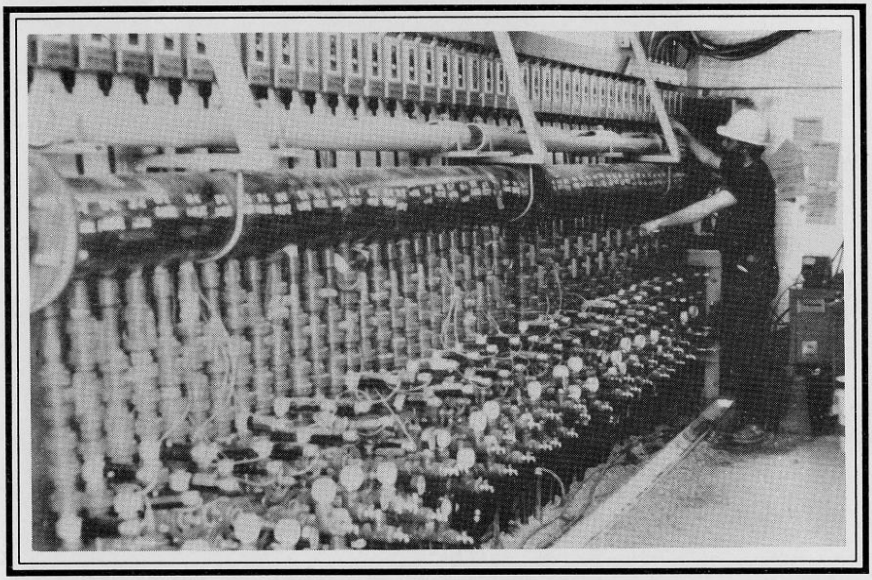
Wyoming Geo-notes

Number 35



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

Laramie, Wyoming
August, 1992

WYOMING GEO-NOTES
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Cover: The bank of pumps that controls the recovery of uranium-rich solutions from an in-situ recovery field at the Irigary Ranch in Johnson County. With the closure of Pathfinder's Shirley Basin uranium mine in May, all of Wyoming's current uranium production is now by in-situ recovery methods.

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Table of Contents

Page

Minerals update 1

Overview 1

Oil and gas update 8
Exploration and development 13
Horizontal drilling 16
Coalbed methane 18

Coal update 19
Developments in western and southwestern Wyoming 26
Developments in the Hanna Coal Field 27
Developments in the Powder River Coal Field 27
Coal contracts - Powder River Coal Field 29

Industrial minerals and uranium update 32
Aggregate (Construction) 34
Bentonite 32
Cement 32
Decorative stone 35
Gypsum 35
Leonardite 35
Limestone (non-aggregate production) 36
Perlite 36
Trona 36
Uranium 37
References cited 39

Metals and precious stones update 40
Gros Ventre 40
South Pass 40
Hartville uplift 40
Medicine Bow-Sierra Madre 40
Granite Mountains 41
Southern Wyoming 41
Cooper Hill and Herman Districts, Medicine Bow Mountains 42
Seminoe Mountains 43
References cited 46

Summary of horizontal drilling in Wyoming 47

Wyoming oil and gas exploration summary for 1991 50
Lease sales 52
Powder River Basin 52
Greater Green River Basin 54
Wind River Basin 54
Horizontal drilling 54
Coalbed methane 54
Reference cited 54

Mineral resource and reserve base estimates for Wyoming 55

Geologic mapping and stratigraphy 56
Geologic road signing project continues in Bighorn Mountains 56
New color geologic map published 56
Casts of Allosaurus skull distributed to state museums 57
New dinosaur find near Lusk, Wyoming 58

Geologic hazards in Wyoming 58
Radon research 58

Tim Moore heads up Coal Section 60

New publications 60

Geological Survey of Wyoming location map 62

MINERALS UPDATE

OVERVIEW

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

A few things changed for the better in the second quarter of 1992. Most notably, oil and gas prices increased. In the case of oil, the posted prices for Wyoming Sour and Wyoming Sweet in the second quarter averaged $16.41 and $19.67, respectively (Figure 1). This compares with an average of $14.18 and $17.40, respectively in the first quarter. For the first six months of the year, we now estimate the average first purchase price for Wyoming crude was approximately $15.68 a barrel, which is $1.18 per barrel more than the price that we forecast in January of 1992. Consequently, we have increased our forecast 1992 oil price to $16.50 (Table 1; Figure 2).

In the case of natural gas, the spot price at Opal, Wyoming, rose again in the last two months of the second quarter and was $1.35 per MCF at the end of June (Figure 3). What makes this increase significant is that it occurred in the second quarter of the year. Normally the spot price for natural gas declines or levels off in the second quarter as well as in part of the third quarter. And in at least the last four years, the spot price had only increased in the fourth quarter. Depending on what the spot price does in the third quarter, we may have to increase our current

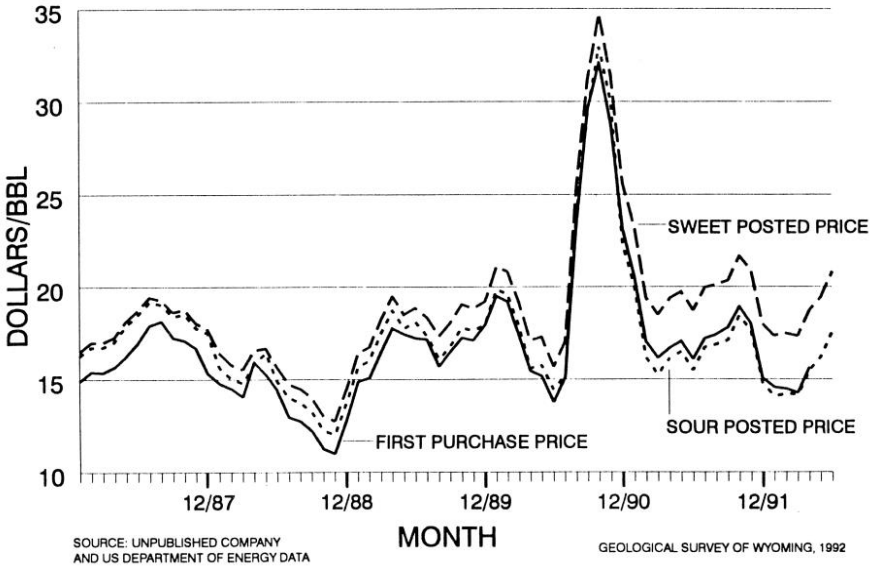


Figure 1. Wyoming posted Sweet and Sour crude prices and first purchase prices averaged by month (1987 to present).

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

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

* Actual value for comparison.

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

[2] First purchase price in dollars per barrel.

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

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

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

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

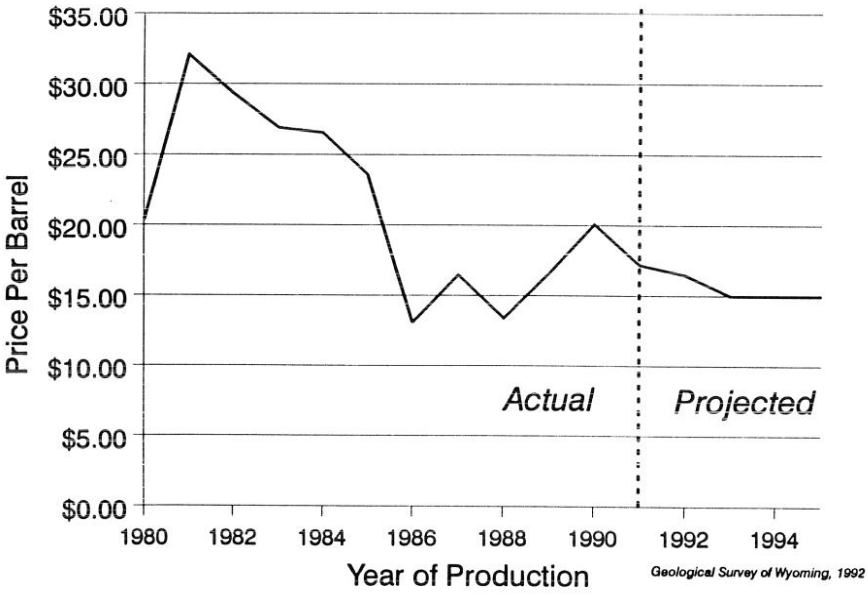


Figure 2. Average prices paid for Wyoming oil (1980 to 1991) with forecast to 1995.

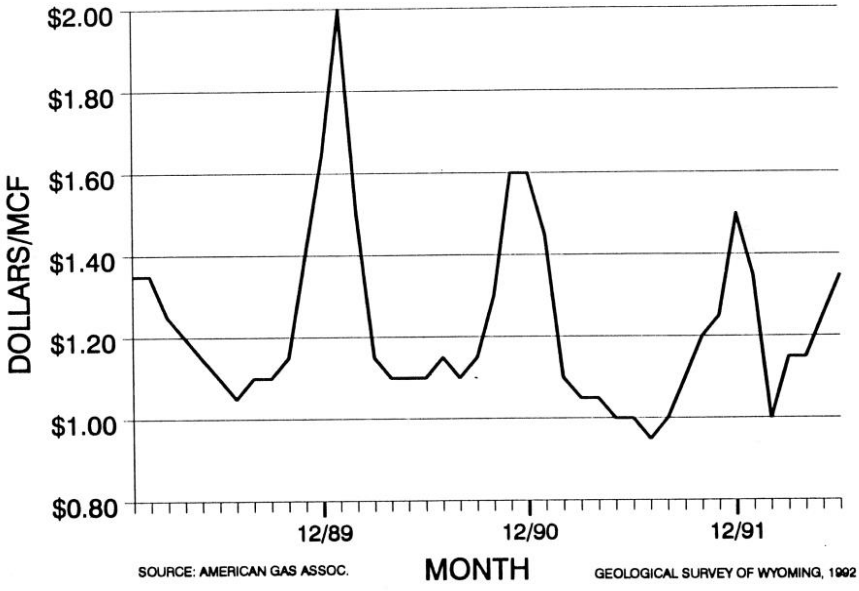


Figure 3. Spot prices for natural gas sales at Opal, Wyoming, averaged by month (1989 to present).

estimate of $1.44 per MCF for the year (Table 1; Figure 4). It is interesting to note that the spot sale price of natural gas at Opal began its rise in March just after the Kern River Pipeline was completed. It is also possible that recent actions taken by the Texas Railroad Commission helped to firm up or cause increases in natural gas prices across the country.

In regard to pipelines, Altamont Gas Transmission Company has announced at least a one-year delay in the construction of its proposed pipeline from Canada to Opal. Shortly after Altamont's announcement, Kern River Gas Transmission Company put its expansion plans for the Kern River pipeline on hold. But Kern River is also surveying Wyoming gas producers to see if there is enough interest to justify an expansion of the pipeline independent of the Altamont line.

The rising oil and gas prices, however, have not done much to stimulate drilling. Although the average daily rig count remained well under 30 rigs for most of the first six months of 1992, it did average more than 30 for June.

The State and Federal oil and gas lease sales also did not show any significant rebounds in the second quarter.

No spot sale prices or contract prices for coal from Wyoming were announced in the second quarter. Figure 5, however, has been altered to not only show the average statewide price paid for coal from Wyoming but also the average prices for coal from northeastern Wyoming and from southern Wyoming.

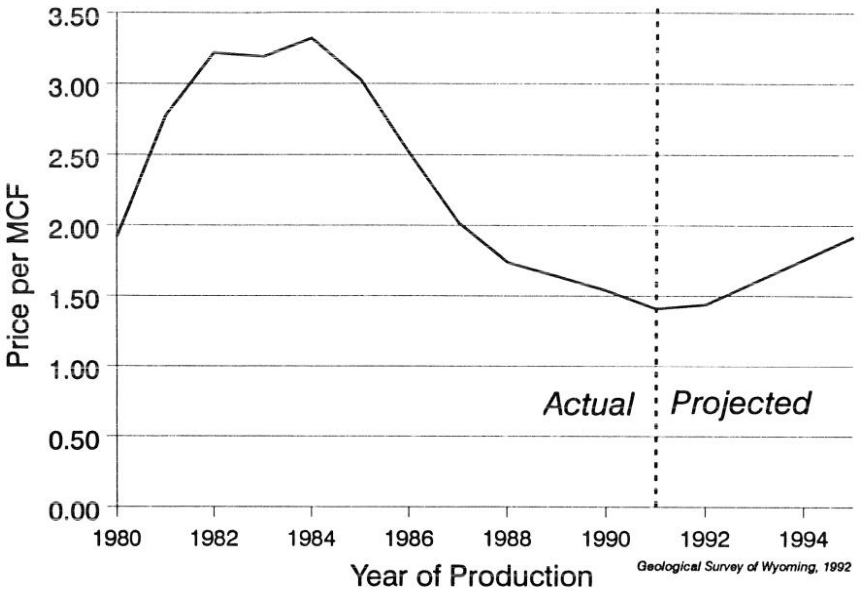


Figure 4. Average prices paid for Wyoming natural gas (1980 to 1991) with forecast to 1995 (includes carbon dioxide and natural gas liquids).

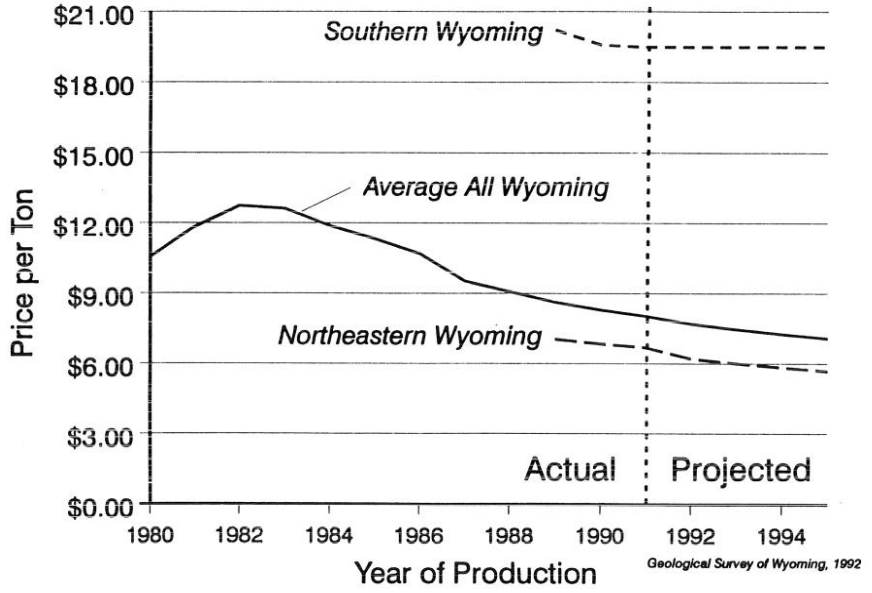


Figure 5. Average prices paid for Wyoming coal (1980 to 1991) with forecast to 1995. *[Data from U.S. Energy Information Administration (1980-1984) and Wyoming Department of Revenue and Consensus Revenue Estimating Group (1985-1991)].*

Following last year's sale of Mobil's Caballo Rojo mine to Marigold Land Company, two more surface mines and a significant mine property in the Powder River Coal Field may be sold this year. It looks like Zeigler Coal Holding Company of Illinois will soon own Triton Coal Company's (Shell Oil) Buckskin mine as well as Shell's North Rochelle property. And Carter Mining Company (Exxon Coal and Minerals USA) is considering the possible sale of its Rawhide mine.

Because monthly coal production declined over the first four months of 1992, cumulative production through April is almost two million tons below last year's cumulative production through April. Only part of this decline is believed attributable to the relatively short railroad strike. The last time that annual production of coal from Wyoming did not exceed the previous year's production was back in 1986 (Table 2; Figure 6). It is still too early to change our forecast coal production for 1992, and 2 million tons is only 1 percent of the annual coal production from Wyoming. This apparent shortfall in production could easily be made up in as little as one month.

Production estimates for oil and natural gas (Table 2; Figures 7 and 8) have not changed from what were forecast in the first quarter of 1992.

Last quarter, Amoco and Chevron announced that they were considering the closure of one or the other of their natural gas processing plants in the Whitney Canyon-Carter Creek Field in Lincoln and Uinta counties. This quarter, a

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

Calendar Year	Oil[2]	Methane[3]	Carbon Dioxide[3]	Helium[4]	Coal[5]	Trona[5]	Mined Uranium[6, 7]	In-situ Uranium[8]	Sulfur[9]
*1981	122.1	408.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	424.7	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	444.0	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	516.7	—	—	130.7	11.0	1.6	—	0.71
*1985	131.0	416.6	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	403.3	23.8	0.15	136.3	11.9	0.2	0.04	0.76
*1987	115.9	498.0	114.2	0.86	146.5	12.4	0.2	0.06	1.19
*1988	114.3	509.1	110.0	0.83	163.6	14.9	0.3	1.16	1.06
*1989	109.1	587.4	126.1	0.94	171.1	16.2	0.1	1.07	1.17
*1990	104.0	681.4	131.0	0.98	184.0	16.2	0.2	1.1	0.91
1991	100.0	728.0	131.0	0.98	*193.9	*16.1	0.3	*1.0	1.00
1992	99.5	787.0	131.0	0.98	203.1	16.3	0.1	0.8	1.00
1993	95.5	846.0	131.0	0.98	213.0	16.6	—	1.0	1.00
1994	91.6	905.0	131.0	0.98	223.7	17.2	—	1.0	1.00
1995	88.0	963.0	131.0	0.98	234.8	17.4	—	1.0	1.00

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

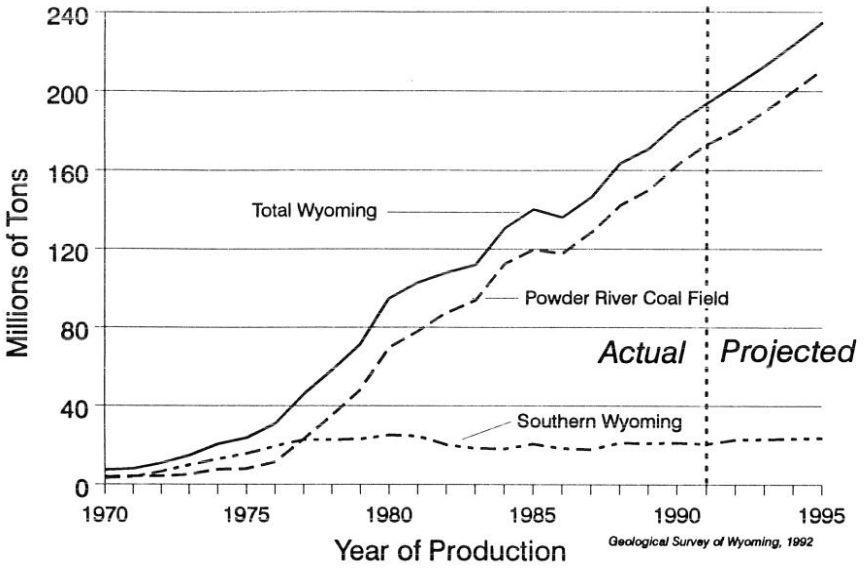


Figure 6. Annual coal production from Wyoming (1970 to 1991) with forecast to 1995.

subsidiary of Coastal Corporation proposed building a new gas processing plant between Evanston and Kemmerer. This plant would process Exxon's gas from the Road Hollow Field.

In May, Solvay S.A. of Brussels, Belgium, completed its $500 million purchase of Tenneco's 80 percent interest in a major trona mine and soda ash refinery in Sweetwater County. Asahi Glass of Japan owns the remaining 20 percent. Additionally, in June BTR Nylex, Ltd. of Australia sold its 49 percent interest in General Chemical's trona mine and soda ash refinery to Tosoh Corporation of Japan. General Chemical retained its controlling interest.

Church & Dwight Company, Inc. announced that they would expand their facilities. They buy Wyoming soda ash and manufacture products under the trade name of Arm & Hammer.

The second quarter also marked the end of conventional uranium mining in Wyoming when Pathfinder Mines closed their Shirley Basin open pit mine. With this closure, all uranium production in Wyoming comes from solution mining (in-situ) operations. In addition, our estimates of uranium production from the remaining operations have been revised downward from previous forecasts (Table 2).

Table 3 has also been revised because production statistics for some of the mineral commodities in the table became available in the second quarter.

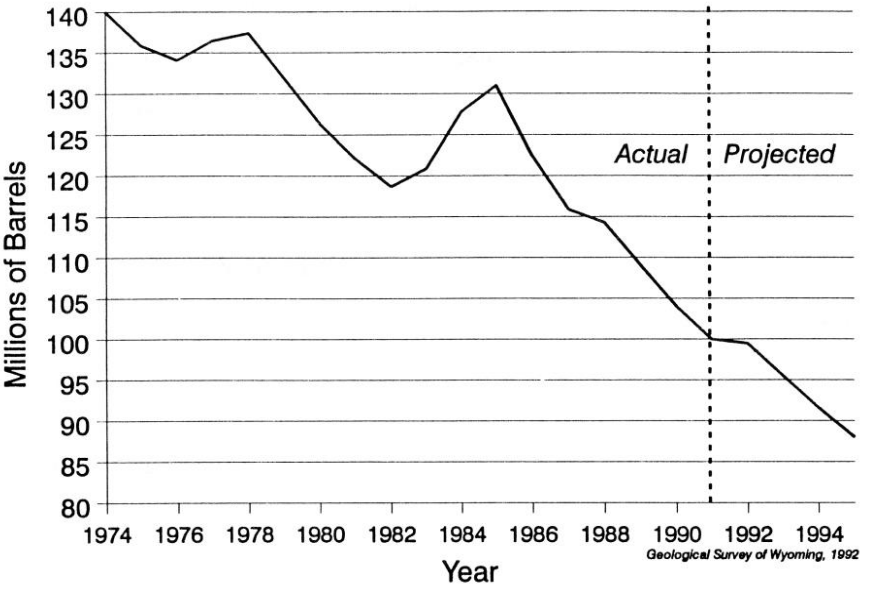


Figure 7. Annual oil production from Wyoming (1974 to 1991) with forecast to 1995.

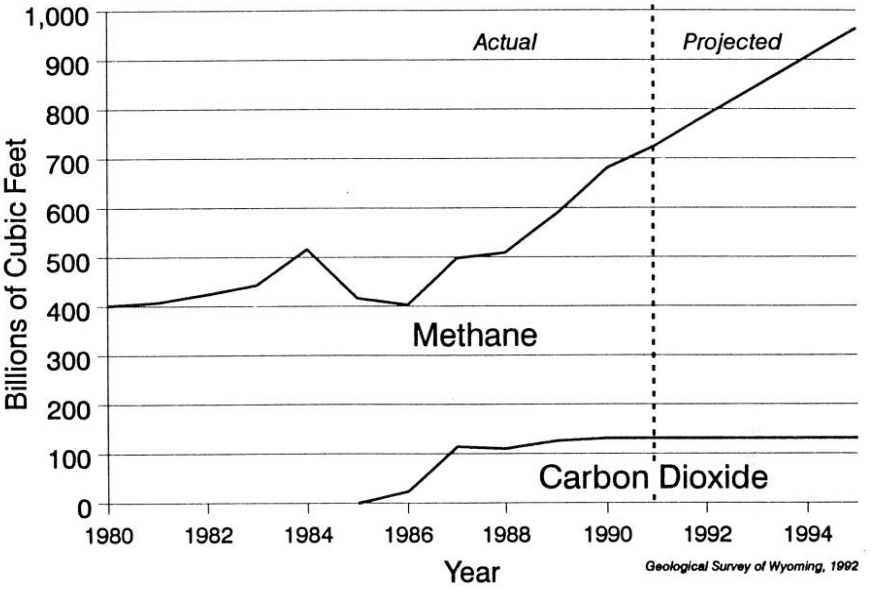


Figure 8. Annual natural gas production from Wyoming (1980 to 1991) with forecast to 1995.

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Bentonite[2]	2.35	2.18	3.08	2.59	1.82	2.16	2.32	2.22[6]	2.43[6]	2.38[6]
Clay[4]	15.7	36.4	59.6	35.9	23.2	1.31	61.1	23.6	---	---
Decorative Aggregate[2]	0.05	0.07	0.08	0.09	0.07	0.06	0.07[7]	0.06[6]	0.06[6]	0.7[6]
Decorative Stone[4]	---	---	---	---	---	---	---	---	---	0.24[7]
Dolomite[2]	0.61	0.66	0.86	0.87	0.81	0.46	0.19[6]	0.15[6]	0.21[6]	0.23[6]
Feldspar[4]	0.17	---	---	---	---	---	---	2.0	---	---
Gypsum[2]	0.26	0.33	0.33	0.35	0.41	0.35	0.40[7]	0.20[6]	0.44[6]	0.42[6]
Iron Ore[2]	3.28	2.48	---	---	---	---	---	minor[8]	minor[8]	---
Leonardite[4]	---	---	---	---	---	---	---	---	22.9[6]	33.3[6]
Limestone[2, 5]	0.59	0.56	0.65	0.32	0.33	0.32	0.64	0.60[6]	0.48[6]	0.49[6]
Construction Aggregate[2, 3]	6.24	6.72	8.31	6.40	5.01	4.12	3.15	6.46[6]	7.73[6]	8.62[6]
Shale[4]	---	---	20.3	14.7	9.88	49.0	50.2	1.8	43.5[6]	158.2
Sodium Sulfate[4]	3.17	3.19	3.25	2.71	2.03	---	2.10[6]	3.2	1.9[6]	1.5[6]

Sources: [1]Wyoming Department of Revenue, unless otherwise noted. [2]Millions of short tons. [3]Includes ballast, scoria, and limestone used for aggregate. [4]Thousands of short tons. [5]Includes chemical grade limestone used for cement rock, sugar beet refining, and other uses. [6]Wyoming State Inspector of Mines. [7]Estimated by Geological Survey of Wyoming. [8]Less than 1,000 tons of iron ore were sold for pigment. Prepared by Geological Survey of Wyoming, July, 1992.

OIL AND GAS UPDATE

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

Petroleum Information's (1992) estimate of 1991 oil production in Wyoming is 99.9 million barrels of oil. This is slightly lower than our estimate of 100.0 million barrels of oil (Table 2; Figure 7). Petroleum Information (1992) also estimates that 960.7 billion cubic feet of natural gas were produced in Wyoming in 1991. Petroleum Information's gas total includes methane, carbon dioxide, helium, other non-hydrocarbon gases, recycled gas, and vented and flared gas. We estimate that 859.98 billion cubic feet of gas were produced in 1991. Of that, 0.98 billion cubic feet were helium, 131.0 billion cubic feet were carbon dioxide, and 728 billion cubic feet were methane (Table 2; Figure 8). Our estimate does not, however, include recycled gas.

In the second quarter of 1992, the average posted prices for Wyoming Sweet and Wyoming Sour crude oils rose to levels near those at the end of 1991 (Figure

1). Wyoming Sweet averaged $20.83 per barrel and Wyoming Sour averaged $17.58 per barrel in June. For comparisons, the average price for Wyoming Sour is only slightly less than the overall average statewide price (first purchase price) that Wyoming producers receive for their oil (Figure 1).

Spot prices for methane at Opal, Wyoming are also higher for the second quarter than they have been in the last three years (Figure 3). The June spot price was $1.35 per thousand cubic feet.

In the second quarter, the average daily rig count remained relatively low (Figure 9). To some extent, drilling has shifted from the Powder River Basin toward infill gas wells in the Greater Green River Basin. There was also increased activity in the Bighorn Basin. It has been several years since this level of activity occurred in that basin.

In a related item, the U.S. Department of Energy (DOE) awarded Sierra Energy Co. a $2.1 million grant to partially fund a horizontal drilling project in the Bighorn Basin in Badger Basin Field. The company plans a 3-D seismic survey of the field and will also drill a well to core all three benches of the Frontier Formation. The company will then drill a 2,000-foot horizontal leg in the Second Frontier. Most of this work will begin in 1993. Sierra may drill a second horizontal test in 1994. Badger Basin Field was discovered in 1930 and has produced just over 2.9 million barrels of oil and over 5.6 billion cubic feet of gas, mainly from the Frontier.

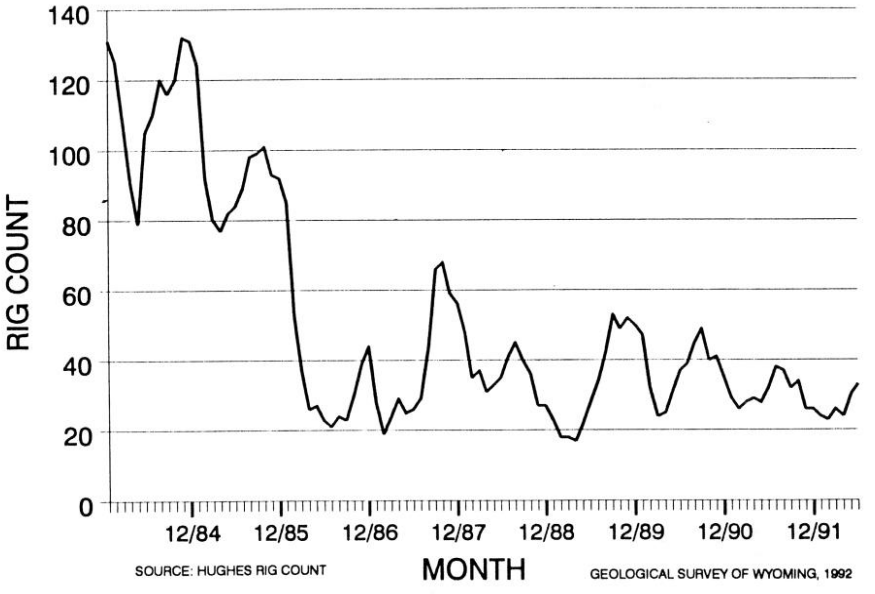


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

Another project to increase oil production from the Bighorn Basin is planned by Carol-Holly Oil Co. and Bomar Production, in cooperation with the Western Research Institute and the DOE. For this project, a 30-foot deep, 15-foot wide, and 200-foot long trench will be excavated on the Sherard Anticline in SW NE section 24, T47N, R90W. The purpose is to expose a 20-foot thick section of the Peay Sandstone Member of the Frontier Formation. Initial production will be by gravity drainage into the trench. Air or water and surfactant will be injected into surrounding wells in an effort to increase production. Several tons of the reservoir will be tested to determine if hydrocarbons can be recovered by excavation and processing. Although no commercial oil production exists on Sherard Anticline, in-place oil is estimated at five million barrels. The project will be funded in part by a $224,283 grant from the State of Wyoming to the Western Research Institute and a possible grant of $250,000 from DOE.

Enron Oil and Gas Co.'s proposal to drill 39 infill gas wells in the La Barge area of southwestern Wyoming should have no significant impact on the environment according to an Environmental Assessment of the proposal. The U.S. Bureau of Land Management (BLM) will release its final decision later this summer. Enron will probably try to drill the wells this year to take advantage of Federal tax credits for the development of tight gas sands. These credits are slated to expire December 31, 1992, unless they are extended.

The BLM also approved Presidio Exploration Inc.'s plans for infill gas wells in Hay Reservoir Field in southwestern Wyoming. Presidio must still have site-specific approval from BLM. Presidio plans to drill as many as 20 additional wells in the field.

The BLM has issued a draft Environmental Impact Statement for the infill drilling plan in Mulligan Draw Field in southern Wyoming. Celsius Energy Co. and other operators want to drill up to 45 infill gas wells in the field. The BLM's preferred alternative is to allow the drilling.

In other news related to natural gas, Union Pacific Resources announced plans to build a 41-mile pipeline to connect eight shut-in sour gas wells with the Whitney Canyon gas processing plant in the Overthrust Belt. The gas will come from one well in Utah and seven wells in Yellow Creek Field near Evanston, Wyoming. The new pipeline will transport approximately 55 million cubic feet of sour gas per day. Federal approval is required for the project to proceed.

A subsidiary of Coastal Corp. proposed a new gas processing plant between Evanston and Kemmerer. The proposed capacity of the plant is around 14 million cubic feet of sour gas per day. The gas would be processed for Exxon from their Road Hollow Field.

The Wyoming Oil and Gas Conservation Commission has submitted recommendations to the Federal Energy Regulatory Commission that two large areas be designated as tight gas sands. The first area is for the Dakota and covers 510,444 acres in the Green River Basin, including all of T20N, R111W; T20N, R113W; T22N, R113W; T22N, R112-113W; and T23N, R111W-R113W. Parts of

T17N, R111W-R114W; T18N, R111W-R114W; T19N, R111W-R114W; T20N, R112W and R114W; T21N, R110W-R113W; T22N, R110W and R111W; and T23N, R110W were also included. The second area, which is in the Wind River Basin, is for the Fort Union, Lance, Meeteetse, and Mesaverde Formations and covers 138,240 acres in T3N-T5N, R2E-R3E.

Two companies announced layoffs that will affect Wyoming. Conoco will reduce employment in its Casper office by four employees. Chevron announced that it will reduce employment in its Evanston office by 28 employees. It is still uncertain how Unocal's announced reorganization will affect employment in Wyoming.

Wyoming's U.S. Senators have introduced legislation that would authorize the DOE to sell Teapot Dome Field to a private operator. Presently no royalties or taxes are paid on production because the field is owned by the Federal government. That situation would change if the field was sold to a private operator.

Richard Ewing, the former co-director of the University of Wyoming's Enhanced Oil Recovery Institute has labeled the huff and puff technology as uneconomic in Wyoming. Ewing based his conclusion on results of State- and industry-funded tests of the process. According to Ewing, in the nearly 40 wells that tested the process in Wyoming, the cost of the carbon dioxide used in the process cost more than the recovered oil was worth.

State and Federal lease sales in Wyoming did poorly again in the second quarter of 1992. All the sales already held in 1992 have raised less revenue, have sold less acres, and have had a lower average price than any previous sale in recent years (Table 4).

The high per-acre bid at the U.S. Bureau of Land Management's (BLM's) April sale was $112 by Louis S. Madrid for a 342.93-acre lease that covers part of sections 30 and 31, T47N, R72W. The lease is about one mile southwest of Hawk Point Field which has produced nearly 2.7 million barrels of oil from the Minnelusa. Hanson and Strahn Energy Land Services made the sale's second highest per-acre bid of $100 for a 120-acre tract that covers the W/2 NE section 30 and NW NE section 29, T38N, R75W. The tract is less than half a mile from Dakota production at Allemand Field.

The high per-acre bid at the State Land and Farm Loan Office's May sale was $230 by Klabzuba Oil and Gas for a 480-acre lease that covers the NE and S/2 section 36, T37N, R64W. The lease is about one half mile northwest of Leo oil and gas production at Swede Draw Field. The second highest per-acre bid was $80 by Monty Kastner for a 480-acre lease that covers NW and W/2 section 16, T43N, R71W, on the southwestern flank of Hilight Field. The revenues from these two parcels accounted for more than 71 percent of the total revenue from the sale.

The high per-acre bid at the BLM's June sale was $220 by Cramer Oil for a 440-acre lease that covers SW and SW SE section 5, NW section 8, SE SW

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

BLM SALES								STATE SALES							
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1988								**1988**			
TOTAL	$27,688,861	4,119	1,591	4,412,513	1,350,897	$20.50	$6,500.00	TOTAL	$6,202,724	1,200	873	445,953	331,943	$18.69	$465.00
				1989								**1989**			
TOTAL	$15,832,105	4,286	1,360	4,028,750	972,403	$16.28	$3,000.00	TOTAL	$3,123,984	1,199	792	461,852	311,274	$10.04	$540.00
				1990								**1990**			
February	$3,301,479	524	259	335,275	141,555	$23.32	$340.00	January	$190,921	200	100	74,987	38,884	$4.91	$46.00
April	$2,163,988	513	218	399,790	138,909	$15.58	$275.00	March	$668,262	200	132	79,405	54,193	$12.33	$85.00
June	$3,480,557	511	315	305,550	172,798	$20.14	$240.00	May	$690,310	199	146	79,667	60,986	$11.32	$270.00
August	$2,892,191	533	251	493,185	187,259	$15.44	$325.00	July	$521,824	200	154	78,507	62,999	$8.28	$60.00
October	$2,580,072	423	265	255,886	141,707	$18.21	$200.00	September	$1,472,248	200	200	80,197	80,197	$18.75	$240.00
December	$3,578,846	467	285	379,452	185,065	$19.34	$260.00	November	$1,435,529	200	192	85,335	83,133	$17.27	$265.00
TOTAL	$17,997,133	2,971	1,593	2,169,138	967,293	$18.61	$340.00	TOTAL	$4,979,094	1,199	732	478,098	380,382	$13.09	$270.00
				1991								**1991**			
February	$4,333,861	370	200	275,600	122,225	$35.46	$16,000.00	January	$2,050,868	300	295	117,677	115,998	$17.68	$401.00
April	$1,880,742	470	217	332,764	132,278	$14.22	$170.00	March	$642,191	197	170	69,652	62,226	$10.32	$110.00
June	$2,002,440	490	176	430,576	120,992	$16.55	$275.00	May	$539,556	199	173	79,156	70,081	$7.70	$77.00
August	$2,005,511	557	211	472,103	120,292	$16.67	$325.00	July	$396,569	200	124	73,179	52,850	$7.50	$70.00
October	$1,616,314	507	175	397,011	94,899	$17.03	$340.00	September	$411,971	200	146	69,025	50,908	$8.09	$260.00
December	$1,095,409	421	168	283,408	85,091	$12.87	$1,600.00	November	$416,730	199	129	71,286	53,847	$7.74	$130.00
TOTAL	$12,934,277	2,815	1,147	2,191,462	675,777	$19.14	$16,000.00	TOTAL	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
				1992								**1992**			
February	$940,581	342	126	213,469	67,205	$14.00	$210.00	January	$138,165	200	96	72,027	37,840	$3.65	$65.00
April	$331,199	355	109	229,407	58,951	$5.62	$112.00	March	$200,000	200	114	70,294	41,034	$4.88	103.00
June	$425,183	314	86	168,230	37,701	$11.28	$220.00	May	$208,166	200	93	60,687	28,605	$7.28	$230.00

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

section 17, and SE NW section 19, T52N, R68W. The lease is near Minnelusa oil production at Heath Field. Celsius Energy Co. made the sale's second highest per-acre bid of $90 for a 240-acre lease that covers NE and S/2 NW section 28, T51N, R70W. The lease offsets Minnelusa oil production in Mapes Field.

Exploration and development

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

A. Exxon Corp. plans to reenter and directionally drill a well in Road Hollow Field in SE NW section 9, T20N, R119W. The well will be drilled to about 15,500 feet to test the Bighorn Dolomite which produces sour gas at Road Hollow Field. The well was originally completed by Exxon as a 13,705-foot dry hole.

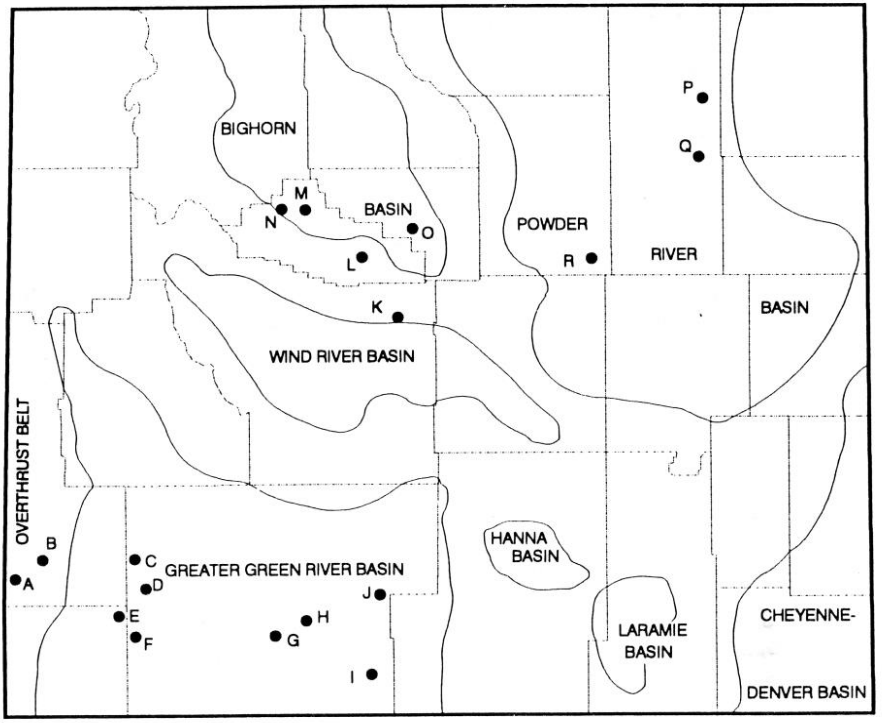


Figure 10. Oil and gas exploration and development activity in Wyoming during the second quarter of 1992 (exclusive of horizontal drilling and coalbed methane activities).

B. Union Pacific Resources also plans to reenter a dry hole in the Overthrust Belt. Plans are to deepen the 9,725-foot dry hole in SE NW section 27, T22N, R117W to 11,500 feet.

C. Union Pacific Resources completed a new producer in Whiskey Buttes Field. The 1 KM-Federal 4-30 well in SW SW section 30, T21N, R111W, produced a daily average of 26 barrels of condensate, 1.6 million cubic feet of gas, and 12 barrels of water during 31 days in March. The well produces from the Frontier and was drilled to 12,175 feet.

D. Washington Energy Exploration completed a new Dakota producer in Fabian Ditch Field. The 1-26-R Federal well in NE SW section 26, T20N, R112W, flowed 11.6 million cubic feet of gas, 28 barrels of condensate, and 24 barrels of water per day from perforations between 12,143 and 12,172 feet.

E. Wexpro Co. completed five new producers in Bruff Field. The 32-2 Pando Federal well in C SE section 32, T18N, R112W, flowed 10.1 million cubic feet of gas per day from perforations in the Dakota between 12,520 and 12,588 feet. The 18 Bruff Unit well in SE SE section 17, T18N, R112W, flowed 2.9 million cubic feet of gas per day from the Frontier between 11,640 and 11,678 feet. The 28-2 Clifton-Federal well in W/2 SE section 28, T18N, R112W, flowed 1.5 million cubic feet of gas per day from the Frontier between 11,874 and 11,912 feet. Wexpro completed the 21 Unit well in SE SE Section 22, T18N, R112W for 2.0 million cubic feet of gas per day from Frontier perforations between 11,858 and 11,908 feet. The 12-2 Hagood-Federal well in NE SE section 12, T18N, R112W, flowed 1.7 million cubic feet of gas per day from the Frontier between 11,698 and 11,770 feet.

F. Wexpro Co. also completed three new wells in Church Buttes Field. The 103 Church Buttes well in SW SW section 22, T17N, R112W, flowed 2.2 million cubic feet of gas per day from the Frontier between 12,140 and 12,190 feet. The 125 Unit well in C SE section 27, T17N, R112W, flowed 2.4 million cubic feet of gas per day from the Dakota between 12,510 and 12,540 feet. The 104 Unit well in C SE section 15, T17N, R112W, flowed 1.4 million cubic feet of gas per day from the Dakota between 12,478 and 12,520 feet.

G. Duncan Energy completed a new Nugget producer in Brady field. The 1-9 UPRC well in SE SW section 9, T17N, R100W, has produced 12,749 barrels of oil and 57,139 barrels of water since its completion in November, 1991. The well was shut-in in February, 1992, after production declined rapidly in both December, 1991, and January, 1992.

H. Texaco Inc. completed the second Frontier well in Table Rock Field. The 22 Table Rock Unit well flowed 725,000 cubic feet of gas and 36 barrels of water per day from the Frontier between 13,942 and 13,970 feet.

I. Celsius Energy completed a new Almond producer in Dripping Rock Field. The 6 Dripping Rock Unit well in SE SE section 17, T14N, R94W, flowed 2.5 million cubic feet of gas and 13 barrels of water per day from an acidized and fractured interval between 12,217 and 12,232 feet.

J. Barrett Resources completed four new Almond producers. The 3-2 North Wamsutter well in SW SW section 9, T20N, R94W, flowed 2.2 million cubic feet of gas, 20 barrels of condensate, and 45 barrels of water per day between 9,927 and 10,085 feet. The 1-16 State-Union Pacific well in NW SW section 16, T20N, R94W, flowed 587,000 cubic feet of gas and 68 barrels of condensate per day between 9,803 and 10,089 feet. Barrett's 5-2 East Wamsutter well in NW SE section 21, T20N, R94W, flowed 1.2 million cubic feet of gas, 73 barrels of condensate, and 121 barrels of water per day from perforations between 9,766 and 10,066 feet. The 6-2 Northeast Echo Springs well in SW SW section 20, T20N, R92W was completed as an Almond gas producer. The well flowed 745,000 cubic feet of gas, 10 barrels of condensate, and three barrels of water per day from perforations between 9,883 and 10,398 feet.

K. The Louisiana Land and Exploration Company's (LL&E's) 3-36 Big Horn well blew out April 22, 1992, while undergoing pressure integrity tests. The fire was extinguished April 30, 1992, by Boots and Coats Inc. with the help of personnel from LL&E, Parker Drilling, and numerous subcontractors. Gas was diverted to sales on May 4, 1992, at a rate of five million cubic feet per day. The gas is probably from the Frontier Formation. The well was approaching total depth of 25,000 feet when the blowout occurred.

L. Daniel C. Wychgram discovered oil in the Phosphoria at the 1-16 Jocelyn Marie well in SE SE section 16, T43N, R94W. The well pumped 27 barrels of oil and 63 barrels of water per day between 1,668 and 1,681 feet.

M. Phillips Petroleum established two new pays in Golden Eagle Field. The 12 Gold Eagle Unit well in NE SW section 12, T45N, R97W, flowed 227 barrels of oil, 10,000 cubic feet of gas, and four barrels of water per day from the Morrison between 7,149 and 7,168 feet. The Phillips' 13 Golden Eagle Unit well in NE SW section 12, T45N, R97W, flowed 407,000 cubic feet of gas per day from the Cody between 3,700 and 3,750 feet.

N. Willard Pease Oil and Gas and National Fuel completed a new oil producer in Enos Creek Field. The 2-SL.U. Sheep well in SW NW section 25, T46N, R100W was completed for 500 barrels of oil per day from two Phosphoria intervals at 6,520 feet and 6,556 feet.

O. Western Production completed a new well in South Fork Field. The T46-24-G South Fork Unit well in NE SW section 24, T46N, R92W, pumped 100 barrels of oil per day from an unreported interval in the Phosphoria. Total depth of the well was 10,260 feet.

P. Lario Oil and Gas and Focus Exploration discovered oil in the Minnelusa at their 1 Ruth Federal well in SE SW section 13, T53N, R70W. The well pumped 322 barrels of oil per day from perforations between 7,457 and 7,462 feet.

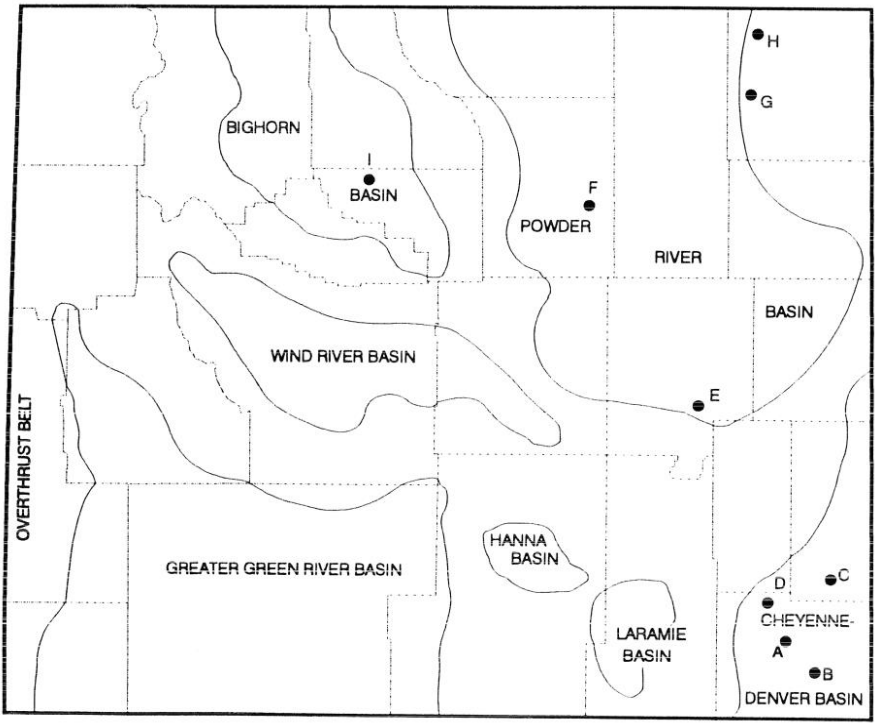
Q. Presidio Exploration Inc. discovered oil in the Minnelusa at the 24-30 Heater well in SE SW section 30, T48N, R71W. The well is reportedly capable of producing 150 barrels of oil per day from an undisclosed interval. The well was scheduled as a 10,550-foot test.

R. General Atlantic Resources discovered oil and gas at the 25-1-A Bozeman-Federal well in NE NE section 25, T42N, R77W. The well pumped 85 barrels of oil and 160,000 cubic feet of gas per day through perforations in the Frontier at approximately 12,182 feet.

Horizontal drilling

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

A. Horizontal drilling in the Niobrara is still fairly active in and around Silo Field. Union Pacific Resources completed the IH McConnaughey 41-27 well at a surface location in NE NE section 27, T16N, R65W. The well flowed 318 barrels of oil, 125,000 cubic feet of gas, and 26 barrels of water per day. True vertical depth is 8,578 feet. Union Pacific Resources also completed the 1H Dino-State well at a surface location in SW NW section 8, T15N, R64W. The



GEOLOGICAL SURVEY OF WYOMING, 1992

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

well flowed 292 barrels of oil and 114,000 cubic feet of gas per day. The true vertical depth of the well was not reported. Union Pacific Resources also reached total depth at the 1H Lemaster-State 12-32 well from a surface location in SW NW section 32, T16N, R64W. The well was scheduled for a total vertical depth of 7,950 feet. No completion details are available. Union Pacific Resources also staked a location for the 1H Epler-State 12-36 well at a surface location in SW NW section 36, T16N, R65W and reached a true vertical depth of 8,945 feet at the 1H Berry 41-13 well at a surface location in NE NE section 13, T16N, R66W. Gerrity Oil and Gas staked a location for the 25-13H Epler well at a surface location in SW SW section 25, T16N, R65W. Wilshire Oil of Texas completed an apparent discovery at the 1-26H McConnaughey well at a surface location in C NE section 26, T16N, R65W. Completion details are not yet available. Exxon Corp. began drilling the 1H Epler B well from a surface location in SW SW section 30, T16N, R64W.

B. Newport Exploration Inc. completed the 42-13 M Lazy M well as a 7,294-foot dry hole. The well tested the Niobrara from a surface location in SE NE section 13, T14N, R62W. In the same area, Union Pacific Resources began drilling a Niobrara test from a surface location in NW NE section 17, T15N, R61W. The projected true vertical depth of the 1-H Pence Ranch 5E-17 well is 7,042 feet.

C. Petro-Hunt Corp. completed the 1-18 Mitchell well as a dry hole. The well was projected as a Niobrara test drilled to a true vertical depth of 6,970 feet from a surface location in NE NE section 18, T23N, R62W.

D. Union Pacific Resources completed the 1H Schannaman-State 12-10 well as a dry hole. The Niobrara test was drilled from a surface location in SW NW section 10, T19N, R68W.

E. Amoco production began drilling the 1-25H Morton Ranch from a surface location in SW SW section 25, T33N, R72W. The well is scheduled for a true vertical depth of 11,667 feet and will test the Niobrara and Frontier.

F. Meridian began drilling the 12-32 HR Ethyl Draw well to test the Frontier. The well will be drilled to a true vertical depth of 11,813 feet from a surface location in SW NE section 32, T46N, R78W.

G. L & J Operating and Hancock Enterprises completed the 1-H Berger well in the Minnelusa. The well flowed 283 barrels of oil per day and was drilled from a surface location in SW SW section 17, T53N, R67W to a true vertical depth of 6,072 feet.

H. Petrorep Inc. reported that three horizontally drilled wells that tested the Muddy are all producing oil at rates of around 100 barrels per day. The three wells are the 19 H Signal Hill-F.A. Bush drilled from a surface location in SE NW section 11, T57N, R67W; the 20 H Signal Hill-F.A. Bush drilled from a surface location in SE NW section 11, T57N, R67W; and the 21 H Signal Hill-

Beltz drilled from a surface location in NW NE section 11, T57N, R67W. The true vertical depths for the wells are not available.

I. Union Pacific Resources reached true vertical depth of 10,480 feet at their 1 H Bass-Federal 33-24 Phosphoria test, drilled from a surface location in NW SE section 24, T48N, R92 W.

Coalbed methane

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

A. A draft Environmental Impact Statement was released in June, 1992, for Metfuel's proposal to drill up to 130 coalbed methane wells. These wells will test the coals in the Hanna Formation in the Hanna Basin. The preferred alternative is to allow up to 130 wells on 160-acre spacing.

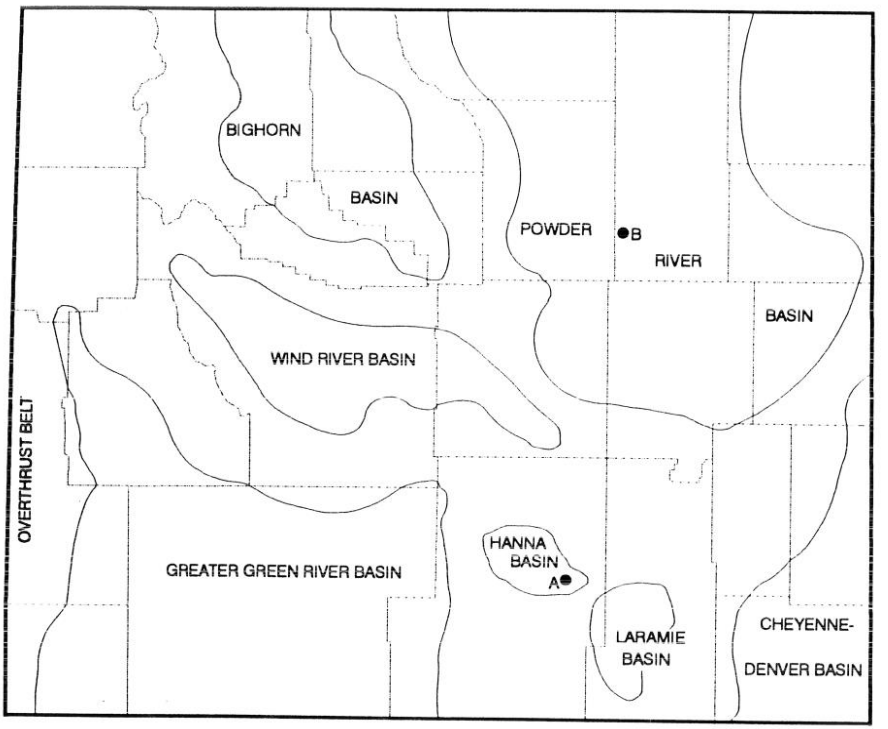


Figure 12. Coalbed methane activity in Wyoming during the second quarter of 1992.

B. Exxon Corp. staked three Fort Union coalbed methane locations in the center of Hartzog Draw Field. The locations are in sections 19, 31, and 33, T45N, R75W.

Reference cited

Petroleum Information, 1992, Wyoming oil and gas production report for December 1991: Petroleum Information, Houston, Texas, 1,948 p.

COAL UPDATE

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

Coal deliveries for the first four months of 1992 indicate that about two million tons less coal were shipped from Wyoming mines than during the same period a year ago (Table 5). Many utilities cut back their coal deliveries in February, March, and April (Figure 13) as the unusually mild winter left large amounts of stockpiled coal. Although it is too early to see any trends developing in these first four months, it is possible that our projected production increase for 1992 (Table 6) may not occur. The mild spring and an unusually cool summer, coupled with a short railroad strike, could result in less coal being burned and less coal delivered.

Recently available data on the distribution and utilization of coal produced in 1991 (Energy Information Administration, 1992) indicates that Wyoming coal was used in 32 different states and four other nations (Figure 14). Texas continued as the largest consumer of Wyoming coal in 1992, followed by Wyoming, Oklahoma, Iowa, Kansas, and Arkansas. Eight states each consumed more than 10 million tons in 1992 and five states consumed more than half of Wyoming's coal. While ten states consumed over 80 percent of Wyoming's coal in 1990, eight states consumed almost 80 percent of the State's coal in 1991.

In 1991, electric utility companies located in 25 states and four other countries used 97.4 percent of Wyoming's total coal production to fuel steam-electric generating plants (Figure 15) (Energy Information Administration, 1992). About one million tons of coal were exported to foreign utility companies, 4.9 million tons were burned in industrial boilers in 18 different states, and about 0.2 million tons of Wyoming coal were used for residential/commercial heating in 10 different states. About 1.8 million tons of the 5.1 million tons used in the "industrial" and "residential/commercial" categories went to Wyoming coal users, mostly other mineral-related industries. Four of the five trona plants in southwestern Wyoming used coal to generate steam for use in their refining process and in some cases, to produce electricity (cogeneration); many of the State's bentonite plants used coal in their refining process (Figure 16). Additional coal was used in FMC

Table 5. Coal deliveries by month from Wyoming mines[1].

	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE	1990 MONTHLY	1990 CUMULATIVE	1991 MONTHLY	1991 CUMULATIVE	1992 MONTHLY	1992 CUMULATIVE
JANUARY	10,976,860	10,976,860	14,283,020	14,283,020	15,059,530	15,059,530	14,960,450	14,960,450	16,407,150	16,407,150
FEBRUARY	11,431,380	22,408,240	11,488,140	25,771,160	13,328,290	28,387,820	15,480,110	30,440,560	14,586,480	30,993,630
MARCH	12,871,090	35,279,330	14,124,330	39,895,490	14,535,270	42,923,090	16,278,870	46,719,430	14,429,650	45,423,280
APRIL	12,694,660	47,973,990	13,489,450	53,384,940	14,155,470	57,078,560	14,820,240	61,539,670	14,063,060	59,486,340
MAY	12,017,500	59,991,490	13,149,170	66,534,110	13,882,590	70,961,150	14,589,790	76,129,460		
JUNE	12,595,480	72,586,970	12,948,350	79,482,460	13,649,070	84,610,220	14,007,600	90,137,060		
JULY	13,905,670	86,492,640	14,043,350	93,525,810	15,368,280	99,978,500	16,451,090	106,588,150		
AUGUST	15,041,090	101,533,730	15,428,210	108,954,020	16,046,910	116,025,410	15,940,620	122,528,770		
SEPTEMBER	13,433,610	114,967,340	13,795,760	122,749,780	15,166,020	131,191,430	15,314,490	137,843,260		
OCTOBER	13,696,190	128,663,530	14,523,480	137,273,260	15,244,760	146,436,190	14,810,510	152,653,770		
NOVEMBER	13,889,890	142,553,420	14,507,130	151,780,390	15,569,280	162,005,470	14,783,000	167,436,770		
DECEMBER	14,540,510	157,093,930	13,527,880	165,308,270	14,479,970	176,485,440	16,716,630	184,153,400		
TOTAL TONNAGE REPORTED		157,093,930		165,308,270		176,485,440		184,153,400		
TOTAL TONNAGE NOT REPORTED		6,494,270		5,831,734		7,521,261		9,710,406		
TOTAL TONNAGE PRODUCED[2]		163,588,200		171,140,004		184,006,701		193,863,806		

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

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

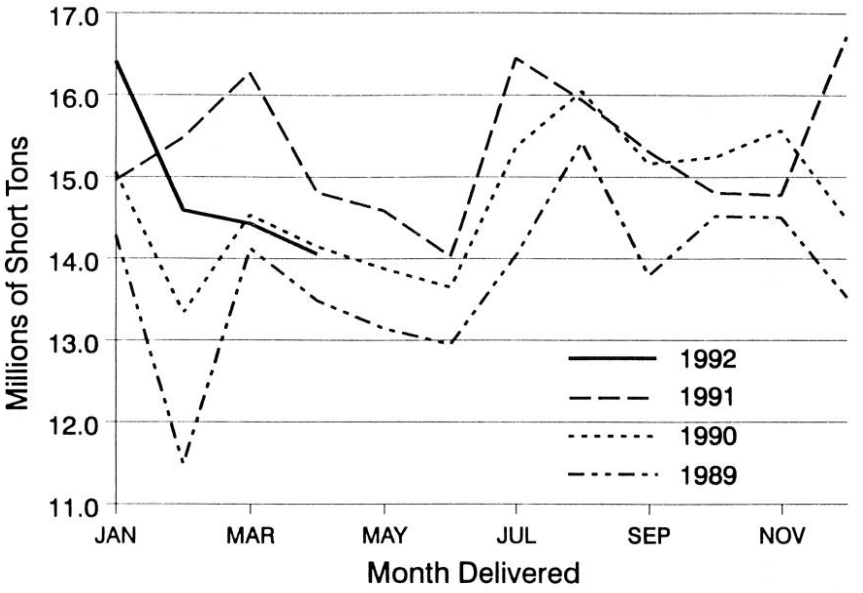


Figure 13. Reported deliveries from Wyoming coal mines *(from COALDAT Marketing Report by Resource Data International, Inc. compiled from FERC Form 423 filed monthly by electric utilities).*

Wyoming Corporation's synthetic coke plant in Lincoln County and in a sugar beet processing plant in Goshen County.

About 87 percent of Wyoming's coal was shipped out of the State in 1991, including the one million tons that was exported. Ironically, 138,500 tons of coal used in Wyoming was imported from Colorado, Montana, Utah, and Pennsylvania. Most of this coal was used in industrial purposes. In many cases, this imported coal is used in Wyoming because it is the closest coal available for the lowest price. In other cases, the imported coal had specific properties or characteristics not presently available in Wyoming.

According to the Energy Information Administration (1992) and the Wyoming Department of Transportation, transportation of Wyoming coal in 1991 (Figure 17) was primarily by railroads (87 percent); coal transported by barge (or ship) on rivers, lakes, or the ocean refers to coal that reached its final destination by barge (or ship) after originating on a railroad. The 180.7 million tons transported by rail in 1991 is 12 million tons (7 percent) greater than the 168.7 million tons transported in 1990.

Burlington Northern (BN) dominates railroad haulage of Wyoming coal; the company's 109.2 million tons of coal accounted for about 60 percent of all coal shipped by rail. The amount of coal transported by BN in 1991 only increased by 1.1 percent (1.2 million tons) over 1990's tonnage; BN's 60 percent share of the

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

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

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

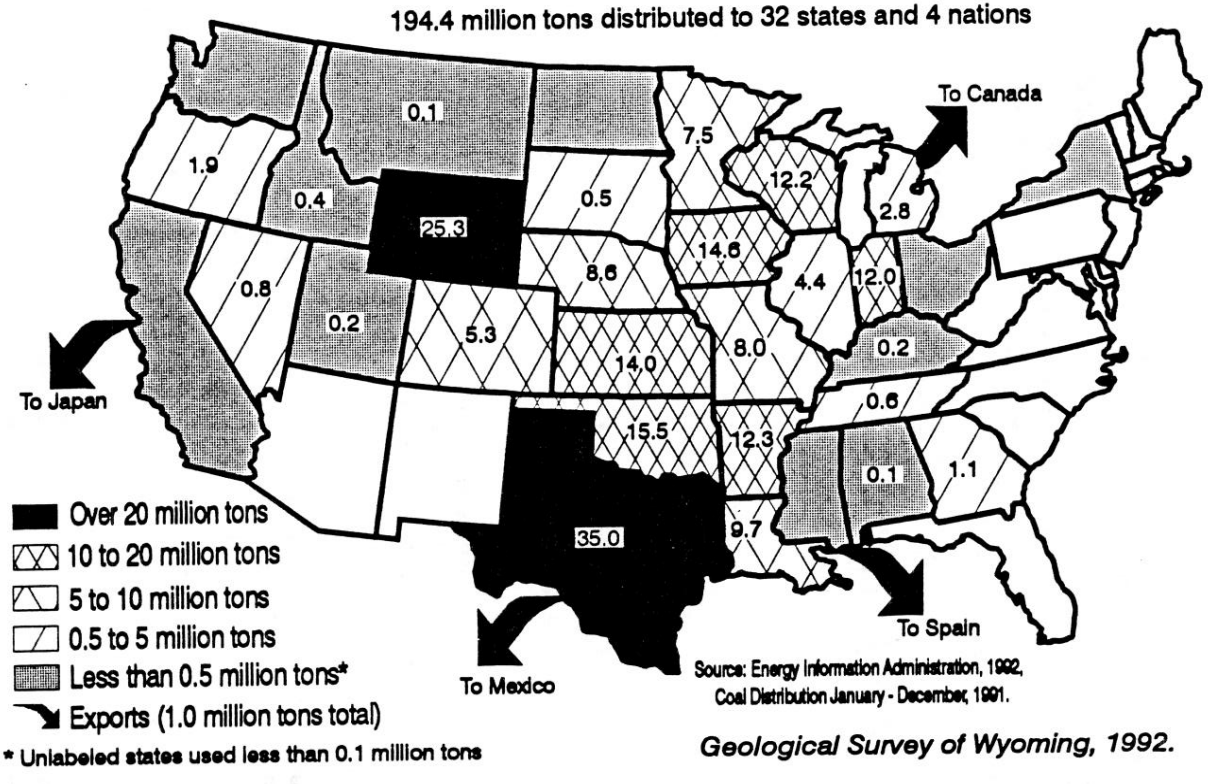
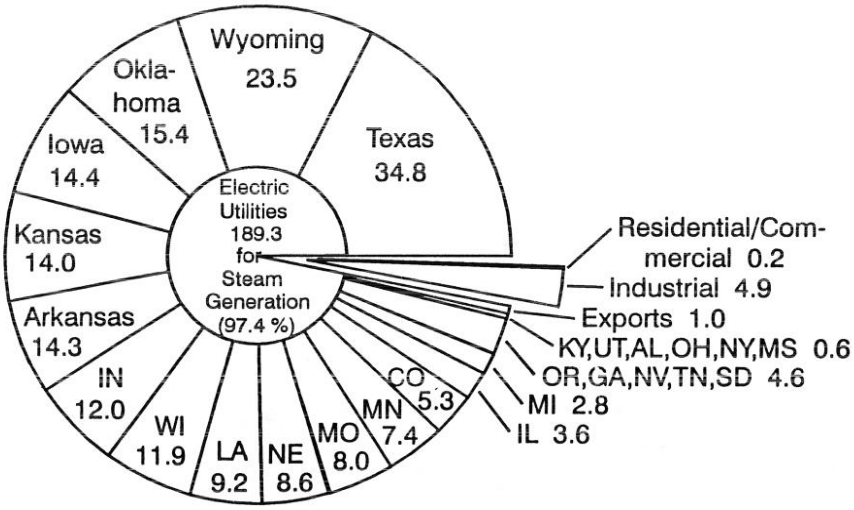


Figure 14. Distribution of Wyoming coal in 1991 in millions of tons. *(Note: The Energy Information Administration's (1992) report shows 0.5 million tons more coal was shipped in 1991 than what the State Inspector of Mines shows. This is a function of independent rounding as well as the timing of shipments).*



Geological Survey of Wyoming, 1992

Figure 15. Utilization of Wyoming coal in 1991 in millions of tons. *(Note: The Energy Information Administration's (1992) report shows 0.5 million tons more coal was shipped in 1991 than what the State Inspector of Mines shows. This is a function of independent rounding as well as the timing of shipments).*

State's total coal carried by rail in 1991 was also less than the 64 percent share that BN carried in 1990. Coal shipments on BN are from coal mines in the Powder River Coal Field and exit the field (and the State) to the east, south, and north (Figure 16).

Western Railroad Properties, Inc. (WRPI), which reports tonnages carried by the Chicago and North Western Transportation Company [a C&NW/Union Pacific (UP) joint-venture railroad out of the Powder River Coal Field] carried 10.7 million tons (22 percent) more coal in 1991 than in 1990; WRPI's share of the total coal haulage in Wyoming also increased from 29 percent in 1990 to 33 percent in 1991.

Southern Wyoming coal fields are served by UP (Figure 16). The 9.8 million tons hauled by UP in 1991 was the same amount hauled in 1990; however, UP's share of the total coal hauled by railroads dropped from 6% in 1990 to 5% in 1991.

Pacific Power and Light Company's (PP&L's) private railroad line between Glenrock Coal Company's mine and the Dave Johnston power plant in Converse County hauled 2.8 million tons of coal in 1991.

The increased tonnages of coal hauled out of the Powder River Coal Field each year since 1983 have almost been matched by a corresponding increase in the amount of coal transported by the C&NW/UP joint-venture ("WRPI" on Figure 18). From 1987 to 1990, BN showed a greater growth in tonnages hauled than did WRPI. But in 1991, WRPI and the joint-venture railroad increased more than

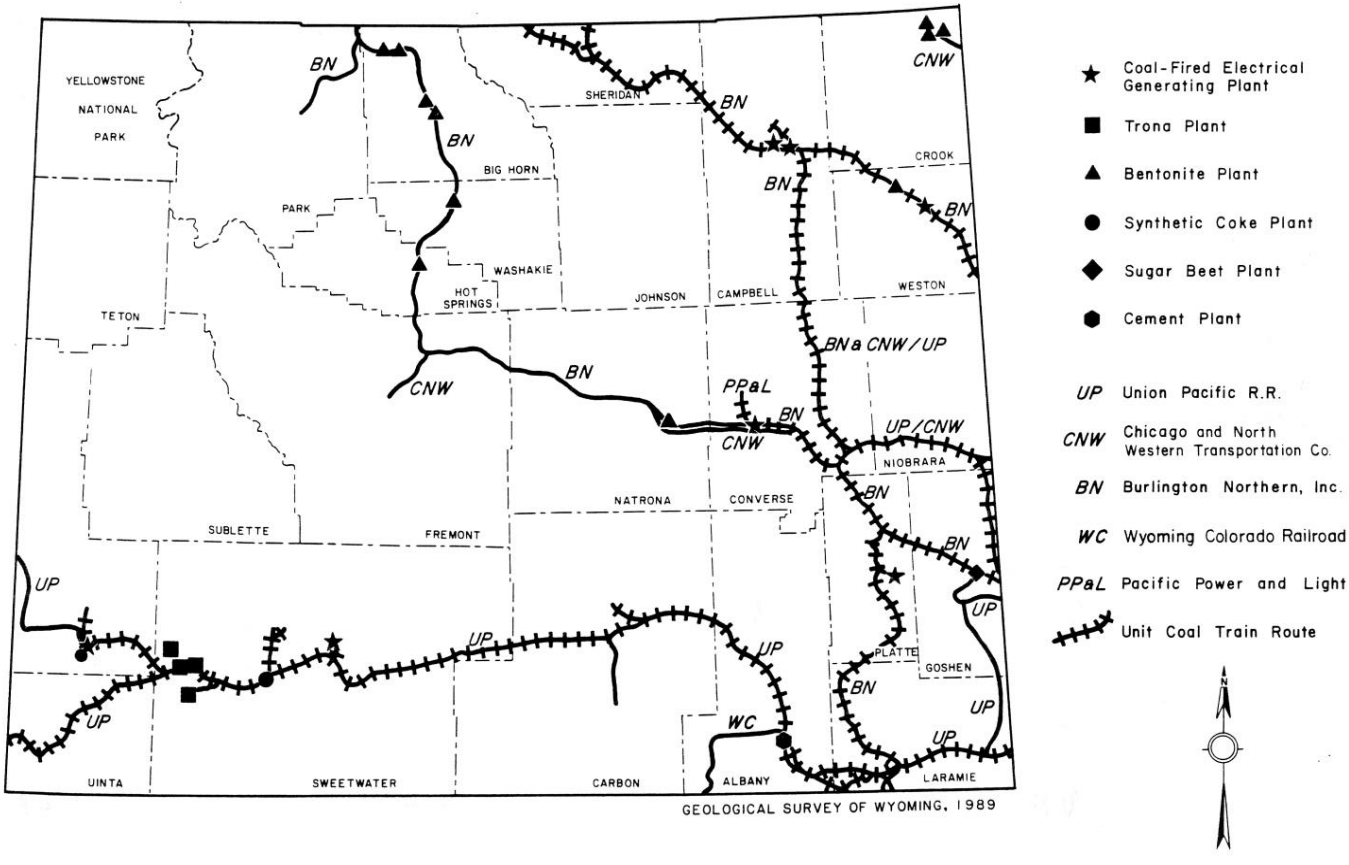


Figure 16. Railroad routes and major coal users in Wyoming.

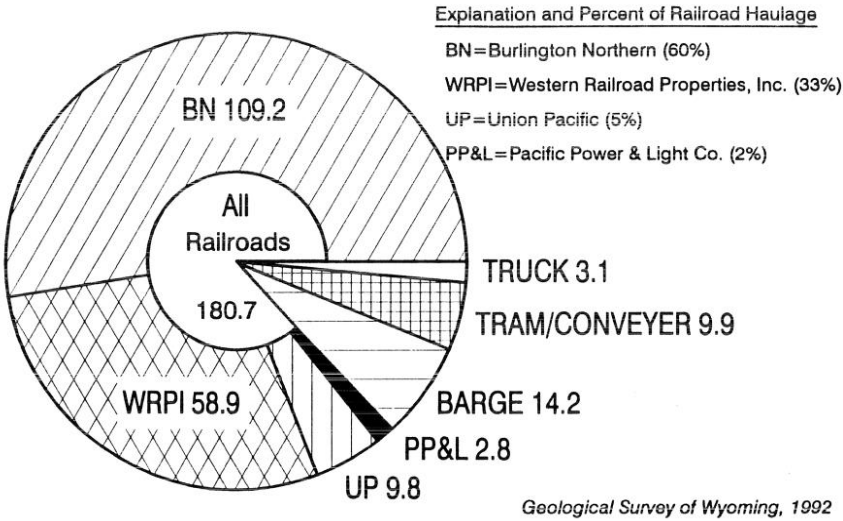


Figure 17. Transportation of Wyoming coal in 1991 in millions of tons *(Note: Compiled from Energy Information Administration (1992) and Annual Reports of railroads to the Wyoming Department of Transportation).*

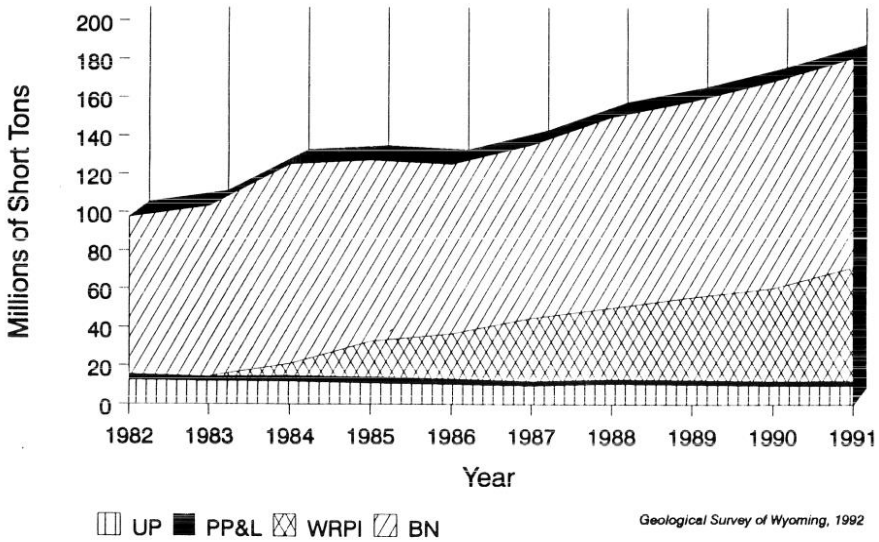


Figure 18. Transportation of Wyoming coal by railroad, 1982 to 1991. *(Note: Compiled from Annual Reports of railroads to the Wyoming Department of Transportation, 1982 through 1991. See Figure 17 for explanation of abbreviations).*

BN. Coal tonnages hauled from southern Wyoming mines have shown little or no increase in recent years, which reflects a plateau in coal production from southern Wyoming coal fields.

Developments in western and southwestern Wyoming

Utah Power and Light Company (UP&L), a subsidiary of Pacificorp and operator of the Naughton power plant, and Pittsburg and Midway Coal Mining Company (P&M), the coal supplier to Naughton, continued to negotiate their coal contract during the second quarter. Because there was some progress made in the negotiations between the two parties, oral presentations to an arbitration panel (which was to make the final ruling on the contract) were postponed in early July.

Bridger Coal Company is constructing a new conveyor system at their surface mine northeast of Rock Springs. This will be the second conveyor system installed at the mine. It should be operational later this year. The first conveyor was installed several years ago between the coal mine and the Jim Bridger power plant. The new conveyor should save much of the coal hauling that is currently done by truck.

Black Butte Coal Company is still developing its recently-acquired Leucite Hills property, which is located some 13 miles north of the rest of the Black Butte mine. In June, Black Butte moved a large overburden shovel into the Leucite Hills area from the main Black Butte mine. The new overburden shovel will help expand production of Almond Formation coals at the Leucite Hills property.

Developments in the Hanna Coal Field

Cyprus Shoshone Coal Company's Shoshone No. 1 coal mine north of Hanna, which was the largest underground coal mine in Wyoming last year, is also reportedly the largest longwall coal mining operation in the country. With their newly installed longwall shearing machine (*Wyoming Geo-notes No. 28*, p. 24), nearly 15 feet of coal is recovered with a single pass down the longwall. This also makes their productivity per miner very high, and accounts in part for the more than 2.0 million tons of coal produced from the mine last year. About 1.3 million tons of Cyprus Shoshone's production was sold under a long term contract to Northern Indiana Public Service Company (NIPSCO); the other 0.7 million tons of coal was sold on the spot market.

Developments in the Powder River Coal Field

The recent sale of the Caballo Rojo mine to Marigold Land Company (*Wyoming Geo-notes No. 33*, p. 24-25) late last year has evidently spawned the sale of another coal mine and mining company and the possible sale of yet another mine. Zeigler Coal Holding Company of Fairview Heights, Illinois, signed a letter of intent to acquire Shell Mining Company, a coal mining subsidiary of Shell Oil Company. As part of the acquisition, Zeigler would take ownership of Triton Coal Company, a mining subsidiary of Shell Mining Company and operator of the Buckskin mine north of Gillette; the Encoal clean coal demonstration plant under

construction at Buckskin; and the North Rochelle property, which is currently under development in southern Campbell County. With expected completion of the transaction in October of this year, Zeigler could become the fourth largest coal producing company in the United States. According to the National Coal Association, in 1990, Zeigler was the 16th largest coal-producing company in the U.S. and Shell Mining was the 8th largest.

Exxon Coal and Minerals USA, owner of the coal mining affiliate Carter Mining Company, has retained an investment banking company to discuss the possible sale of Carter's Rawhide mine. Exxon is reportedly appraising the value of the Rawhide mine and has neither made a decision to sell the mine nor has it received any offers for the mine. However, Exxon did say that they would sell the mine if they received a good enough offer. In 1991, the Rawhide mine produced about 11.8 million tons of coal and employed 194 people. This large surface mine north of Gillette began coal production in 1977 and has produced a total of 124 million tons of coal through 1991.

The highly competitive market for coal from the Powder River Coal Field is forcing the coal producers to become even more productive and efficient in all phases of mining and reclamation. Another round of new developments in equipment and mining techniques has begun at many of the coal mines. These developments are related to increased thicknesses of overburden, increased haulage distances for both coal and overburden, and demand for increased coal production. The following paragraphs briefly describe some of these developments.

Wyodak Resources Development Corporation is spending $26 million to expand their mining operation at Wyodak. In addition to installing two in-pit crushers and an overland conveyor system to the north end of the Wyodak property (the Peerless pit north of the power plant), two 5,000-ton coal blending silos will be constructed. Wyodak is also purchasing a new coal-loading shovel and three 150-ton coal/overburden haulers.

Carter Mining Company is completing the construction and installation of a bucket wheel excavator and overburden spreader at its Caballo mine south of Gillette. This machine is reportedly the largest compact bucket wheel excavator in the world and will be the first of its kind to operate in Wyoming. The excavator alone is 55 feet tall and weighs 2.7 million pounds. It will remove the uppermost of three overburden benches at Caballo. About 12,000 feet of mobil transfer conveyors will transport the overburden to a spreader unit. The spreader unit stands 110 feet tall, contains a 200-foot long discharge boom, and weighs 2 million pounds. Carter Mining Company purchased the machine from the Lower Colorado River Authority, which originally purchased the machine for operation at a lignite mine in Texas. Carter plans to have the machine operational by October, 1992.

Cordero Mining Company's Cordero mine and Marigold Land Company's Caballo Rojo mine are both constructing large draglines for overburden removal. Cordero plans to have their new equipment working by October, 1992. Caballo

Rojo is in the process of moving their new dragline from Alabama, where it was previously used by Drummond Company (parent company of Marigold and Caballo Rojo, Inc.). Caballo Rojo plans to have the new equipment stripping overburden by 1994. The dragline is one of the world's largest, with a bucket capacity of 135 cubic yards.

Thunder Basin Coal Company is currently completing construction of the mine's third dragline for use in removing overburden. The new dragline, which should be in operation by December of this year, will be the third largest dragline in the world, with a bucket capacity of 160 cubic yards. This dragline has a 360-foot long boom, weighs about 15 million pounds, and contains fourteen 700-horsepower motors.

Powder River Coal Company, a subsidiary of Peabody Holding Company, recently completed construction of a new coal silo and belt line at the Rochelle mine in southern Campbell County. This new silo will increase Rochelle's coal handling capacity from the present 12 million tons to 22 million tons per year. This year, Rochelle Coal Company will also add four 240-ton haul trucks, a new overburden drill, and a 56-cubic-yard overburden-stripping shovel. Powder River Coal Company's nearby North Antelope mine was one of the first large coal mines in the Powder River Coal Field to employ a large dragline for overburden removal.

Coal contracts - Powder River Coal Field

Coal purchasing activities during the second quarter of 1992 consisted of new contracts and spot purchases as well as numerous purchases of coal for test burns. The letters preceding the discussion below refer to locations on Figure 19.

A) Amax Coal Company's Belle Ayr mine will furnish 50,000 tons of coal to Pacific Power and Light Company's (a division of Pacificorp) Dave Johnston power plant near Glenrock. The coal will be delivered from July through December, 1992.

B) Amax Coal Company will supply some spot coal from the Belle Ayr and Eagle Butte mines to partially fill the need of West Texas Utilities' Oklaunion, Texas, power plant during the second half of 1992. The total need is 0.5 million tons.

C) Caballo Rojo, Inc.'s Caballo Rojo mine will supply the other part of the 0.5 million tons of spot coal needed by West Texas Utilities' Oklaunion, Texas, power plant. The coal will be delivered during the second half of 1992.

D) Amax Coal Company's Eagle Butte or Belle Ayr mines will supply 0.8 million tons of coal to Omaha Public Power District's Nebraska City (D on Figure 19) or North Omaha (E on Figure 19), Nebraska, power plants. The coal will be supplied from April through December, 1992. Deliveries through June of this year were all from the Eagle Butte mine and went only to the Nebraska City plant.

E) Amax Coal Company can supply Omaha Public Power District's North Omaha plant with coal from either the Eagle Butte or the Belle Ayr mine during the last

Figure 19. Index map of coal contracts and sales activities involving Wyoming coal mines during the second quarter of 1992.

three quarters of 1992, but through June, no deliveries from Amax had been made to this plant. An optional 100,000 tons of coal may also be delivered.

F) Triton Coal Company's Buckskin mine will supply from 0.3 to 0.5 million tons of coal to Iowa Southern Utility Company's Ottumwa, Iowa, power plant. If a test burn of the first 55,000 tons is successful, the remainder of the coal will be delivered via BN during the last half of 1992.

G) An unspecified coal supplier from this coal field supplied 50,000 tons of spot coal to Consumers Power Company of Jackson, Mississippi. The plant or plants that used this coal were not announced.

H) Rochelle Coal Company (a subsidiary of Peabody Holding Company's Powder River Coal Company) will supply 77,000 tons of spot coal to Wisconsin Power and Light Company's Edgewater Units 3 and 4 in Wisconsin during the second and third quarters of 1992. The coal will be mined at the Rochelle mine.

I) Rochelle Coal Company's Rochelle mine will supply Wisconsin Power and Light Company's Edgewater Unit 5 in Wisconsin with 145,000 to 235,000 tons of coal during the second half of 1992. The coal will be transported by the C&NW/UP joint venture railroad, then UP, and finally by C&NW.

J) In May, Nerco Coal Company's Antelope mine supplied 55,000 tons of spot coal to Northern Indiana Public Service Company's (NIPSCO's) Dean H. Mitchell, Indiana, power plant.

K) Caballo Rojo, Inc. supplied a total of 88,000 tons of spot coal from the Caballo Rojo mine to NIPSCO's Mitchell, Indiana, power plant during June and July, 1992.

L) Amax Coal Company's Belle Ayr mine also supplied NIPSCO's Mitchell plant with 33,00 tons of spot coal in July, 1992.

M) In August, Rochelle Coal Company's Rochelle mine will supply 2,000 tons of test coal to Tacoma Public Utility Company's newly refurbished 50-megawatt generating plant in Washington.

N) Amax Coal Company's Eagle Butte mine will supply an unspecified amount of test coal to West Texas Utilities' Oklaunion, Texas, power plant. The test coal is part of the 0.5 million ton spot sale discussed in item B above.

O) Cordero Mining Company's Cordero mine and Thunder Basin Coal Company's Black Thunder mine will supply a total of 0.2 to 0.3 million tons of coal for testing at Minneapolis Power and Light Company's Boswell, Minnesota, power plant. Exactly how much coal will come from each mine was not announced. The test burns, which will occur this summer, are in anticipation of a possible contract that calls for deliveries of 3.0 million tons of coal per year over a five- or ten-year period.

P) Triton Coal Company's Buckskin mine provided about 55,000 tons of test coal to Iowa Southern Utility Company's Ottumwa, Iowa, power plant. It the test burn is successful, the utility will purchase additional coal under a short term contract (see discussion under F, above).

Q) An unnamed producer(s) from the Powder River Coal Field provided a total of 20,000 tons of test coal in two 10,000-ton shipments to Muscatine (Iowa) Power and Light Company in May and June of this year.

R) Caballo Rojo, Inc. supplied an unspecified amount of coal to Iowa Electric Light and Power Company's Sixth Street, Iowa, generating plant. The coal is being tested in a blend with 20 percent petroleum coke from a refinery in Minnesota.

S) Carter Mining Company's Caballo mine supplied 26,000 tons of test coal to Wisconsin Electric Power Company's Presque Isle, Wisconsin, power plant. The coal was hauled by rail to Superior, Minnesota, where it was loaded on barges and then shipped to Presque Isle on Lake Superior.

T) Unspecified coal suppliers from the Powder River Coal Field will supply 30,000 to 40,000 tons of test coal to Commonwealth Edison's Fisk, Illinois, power plant. The tests are scheduled for this summer.

U) Unspecified coal suppliers from this coal field are also supplying from 30,000 to 40,000 tons of coal for testing this summer at Commonwealth Edison's Joliet, Illinois, power plant.

V) During May and June, Rochelle Coal Company supplied 65,000 tons of test coal from the Rochelle mine to Indiana-Kentucky Electric Cooperative's Clifty Creek, Indiana, power station. The coal is being blended with 30 percent eastern high-sulfur coal.

W) An unspecified coal supplier from the Powder River Coal Field shipped test coal to LaForge Cement Corporation's Alpena, Michigan, cement plant. The coal was blended with petroleum coke.

X) Powder River Coal Company supplied about 11,000 tons of test coal to Ohio Edison's Burger, Ohio, generating plant. The coal was from either the North Antelope or the Rochelle mine and was hauled by Burlington Northern. The coal is being blended in various amounts (from 30 to 50 percent) with eastern high-sulfur coals.

Y) An unspecified coal producer in this coal field supplied a unit train (11,000 tons) of test coal to Tampa Electric Company's generating plant near Tampa, Florida.

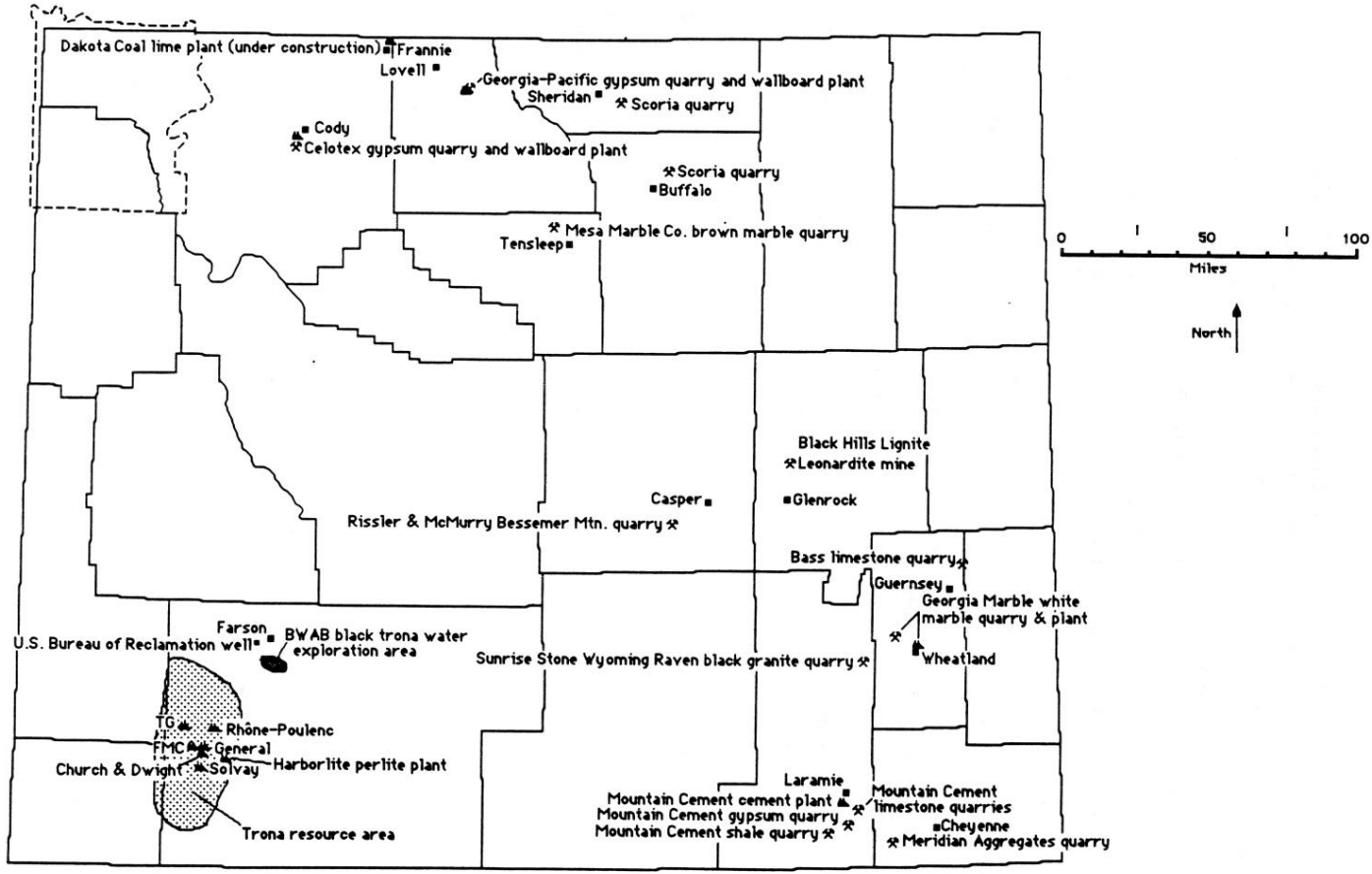
INDUSTRIAL MINERALS, CONSTRUCTION MATERIALS, AND URANIUM UPDATE

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

Aggregate (construction)

The production of construction aggregate in the United States in 1991 was 2.2% greater than in 1990, according to the U.S. Bureau of Mines (Tepordei, 1992). Wyoming's State Inspector of Mines reported that 5,889,471 short tons of sand and gravel, 2,148,920 short tons of crushed granitic gneiss (including railroad ballast), 533,300 short tons of crushed limestone, and 45,277 short tons of crushed scoria (clinker or baked and fused rock) were produced in Wyoming in 1991 for a total of 8,616,968 short tons of construction aggregate (Hannum, 1992). This is an increase over the 7,729,529 short tons produced in 1990 (Hannum, 1992). The largest construction aggregate producer in Wyoming is Meridian Aggregates, which operates a railroad ballast and construction aggregate quarry in Precambrian granitic gneiss 25 miles west of Cheyenne in Laramie County (Figure 20).

The production of construction aggregate is expected to decrease in Wyoming in 1992 and 1993 due to a decline in highway construction. According to the


Dakota Coal lime plant (under construction)
Frannie
Lovell
Georgia-Pacific gypsum quarry and wallboard plant
Sheridan
Scoria quarry
Cody
Celotex gypsum quarry and wallboard plant
Scoria quarry
Buffalo
Mesa Marble Co. brown marble quarry
Tensleep
0
50
100
Miles
North
Black Hills Lignite
Leonardite mine
Casper
Glenrock
Rissler & McMurry Bessemer Mtn. quarry
Bass limestone quarry
Guernsey
Georgia Marble white marble quarry & plant
Wheatland
Farson
BWAB black trona water exploration area
U.S. Bureau of Reclamation well
Sunrise Stone Wyoming Raven black granite quarry
TG
Rhône-Poulenc
FMC
General
Church & Dwight
Solvay
Harborlite perlite plant
Trona resource area
Laramie
Mountain Cement cement plant
Mountain Cement gypsum quarry
Mountain Cement shale quarry
Mountain Cement limestone quarries
Cheyenne
Meridian Aggregates quarry

Wyoming Department of Transportation, approximately $135,000,000 may be spent on highway construction in the 1993 Federal fiscal year (Ffy) (October, 1992 - October, 1993), down from $171,600,000 in Ffy 1992 and $172,800,000 in Ffy 1991. Increased production of aggregate at the Meridian quarry for non-highway construction projects such as the Denver airport should slightly offset the decrease due to the downturn in highway construction.

Rissler & McMurry Co. (R&M) continues to encounter opposition to the expansion of its limestone aggregate quarry in the Triassic Alcova Limestone at Bessemer Mountain, west of Casper (Figure 20). R&M had applied for a small mining permit from the Wyoming Department of Environmental Quality. In April, the Wyoming Environmental Quality Council approved a designation of a rare or uncommon environment for an area including the limestone quarry. If the designation is upheld, the company's new permit application may be rejected. In this case, the company might have to cease operations when the current ten-acre mining permit expires. Meanwhile, R&M is trying to acquire limestone resources in the vicinity of Jackson Canyon, also west of Casper. The U.S. Bureau of Land Management (BLM) has decided to pursue a land exchange in this area with the State of Wyoming. If the exchange is made, R&M could apply for a State lease and mining permits on the exchanged State land.

Bentonite

Bentonite production in Wyoming was 2,415,036 short tons in 1991, which is almost identical to the 2,425,307 short tons produced in 1990 (Hannum, 1991 and 1992). Most of this production went to non-drilling mud uses (especially as binders for foundry sands and barriers for waste isolation). 1992 production should show a slight increase over 1991 due to a continued increase in non-drilling mud uses of bentonite.

Cement

The State Inspector of Mines also reported that Mountain Cement's Laramie plant (Figure 20) produced 396,788 short tons of cement in 1991, up from 349,608 short tons in 1990 (Hannum, 1991 and 1992). Cement production at Laramie should increase slightly in 1992 due to an increase in demand for cement in the Denver area. Because the plant is operating near capacity, any increase most probably will come from streamlining plant operating procedures. Mountain Cement uses limestone from the Permian-Pennsylvanian Casper Formation, gypsum from the Triassic Chugwater Formation, and shale from the Cretaceous Mowry and Thermopolis Formations.

A spokesman for Mountain Cement's parent company, Centex Corporation, said the company may continue to develop plans to burn hazardous waste in the Laramie plant if it can convince the public that the burning is safe. The company has been given permission to burn hazardous waste at a cement plant in northern Illinois.

Decorative stone

Sunrise Stone continues to produce black granite (petrologically an amphibolite) at its Wyoming Raven quarry in northern Albany County (Figure 20). In the second quarter of 1992, most of this production was limited to monument blocks shipped to two South Dakota stone fabricators. Monument stone is fabricated into tombstones, memorials, historic monuments, and similar products.

Mesa Marble Co., of Powell, Wyoming, is quarrying small amounts of brown marble from an unnamed Triassic unit in the Chugwater Group near Tensleep, in Washakie County (Figure 20). This decorative stone is used in trim, flagstone, and landscape rock. Some rock products have been shipped to New York, and were featured in an article on page 41 of the March 1992 issue of *Dimensional Stone*.

Wyoming was also featured in an article on pages 22-28 of the May 1992 issue of *Stone in America*. The article concluded that Wyoming could become an important producer of dimensional granite and marble due to the variety of stone found in the State. Sunrise Stone's Wyoming Raven quarry was also featured in the article.

Production of white marble aggregate at Georgia Marble's quarry and processing plant at Wheatland (Figure 20) increased from 61,086 short tons in 1990 to 69,685 short tons in 1991 (Hannum, 1991 and 1992). In addition, 15,000 tons of scoria (clinker or baked and fused rock) were produced near Buffalo and Sheridan for landscape rock and other decorative products (Figure 20).

Gypsum

Gypsum production in Wyoming decreased slightly from 436,367 short tons produced in 1990 to 419,584 short tons produced in 1991 (Hannum, 1991 and 1992). Production decreased at Georgia-Pacific's wallboard plant near Lovell and at Celotex's wallboard plant at Cody, while increasing a little at Mountain Cement's cement plant at Laramie. Since the wallboard plants are operating near capacity, 1992 production should be near the amounts produced in 1990 and 1991.

Leonardite

According to Hannum (1991 and 1992), Black Hills Lignite increased the production of leonardite from its Glenrock site from 22,865 short tons in 1990 to 33,274 short tons in 1991. Leonardite was first produced in relatively large quantities at Glenrock in 1990, and production at this location should continue to increase. Leonardite is a natural product of or from oxidized coal or lignite, and is used in drilling fluid, wood stain, and especially soil conditioners and other agricultural products. A Fort Worth, Texas-based company has been exploring in Wyoming for additional sources of leonardite.

Limestone (non-aggregate production)

Limestone used for the production of lime must meet rigorous chemical specifications and is valued much higher than limestone used for aggregate. Limestone is quarried near Laramie from the Permian-Pennsylvanian Casper Limestone for use in cement, and from the Mississippian-Devonian Guernsey Limestone at the Bass quarry north of Guernsey for emission control at power plants. The total production of this material has remained nearly constant, increasing slightly from 484,084 short tons in 1990 to 487,115 short tons in 1991. At the Bass quarry, the production of lime for emission control at power plants increased from 35,000 short tons in 1990 to 50,000 tons in 1991 (Hannum, 1991 and 1992).

In June, Dakota Coal broke ground for its new lime plant at Frannie in the northern Bighorn Basin (Figure 20). The $10 million facility will produce lime from the Mississippian Madison Limestone quarried in Montana for use in controlling emissions at power plants. This quarry will replace the Bass quarry operation. The new plant is expected to produce 400,000 tons of lime per year and will use coal as a fuel.

Perlite

At its plant west of Green River, the Harborlite Corporation produces expanded perlite from perlite mined in Arizona. Perlite is a glassy volcanic rock that expands and fractures into semi-uniform shards when heated. Expanded perlite from the Green River plant is used by the five Wyoming soda ash producers as a filter aid. Due to the expansion of the soda ash industry (see below), Harborlite produced 7,337 tons of expanded perlite in 1991, up from 6,491 tons in 1990. This production was reported by the State Inspector of Mines (Hannum, 1991 and 1992).

Trona

Trona remains the most important nonfuel mineral mined in Wyoming. Five companies mine trona and refine it into soda ash and other sodium compounds from the trona resource area west of Green River (Figure 20).

Trona production has been relatively constant for the past three years (Table 2). The amount of trona mined in 1991 (16,142,339 short tons) was only 0.2% less than 1990, and about 0.3% less than the record year of 1989 (Hannum, 1991 and 1992).

In late April, Tenneco Minerals announced the sale of its 80 percent share of its Wyoming trona mine and sodium refining plant to Solvay America, Inc., a unit of Solvay S. A. of Brussels, Belgium. This $500 million sale was finalized in May. The Wyoming producer will apparently be known as Solvay Minerals, Inc. The remaining 20% is owned by Asahi Glass of Japan.

Solvay S.A., is currently the largest soda ash producer in the world, with all of its current production coming entirely from a synthetic process. In fact, the process of producing soda ash synthetically from salt, limestone, and other materials is known as the solvay process. The effect of this purchase on the Wyoming trona industry is still uncertain. Before this acquisition, Solvay S.A. supported restrictions on imports of Wyoming soda ash into the European market. Since Solvay S.A. controls about 70 percent of European soda ash, the market could open for Wyoming producers, particularly Solvay. Solvay is also in a position to affect the worldwide price of soda ash.

It was reported earlier this year that an Australian company, BTR Nylex, Ltd, was trying to sell its 49 percent interest in General Chemical's trona mine and soda ash refining plant (*Wyoming Geo-notes No. 34*, p. 37). This sale, to Japan's largest synthetic soda ash manufacturer, Tosoh Corp., was completed in June. General Chemical retains its majority interest in the operation, which will continue to be known as General Chemical Soda Ash Partners. Tosoh will operate under the name Tosoh Wyoming Inc., a subsidiary of Tosoh America Inc., the domestic subsidiary of Tosoh Corporation.

In other news from the trona patch, Church & Dwight Company, Inc., announced a $1.3 million expansion project at its Green River facility. Church & Dwight buys soda ash from the Green River producers and manufactures a variety of products under the Arm & Hammer trade name.

BWAB, Inc., a Denver-based company, has permits to explore for black trona water in an area south of Farson, Wyoming, but it has not yet begun its exploration work. Black trona water is subsurface water saturated with trona and containing organic compounds which give the water its dark color. In early June of this year, the U.S. Bureau of Reclamation, seeking artesian fresh water for a fish habitat, encountered artesian black trona water in a well northwest of BWAB's permit area. This water was under pressure and efforts to plug the well and stop the flow of up to 4,000 gallons per day were unsuccessful until early July. The trona-laden water from this well contaminated a portion of the Big Sandy River before it was contained.

Uranium

The NUEXCO spot market price for yellowcake declined to $7.75 per pound in the second quarter of 1992, down from $8.00 per pound at the end of the first quarter of 1992 and $8.75 at the end of 1991.

When the last ore was mined at Pathfinder's Shirley Basin uranium mine on March 26, 1992, and the last barrel of yellowcake was produced at the Shirley Basin mill in mid-June, conventional uranium production in Wyoming ended (Figure 21). This closure marked the end of an era that began in 1957. Since that year, some uranium has been mined each year from surface or subsurface mines in Wyoming, peaking at over 12,000,000 pounds of yellowcake in 1980 (Chenoweth, 1991). The town of Shirley Basin was also closed down following the mill closure in mid-June.

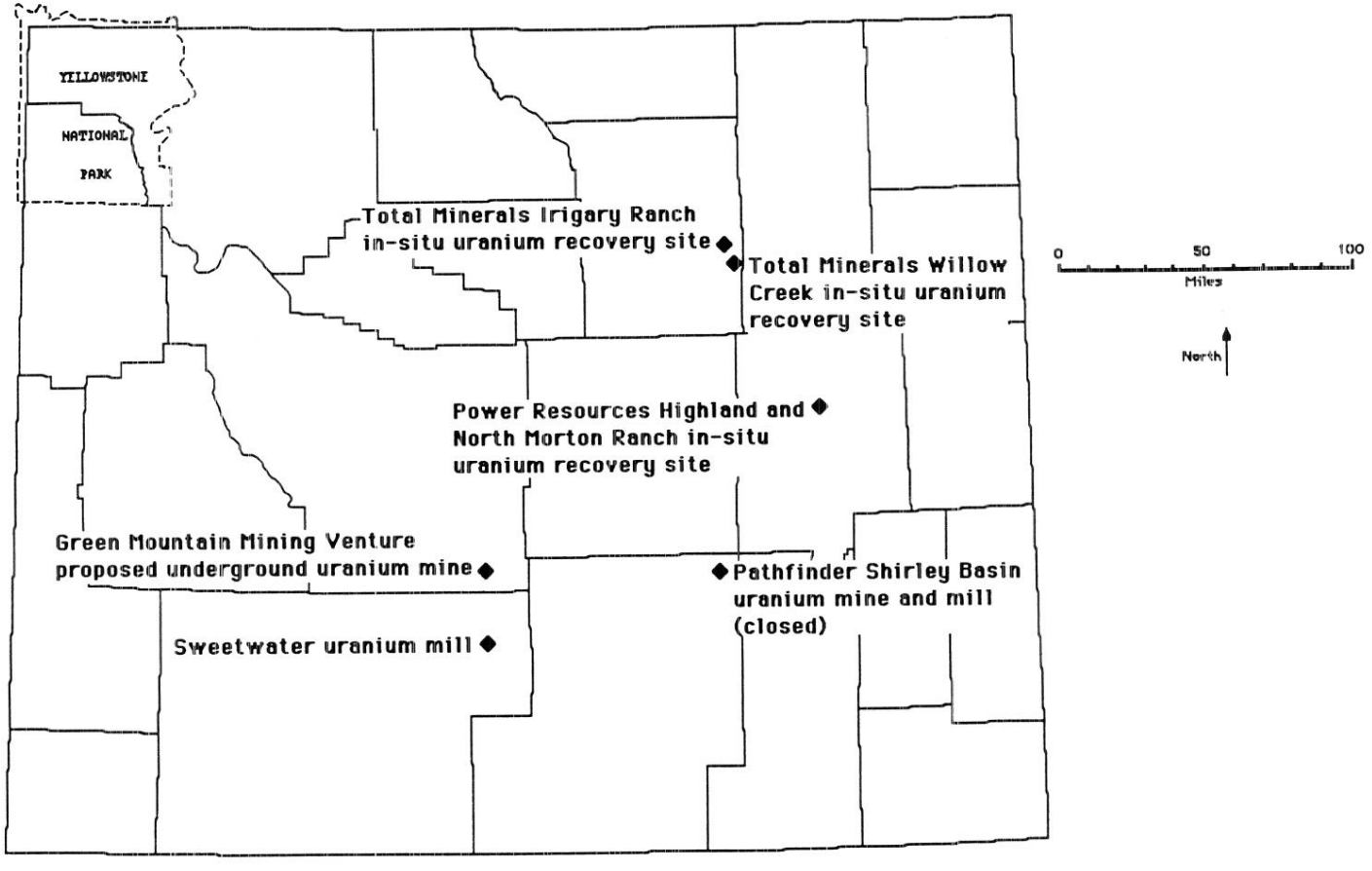


Figure 21. Uranium activities in Wyoming in the second quarter of 1992.

Uranium is still produced in Wyoming by in-situ recovery processes at two locations. According to the Riverton Ranger (June 17, 1992), Power Resources, owned by the Central Electric Generating Board of Great Britain, plans to produce about 750,000 pounds of yellowcake in 1992 from the Highland and North Morton Ranch properties in the southern Powder River Basin (Figure 21). This will be a decrease from the 1,000,000 pounds reported to the State Inspector of Mines in 1991 (Hannum, 1992). Total Minerals has begun small-scale production from the Irigary Ranch and Willow Creek Properties. It purchased these properties from Malapai Resources in 1990 according to the Wyoming Department of Revenue (Figure 21). Total Minerals is owned by Electricitie de France.

The Riverton Ranger (June 17, 1992) also reported that plans to develop an underground uranium mine on Green Mountain (Figure 21) are on hold, waiting for higher uranium prices. This property is being developed by the Green Mountain Mining Venture, a partnership between Kennecott Uranium Company and U.S. Energy-Crested Corporation of Riverton. Jack Larsen, President of U.S. Energy, was quoted in the Riverton Ranger article as saying the price of yellowcake had to be at $15 to $20 per pound to make the proposed mine profitable. Meanwhile, the partnership has purchased the Sweetwater uranium mill from Unocal (Figure 21).

References cited

Chenoweth, W.L., 1991, A summary of uranium production in Wyoming: Wyoming Geological Association Forty-second Annual Field Conference Guidebook, p. 169 - 179.

Hannum, A.M., 1991, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 1990: Office of the State Inspector of Mines, Rock Springs, Wyoming, 52 p.

Hannum, A.M., 1992, Annual report of the State Inspector of Mines of Wyoming for the year ending December 31, 1991: Office of the State Inspector of Mines, Rock Springs, Wyoming, 53 p.

Tepordei, V.V., 1992, Construction sand and gravel, April 1992: U.S. Bureau of Mines, Mineral Industry Survey, 34 p.

METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel,
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Exploration was reported in several areas of the State for gold, base metals, and rubies during the second quarter of 1992. The Metals and Precious Stones Section continued research for metals and precious stones in southern Wyoming and in some historic mining districts.

Gros Ventre

The West Australia newspaper from Perth (April 6, 1992) reported Falcona Mining and Exploration targeted a paleoplacer gold deposit in the Gros Ventre of northwestern Wyoming (Figure 22). The report states that the deposit has estimated reserves of 2.25 million ounces of gold within 30 feet of the surface based on exploration results from a 1960 Australian venture. Falcona drilled 15 holes in June to verify the earlier reserves and to conduct metallurgical tests at Hazen Research in Colorado (I. Reid, pers. comm., 1992).

South Pass

Exploration for gold by small prospecting groups continued in the South Pass mining region of the southern Wind River Range (Figure 22). In the same area, Gyorvary Mining Company obtained a permit to mine and mill gold ore at the historic Mary Ellen mine. The mine is in a quartz vein in an Archean tonalite plug. Historic records suggest the ore averaged 0.4 ounce per ton (opt) Au. At full operation, about 10 tons of ore will be milled per day (Casper Star-Tribune, July 6, 1992).

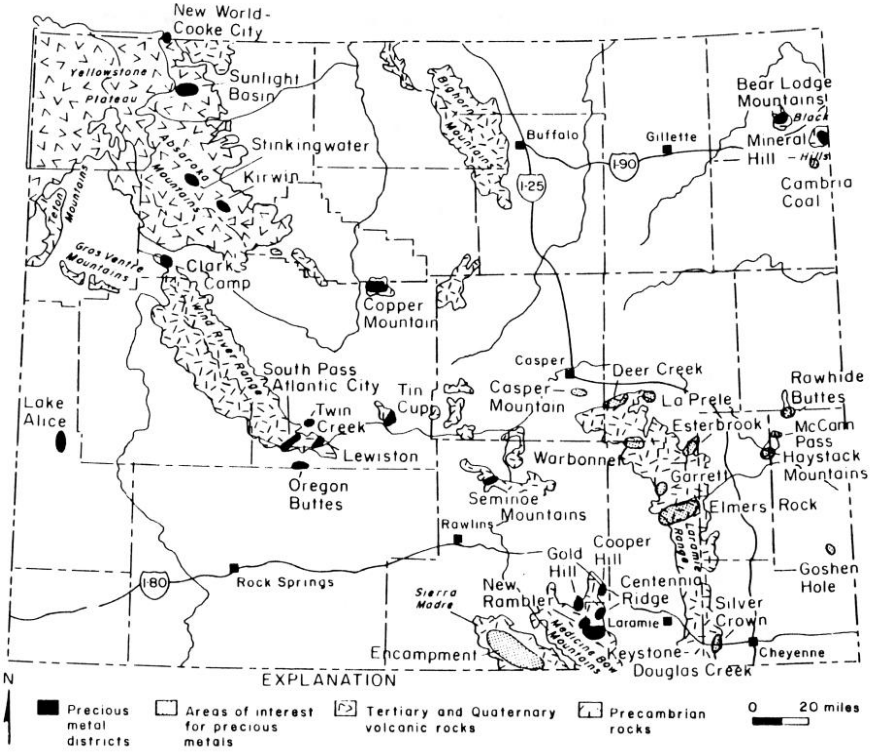
Elsewhere in the South Pass region, two prospectors discovered a placer ruby deposit in the southern Wind River Range west of South Pass (Joe and Russ Sims, pers. comm., 1992). They are recovering both gem and industrial grade corundum by dredge.

Hartville uplift

In the Hartville uplift of eastern Wyoming, exploration for metasedimentary-hosted massive sulfide mineralization continued. Several mining companies are conducting exploration in that region. No major discoveries have been reported to date.

Medicine Bow-Sierra Madre

Exploration continued in the Medicine Bow Mountains and Sierra Madre for base and precious metal deposits (Figure 22). No results are available at this time.



Geological Survey of Wyoming, 1992

Figure 22. Principal metal districts and mineralized regions of Wyoming.

Granite Mountains

Exploration for gold was reported in the Granite Mountains of central Wyoming. Much of the future exploration is expected to occur in the vicinity where the Geological Survey of Wyoming identified anomalous gold in Archean metamorphic rocks in 1982. No further information is available at this time.

Southern Wyoming

The Geological Survey of Wyoming continued studies in search of precious metals and stones in southern Wyoming. A few hundred pounds of olivine lamproite were collected from the Leucite Hills for diamond testing, and potential paleo-hot spring deposits were sampled at a few locations for gold. Some of the deposits have yielded arsenic anomalies.

Cooper Hill and Herman Districts, Medicine Bow Mountains

The Geological Survey of Wyoming (GSW) initiated investigations in the Cooper Hill and Herman historic mining districts of the northeastern Medicine Bow Mountains last summer (Figure 22). Preliminary results of the study were reported in Hausel and others (1992).

Cooper Hill lies along the northeastern edge of the Medicine Bow Mountains in southeastern Wyoming and is formed of Proterozoic metasedimentary and metaigneous rock deposited in a miogeoclinal terrane along the margin of the Wyoming craton possibly 1.7 to 2.5 Ga (billion years) ago.

Cooper Hill stands out as a steep-sided bald hill flanked on the east side by the North Fork of Cooper Creek and on the west side by Dutton Creek. The hill has been interpreted as a gravity slide originating from the west in the Medicine Bow Mountains proper (King, 1963). But whether Cooper Hill is a gravity slide or a overthrust salient, is unknown.

Quartz-pebble conglomerate with quartz and black chert pebbles typically found in Cascade Quartzite (P.J. Graff, pers. comm., 1991) was mapped by the GSW on the northern half of Cooper Hill. If this is Cascade Quartzite conglomerate, it is underlain by metalimestone, mica schist, and quartzite typical of the younger Vagner Formation suggesting the lithologies at Cooper Hill may be overturned.

Precambrian rocks on Cooper Hill are complexly folded and have been subjected to more than one episode of Proterozoic deformation. Laramide deformation resulted in Cooper Hill being thrust eastward followed by the breaking of the hill into a series of fault blocks. Cooper Hill was thrust over younger Phanerozoic sedimentary rocks producing a rootless klippe lying on the Cretaceous Steele Shale, Mesaverde Formation, and Tertiary Hanna Formation (Blackstone, 1973, Plate 2).

Folding of Cooper Hill was accompanied by regional amphibolite grade metamorphism, and by one or more episode of intrusion of gabbroic and basaltic dikes and sills. Hydrothermal alteration accompanied the intrusion of some mafic sills producing localized skarns in metalimestone.

Typically, the skarns are erratic, and include: (1) hydrogrossular, epidote, actinolite, chlorite, calcite, limonite, ± magnetite hornfels; (2) epidote, pyrite, calcite, quartz hornfels; (3) magnetite hornfels; (4) calcite, epidote, actinolite, pyrite, magnetite marble; (5) actinolite, calcite, quartz, chlorite, ± chalcopyrite hornfels; (6) tremolite, quartz, calcite marble; (7) calcite, uvarovite, magnetite hornfels, and (8) pyrite-sericite-limonite-calcite (Hausel, in press).

There are several classical, well-defined, quartz veins in the district. One vein found at the Richmond mine near the apex of Cooper Hill, is a conformable, limonite-stained quartz breccia vein with vugs filled with radiating actinolite, pyrite, and chlorite. Other conformable veins, as well as some crosscutting veins,

are found in the district. According to Schoen (1953), the crosscutting veins are typically barren with the exception of an argentiferous-galena bearing quartz vein at the Albion mine on the west flank of Cooper Hill.

In addition to investigating numerous adits in these districts, the GSW also investigated several thousand acres of placer ground along the North and South Forks of Cooper Creek and the South Fork of Dutton Creek. The gravel reportedly contained 0.02 to 0.04 oz/yd^3 Au (EMJ, 1896, v. 62, July 4, p. 15). Samples collected by the GSW confirmed the presence of anomalous gold in Cooper Creek (Hausel and others, 1992). Every panned sample collected from Cooper Creek was highly anomalous and contained visible gold. Dutton Creek was not sampled.

Seminoe Mountains

The Seminoe mining district was recently investigated by the Geological Survey of Wyoming (GSW). The results are currently being compiled.

The district lies within the Seminoe Mountains in central Wyoming and is primarily restricted to the metamorphic rocks cropping out along the western and northern flanks of the range in the vicinity of Bradley Peak (Figure 22). The district is known for its iron ore and gold deposits, but also hosts some copper, silver, serpentine, asbestos, jasper, nephrite jade (?), and leopard rock. During the study by the GSW, previously unrecognized zones of anomalous lead and zinc were discovered in shear zones and pyrope garnet was recovered from a gold placer along the northern flank of the range. Ore production from the district has been minor.

The core of the Seminoe Mountains is formed by Archean crystalline rock consisting of an ancient greenstone terrane of metamorphosed volcanic, sedimentary, and plutonic rock intruded by granodiorite. These metamorphic rocks include metatholeiite, metakomatiite, metagreywacke, metapelite, and banded iron formation. The Precambrian core is unconformably overlain by Phanerozoic sedimentary rock that forms spectacular steeply dipping precipices along the southern flank of the range.

In the past, prospecting and exploration concentrated on iron deposits, gold, copper, and jade. Production from the district, however, has been minimal. According to Knight (1893) early gold production from the district amounted to about 500 ounces.

Banded iron formation (BIF) is widespread in the Seminoe Formation in the district. Attempts to determine the extent of the iron resources in the district began with a study by Hendricks (1902). Hendricks estimated the Patterson Basin area south of Bradley Peak hosted a resource of one million tons of ore containing 60% Fe. In 1951, Wilson Exploration Company estimated the Patterson Basin area to have several million tons of iron ore (Harrer, 1966).

Harrer (1966) reviewed the data on the Patterson Basin area and more specifically looked at one small block of high grade ore. This block, was estimated

to have a potential for about 200,000 tons of ore to a depth of 50 feet. Twenty samples from the BIF assayed 31.4 to 68.72 % iron, 0.015 to 0.223 % P, and 1.37 to 54.28 % SiO_2 (Harrer, 1966).

Much of the early work on the iron deposits in the Seminoe district were concentrated in Patterson Basin. Although the iron deposits in the basin are oxidized and generally higher grade than the BIF to the north on Bradley Peak, Junk Hill, and the region east of Junk Hill, they are also less extensive and lie in a highly fractured and broken landslide block that originated from the south slope of Bradley Peak (Blackstone, 1965). Therefore, the depth of these deposits is very limited.

Harrer (1966) expanded the study of the iron resources of the district to the much larger, low-grade iron deposits to the south on Bradley Peak. In particular, Harrer (1966) noted that the Twin Creek BIF on the north slope of Bradley Peak contained a considerably larger iron resource than Patterson Basin. The Twin Creek BIF forms a substantial block of low-grade iron formation with a maximum width of 800 feet that can be traced down the northern slope for 3,500 feet. The block has been faulted along its southern edge and offset to the east by the Twin Creek fault, where it continues another 2,000 feet to the south before it terminates at the Bradley Peak thrust. This latter outcrop is disseminated by interlayers of amphibolite. The Twin Creek taconite was estimated by Harrer (1966) to have potential for about 100 million tons of low grade ore.

In addition to BIF in Patterson Basin and on Bradley Peak, abundant BIF crops out along Junk Hill to the north and in the fault block to the east of Junk Hill bounded by the Deweese Creek and Kortes faults. In total, the iron resource is large, with the greatest potential for minable ore on the Twin Creek BIF. Here the ore could be mined with open pit techniques.

The BIF in the Seminoe greenstone belt has also been noted for trace amounts of precious metals. Dickman (1906) reported samples of BIF yielded anomalous gold and silver. One sample of the iron formation yielded 33.5% iron, 0.5 opt Ag, and 0.02 opt Au (Dickman, 1906).

Reports of precious metals in the BIF were common knowledge to prospectors in the district. Lovering (1929) writes, "High gold assays are said to have been obtained from the banded jasper of the iron formation, but the writer was unable to verify this statement, as the samples of the iron formation that he gathered carried only traces of gold, with one exception, which ran 0.01 ounce in gold to the ton."

Numerous BIF samples recently collected by the GSW, show trace amounts of precious metals. Gold is rare, but silver anomalies are notable. In all but one BIF sample that yielded anomalous precious metals, clear evidence of epigenesis was present. It is also notable that one sample also produced a zinc anomaly (0.28% Zn).

Vein samples in the district generally yield anomalous gold. The veins are narrow quartz-carbonate veins in a broad zone of propylitized amphibolites. The altered zone is approximately 0.5 mile in diameter (Klein, 1981). Quartz vein samples within this altered zone are typically narrow and poorly exposed. The auriferous veins include sulfides (pyrite and chalcopyrite) hosted by propylitized metagabbro and metabasalt. Samples collected from the altered zone ranged from <0.05 ppm to 89.3 ppm Au, <1.0 to 55.0 ppm Ag, 0.03 to 3.75% Cu, 3.0 ppm to 0.39% Pb, and 22 ppm to 4.3% Zn. Limonite-stained metatholeiite wall rock from the altered zone yielded 0.32 opt Au, 0.39 opt Ag, and 0.81 % Cu. Another sample of chloritized metatholeiite yielded 0.12 ppm Au, <1.0 ppm Ag, and 0.09% Cu.

Copper prospects in the district are small. The Sunday Morning prospect located on cupriferous milky quartz in the Apex shear zone east of Bradley Peak contains some chrysocolla and cuprite. At the Apex mine west of the Sunday Morning prospect, the shear grades into a quartz breccia vein. One sample of cupriferous breccia from the dump assayed 3.81% Cu, 1.86 opt Ag, and a trace gold. Other samples collected from the Apex mine and Sunday Morning prospect yielded 0.001 to 2.1 ppm Au, 0.3 to 63.8 ppm Ag, 0.14 to 5.8% Cu, 61 to 9,530 ppm Pb, and 47 to 2,330 ppm Zn.

Minor asbestos veinlets were encountered in serpentinite along Sunday Morning Creek and near the toe of the extreme southeastern flank of Bradley Peak. The asbestos occurs in narrow (less than one inch) cross-fiber veinlets in the serpentinite.

Nephrite jade was reported by Bishop (1964) along the northern flank of the Seminoe Mountains in secs. 23, 26, and 28, T26N, R85W and in a granite outlier to the north in sec. 12, T26N, R84W. Sherer (1969) described Bishop's nephrite-like dikes as actinoliferous amphibolite dikes. These rocks are probably some of the tremolite-talc-chlorite-serpentine schists (metakomatiites) of the Bradley Peak ultramafics. These rocks have been locally cut by quartz veins. One vein hosted small mafic inclusions (up to 2 cm) with small patches of nephrite (Sherer, 1969).

Another jade occurrence reported by Bishop (1964) was the Sage Creek nephrite deposit found in the granite outlier to the north (NE SE sec. 12, T26N, R84W). This consists of a pod like mass of olive-green nephrite in association with quartz in a quartz diorite dike (Sherer, 1969).

Because of the presence of ultramafic komatiites in the greenstone succession, serpentinite samples collected during this study were regularly sampled for chromium and nickel, and gossans at the base of cumulate zones were prime sample sites. The results of the samples were discouraging. Some weak chromium anomalies were detected, but no nickel anomalies were identified.

Lapidary materials include banded tawny and brown jasperized BIF principally found as float along Deweese Creek. Samples of leopard rock, a porphyritic metagabbro with large, rounded, white, feldspar crystals in a black aphanitic groundmass, were mapped at a few locations in the Seminoe Formation. The most extensive and better quality material occurs in the SE sec. 20, T26N, R85W on a ridge between Wood Creek and an unnamed creek.

References Cited

Bishop, D.T., 1964, Retrogressive metamorphism in the Seminoe Mountains, Carbon County, Wyoming: M.S. thesis, University of Wyoming, Laramie, 49 p.

Blackstone, D.L., Jr., 1965, Gravity thrusting in the Bradley Peak-Seminoe Dam Quadrangles, Carbon County, Wyoming and relationships to the Seminoe iron deposits: Geological Survey of Wyoming Preliminary Report 6, 13 p.

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

Dickman, R.H., 1906, Report on iron ore development of the Seminoe mining district, north from Rawlins, Wyoming: Geological Survey of Wyoming unpublished Mineral Report 06-69, 7 p.

Harrer, C.M., 1966, Wyoming iron-ore deposits: U.S. Bureau of Mines Information Circular 8315, 112 p.

Hausel, W.D., in press, Economic geology of the Cooper Hill mining district, Medicine Bow Mountains, Wyoming: Wyoming Geological Association Forty-third Annual Field Conference Guidebook.

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

Hendricks, C.E., 1902, Seminoe iron deposits: Geological Survey of Wyoming unpublished Mineral Report 02-1, 5 p.

Klein, T.L., 1981, The geology and geochemistry of the sulfide deposits of the Seminoe district, Carbon County, Wyoming: Ph.D. dissertation, Colorado School of Mines, Golden, 232 p.

King, J.S., 1963, Petrology and structure of the Precambrian and post-Mississippian rocks of northeastern Medicine Bow Mountains, Carbon County, Wyoming: Ph.D. dissertation, University of Wyoming, Laramie, 125 p.

Knight, W.C., 1893, Notes on the mineral resources of the State: University of Wyoming Experiment Station Bulletin 14, p. 103-212.

Lovering, T.S., 1929, The Rawlins, Shirley, and Seminoe iron-ore deposits of Carbon County, Wyoming: U.S. Geological Survey Bulletin 811-D, p. 203-235.

Schoen, R., 1953, Geology of the Cooper Hill district, Carbon County, Wyoming: M.A. thesis, University of Wyoming, Laramie, 41 p.

Sherer, R.L., 1969, Nephrite deposits of the Granite, the Seminoe, and the Laramie Mountains, Wyoming: Ph.D. dissertation, University of Wyoming, 194 p.

SUMMARY OF HORIZONTAL DRILLING IN WYOMING

by Donald B. Basko, Oil and Gas Supervisor
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Table 7 is a summary of horizontal drilling in Wyoming through early August 1992. The number preceding each well discussion refers to locations on Figure 23.

Table 7. Summary of horizontal drilling in Wyoming through early August 1992.

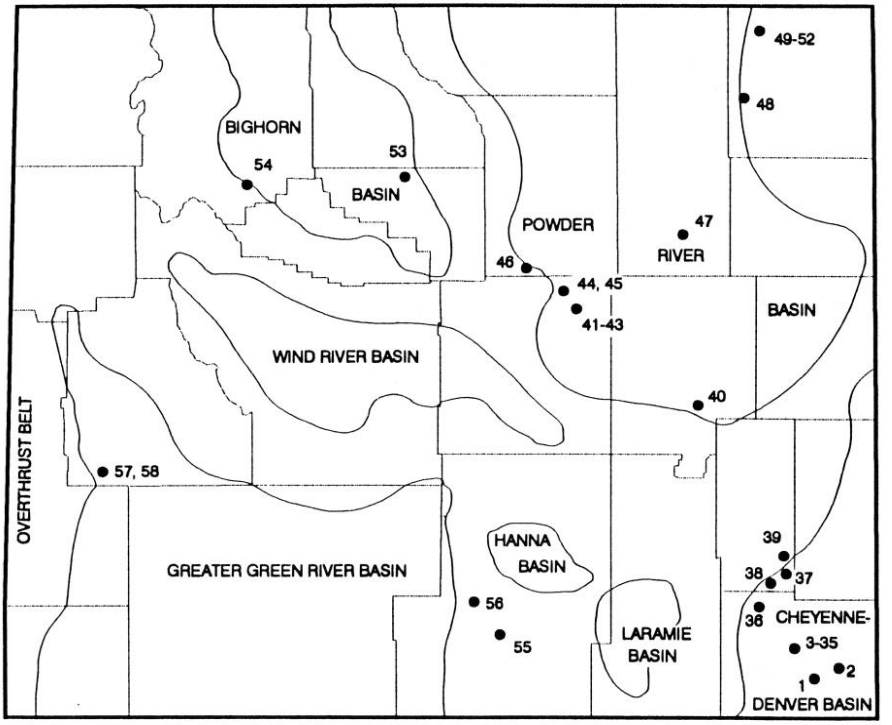
	COMPANY	WELL NAME/ NUMBER	LOCATION (Sec-T-R)	DATE DRILLED/ PERMITTED	CURRENT STATUS	REMARKS
1	EOG	Louth 14-16H	16-14-63	9/91	Plugged	Re-entry
2	UPRC	1-H Pence 5 E-17	17-15-61	6/92	Completing	Confidential
3	Chesapeake	McConnaughey 1-H	26-16-65	10/91	Not drilled	See No.35
4	Chesapeake	Goertz 1-H	1-15-65	12/91	Shut-in	IPF=1,662 BOPD
5	Chesapeake	McConnaughey 1-13H	13-16-65	7/92		
6	Cowan	Warren 1-11 H	11-15-65	6/90	Shut-in	Re-entry; IPF=1,460 BOPD Operated by TP
7	Cowan	Willett 1-H	22-16-64	8/90	Not drilled	
8	Cowan	Willett 3-H	21-16-64	8/90	Not drilled	
9	Cowan	Willett 4-H	20-16-64	8/90	Not drilled	
10	Cowan	Parker 2-H	29-16-64	8/90	Not drilled	
11	Exxon	Blevins 1-H	6-15-64	3/91	Producing	IPF=288 BOPD on choke

Table 7 continued.

	COMPANY	WELL NAME/ NUMBER	LOCATION (Sec-T-R)	DATE DRILLED/ PERMITTED	CURRENT STATUS	REMARKS
12	Exxon	1-H Epler B	30-16-64	6/92	Producing	IP=Unknown
13	Gerrity	State 4-9 H	4-15-64	3/91	Producing	IPF=2,026 BOPD
14	Gerrity	Epler 19-13 H	19-16-64	5/91	Not to be drilled	See No. 20
15	Gerrity	State 10-1 H	10-15-64	6/92	Producing	IPF=1,470 BO/ 12 Hours
16	Gerrity	Epler 25-13 H	25-16-65	7/92	Drilling	
17	Silverado	1-18-16H State	18-16-64	11/91	Shut-in	To be returned to vertical well
					completion	
18	Silverado	Hutton 10-21H	21-16-64	3/91	Producing	IP=100 BOPD on pump-formerly SOCO's well
19	SOCO	Willett 2-H	22-16-64	11/90	Shut-in	
20	SOCO	20-18 H Epler	19-16-64	5/91	Not to be drilled	See Gerrity 19-13H
21	UPRC	Antelope 9-11H	11-15-64	10/90	Producing	IPF=373 BOPD on choke
22	UPRC	McGahan 21-5H	5-15-64	11/90	Producing	IPF=312 BOPD on choke
23	UPRC	1-H Hagemeir 14-11	11-15-64	11/90	Not drilled	
24	UPRC	Goertz 5-12H	12-15-65	1/91	Producing	IPF=368 BOPD on choke
25	UPRC	Epler 14-7 H	7-15-63	2/91	Producing	IPF=390 BOPD
26	UPRC	1-H Berry Fed. 41-22	22-16-65	2/91	Never drilled	
27	UPRC	Goertz 14-3 H	3-15-64	3/91	Producing	IPF=230 BOPD on choke
28	UPRC	1-H McConnaughey 41-27	27-16-65	2/92	Producing	IPF=318 BOPD on choke
29	UPRC	1-H Dino State 12-8	8/15/64	4/92	Producing	IPF=292 BOPD on choke
30	UPRC	1-H Berry 41-13	13-16-66	5/92	Completed	Confidential
31	UPRC	1-H Arden State 14-36	36-16-65	4/92		Formerly Epler State 12-36
32	UPRC	1-H Lemaster State 12-32	32-16-64	6/92	Completed	Confidential
33	UPRC	1-H Donald 14-23	23-16-65	7/92		
34	UPRC	1-H Patricia 41-22	22-16-65	8/92		
35	Wilshire	1-26H McConnaughey	24-16-65	6/92	Producing	IP=Unknown
36	UPRC	1-H Schanaman State 12-10	10-19-68	11/91	Plugged	
37	UPRC	1-H Hellbaum 11-11	11-21-66	4/91	Plugged	
38	Presidio	Voight 44-9H	9-21-67	5/92	Confidential	
39	Presidio	Phillipi 11-15H	15-23-66	8/91	Plugged	
40	Amoco	Morton Ranch 1-25-H	25-33-72	3/92	Drilling	
41	GLG	Si Tanka 32-6 H	6-38-77	12/90	Temp. abandoned	
42	GLG	E. Salt Creek 44-36 H	36-39-78	9/90	Not drilled	
43	GLG	31-3H-2	3-39-78	3/91	Not drilled	
44	Amoco	40WC2 NE 25H	30-40-78	8/90	Shut-in	IP=10 BOPD on pump
45	Hondo	E. Salt Creek 1-16H	15-40-78	10/89	Producing	IP=185 BOPD on pump
46	Conoco	N. Tisdale 67	9-41-81	1/90	Producing	IP=17 BOPD on pump
47	Yates	Stuart Ranch 19-22H	19-44-71	12/90	Shut-in	To be redrilled/ deepened
48	L & J	1-H Berger	17-53-67	4/92	Producing	IP=281 BOPD re-entry
49	Petrorep	Signal Hill 19-H	11-57-67	5/92	Producing	IP=100 BOPD pumping

Table 7 continued.

	COMPANY	WELL NAME/ NUMBER	LOCATION (Sec-T-R)	DATE DRILLED/ PERMITTED	CURRENT STATUS	REMARKS
50	Petrorep	Signal Hill 20-H	11-57-67	6/92	Producing	IP=100 BOPD pumping
51	Petrorep	Signal Hill 21-H	11-57-67	6/92	Producing	IP=100 BOPD pumping
52	Terry	Thompson Creek 10	10-57-67	9/89	Shut-in	IP=50 BOPD
53	UPRC	1-H Bass Fed. 33-24	24-48-92	4/92	Completed	Confidential
54	Conoco	N. Sunshine May 4	15-47-101	11/87	Producing	IP=60 BOPD on pump
55	UPRC	1-H Cougar 33-20	20-19-86	11/91	Confidential	
56	UPRC	1-H A.K. Bar	12-20-88	11/91	Confidential	
57	Texaco	LaBarge G 634AY-H	34-27-113	8/90	Producing	IP=37 BOPD-ultra short radius
58	Texaco	LaBarge J 634-H	34-27-113	9/90	Producing	IP=16 BOPD-ultra short radius



GEOLOGICAL SURVEY OF WYOMING, 1992

Figure 23. Index map of horizontal drilling in Wyoming through early August, 1992.

WYOMING OIL AND GAS EXPLORATION SUMMARY FOR 1991

by Rodney H. De Bruin
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Drilling activities and completions

Based on preliminary data available from Petroleum Information (1992), there were close to 630 well completions in Wyoming in 1991, which is a decrease from 1990 completions and just slightly ahead of 1989 completions (Figure 24). Of the 453 wells drilled in 1991 for which Petroleum Information already has data, 153 were exploration wells. The success rate for exploration wells was 21.6 percent compared to a success rate for exploration wells in 1990 of 25.5 percent. In all, at least 272 wells in 1991 found oil or gas for a success rate of 60.0 percent. In 1990, 491 wells found oil or gas for a success rate of 64.0 percent.

The average daily rig count in 1991 was only 34 compared to an average of 38 in 1990. The daily rig count averaged by year has not been above 40 since 1985 (Figure 25). Rigs in Wyoming drilled about 4.6 million feet in 1991, which was down from 5.2 million feet drilled in 1990. Since 1980, only 1989 had less footage drilled than 1991 (Figure 26). The average depth of a well in Wyoming in 1991 was 7,272 feet, which is the highest average in the last 12 years (Figure 27). The

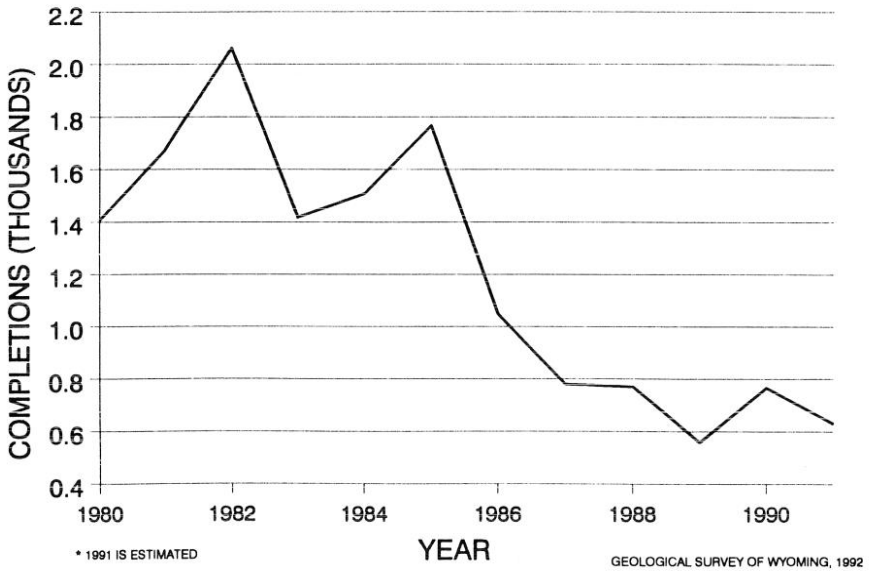

Figure 24. Number of oil and gas well completions in Wyoming by year (1980 to 1991) (Based on data published by Petroleum Information).

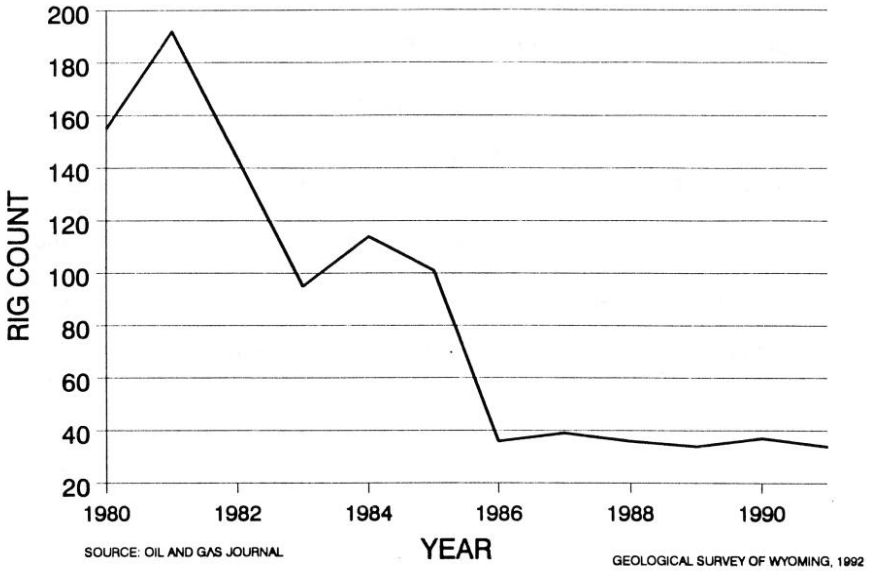

Figure 25. Wyoming daily rig count averaged by year (1980 to 1991).

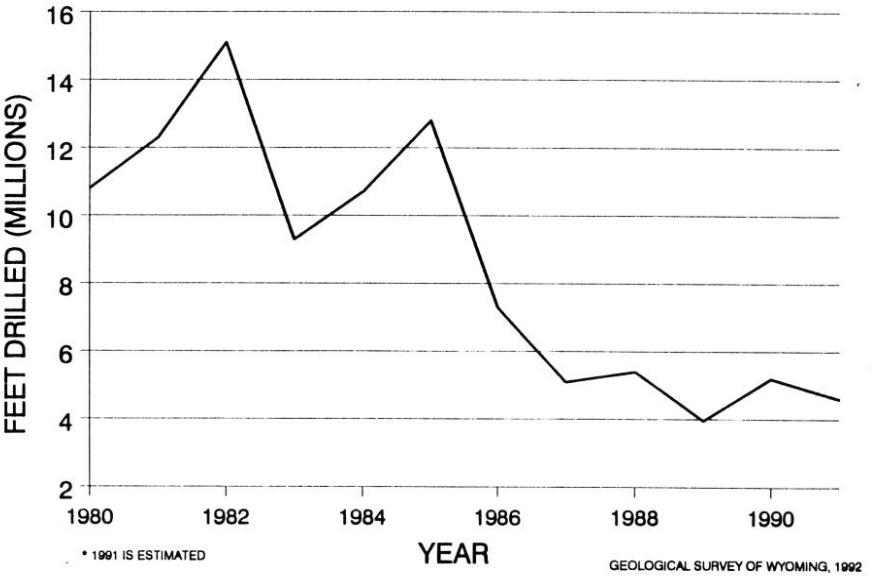

Figure 26. Number of feet drilled for oil and gas in Wyoming by year (1980 to 1991) (Based on data published by Petroleum Information).

average depth of an exploration well in Wyoming in 1991 was 7,635 feet. Figure 27 shows that this is an increase over 1989 and 1990.

Lease sales

Six lease sales held by the U.S. Bureau of Land Management (BLM) in 1991 grossed nearly $13 million. Of the 2.19 million acres that were available for lease, only 30.9 percent were leased at an average of $19.14 per acre. In comparison, the six BLM sales in 1990 grossed nearly $18 million, and 44.6 percent of the 2.17 million acres were leased for an average of $18.61 per acre. Figures 28 and 29 show total revenue and average price per acre leased for recent BLM sales.

Six lease sales held by the State Land and Farm Loan Office in 1991 grossed almost $4.5 million. The average price per acre was $10.98 and 84.6 percent of the 480,000 available acres were leased. The six State sales in 1990 grossed nearly $5 million. Of the 478,000 acres available in 1990, 79.5 percent were leased for an average price of $13.09 per acre. Figures 28 and 29 show total revenue and average price per acre for State sales in recent years.

Powder River Basin

Wells drilled to the Minnelusa, Muddy, and Dakota accounted for most of the exploration and development activity in the Powder River Basin. Campbell

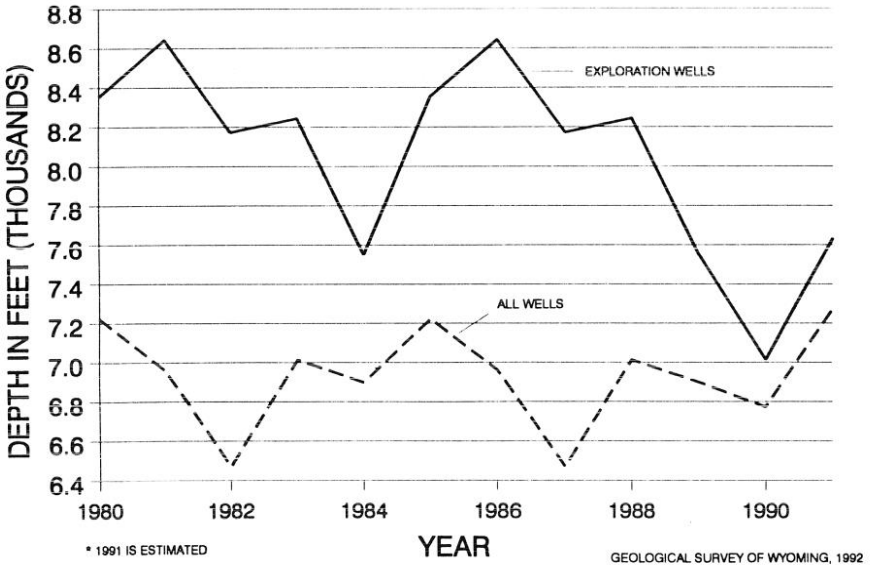

Figure 27. Average depth of Wyoming oil and gas wells drilled by year (1980 to 1991) Petroleum Information, 1992).

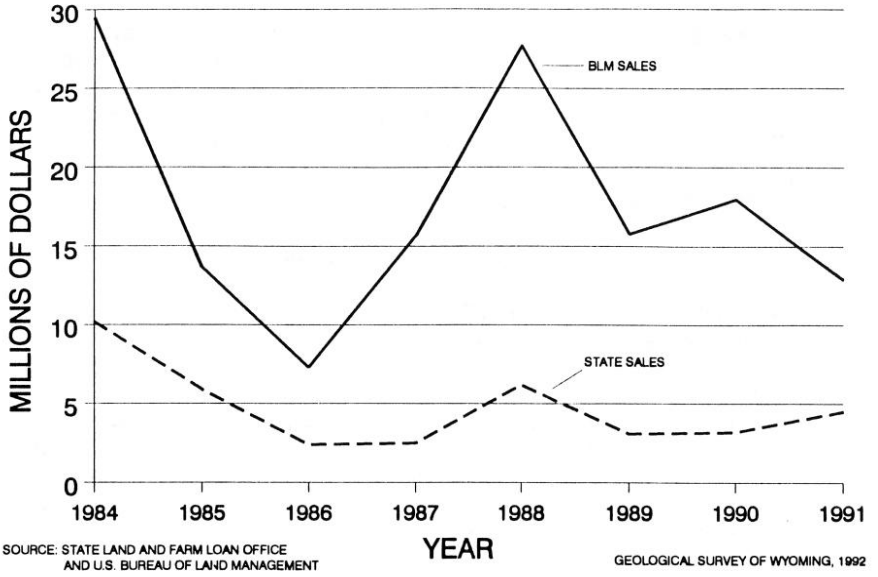

Figure 28. Total revenue from Wyoming oil and gas lease sales by year (1984 to 1991).

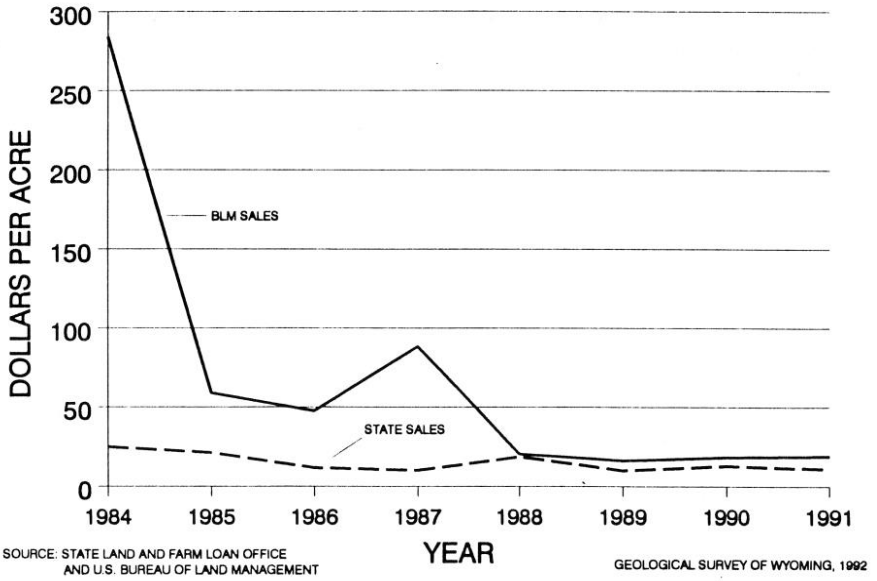

Figure 29. Average price per acre leased in Wyoming oil and gas lease sales by year (1984 - 1991).

County was again the most heavily explored county in the United States with 50 wildcat completions (Petroleum Information, 1992). Of those 50 completions, three found oil and three found gas. Crook County tied for eleventh place among the most heavily explored counties in the United States with 14 wildcat completions (Petroleum Information, 1992). In all, the Powder River Basin accounted for 50.1 percent of the total well completions in Wyoming. The majority of these completions were Minnelusa tests.

Greater Green River Basin

Sweetwater County ranked sixth in the United States with 16 wildcat completions. There were 41 exploration wells drilled in this basin in 1991. Twelve discovered gas and one discovered oil. An additional 117 development wells were drilled. Ninety-seven of these wells found gas and five found oil. The high success rate for exploration and development wells in this province, especially for gas wells, underscores the very large resources of natural gas in this area. Almost 35 percent of the well completions in Wyoming were in the Greater Green River Basin and most targeted Cretaceous objectives, primarily in the Frontier and Dakota. The Kern River Pipeline began operating in early 1992 and has a capacity of 700 million cubic feet of gas per day. This pipeline and several new pipeline expansions help explain the high rate of gas completions in this area in 1991.

Wind River Basin

The most important activities in this basin involved the completion of two high-volume gas wells. One was completed in the Sussex and the other was completed in the Mesaverde in the Madden area. Both wells flowed over 10 million cubic feet of gas per day.

Horizontal drilling

There were 21 horizontal well completions in Wyoming in 1991, compared to 10 in 1990. Most of the horizontal well completions were in the Niobrara Formation in and around Silo Field in the Denver-Cheyenne Basin. Six companies completed nine Niobrara producers in the area. Union Pacific Resources completed four of the productive wells.

Coalbed methane

There were 39 coalbed methane wells completed in Wyoming in 1991 compared to 32 completions in 1990. Most of these wells were completed in Fort Union Formation coals in the Powder River Basin. Metfuel announced plans to drill as many as 130 coalbed methane wells in the Hanna Basin to test the coalbed methane potential of the Hanna Formation.

Reference cited

Petroleum Information, 1992, Resume 1991: Petroleum Information, Littleton, Colorado, 381 p.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1992)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.6	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.2	billion barrels
Remaining Reserve Base (January 1, 1992)		
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.45	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.25	billion barrels

NATURAL GAS

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

COAL

Remaining Resources (January 1, 1992)		
Identified and Hypothetical (Discovered)	1,428.4	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,459.9	billion tons
Remaining Reserve Base (January 1, 1992)		
Demonstrated strippable (Measured and indicated reserve base)	26.8	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	69.3	billion tons

TRONA

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

URANIUM

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

OIL SHALE

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

[1] Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.

[2] Modified from Energy Information Administration, 1991, U.S. crude oil, natural gas, and natural gas liquids reserves: 1990 Annual Report, September.

[3] De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.

[4] Jones, R.W., and De Bruin, R.H., 1990, Coalbed methane in Wyoming: Geological Survey of Wyoming Public Information Circular 30, 15 p.

[5] Law, B.E., and others, 1989, Estimates of gas resources in overpressured low-permeability Cretaceous and Tertiary sandstone reservoirs, Greater Green River Basin, Wyoming, Colorado, and Utah: Wyoming Geological Association, 40th Annual Field Conference Guidebook, Casper, Wyoming p. 39-61.

[6] Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000 scale (color) and 44 p. pamphlet.

[7] Modified from Geological Survey of Wyoming, December, 1991, unpublished report for the Energy Information Administration, 29 p.

[8] Modified from Culbertson, W.C., 1983, Genesis and distribution of trona deposits in Wyoming (abstract) in Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19, p. 34.

[9] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.

[10] Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

GEOLOGIC MAPPING AND STRATIGRAPHY

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

GEOLOGIC ROAD SIGNING PROJECT CONTINUES IN BIGHORN MOUNTAINS

The Geologic Mapping Section of the Geological Survey of Wyoming (GSW) recently met with Mike Flynn of Sheridan College to provide input into the geologic signing project for U.S. Highway 14 through Shell Canyon. The project involves placing signs which identify the geologic formations that crop out between the Shell Falls area and the area immediately west of the mouth of Shell Canyon (Figure 30). The formations tentatively selected for signing include the Precambrian, Bighorn Dolomite, Madison Limestone, Tensleep Sandstone, and Chugwater Formation. The Wyoming Department of Transportation will construct and install the signs, which will show each formation name and its approximate age. The signs should be placed by late summer.

Mike Flynn, with assistance from the GSW, previously placed geologic road signs on the east side of the Bighorn Mountains along U.S. Highway 14 above Dayton, Wyoming, and in Tensleep Canyon on U.S. Highway 16 (Figure 30). These projects are all part of an ongoing effort by the Wyoming Geological Association's Highway Signs Committee, chaired by Flynn. This most recent project completes the planned signing for the Bighorn Mountains area.

NEW COLOR GEOLOGIC MAP PUBLISHED

The GSW recently published the first in its planned series of 1:100,000-scale, color, geologic maps of Wyoming. This new map is titled, *Geology of the Nowater Creek 30' x 60' Quadrangle, northcentral Wyoming,* and was released as Map Series 39. The map is located in northcentral Wyoming (Figure 30) and includes the southeastern portion of the Bighorn Basin, the southwestern flank of the Bighorn Mountains, and the northeastern flank of the Bridger Mountains. Rocks from Quaternary to Precambrian in age are portrayed on the map. Some of the structural features on this map are the Big Trails fault system (*Wyoming Geo-notes No. 33*, p. 47; *Wyoming Geo-notes No. 28*, p. 41-42; and *Wyoming Geo-notes No. 24*, p. 31-33), Chabot anticline, Mahogany Butte anticline, Bud Kimball anticline, Black Mountain anticline, and Wild Horse Butte anticline. While the west half of the map was compiled and in some cases modified from previous mapping, the east half summarizes 1:24,000-scale mapping completed by the GSW's Geologic Mapping Section as part of the Southern Bighorn Mountains mapping project from 1988 through 1991.

The GSW initiated this map series to provide land use planners, State and Federal agencies, and industry with geologic maps at a scale more suitable for their needs. Ideally, the Geologic Mapping Section compiles these maps from

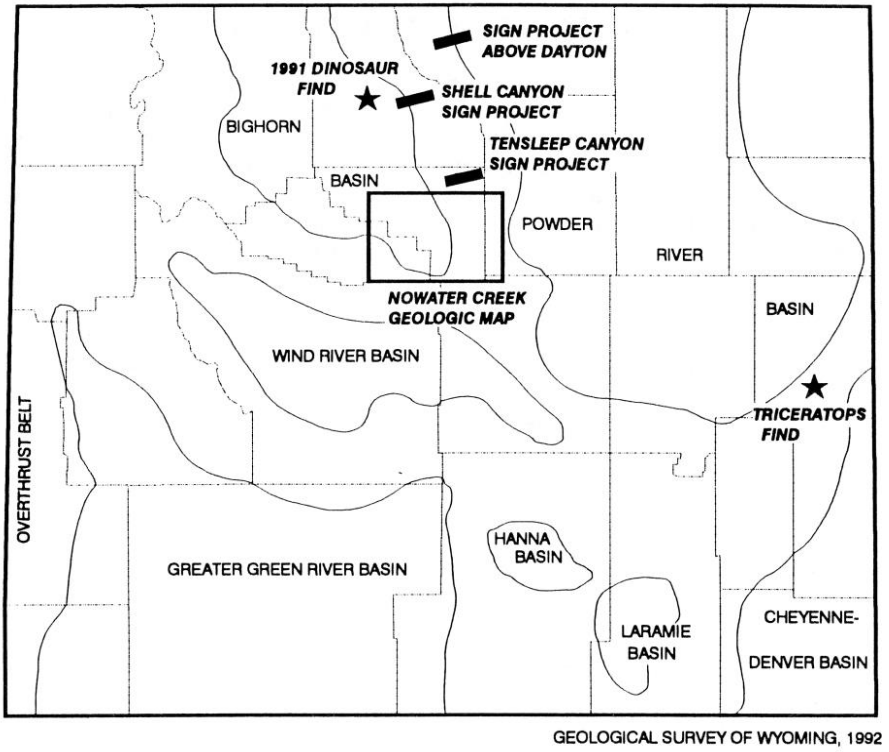

Figure 30. Index to selected geologic mapping and stratigraphy projects in Wyoming.

existing larger scale geologic maps. Airphoto interpretation and field mapping are used to augment these compilations in areas of inadequate information. The next map will be an urban area of Wyoming, either the Cheyenne, Casper, or Laramie sheet.

CASTS OF ALLOSAURUS SKULL DISTRIBUTED TO STATE MUSEUMS

The Museum of the Rockies of Bozeman, Montana, recently distributed casts of an Allosaurus skull to the University of Wyoming Geology Museum, the Greybull Museum, and the Cody and Cheyenne offices of the U.S. Bureau of Land Management (BLM). Last fall, the complete skeleton of the *Allosaurus* was found on BLM-administered land near Shell, Wyoming (Figure 30) (*Wyoming Geo-notes No. 32*, p. 40-41). According to Pat Leiggi, the chief fossil preparer at the Museum of the Rockies, the find produced the first complete allosaur foot, including some missing bone structure only guessed at previously.

NEW DINOSAUR FIND NEAR LUSK, WYOMING

A group from the University of New Orleans recently announced the discovery of a Tricer*atops* skeleton on private land north of Lusk, Wyoming (Figure 30). Kraig Derstler, leader of the 1992 Lance Dinosaur Expedition from the University of New Orleans, indicated the highlight of the discovery was the broken *Tyrannosaurus rex* tooth found with the *Triceratops* skeleton. This represents one of the first pieces of direct evidence that the *Tyrannosaurus rex*, a meat eating dinosaur regularly fed on *Triceratops*, a plant eating dinosaur. Scientists have long speculated that the *Triceratops* represented one of the main sources of food for the *Tyrannosaurus rex*.

The fossilized skeleton was found in the Lance Formation which is over 66 million years in age. Most of the bones recovered to this point represent the rear portion of the animal and excavation is continuing in hopes that the entire skeleton will be present. The skeleton is being shipped to the University of New Orleans for further study. Eventually it will be returned to Wyoming according to Derstler.

GEOLOGIC HAZARDS IN WYOMING

RADON RESEARCH

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

Wyoming Geo-notes No. 34 (p. 49-50) contained an article on the radon research program at the Geological Survey of Wyoming (GSW). As stated in that issue, twelve soil-gas sample sites were selected in the Laramie Basin, and those sites are monitored on a weekly basis. The primary purpose of the program is to determine if the relative radon relationships that are observed among the sites during one sampling period are repeatable. If the relationships are repeatable, soil-gas radon sampling techniques may be used to rapidly characterize large areas with some degree of confidence.

The GSW is using soil-gas radon sampling techniques developed by the U.S. Geological Survey in Denver, Colorado. A narrow tube is pounded into the soil to be sampled and a small soil-gas sample is extracted through it for analysis. The gas is analyzed using Lucas cells coated with zinc sulfide and a Pylon Portable Radiation Monitor.

Soil-gas radon samples have been collected from all twelve sites since April 8, 1992. Samples at all sites have been collected on a weekly basis. A graph of radon data obtained from three of the sites is presented in Figure 31. It is obvious

from the data presented in Figure 31 that there is considerable variability in soil-gas radon from one site to another, and at one site from one point in time to another. A visual analysis of the data indicates that for the period sampled, soil-gas radon relationships that were observed between sites at one point in time may not be entirely repeatable. For example, on April 8, 1992, site 9 had a soil-gas radon level of 862 picocuries per liter (PCi/L) and site 11 had a level of 174.1 PCi/L. Site 9 had a radon level nearly fives times higher than site 11. On June 15, 1992, site 11 had a soil-gas radon level of 506 PCi/L and site 9 had a level of 233 PCi/L. On this date, site 11 had a radon level over two times higher than site 9. Relationships that were observed on April 8, 1992, were not repeated on June 15, 1992. A preliminary analysis indicates that caution should be exercised when trying to characterize the potential for radon occurrence of an area based upon a single, or even a few soil-gas radon traverses. The GSW is now investigating various statistical programs in order to determine which analytical techniques should be applied to the data set. Additional information on the radon research program can be obtained from Jim Case or Tracey Ziegler at the Geological Survey of Wyoming (307-766-2286). Figure 31 was generated from data collected by Tracey Ziegler.

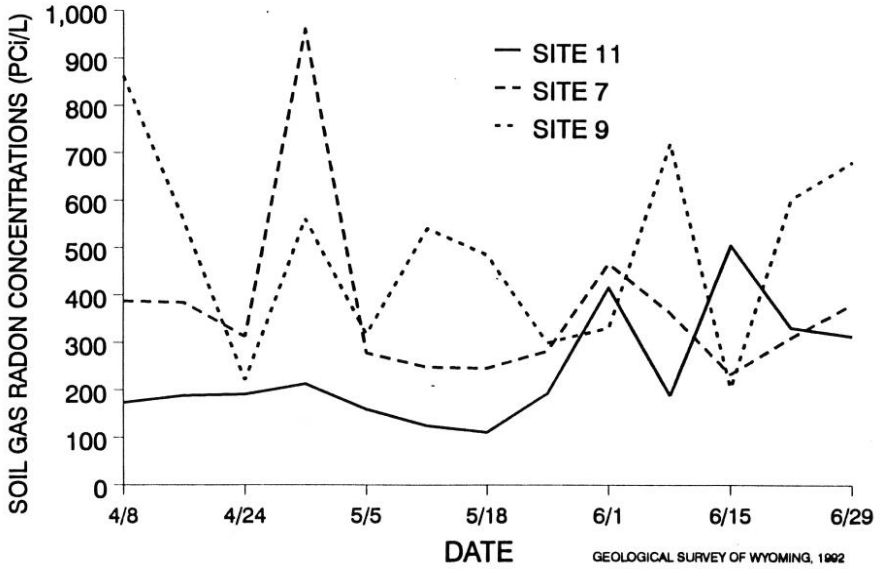

Figure 31. Areal and temporal variations in soil-gas radon concentrations at three sampling sites.

TIM MOORE HEADS UP COAL SECTION

Dr. Timothy A. Moore took over the reins of the Geological Survey of Wyoming's (GSW's) Coal Section in late July. Tim filled a vacancy left when Richard W. Jones became the GSW's Editor and Head of the Publication's Section.

Tim brings with him an excellent background in coal geology. After receiving his Bachelor of Science Degree from the University of Maryland, Tim received his Master of Science and Ph.D. degrees at the University of Kentucky under the direction of Dr. John C. Fern.

Tim came to the GSW from a Post-Doctoral Fellowship at the Department of Geology at the University of Canterbury, Christchurch, New Zealand, where he was involved in the sedimentology and analysis of Tertiary and Cretaceous coal basins in the central North Island. In addition, Tim has done research on Carboniferous coal beds in Appalachia, on Tertiary coal beds in the Powder River Basin of Wyoming and Montana, and on Tertiary coals of Indonesia as a National Research Council Fellow with the U.S. Geological Survey.

With this background, Tim will tackle the job of characterizing the chemical, physical, and petrographic attributes of the more than one trillion tons of coal resources underlying the State of Wyoming.

NEW PUBLICATIONS

Publications available from the Geological Survey of Wyoming - free.

Organization, mission, goals, and authorities of the Geological Survey of Wyoming, Information Pamphlet 4, 1992 - free.

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

*Geologic map of the Nowater Creek 30' x 60' Quadrangle, north-central Wyoming, by A.J. Ver Ploeg and P.L. Greer: Map Series 39, 1992, 1:100,000 (color) - $5.00 ($6.50 mailed rolled)

*Second draft of a stratigraphic chart showing Phanerozoic nomenclature for the State of Wyoming, by J.D. Love, A.C. Christiansen, and A.J. Ver Ploeg: Open File Report 92-2, 1992 -.$3.00 flat ($4.50 mailed rolled).

*The John Blue Canyon silica sand deposit, Big Horn County, Wyoming, by R.E. Harris and R.J. Warchola: Open File Report 92-3, 1992 -$4.00.

*Coal fields and coal beds of Wyoming, by G.B. Glass and R.W. Jones: Reprint 47, 1992 - $4.00.

*Field guide to the Seminoe Mountains, by D.L. Blackstone, Jr. and W.D. Hausel: Reprint 48, 1992 - $3.00.

*Field guide to the geology and mineralization of the South Pass region, Wind River Range, Wyoming, by W.D. Hausel and J.D. Love: Reprint 49, 1992 - $3.00.

*Industrial minerals and construction materials of Wyoming, by R.E. Harris,: Reprint 50, 1992 - $3.00.

*Form, distribution, and geology of gold, platinum, palladium, and silver in Wyoming, by W.D. Hausel: Reprint 51, 1992 - $3.00.

*Geology and mineralization of the Wyoming Province, by W.D. Hausel, B.R. Edwards, and P.J. Graff: Reprint 52, 1992 - $3.00.

*Subsurface geology of Upper Cretaceous and Lower Tertiary coal-bearing rocks, Wind River Basin, Wyoming, by D.G. Hogle and R.W. Jones: Reprint 53, 1992 -.$6.00.

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

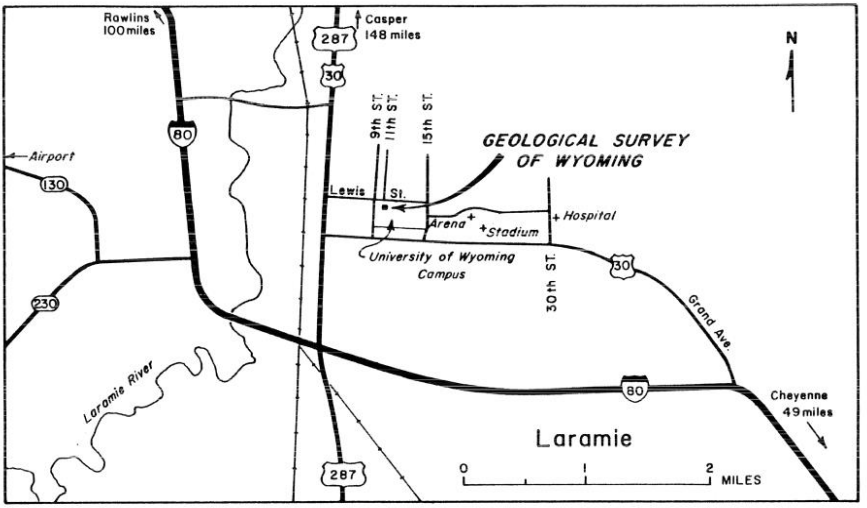
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

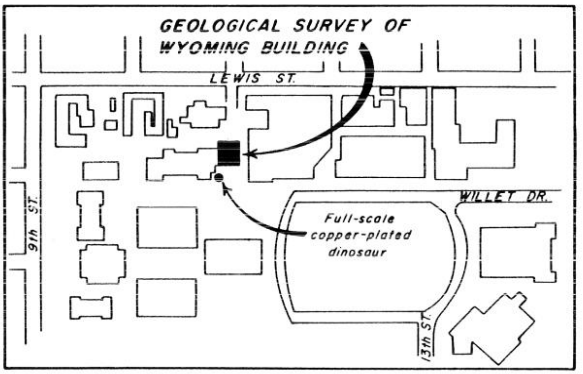
No first class postage charge for prepaid orders, unless otherwise marked.

— WYOMING GEOLOGICAL ASSOCIATION —

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

GEOLOGICAL SURVEY OF WYOMING
LOCATION MAPS





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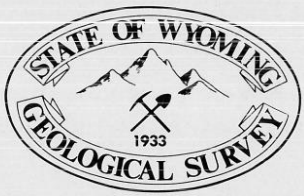
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