Mica	Open File Report 89-8
Niobium	Open File Report 87-6
Platinum Group Minerals	Bulletin 68
	Open File Report 87-7
Potash	Open File Report 86-23
Pumice and Pumicite	Open File Report 86-17
Rare Earth Elements	Open File Report 87-8

Rutile	Open File Report 90-2
Silver	Bulletin 68
Sinter	Open File Report 86-20
Sulfur	Open File Report 86-15
Tantalum	Open File Report 87-6
Travertine	Open File Report 86-20
Tripoli	Open File Report 89-4
Vermiculite	Open File Report 90-3
Yttrium	Open File Report 87-8
Zeolites	Open File Report 90-4
Zinc	Bulletin 68

1989 WYOMING EXPLORATION SUMMARY

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

METALS AND PRECIOUS STONES

Based on inquiries directed to the State Geological Survey, company interest in Wyoming's mineral resources continued at a moderate pace in 1989. While the greatest number of inquiries were in regard to gold, platinum, and palladium, there were also requests for information on the State's copper, zinc, manganese, iron, diamond, and titanium resources. The Geological Survey of Wyoming was also involved in several field projects, one of which led to the identification of significant gold, silver, and zinc anomalies.

Gold exploration activities were reported at a number of locations in the State including the Black Hills of northeastern Wyoming, the Medicine Bow and Laramie Mountains of southeastern Wyoming, the Bighorn Basin of northwestern Wyoming, and the South Pass area of western Wyoming. Company drilling and exploration activities for platinum and palladium in the Medicine Bow Mountains continued with the discovery of a narrow zone containing anomalous platinum group mineralization. Drilling in South Pass confirmed the presence of a highly mineralized auriferous shear zone enclosed by a wide envelope of low-grade gold mineralization. Diamond exploration was also reported in the Bighorn Mountains of northern Wyoming, and the State Geological Survey continued to search for kimberlitic "satellite" minerals in the Archean craton of the Laramie Mountains of southeastern Wyoming. Some reconnaissance investigations of porphyry copper deposits in the Absaroka Mountains of northwestern Wyoming were also reported.

Bighorn Basin

Gold anomalies were reported by the U.S. Geological Survey in the Cedar Mountain wilderness study area north of Thermopolis in the southeastern Bighorn Basin (Larsen, and others, 1988). Sediment sample concentrates collected in secs. 12 & 24, T.45N., R.94W., and sec.6, T.45N., R.93W. yielded 20 ppm (parts per million), 30 ppm, and 100 ppm gold, respectively.

In the northwestern portion of the basin near the Clarks Fork River, American Mining and Milling Company announced plans to proceed with their permitting of a placer gold mine. The mine will be developed in terrace bank gravels and is estimated to have a 10-year lifetime. Apparently, all environmental concerns were recently satisfied by the company.

Keystone district (Medicine Bow Mountains)

Several rich gold veins, associated with Keystone quartz diorite, were discovered in the Keystone district in the 1860s, and gold and platinum placers were mined in the adjacent Douglas Creek and its tributaries. The Keystone district includes several abandoned gold mines sunk in N60°W trending shears and veins subsidiary to the Nash Fork-Mullen Creek shear zone, which is a major suture zone dividing the Medicine Bow Mountains into two different tectonic regimes. The principal ore bodies occur either in veins hosted by narrow shears, or along vein intersections. The shear structures range from 2 to 6 feet wide, but splay to as much as 300 feet wide, locally.

Samples recently collected from the Keystone shear by the State Geological Survey showed anomalous gold with values of 2.1 ppm to 22.0 ppm gold. A brief examination of the mineralized zone revealed tight folding associated with the shear structure.

Laramie Mountains

During the year, Royal Gold, Inc., of Denver dropped its option with Kirkwood Oil of Casper, Wyoming, on the Copper King mine located in the Silver Crown district west of Cheyenne. The mine is in a Proterozoic porphyry. Reserves include a higher grade zone of 4.5 million tons of 0.044 oz/ton gold, included in a larger low-grade envelope of 35 million tons of 0.21% copper and 0.022 oz/ton gold. The mine is described in Hausel (1989).

Mineral Hill (Black Hills)

TRYCCO, Inc. of Alberta, Canada, initiated an exploration and evaluation program of placer and lode deposits in the Mineral Hill district of northeastern Wyoming. The placers were evaluated for gold, tin, tantalite, magnetite, and other heavy minerals. The Mineral Hill district is a Tertiary alkalic ring complex with a history of tin and gold mining.

TRYCCO, in cooperation with the Geological Survey of Wyoming, examined some lode deposits along the flank of the Mineral Hill complex. Samples taken by the State Geological Survey from the northwestern flank at the Treadwell mine included feldspathic breccia, silicified trachyte, and limonitic quartz veins. The samples yielded values of less than 5 ppb (parts per billion) to 130 ppm gold (3.79 oz/ton), and silver values of less than 5 ppm to 330 ppm (9.62 oz/ton) (Hausel, 1990c). The high gold and silver values were from two parallel, near horizontal, veins and associated silicified wallrock in the trachyte country rock. These veins carry considerable limonite with some primary sulfides (pyrite). In addition to gold and silver, vein samples also yielded 0.19 to 0.29% copper and 1.47 to 2.32% lead.

Samples of silicified trachyte from the Artic mine on the southwestern edge of Mineral Hill yielded gold values of 19 ppb to 60 ppb, and a trace of silver. Although no significant metals were detected, some specimen samples of altered trachyte with drusy, purple, chalcedony-coated fracture fillings were recovered along with amethyst crystals. This is the first known report of amethyst in this district.

At the Birdsnest mine on the northern flank of the district, samples of breccia, pyroxenite, and quartz were collected for assay. The breccia was unmineralized. The pyroxenite contained minor disseminated pyrite and assayed 0.168 ppm gold. The quartz vein contained minor pyrite and malachite and assayed 0.29% copper, 15 ppm gold, and 120 ppm silver.

Red Desert Basin

The Red Desert Basin has produced some enigmatic gold anomalies. In 1986, the Geological Survey of Wyoming reported that stream sediment samples collected in the middle of the basin yielded values as high as 6.55 ppm gold (Albert, 1986). Recently the State Geological Survey collected two additional stream sediment samples in the basin, south of Crooks Gap (secs. 2 & 10, T.26N., R.93W.). These samples were taken within one foot of the surface in poorly developed dry channels. After the samples were concentrated on a Wilfley table, one sample concentrate assayed 2.4 ppm gold.

Seminoe Mountains

The Geological Survey of Wyoming initiated a mapping and mineral resource evaluation project of the Seminoe Mountains greenstone belt in 1989. The Seminoe Mountains lie northeast of Rawlins, Wyoming, and consist of an Archean (> 2.5-billion-year-old) greenstone belt similar to some gold- and nickel-rich terranes in southern Africa and Western Australia. The Seminoe Mountains consist of metamorphosed sedimentary, volcanic, and plutonic rocks including metagabbro, metabasalt, metafelsite, serpentinite, metakomatiite, banded iron formation, and mica schist.

Initial studies by the State Geological Survey produced a reconnaissance map of a portion of the greenstone belt (Hausel, 1989). Samples collected in the district

were chosen to test for anomalous nickel and chrome associated with komatiite and serpentinite; gold, silver, and copper associated with veins, iron formation, and stockworks; and copper, zinc, and lead associated with shear zones and massive sulfides. Samples are also being collected to search for kimberlitic "satellite" minerals as an aid in locating diamond deposits.

Sampling, to date, has produced: (1) positive identification of pyrope garnet (a kimberlitic "satellite" mineral) in stream sediment samples; (2) numerous gold anomalies ranging from a trace to 28 ppm (0.82 ounce/ton); (3) silver anomalies ranging from a trace to 55 ppm (1.6 ounce/ton); (4) copper anomalies ranging from a trace to 3.7%; (5) zinc and lead anomalies ranging from a trace to 4.3% zinc and a trace to 0.39% lead; and (6) weak nickel and chrome anomalies of a trace to 0.17% nickel and a trace to 0.73% chromium (Hausel, 1990b).

The gold anomalies are consistent with earlier samples taken by the State Geological Survey in the same region in 1981. In 1981, selected samples containing visible gold assayed as high as 98 ppm gold.

The recent samples show that gold, silver, and copper occur in shoots formed at vein intersections and fold closures. Anomalous gold (0.34 ppm) was also detected in a crosscut vein in iron formation and in stockworks (0.12 to 2.2 ppm) in amphibolite suggesting possibilities for large-tonnage, low-grade, mineralized structures as well as high-grade veins. Anomalous zinc and lead were detected along a sheared, cherty contact between banded iron formation and amphibolite. Little is known about this zone and follow-up studies will be necessary to verify the initial sample results.

South Pass (Wind River Range)

Gold exploration was reported in the South Pass greenstone belt at the southern tip of the Wind River Range of western Wyoming. The South Pass greenstone belt is an Archean greenstone terrane containing greenschist to amphibolite facies metamorphosed volcanic, sedimentary, and plutonic rocks folded into a regional synclinorium. Gold occurs in shear zones, low-grade envelopes surrounding some high-grade shear structures, in quartz-copper-carbonate veins, and in extensive Tertiary paleoplacers and Recent placers.

During the late summer to early fall, Consolidated McKinney Resources of Vancouver, B.C., drilled the Carissa and Alpine properties along the northern margin of the greenstone belt and intersected significant gold mineralization on the Carissa property. At the Carissa property, eight drill holes identified a mineralized zone (up to 80 feet wide) at more than 500 feet below the surface. This is below the area where surface sampling by the State Geological Survey previously identified a relatively wide (> 97 feet), low-grade, mineralized zone. The company's drill holes intersected mineralized rock yielding from 1.06 ppm to 86.95 ppm (2.54 ounce/ton) gold. These results are consistent with earlier drilling by Anaconda Minerals Company, which showed mineralized zones running from a trace to as much as 54.54 ppm gold at depths up to 930 feet (de Quadros, 1989).

Drilling on the nearby Alpine mine property identified only traces of gold (de Quadros, 1989). The results are consistent with earlier mine sampling and mapping by the State Geological Survey, which showed that the Alpine vein contained low-grade gold mineralization (0.08 ppm to 2.3 ppm gold) with a narrow ore shoot (< 30 feet), in an open fold nose. This ore yielded assays of 9.8 ppm to 101.0 ppm gold (Hausel, 1989).

Elsewhere in the South Pass belt, preliminary trenching and bulk sampling was completed on another possible large-tonnage, low-grade gold deposit at an undisclosed location. Also on Rock Creek, the Stout placer gold mine continued operations throughout the summer and fall.

In 1984, the Geological Survey of Wyoming began studying the geology of the South Pass greenstone belt and its mineral resources. The project resulted in the completion of eight 1:24,000 quadrangles. Recently these quadrangles were compiled into a colored, 1:48,000-scale regional map showing mine locations and auriferous shear zones (Hausel, 1990a). The new map was prepared to aid prospectors and mining companies in their evaluation of the region.

INDUSTRIAL MINERALS

In 1989, there was exploration for both developed and undeveloped industrial minerals in Wyoming. In the case of developed minerals, exploration for trona, bentonite, construction aggregate, gypsum, and limestone continued. In regard to undeveloped minerals, exploration was aimed at finding decorative aggregate, silica rock, zeolites, non-bentonitic clay, mineral pigments, and vermiculite.

Increased production of soda ash from mined trona in Wyoming prompted all five of the existing producers to announce plans for expansion by the year's end. In addition, one new venture was reportedly exploring for trona in the area near the junction of the Black's Fork and Green Rivers south of Green River.

Because of the heterogeneity of bentonite deposits, bentonite producers continually explore for and develop varying grades of bentonite. Companies blend the different grades of bentonite in their mills to produce consistent products to satisfy the diverse uses of this unique clay.

Exploration for construction aggregate, including base and sub-base materials for highways as well as railroad ballast, continued in Wyoming in 1989. Exploration efforts in the Hartville uplift in east-central Wyoming not only located a limestone deposit suitable for aggregate, but also culminated in a contract to ship it to Nebraska for use in highway construction.

In regard to gypsum and limestone, Mountain Cement, which operates a recently expanded cement plant at Laramie, explored for both these industrial minerals to add to its reserves. A new gypsum source was investigated south of Laramie, and at year's end this deposit was the primary source of Mountain Cement's

gypsum. In addition, two wallboard manufacturers in northwestern Wyoming explored for gypsum.

Several companies continued to explore for limestones suitable for use as sugar rock or for use in emissions control at coal-fired power plants. The State Geological Survey also continued field and laboratory studies of limestones in an area north of Hartville.

Recent exploration for decorative aggregate resulted in shipments of some marbles, clinker, and granite in 1989. Georgia Marble's white marble from Wheatland was the most important decorative rock product produced last year. Red clinker (baked and fused rock), grey marble, and small amounts of a red granite were also shipped. There was also exploration for green and red quartzite, granites of varying colors, and onyx. The Geological Survey of Wyoming continued to help several companies find decorative rock, which might be marketable, especially in Japan and the Far East.

Exploration for high-silica deposits continued in Wyoming with one company acquiring the Cassa silica rock deposit in Platte County in southeastern Wyoming. Initial exploration of this deposit, which was recently described by Harris (1988), was funded by county government through a planning-only grant from the Wyoming Economic Development and Stabilization Board. As of year's end, the company's exploration activities had proven up more than 100 million tons of high-grade silica.

The Geological Survey of Wyoming is continuing its field investigations in search of additional high-silica rock deposits. In 1989, the State Geological Survey examined a high-silica volcanic ash deposit north of Hartville (Harris, 1990) and assisted in the evaluation of a silica deposit in Big Horn County in northern Wyoming.

Other commodities that were the subject of exploration efforts in 1989 included zeolites, mineral pigments, vermiculite, and non-bentonitic clay for local uses.

URANIUM

In Wyoming, there was apparently no exploration for new uranium deposits in 1989. The existing producers, Pathfinder Mines in the Shirley Basin and Power Resources and Malapai Resources (both in the Powder River Basin), continued testing their existing properties. Union 76 in the Red Desert and Pathfinder in the Gas Hills did no exploration drilling on their properties in 1989. Rio Algom acquired some former Kerr-McGee property in the southern Powder River Basin and conducted some feasibility tests for *in situ* solution mining. U.S. Energy-Crested Corporation continued their developmental-assessment of properties at Green Mountain and Crooks Gap, south of Jeffrey City.

COAL

Continuing the trends of the past few years, low coal prices, a soft coal market, and a large productive over-capacity have all decreased incentives for coal explo-

ration in Wyoming. Most of the coal companies operating in Wyoming are emphasizing production of existing reserves rather than proving or acquiring additional reserves through exploration. However, there was increased exploration activities by some companies as a result of their efforts to expand reserves beyond currently permitted areas. Despite limited exploration, Wyoming coal production in 1989 was 4.6 percent greater than 1988's production and reached a record high 171.1 million short tons.

Seven Federal coal exploration licenses, all in Campbell County (eastern Powder River Basin), were active in 1989. Four of these exploration licenses were at least partially drilled in 1987 or 1988, including a 40.8-acre tract and a 9,527.67-acre tract held by Powder River Coal Company, a 640-acre tract held by Triton Coal Company, and a 1,910.17-acre tract held by Kerr-McGee Coal Corporation. Three additional coal exploration licenses were issued in 1989: Thunder Basin Coal Company explored a 6,084.3-acre tract, Powder River Coal Company explored a 320.18-acre tract, and Carter Mining Company explored a 44.44-acre tract. A total of 18,567.56 acres of Federal coal in the Powder River Basin, Wyoming, were under exploration license in 1989.

Coal exploration drilling by private industry is tracked by the State of Wyoming's Department of Environmental Quality through their Abandoned Drill Hole Program. Data for 1989 will not be available until late 1990 because statutes allow for submittal of drill hole data up to one year after drilling is completed. Data from 1988, which became available in late 1989, indicated that exploration drilling for coal in 1988 increased from the previous year. Nearly all of the drilling was on active coal mine permits; development drilling in advance of mining is not included in the totals.

A total of 756 coal exploration holes were drilled in 1988, a substantial increase over the 352 holes in 1986 and the 257 in 1987. Total footage increased from 45,064 feet drilled in 1987 to 114,423 feet drilled in 1988. All of the coal exploration holes reported under the Abandoned Drill Hole Program for 1988 were located in Campbell County, Wyoming. About 46% of the footage, or 52,809 feet, and about 51% of the drill holes were on privately-owned lands; about 52% of the footage, or 59,001 feet, and about 43% of the drill holes were on Federal lands; and the remainder of the drill holes were on State lands.

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GEOLOGIC MAPPING AND STRATIGRAPHY

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

WGA CENTENNIAL FIELD TRIP

For those readers who are not members of the Wyoming Geological Association (WGA), the WGA recently announced their Wyoming Centennial Field Trip which will be held August 17-23. The trip will begin and end in Casper with the option to join or exit the trip at Jackson, Wyoming, on August 21. This extended field trip, which coincides with Wyoming's centennial celebration of statehood, will have a sedimentation and tectonics theme. Papers on this theme will be presented in the evenings along the route of the field trip.

The trip will traverse the geology of central and northwestern Wyoming including the Powder River Basin, Bighorn Mountains, Bighorn Basin, Cody arch, Absaroka Basin, Absaroka volcanics, Yellowstone National Park, the Tetons, Fish Creek Basin, Wind River Basin, Wind River Range, Washakie Range, and the Casper arch. Geologists leading the field trip will discuss the latest ideas and theories relating to the geology of these portions of the State. This should be an excellent trip and a once in a lifetime opportunity to be ushered through the fantastic geology of this portion of Wyoming. Anyone wishing more information on registration, costs, etc., should contact the conference chairman:

Dr. Kent A. Sundell
Absaroka Exploration Co.
(307) 266-4760

RECENT TRENDS IN GEOLOGIC MAPPING

In a recent article in the annual review issue of *Geotimes*, Russell Guy pointed out the continuing trend toward less and less new original geologic mapping by the U.S. Geological Survey (Guy, 1990). A review of new geologic maps produced by the U. S. Geological Survey (USGS) indicates only 181 new maps were published in 1989. This is a 25 percent drop from 1988 and a 40 percent drop from 1987, and the lowest total for the decade. Publication of 23 new GQ-series maps was the only bright spot, representing the highest total since 1979. Only 77 new MF-series maps were published, representing a 67 percent decrease from the decade high in 1984. Guy notes that the maps published in 1989 represent projects started 4 to 5 years ago. Guy feels this decreased emphasis on mapping may continue and results from two major factors. First, Congress continues to cut the portion of the USGS budget dedicated to geologic mapping. Secondly, there is apparently an unwillingness of many in the geologic community to stress or recognize the importance of new geologic mapping.

In some circles, mapping and field studies are not even considered significant professional activities. These latter views seem unbelievable as information gathered by field mapping studies have traditionally been crucial in mineral development and exploration, in helping protect the environment, and in mitigating the potential effects of geologic hazards. While Guy notes that the first factor can be addressed by management within the USGS, he gives no way to address the second factor.

It should be noted that the State Geological Survey's have not only seen this growing trend, but are trying to do something about it. The Association of American State Geologists (AASG) is preparing a national mapping initiative, which calls for substantial Federal funding for original geologic mapping. The initiative will involve many if not all the State Geological Surveys and the U.S. Geological Survey. In the meantime, an inadequately funded USGS program, called COGEOMAP, is about all that keeps mapping alive at the Federal level.

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NEWS FROM THE GEOLOGIC HAZARDS DIVISION

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

COOPERATIVE AGREEMENT WITH THE WYOMING OIL AND GAS CONSERVATION COMMISSION

Late in 1989, the Geological Survey of Wyoming and the Wyoming Oil and Gas Conservation Commission (WOGCC) entered into a cooperative agreement in which the Geological Survey of Wyoming will assist the WOGCC with their Underground Injection Control (UIC) Program. The Program is partially funded through the U.S. Environmental Protection Agency. The primary goal of the UIC Program is to protect ground-water resources from underground injection of oil field waters. The State Geological Survey will provide information and data on the surface and subsurface geology at proposed sites, as well as references to published ground-water studies. Structure contour maps, isopach maps, and other computer-generated maps for specific geological formations or groups of formations will be supplied as needed.

The first product of the cooperative agreement was Open File Report 90-5 titled, *Bibliography of the ground-water hydrology within the Greater Green River Basin (Green River, Washakie, and Great Divide Basins)* by Brett D. Boundy and James C. Case. The bibliography has 126 title/author listings and an extensive index.

EARTHQUAKE EDUCATION MATERIALS

The Geological Survey of Wyoming and the Wyoming Emergency Management Agency (WEMA) have acquired a series of earthquake education materials from the Federal Emergency Management Agency (FEMA). The materials are suitable for distribution to both the general public and the school systems in the State. One of the publications, geared towards the elementary schools, is titled *Earthquakes: a teachers package for K-6.* The publication is endorsed by the National Science Teachers Association. Another publication is titled *Guidebook for developing a school earthquake safety program.* That publication addresses hazard identification, earthquake drills, and response alternatives.

Three pamphlets for the general public are also available. They are the "Family Earthquake Safety Home Hazard Hunt and Drill", "Earthquake Safety Checklist", and

"Safety Tips for Earthquakes". Also available is a poster titled "A Blueprint for Earthquake Survival".

Three items that have been made available by FEMA are geared towards children from pre-school to fourth grade. In order to make the message more appealing to youngsters, FEMA has utilized characters from Sesame Street, primarily Big Bird. Numerous Big Bird "Get Ready for Earthquake" buttons are available, as are Big Bird earthquake board games. The board games are made of folded posterboard. There are also a series of songs available on cassettes titled "Beat the Quake"and "Elmo and the Earthquake".

For more information on earthquake education materials, contact James C. Case at the Geological Survey of Wyoming (307) 766-2286, or Grant Sorensen at the Wyoming Emergency Management Agency (307) 777-7566.

WYOMING'S UNIQUE PERIODIC SPRING

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

An interesting article by Robert H. Mohlenbrock (1990) on the Periodic Spring, Wyoming, was recently published in the April issue of *Natural History Magazine*. Periodic Spring is located east of Afton on Swift Creek in the Bridger-Teton National Forest. Cold water (as contrasted to the hot water volcanic geysers of Yellowstone) gushes from an opening in the Madison Limestone for several minutes, stops abruptly, and then begins flowing in a new cycle. The first geologist to describe the phenomenon was William W. Rubey of the U. S. Geological Survey in the spring of 1931. Rubey calculated the flow of the spring at about 285 gallons per second at peak flow. He theorized that a reservoir existed within the Madison Limestone and that water was drawn out of the reservoir through a curved (s-shaped) passage acting as a siphon. As long as the water level in the reservoir remains low, the passage contains mostly air. When the reservoir fills to a sufficient level, water spills into the siphon and displaces the air, causing the spring to flow. When the water level drops below the siphon, flow ceases and the cycle begins again. Rubey estimated that approximately 100,000 gallons of water must move into the reservoir before a new cycle will begin. Various observers have timed the flows at anywhere from four to twenty-five minutes with equally variable intervening dry spells.

Dr. Peter Huntoon and student, James Coogan, of the University of Wyoming's Department of Geology and Geophysics, recently attempted to identify the sources of the water. Outcrops of the same Madison Limestone occur approximately four miles east of the spring at a considerably higher elevation, on Divide anticline. Huntoon and Coogan (1987) theorize that the water, originating from snowmelt and summer rainstorms at this higher elevation, flows downdip into Mill Hollow syncline through fissures and caverns in the Madison Limestone and then up the flank of the

syncline into the reservoir. During periods of heavy rain and peak snowmelt, the spring fluctuates, but does not cease entirely. The intermittent flow is best exhibited in late summer and early fall, all consistent with Huntoon and Coogan's theory as to the source of the water. This is a very interesting geological phenomenon which is relatively easy to reach and well worth visiting.

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NEW PUBLICATIONS BY THE GEOLOGICAL SURVEY OF WYOMING

*Selected bibliography on selenium by J.C. Case, L.R. Zellmer, M.T. Harris, R.L. Anderson, and L.L. Larsen: Bulletin 69, 1990 - $5.00.

*Geologic map of the Gillette 1° x 2° Quadrangle, northeastern Wyoming and western South Dakota by J.D. Love, A.C. Christiansen, L.W. McGrew, and J.K. King: Map Series 25G, 1990, 1:250,000 - $4.00.

*Geologic map of the Leavitt Reservoir Quadrangle by Karen Noggle-Perrin: Map Series 29, 1989, 1:24,000 (color) - $4.00.

*Industrial minerals and construction materials map of the Powder River Basin and adjacent uplifts by R.E. Harris and J.K. King: Map Series 30, 1989, 1:500,000 (color) - $4.00.

*Oil and gas fields map of the Powder River Basin by R.H. DeBruin and C.S. Boyd: Map Series 31, 1990, 1:316,800 - $4.00.

*Map of the South Pass granite-greenstone belt, southern Wind River Range, Wyoming by W.D. Hausel: 1990, 1:48,000 - $5.00 (map only, the rest of the report will be available in mid-1990).

Preliminary landslide maps, by J.C. Case and others: call for the availability of particular 1:24,000- and 1:62,500-scale maps, 1989 and 1990 - $3.00.

*Anorthosite in Wyoming by R.E. Harris: Open File Report 90-1, 1990, 7. p. - $2.00.

*Rutile in Wyoming by R.E. Harris: Open File Report 90-2, 1990, 7 p. - $2.00.

*Vermiculite in Wyoming by R.E. Harris: Open File Report 90-3, 1990, 11 p. - $2.00.

*Natural zeolites in Wyoming by R.E. Harris and J.K. King: Open File Report 90-4, 1990, 51 p. - $7.00.

*Bibliography of ground-water hydrology within the Greater Green River Basin (Green River, Washakie, and Great Divide basins) by B.D. Boundy and J.C. Case: Open File Report 90-5, 1990, 57 p. - $7.00.

*Industrial mineral resources of the upper Patten Creek area, Platte County, Wyoming by R.E. Harris: Report of Investigations No. 45, 1990, 20 p. - $4.00.

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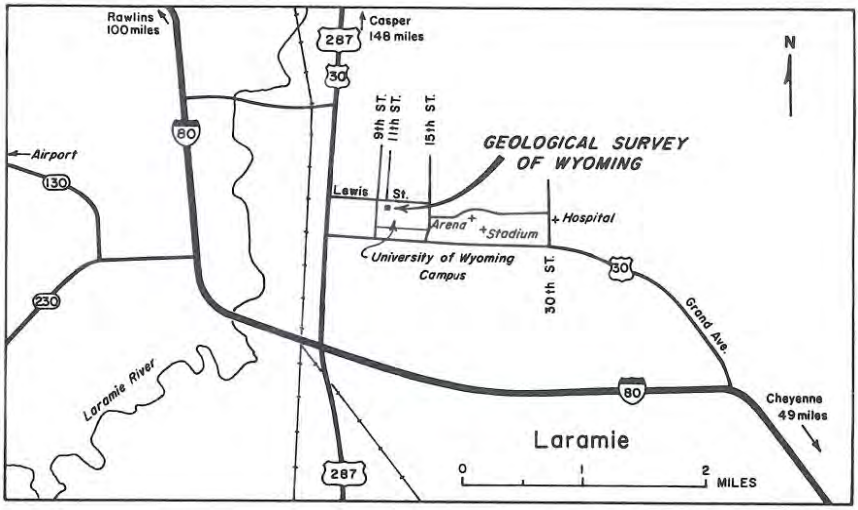
* New releases since the last issue of *Wyoming Geo-notes*.

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

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

— NEW SERVICE AVAILABLE —

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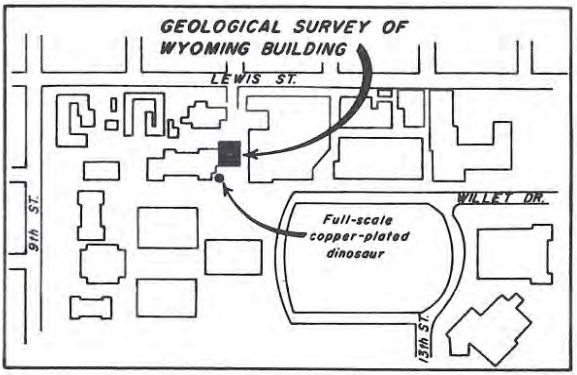
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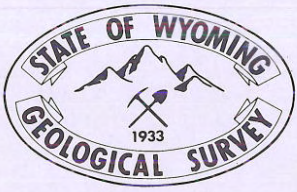
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