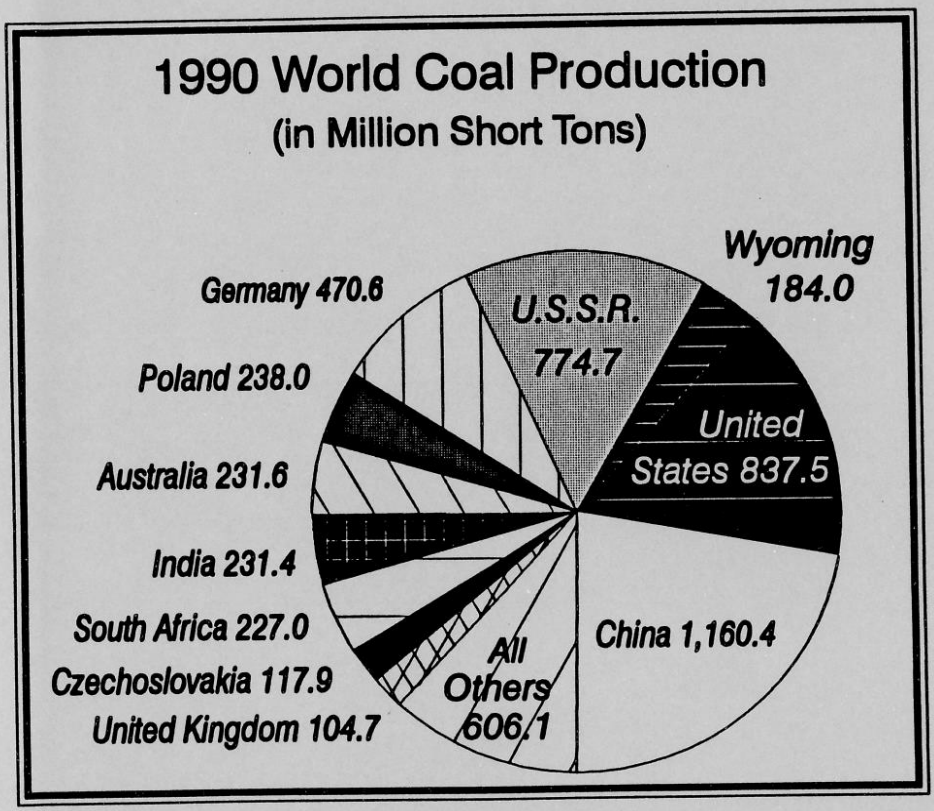
Wyoming Geo-notes

Number 33



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

Laramie, Wyoming
February, 1992

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

Printed on 50% recycled fiber paper.

Cover: A recent report in *Mining Magazine* shows that only eight countries produced more coal than Wyoming in 1990. See page 17 for more details.

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

Table of Contents

MINERALS UPDATE

OVERVIEW

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

While the average posted price for Wyoming Sweet in 1991 was $20 per barrel, a barrel of sour crude only averaged $16.77. By December, however, the posted prices for Wyoming Sweet and Wyoming Sour had dropped to $18.03 and $14.78, respectively. Based on the posted prices for the year, the average price paid for Wyoming oil was probably close to the projected $17.21.

Because 65 percent of the State's oil production is sour and/or heavier gravity crudes, the average price for Wyoming crude is going to remain considerably below the price of Wyomin Sweet. In addition, the glut of sour crude from imports has significantly reduced the demand and consequently the price paid for Wyoming sour crude. There is little reason to expect this situation to change in the near term as Saudi Arabia and other producers of sour crude show little sign of making significant cutbacks in production. Consequently, prices are likely to stay down (Table 1 and Figure 1).

Oil production also apparently fell about 1.5 million barrels short of the 101.5 million barrels originally forecast for 1991 (Table 2 and Figure 2). In part, this may have been in response to relatively low prices.

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

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

* Actual value for comparison.
1 Modified from Consensus Revenue Estimating Group, [Revised] Wyoming State Government Revenue Forecast FY91-FY95, January, 1992, 21 p.
2 First purchase price in dollars per barrel.
3 Wellhead price in dollars per MCF (includes carbon dioxide and natural gas liquids).
4 Dollars per short ton (weighted average price for coal mined by surface and underground methods).
5 Dollars per ton of trona, not soda ash.
6 Uranium prices are all estimated by the Geological Survey of Wyoming (October, 1991); in dollars per pound of yellowcake (weighted average price for in-situ and surface-mined uranium).

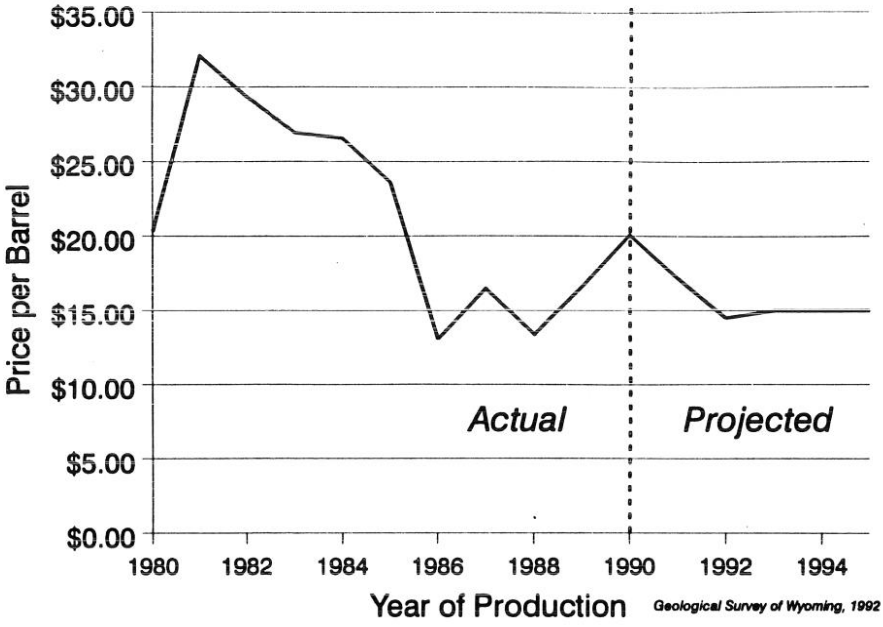


Figure 1. Average price paid for Wyoming oil (1980 to 1990) with forecast to 1995.

In 1991, the average price paid for methane in Wyoming was about $1.24/MCF. When the value of natural gas liquids are added to the methane price, the average value of natural gas from Wyoming increases to $1.41 (Table 1). The low average price for Wyoming's methane gas reflects the very low spot sale prices quoted for Opal, Wyoming. The average spot sale price at Opal was only $1.14 for 1991 and 70-75 percent of Wyoming gas was reportedly sold on the spot market. A lingering and growing glut of natural gas and relatively high transportation costs continue to plague Wyoming gas producers.

It is expected that contracts for the Kern River Pipeline will increase production (Table 2 and Figure 3). Higher contract prices could also reverse the downward trend in prices although there are indications that much of the gas going into the Kern River Pipeline will be purchased on the spot market (Table 1 and Figure 4). Other new pipelines such as the Northwest Pipeline Project may also help expand the market for Wyoming gas.

Coal prices and production are holding steady with earlier forecasts (Tables 1 and 2; Figures 5 and 6). Wyoming coal production should set another production record in 1991. During the fourth quarter, at least one spot sale in the Powder River Coal Field was $4.70 per ton, which may signal some strengthening in spot sale prices, but it is really too early to predict. Also, Mobil Coal Producing was able to sell its Caballo Rojo mine in the fourth quarter.

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

Calendar Year	Oil[2]	Methane[3]	Carbon Dioxide[3]	Helium[4]	Coal[5]	Trona[5]	Mined Uranium[6, 7]	In-situ Uranium[8]	Sulfur[9]
*1981	122.1	408.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	424.7	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	444.0	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	516.7	—	—	130.7	11.0	1.6	—	0.71
*1985	131.0	416.6	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	403.3	23.8	0.15	136.3	11.9	0.2	0.04	0.76
*1987	115.9	498.0	114.2	0.86	146.5	12.4	0.2	0.06	1.19
*1988	114.3	509.1	110.0	0.83	163.6	14.9	0.3	1.16	1.06
*1989	109.1	587.4	126.1	0.94	171.1	16.2	0.1	1.07	1.17
*1990	104.0	681.4	131.0	0.98	184.0	16.2	0.2	1.1	0.91
1991	100.0	728.0	131.0	0.98	193.4	16.2	0.3	1.1	1.00
1992	99.5	787.0	131.0	0.98	203.1	16.3	0.1	1.6	1.00
1993	95.5	846.0	131.0	0.98	213.0	16.6	—	2.2	1.00
1994	91.6	905.0	131.0	0.98	223.7	17.2	—	2.5	1.00
1995	88.0	963.0	131.0	0.98	234.8	17.4	—	2.5	1.00

*Actual values for comparison; [1]Geological Survey of Wyoming, January, 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 1989-1994 are based on company information); [9]millions of tons (prior to 1989, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission).

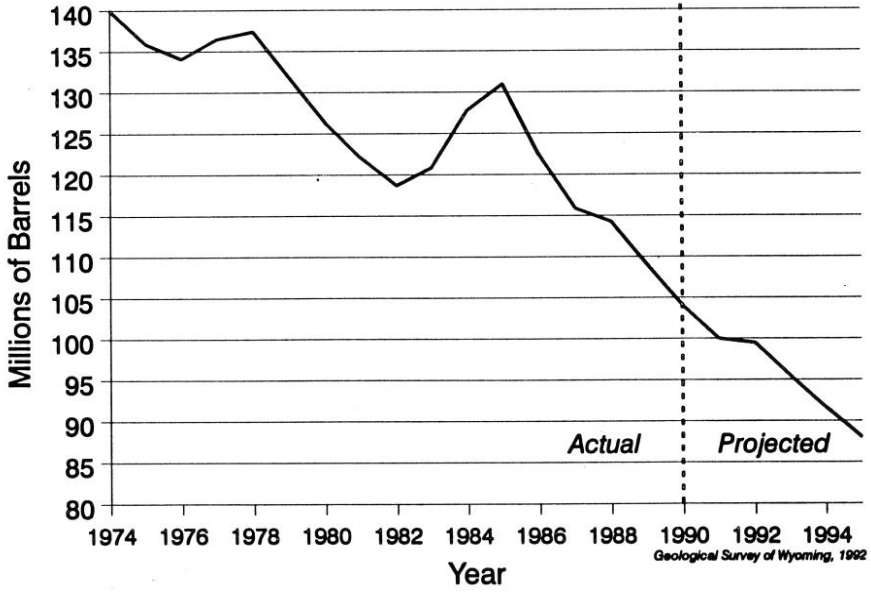


Figure 2. Annual oil production from Wyoming (1974 to 1990) with forecast to 1992).

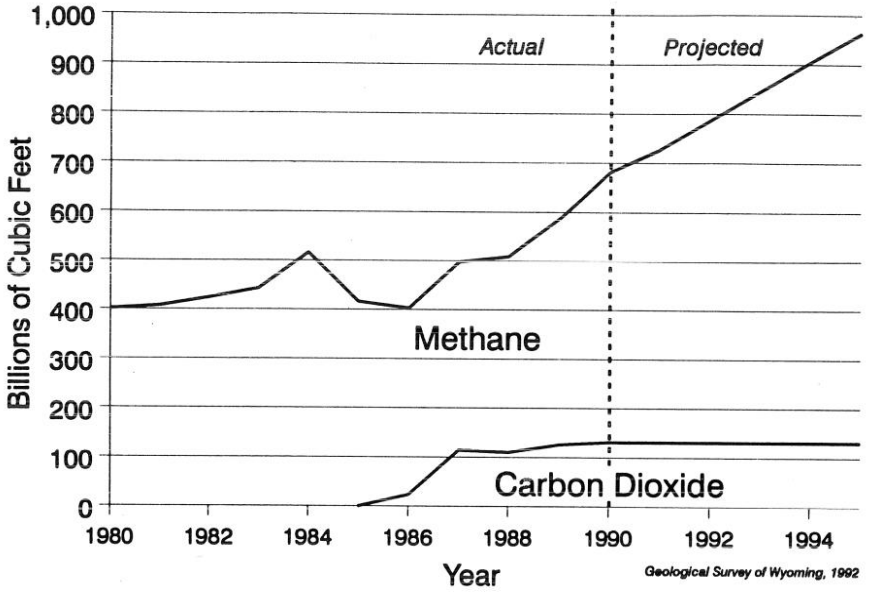


Figure 3. Annual gas production from Wyoming (1980 to 1990) with forecast to 1995.

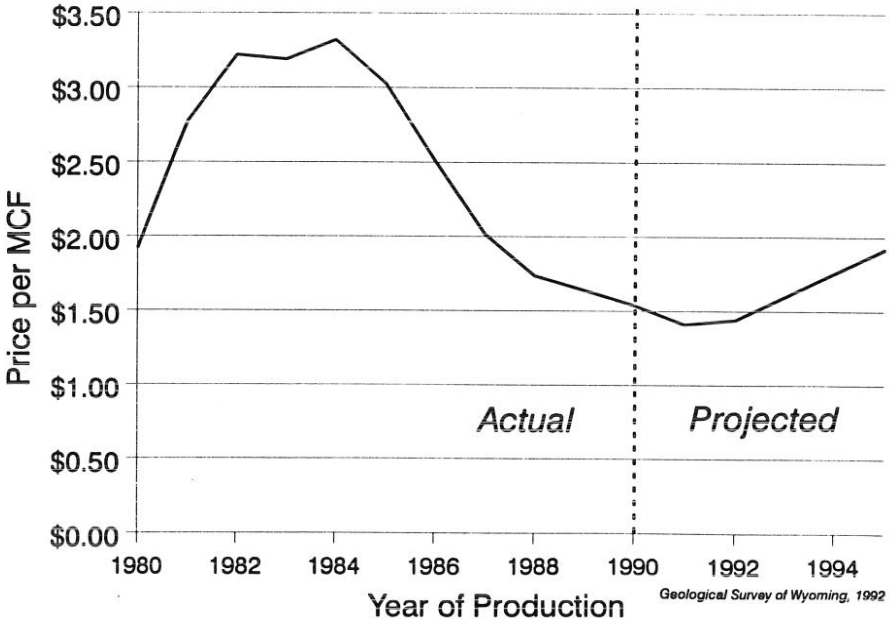


Figure 4. Average price paid for Wyoming natural gas (1980 to 1990) with forecast to 1995.

In addition, a recent study by the Geological Survey of Wyoming indicates that 15.8 billion tons of the 27 billion tons of remaining strippable coal reserves in Wyoming are compliant with environmental regulations for the burning of coal. Compliant coal means that it emits less than 1.2 pounds of sulfur dioxide per million Btu when it is burned. This new estimate more than doubles previous estimates of compliant coal in Wyoming and bodes well for increased usage of the State's coal in power plants that need to reduce their sulfur dioxide emissions (see p. 21).

While exploration for trona picked up in the last quarter, early in 1992 Pathfinder Mines announced that they plan to close their open pit uranium mine in the Shirley Basin. This is the last active conventional uranium mine in Wyoming. After this closure, Power Resources' in-situ recovery operation in the Powder River Basin may become the only active producer of uranium in the State.

There is also some indication that the market for sulfur recovered from natural gas processing plants in Wyoming may be weakening. The price for sulfur could also fall precipitously as coal-fired power plants sell more and more sulfuric acid recovered from their stack scrubbers (see p. 21).

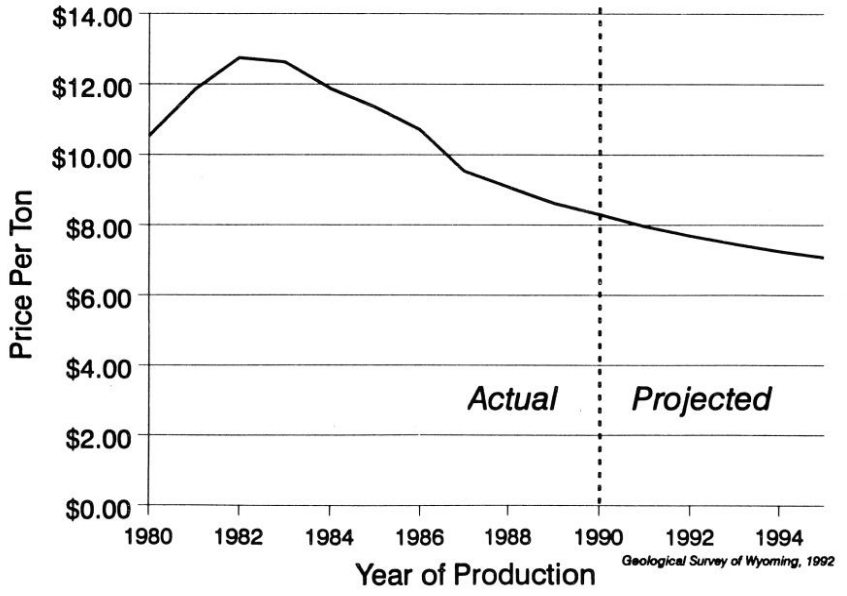


Figure 5. Average price paid for Wyoming coal (1980 to 1990) with forecast to 1995.

In regard to other mineral products produced in Wyoming, 1991 production of railroad ballast should show a large increase over 1990 production. 1991 production of most if not all the other mineral commodities in Table 3 should be similar to that of 1990.

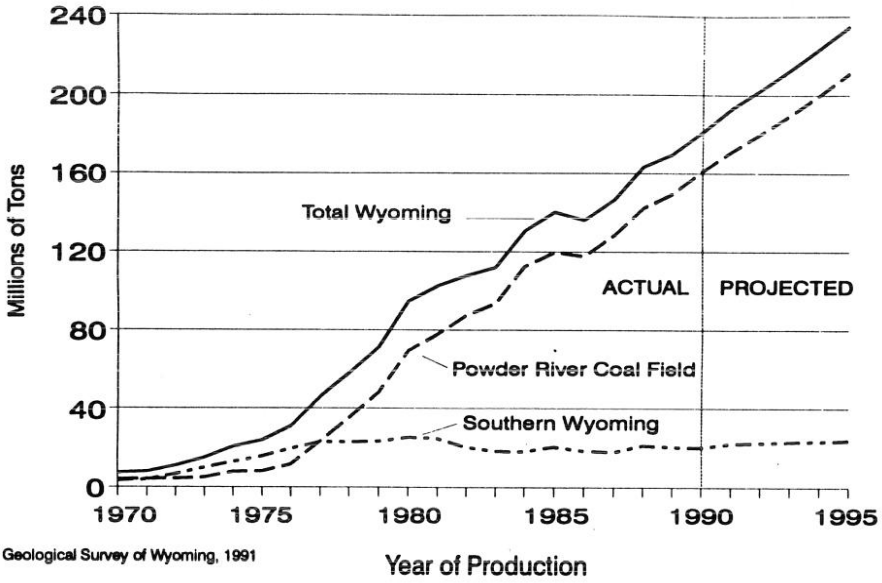


Figure 6. Annual coal production from Wyoming (1970 to 1990) and forecast to 1995.

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

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

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

OIL AND GAS UPDATE

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

While the average posted price for Wyoming Sweet crude oil was over $20 per barrel in October and November, it dropped to $18 per barrel in December (Figure 7). The average price received for Wyoming crude in 1991, however, was probably close to the projected $17.21. OPEC's inaction or only token actions on quota issues, Kuwait's resumption of oil production, the possibility of resumed production by Iraq, the lack of demand for Wyoming sour and heavy gravity oils, and projected lower demands for all oil in the second quarter of 1992 are all working to keep prices down in the near term.

At Opal, Wyoming, the spot price of natural gas went up to $1.50 per thousand cubic feet (MCF) in December, but this December price is still lower than in recent years (Figure 8). For the year as a whole, the spot price at Opal only averaged $1.14. Overall, the average price received for methane gas in Wyoming in 1991 was an estimated $1.24 per MCF.

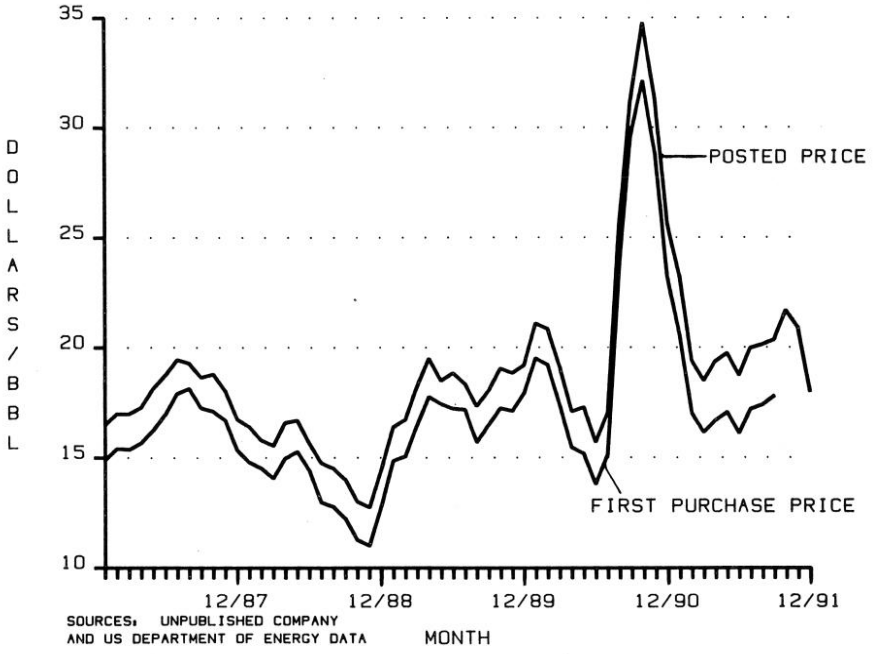


Figure 7. Wyoming posted sweet crude oil prices and first purchase prices averaged by month (1987 to present).

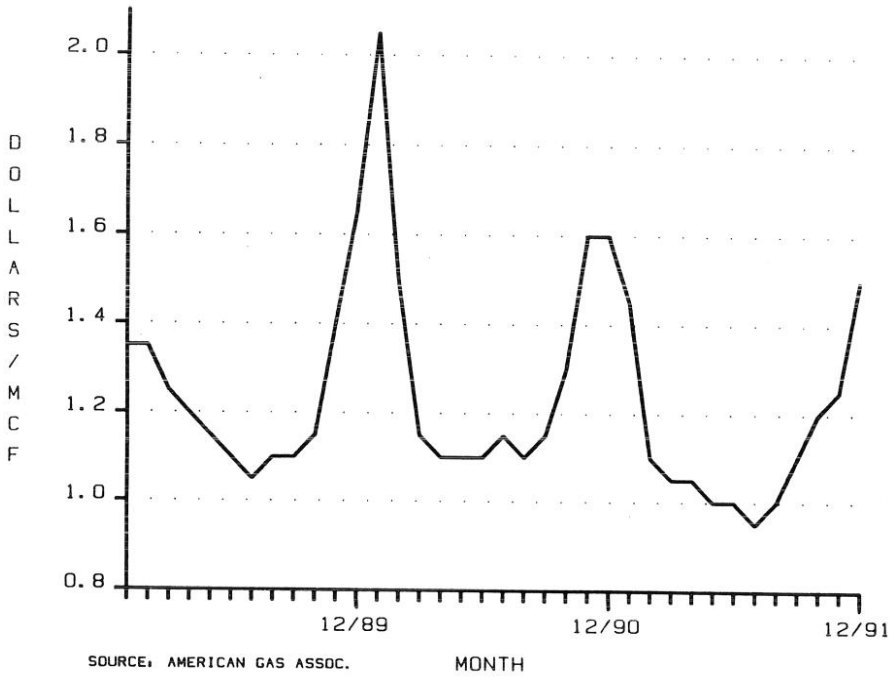


Figure 8. Spot prices for natural gas sales at Opal, Wyoming, averaged by month (1989 to present).

With oil and gas prices at their present levels, the prospects are slim for improving Wyoming's dismal rig count of the past few years (Figures 9 and 10). In fact, Wyoming's rig count in 1991 would have been even lower without the Kern River Pipeline project. Kern River is now scheduled to start transporting natural gas in February, 1992.

The Wyoming Refining Co. in Newcastle will have to find new customers for its products by 1995. About 26 percent of the refinery's total production is jet fuel for the Ellsworth Air Force Base in Rapid City, South Dakota. The Air Force is switching to a new type of jet fuel in 1995 and the Newcastle refinery does not have the resources to install the $30 million worth of additional units that it needs to make the new jet fuel. The recent closing of the Amoco refinery in Casper, however, may enable the Newcastle refinery to increase its share of the local market for gasoline.

Exxon Corp. withdrew its application for a permit to drill a well on the flanks of Carter Mountain in the Shoshone National Forest. Forest Service managers had wanted Exxon to use helicopters to get to the well.

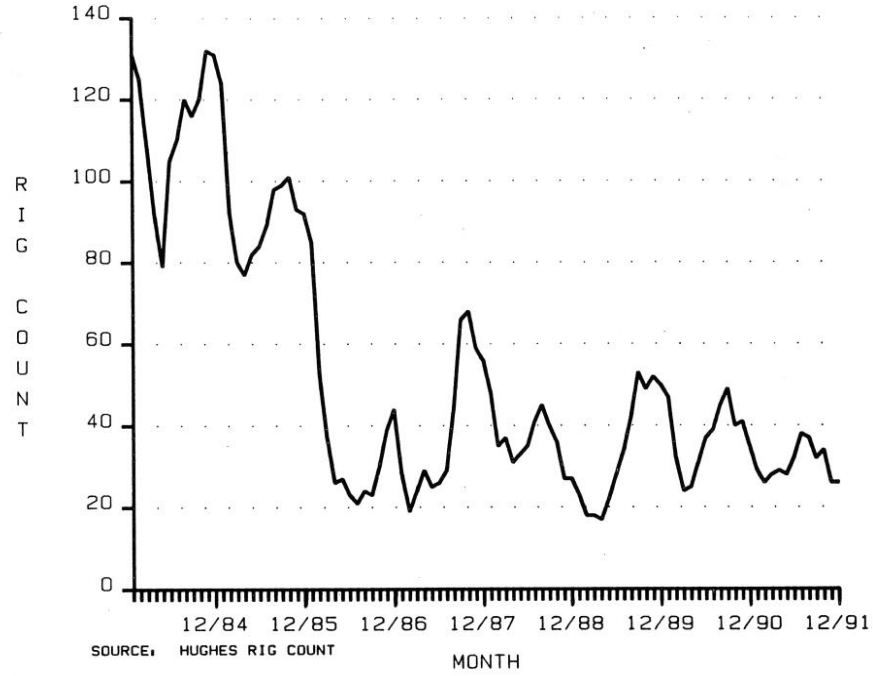


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

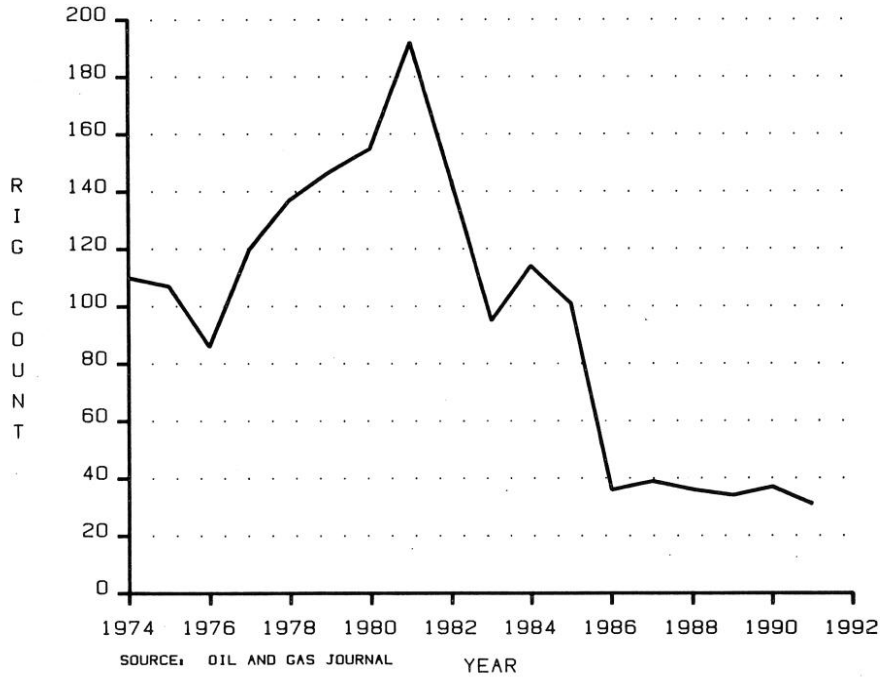


Figure 10. Wyoming daily rig count averaged by year (1974 to present).

The U.S. Department of the Interior's Board of Land Appeals (IBLA) ruled that the Bureau of Land Management (BLM) must now require a 30-day appeals period before it approves or rejects an application for a permit to drill on Federal land. If an appeal is filed on an application during the 30-day period, all action is automatically stayed until the IBLA issues a decision on the appeal. Prior to the new ruling, applications for permits to drill were not automatically stayed on appeal. If an appeal was filed on an approved application, the application was considered valid until the IBLA ruled that it was invalid.

The Federal Energy Regulatory Commission (FERC) issued a Record of Decision that designates the Muddy and Dakota sands in a portion of Mary Draw Field as "tight" formations. The decision will affect all of section 26, T41N, R72W. FERC also ruled that the lower Lewis Shale qualifies as a "tight" formation in sections 15, 21, 22, 27 through 29, 33 through 35, T24N, R97W.

The Wyoming Oil and Gas Conservation Commission has requested that FERC designate the second Frontier as a "tight" formation in sections 1 through 12, T20N, R102W; all sections, T21N, R102W; all sections, T22N, R102W; sections 1, 2, 11 through 14, 23 through 26, 35, 36, T21N, R103W; and sections 1, 2, 11 through 14, 23 through 26, 35, 36, T22N, R103W.

The BLM has proposed a royalty rate reduction for wells on Federal land that produce less than 15 barrels of oil per day. The proposed royalty rates range from 1.3 percent for wells that produce one barrel per day to 11.7 percent for wells that produce 14 barrels per day. The current royalty rate is 12.5 percent for all production. The BLM hopes the new royalty rate will encourage companies to keep low-volume wells in production and possibly return a number of marginally economic wells to production. In 1990, 211 stripper wells were abandoned in Wyoming.

The Geological Survey of Wyoming and Barlow and Haun, Inc. of Casper are jointly working on the Wyoming portion of a multi-state atlas of major Rocky Mountain gas reservoirs. The project is funded through a contract from the Gas Research Institute. The New Mexico Bureau of Mines and Mineral Resources is administering the contract, which involves the state geological surveys of Wyoming, New Mexico, Colorado, and Utah as well as several other private subcontractors like Barlow and Haun, Inc. The atlas will include over 200 reservoirs in Wyoming that have each produced at least five billion cubic feet of gas. These reservoirs have been placed within six megaplays. The megaplays have been subdivided into 23 plays and a number of subplays based on producing formations, depositional environments, and the type of traps. Geologic, engineering, and production information for 60 individual reservoirs have already been collected. A computer data base that contains data on all reservoirs will be available with the atlas.

Lease sales in the State did poorly in the last quarter of 1991 and the total revenue dropped off over $5 million compared to the total revenue from sales in 1990 (Table 4). In fact, revenue from the BLM sales were the lowest they had been since 1986.

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

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

The high per-acre bid at the U.S. Bureau of Land Management's (BLM's) October sale was $340 by Marathon Oil Company for a 79.65-acre parcel in lots 7 and 12 of section 27, T36N, R75W. The tract is about a mile southeast of Frontier and Dakota oil and gas production in Sand Dunes Field. Kerr-McGee Corp. made the second highest per-acre bid of $140 for a 603-acre lease for parts of sections 30 and 31, T41N, R76W. The lease is about a mile east of Frontier and Muddy oil and gas production in Crawford Draw Field. Diamond Resources also bid $140 per acre for a 360-acre tract in sections 24 and 25, T38N, R75W. The tract is about a mile west of Muddy oil and gas production in Bear Creek Field.

The high per-acre bid at the December BLM sale was $1,600 by Hanson and Strahn Energy Land Services for a 38.04-acre lease in NE NE section 24, T25N, R112W, which offsets Frontier oil and gas production in Fontenelle Field. The sale's second highest per-acre bid was $200 by LCM Ltd for a tract that covers NW NW section 32, T22N, R111W. The tract is about a mile northeast of Frontier oil and gas production in Whiskey Butte Field. Six tracts received bids of $100 or more at this sale.

The high per-acre bid at the State Land and Farm Loan Office's November sale was $130 by Samedan Oil Corp. for a 640-acre parcel covering section 36, T22N, R111W. The lease is adjacent to Dakota oil and gas production on the southern flank of Sugarloaf Butte Field. The sale's second highest per-acre bid was $117 by Brown Operating Inc. for a 36.43-acre lease in NW SW section 30, T54N, R69W. The lease is just over a mile northwest of Minnelusa production at York North Field and just over a mile northeast of Minnelusa oil production at Stragg Draw 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 fourth quarter of 1991. Activities related to horizontal drilling and coalbed methane are discussed in separate sections. The letters preceding discussions below refer to locations on Figure 11.

A. Chevron USA will drill a 17,000-foot wildcat well to test the gas and condensate potential of the Nugget Sandstone and Twin Creek Limestone in the Overthrust Belt about five miles southeast of Evanston. The 1-14 Chevron-Federal well is located in SW NW section 14, T14N, R120W, which is less than a mile southwest of an earlier Chevron test that encountered hydrocarbon shows in 300 feet of Nugget (*Wyoming Geo-notes No. 32*, p. 8). No further details are available on the earlier well.

B. Exxon Corp. plugged and abandoned their 1 Boxer Jack Unit well in NW SE section 4, T21N, R118W. The well was drilled to a total depth of 12,916 feet and bottomed in subthrust Cretaceous rocks.

C. Church Buttes Field has two new Frontier gas producers. Wexpro Co. completed the 99 Church Buttes Unit well in SE NE section 14, T17N, R112W.

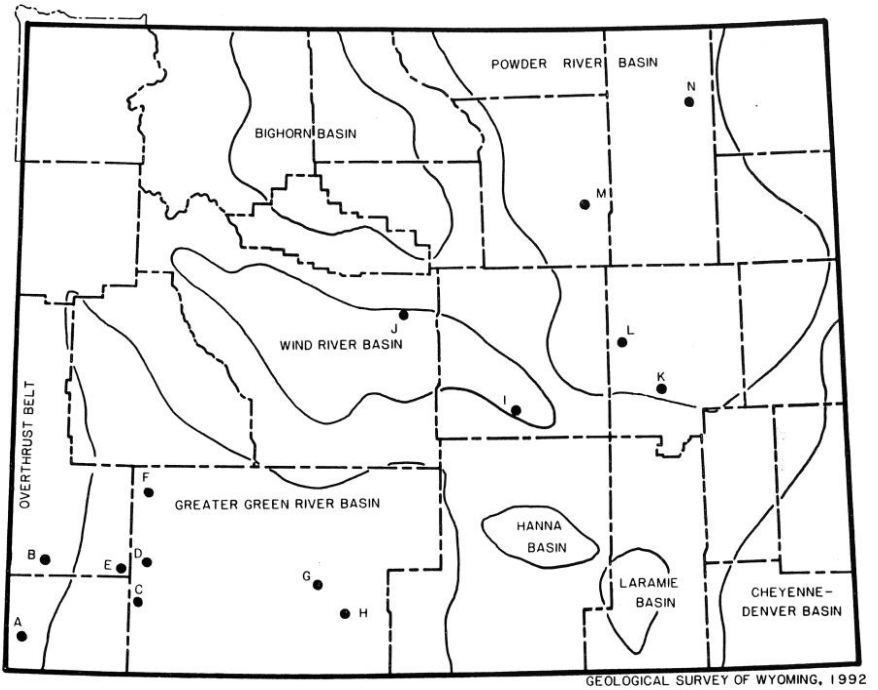


Figure 11. Oil and gas exploration and development activity in Wyoming during the fourth quarter of 1991.

The well flowed 5.9 million cubic feet of gas per day. Wexpro's 94 Church Buttes Unit well in NE SE section 11, T17N, R112W flowed 2.6 million cubic feet of gas per day. Both wells were tested below a depth of 12,000 feet.

D. Washington Energy Exploration completed their 10-6 Sequoyah-Federal well in SE NW section 6, T19N, R111W. The well flowed 2.8 million cubic feet of gas, eight barrels of condensate, and six barrels of water per day comingled from the Frontier and Dakota. Washington Energy also completed their 20-24 Mesquite-Federal well in NW NE section 24, T20N, R112W for an initial flowing potential of 1.2 million cubic feet of gas per day.

E. Wexpro Co. completed their 14 Bruff Unit well in NE SE section 16, T19N, R112W. Gas flowed at a rate of 4.3 million cubic feet per day from the Dakota. Wexpro was setting production casing at their 28-2 Lansdale-Federal well in NW SE section 28, T19N, R112W.

F. Washington Energy Exploration completed two new development wells in Lincoln Road Field. The 10-5 Lincoln Road well in SW NW section 5, T24N, R111W flowed 1.15 million cubic feet of gas per day from the Frontier. The

43-21 well in N/2 SE section 21, T24N, R111W flowed 400,000 cubic feet of gas per day from the Frontier.

G. Union Pacific Resources Co. staked a 22,000-foot test to the Madison Limestone on the northwestern flank of the Washakie Basin about six miles south of Table Rock Field. The 1 Glasnost-Federal 43-20 well is located in NE SE section 20, T18N, R97W. The prospect is a deep structural play that is controlled by two high-angle reverse faults. The well will test the Nugget Sandstone, the Weber Sandstone, and the Madison Limestone.

H. Celsius Energy Co. completed a new Almond Formation well. The 4 Mulligan Draw Unit well in NW NE section 33, T16N, R95W flowed 400,000 cubic feet of gas per day. Celsius is presently drilling the 6 Mulligan Draw Unit well in NW NE section 25, T15N, R95W.

I. W.D. Cameron, Jr. will deepen a 9,231-foot dry hole on the southeastern flank of the Wind River Basin to test subthrust Paleozoic rocks at their 1-32 Cameron well in NW SE section 32, T32N, R84W. The main objectives of the 12,250-foot test are the subthrust Phosphoria Formation and Tensleep Sandstone.

J. Louisiana Land and Exploration Co. completed two new high-volume gas producers in Madden Field. Their 2-34 Quincy well in NW SE section 34, T39N, R91W flowed 12.1 million cubic feet of gas and 59 barrels of water per day from the Sussex and Sussex "B". The well was originally completed by Monsanto Oil in 1982 as a Shannon gas producer. Louisiana Land and Exploration's second well, the 1-6 Margaret in NW NE section 6, T38N, R90W, flowed 10.9 million cubic feet of gas per day from the Fales Member of the Mesaverde. The well was originally completed in 1977 by Monsanto as a Cody producer. The well produced over 19 billion cubic feet of gas from the Cody before it was shut in.

K. Crawley Petroleum Corp. completed a new Frontier oil and gas discovery in the southern Powder River Basin. Their 1 Catherine well in SE NW section 21, T33N, R72W pumped 76 barrels of oil, 150,000 cubic feet of gas, and 129 barrels of water per day. The First Frontier was sand fractured and acid treated between 10,983 feet and 11,135 feet. The well is about three miles west of Sussex and Frontier production at Orpha Field.

L. Derrick Draw Field has a new Muddy Sandstone producer. Kerr-McGee Corp. completed their 32-25 SDMU well in SW NE section 25, T36N, R76W flowing 832 barrels of oil and 832,000 cubic feet of gas per day.

M. Culp Draw Field has a new Shannon Sandstone producer. Presidio Exploration completed their H-94CDU well in SW NW section 24, T46N, R77W on pump for 195 barrels of oil and 58,000 cubic feet of gas per day.

N. Plains Petroleum Operating is ready to complete an indicated Minnelusa oil discovery at their 43-27 Plains-Federal well in NE SE section 27, T52N,

R70W. Pipe recovery was 1,657 feet of oil and 110 feet of mud-cut water on a drillstem test between a depth of 8,000 and 8,017 feet.

Horizontal drilling

During the fourth quarter of 1991, the following significant activities related to horizontal drilling occurred. The letters preceding the discussions below refer to locations on Figure 12. The discussions are based on company data and on information compiled and published by Petroleum Information.

A. Union Pacific Resources Co. recovered 19 feet of oil-saturated and fractured core between 3,417 and 3,436 feet at their 1HAK Bar Unit 24-12 well in SE SW Section 12, T20N, R88W. Plans call for the drilling of a horizontal leg to the northwest in the Niobrara "KN-1" bench.

B. More horizontal tests are scheduled for the Niobrara Formation at Silo Field. Union Pacific Resources Co. will drill the 1 H McConnaughey 41-27 well in NE NE section 27, T16N, R65W. Chesapeake Operating Inc. is currently drilling the 1H Frances Goertz well in S/2 SW section 1, T15N, R65W and has staked a location for their 1H McConnaughey well in S/2 SW section 26, T16N, R65W.

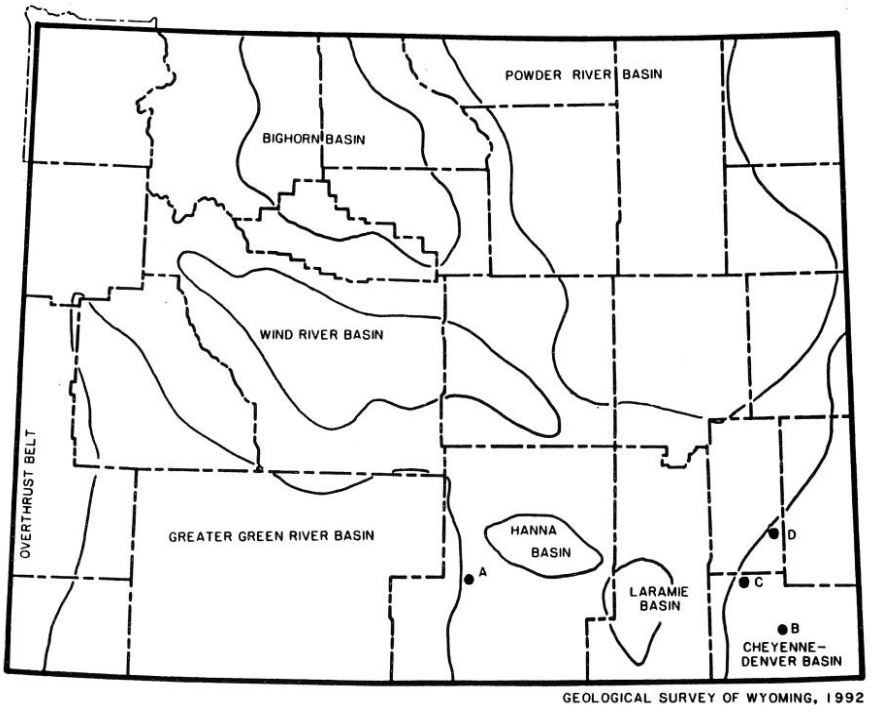


Figure 12. Horizontal-drilling activity in Wyoming during the fourth quarter of 1991.

C. Union Pacific Resources is drilling a horizontal Niobrara test at their 1H Schanaman-State 12-10 well in SW NW section 10, T19N, R68W. The test is in a non-producing township 12 miles southwest of the town of Chugwater.

D. Presidio Exploration reached total depth at their horizontal Niobrara test. The 11-15H Phillippi well in NW NW section 15, T23N, R66W is just south of a non-commercial, vertical, Niobrara well completed in 1984.

Coalbed methane

During the fourth quarter of 1991, the following significant activities related to coalbed methane occurred. The letters preceding the discussion below refer to locations on Figure 13. The discussions are based on company data and on information compiled and published by Petroleum Information.

A. Petroleum Inc. temporarily abandoned their Mesaverde coalbed methane test in SE NW Section 36, T45N, R96W. The company also reentered the 14-12 Federal well (NW SW section 14, T45N, R96W), a dry hole drilled by Apache Corp. in 1984. They ran production casing to test the coalbed methane potential of Cretaceous coals, but no other details are available.

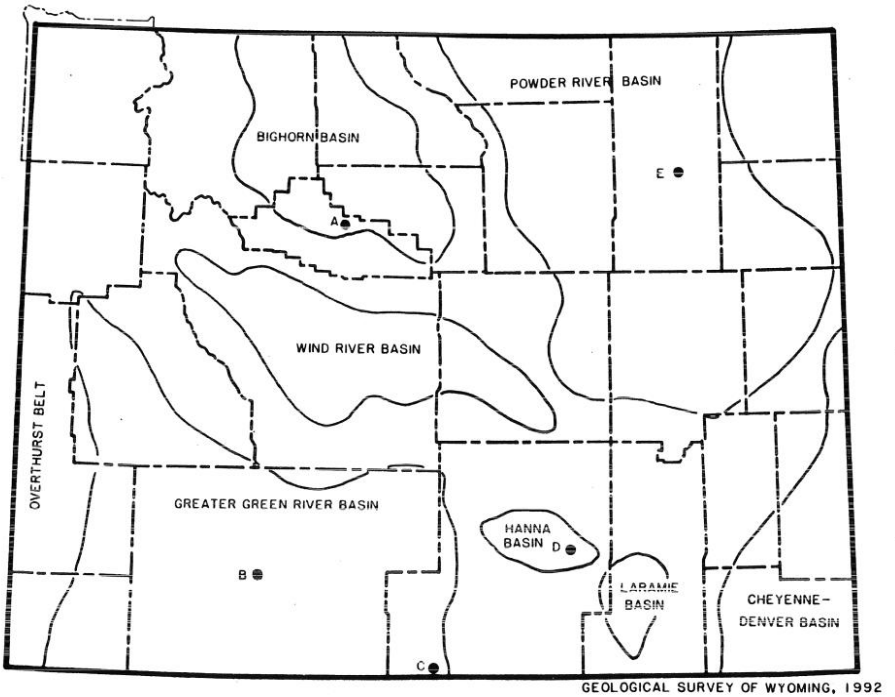


Figure 13. Coalbed methane activity in Wyoming during the fourth quarter of 1991.

B. A preliminary report by the Texas Bureau of Economic Geology for the Gas Research Institute (GRI) rates the coalbed methane potential of the Greater Green River Basin of Wyoming and Colorado higher than that of the Piceance, Raton, and Powder River Basins. The report recommends that GRI support geologic and hydrologic characterization of coalbed methane in the Greater Green River Basin.

C. Fuel Resources Development had produced over 53 million cubic feet of gas and over 2.6 million barrels of water through September, 1991, from 11 coalbed methane wells in Dixon Field.

D. Metfuel Inc. notified the BLM that they intend to drill as many as 130 coalbed methane wells on about 28,800 acres in the Hanna Basin. The company plans to drill four more evaluation wells before the end of February, 1992. The decision for full field development is dependent on the results of the four new wells. In addition, the BLM has determined that an Environmental Impact Statement will be required for this project.

E. Martens and Peck Operating Co. completed a new coalbed methane well. The 1-23 McCreery well in NE SW section 1, T48N, R72W flowed 202,000 cubic feet of gas per day with no water from a Fort Union coal interval between 350 and 380 feet deep.

COAL UPDATE

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

Coal deliveries in July reached the highest monthly level ever, as almost 16.5 million tons of coal were shipped from Wyoming mines. Although August and September deliveries were about the same as those for the same two months last year (Figure 14), total coal deliveries during the third quarter were still about one million tons greater than the third quarter of 1990. Coal deliveries for three quarters of the year were about five percent ahead of those during a similar period in 1990 (Table 5). Based on coal deliveries through the third quarter, production of coal in Wyoming will set another record in 1991 at an estimated 193.4 million tons. Forecast coal production is shown in Table 2 and Figure 6.

Recently released figures for world coal production in 1990 indicate that the United States was second in total coal production behind China, but ahead of the U.S.S.R. (Chadwick, 1991). Production of all coal ranks from China was about 1.16 billion short tons (s.t.), followed by 1.02 billion s.t. from the United States, and 774 million s.t. from the U.S.S.R. Germany (471 million s.t.), Poland (238 million

s.t.), Australia (232 million s.t.), India (231 million s.t.), and South Africa (227 million s.t.) complete the top eight coal producing countries in the world in 1990. If Wyoming were a separate country, its 1990 production of 183 million s.t. would rank it as the ninth largest coal producer in the world.

Total coal production for the world in 1990 was about 5.2 billion s.t. with about 47 percent of the total used for the generation of electricity, 19 percent for the manufacture of steel and coke, and 34 percent for industrial and domestic uses (Chadwick, 1991).

The average price for Wyoming coal has decreased every year since 1982 and is forecast to continue decreasing at least through 1995 (Table 1 and Figure 5). Much of the decrease in price from 1982 to 1987 was related to the increasing amount of less expensive coal produced from mines in the Powder River Coal Field. Price decreases from 1987 through 1990 as well as projected decreases in 1991 through 1995 are related to the increasing amount of coal priced below $5.00 that is sold on the spot market, through short-term contracts, or through renegotiated longer-term contracts. The amount of low-priced coal sold each year from Wyoming coal mines may account for almost half the State's coal production by 1995 (see Table 6). This could lower the average price for Wyoming coal to slightly more than $7.00 per ton by 1995.

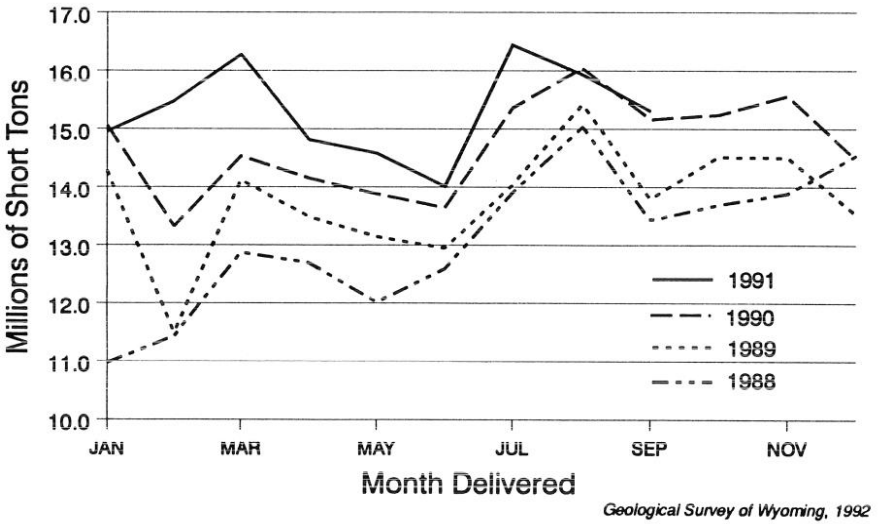


Figure 14. Reported deliveries from Wyoming coal mines (from COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).

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

	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE	1990 MONTHLY	1990 CUMULATIVE	1991 MONTHLY	1991 CUMULATIVE
JANUARY	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020	15,059,530	15,059,530	14,960,450	14,960,450
FEBRUARY	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160	13,328,290	28,387,820	15,480,110	30,440,560
MARCH	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490	14,535,270	42,923,090	16,278,870	46,719,430
APRIL	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940	14,155,470	57,078,560	14,820,240	61,539,670
MAY	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110	13,882,590	70,961,150	14,589,790	76,129,460
JUNE	11,953,650	65,840,160	12,595,480	72,586,970	12,948,350	79,482,460	13,649,070	84,610,220	14,020,100	90,149,560
JULY	12,850,240	78,690,400	13,905,670	86,492,640	14,043,350	93,525,810	15,368,280	99,978,500	16,451,090	106,600,650
AUGUST	13,460,470	92,150,870	15,041,090	101,533,730	15,428,210	108,954,020	16,046,910	116,025,410	15,940,620	122,541,270
SEPTEMBER	12,651,550	104,802,420	13,433,610	114,967,340	13,795,760	122,749,780	15,166,020	131,191,430	15,314,490	137,855,760
OCTOBER	12,248,080	117,050,500	13,696,190	128,663,530	14,523,480	137,273,260	15,244,760	146,436,190		
NOVEMBER	12,340,720	129,391,220	13,889,890	142,553,420	14,507,130	151,780,390	15,569,280	162,005,470		
DECEMBER	13,008,300	142,399,520	14,540,510	157,093,930	13,527,880	165,308,270	14,479,970	176,485,440		
TOTAL TONNAGE REPORTED		142,399,520		157,093,930		165,308,270		176,485,440		
TOTAL TONNAGE NOT REPORTED		4,089,128		6,494,270		5,831,734		7,521,261		
TOTAL TONNAGE PRODUCED[2]		146,488,648		163,588,200		171,140,004		184,006,701		

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

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

Table 6. Coal production (1983 to 1990) with forecast to 1995 (millions of tons).

	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1988[1]	1989[1]	1990[1]	1991	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	154.7	162.5	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	8.5	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	0.1	M[2]	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.5	4.5	4.1	3.8	3.5
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	12.0	11.9	12.7	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	5.1	5.3	5.5	5.6	5.8
Hot Springs County	M	M	M	M	M	M	M	0.1	M	M	M	M	M
Total Wyoming[3]	112.2	130.7	140.7	135.7	146.5	163.6	171.1	184.0	193.4	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%	5%	5%	5%	5%
Low-priced coal[4]			6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%

[1] These are actual values for comparison. [2] M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, September, 1991. [3] Totals may not equal sum of components because of independent rounding. [4] Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under $5.00.

Additional data on 1990 coal production from Wyoming became available in the fourth quarter of 1991 (see Table 7 and Figure 15). Federal coal produced in Wyoming increased by nearly 20 percent from 1989 and accounted for 97 percent of the State's total production. This compares to 85 percent of the State's total production in 1989. According to the Minerals Management Service (1991), the 175 million tons of Federal coal produced in Wyoming in 1990 was about 69 percent of the total 253 million tons of Federal coal produced in the United States. Production of Federal coal in 1990 accounted for almost 25 percent of the total coal production in the U.S. The Federal coal produced in Wyoming during the 1990 calendar year had a total market value of about $1.3 billion, an average value of about $7.51 per ton, and generated royalties, rentals, and bonus payments of about $111 million. The State of Wyoming receives half these Federal revenues collected on the coal.

Production from State of Wyoming coal leases decreased again in 1990 with only about 1.2 million tons produced; the State coal accounted for only one percent of the State's total production (Table 7). According to the 1990 Annual Report of the State Land and Farm Loan Office, most of the production on State coal leases was from Sweetwater County. The value of the coal decreased from $39.6 million in 1989 to $30.6 million in 1990 and the royalties generated from the coal also decreased from $5.1 million in 1989 to $3.8 million in 1990.

Production of private coal in Wyoming dropped significantly from 1989 to 1990; the 3.8 million tons produced in 1990 was 19.3 million tons less than the previous year. The increased amount of coal produced from Federal lands was at the expense of coal produced from private lands.

The Geological Survey of Wyoming (GSW) recently completed a year-long assessment of Wyoming's strippable coal reserves under a cooperative agreement with the U.S. Department of Energy's Energy Information Administration (Figure 16). The assessment quantifies the State's remaining strippable coal reserves by both sulfur content and heating value (Btu/pound). About 15.8 billion short tons, or 58 percent, of the total 27 billion tons of remaining demonstrated reserve base of strippable coal in Wyoming is compliant coal that emits 1.2 or less pounds of sulfur dioxide per million Btu when it is burned. This is about 8.0 billion tons more compliant coal than has been reported in earlier studies. All but 214 million tons of the strippable compliant coal is subbituminous in rank.

Of the 15.8 billion tons of strippable compliant coal in the reserve base, about 13.8 billion tons is considered recoverable (excludes any inaccessible reserves due to environmental and other restrictions as well as any mining and production losses). Of the 69.5 billion short tons of total demonstrated reserve base, which includes both strippable and underground coal, about 36.4 billion tons is considered compliant coal.

Table 7. Coal production statistics for Wyoming arranged by coal ownership.

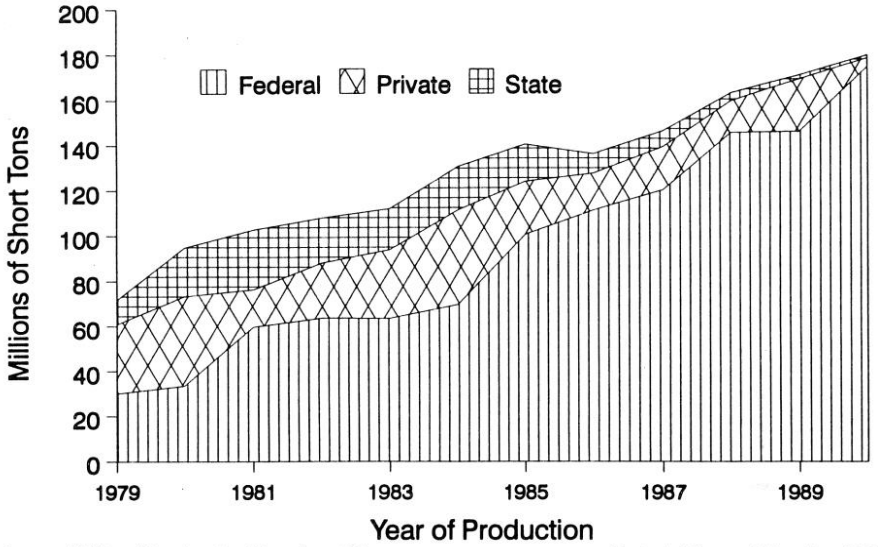
Calendar Year	FEDERAL[1] Short tons	FEDERAL[1] Percent	STATE[2] Short tons	STATE[2] Percent	PRIVATE[3] Short tons	PRIVATE[3] Percent	TOTAL[4] Short tons
1979	30,120,589	42%	10,805,182	15%	30,690,060	43%	71,615,831
1980	33,433,532	35%	21,592,173	23%	39,768,902	42%	94,794,607
1981	59,576,163	58%	26,485,276	26%	16,722,025	16%	102,783,464
1982	63,612,335	59%	19,872,591	18%	24,469,657	23%	107,954,583
1983	63,536,141	57%	18,189,147	16%	30,462,615	27%	112,187,903
1984	69,610,380	53%	19,166,425	15%	42,035,878	32%	130,812,683
1985	100,621,788	72%	16,541,094	12%	23,531,104	17%	140,693,986
1986	111,407,678	82%	8,535,191	6%	16,362,187	12%	136,305,056
1987	120,404,308	82%	6,850,053	5%	19,234,287	13%	146,488,648
1988	145,925,209	89%	3,530,651	2%	14,132,340	9%	163,588,200
1989	146,264,126	85%	1,744,190	1%	23,131,688	14%	171,140,004
1990	175,013,698	97%	1,186,927	1%	3,806,076	2%	184,006,701

COAL PRODUCTION ON STATE LEASES BY COUNTY[2]

Calendar Year	Campbell	Carbon	Converse	Lincoln	Sheridan	Sweetwater	Total
1978	2,103,806	203,818	0	24,917	10,454	0	2,342,995
1979	10,292,768	376,112	0	136,302	00	0	10,805,182
1980	21,417,481	160,584	0	14,107	0	0	21,592,172
1981	26,274,778	186,430	17,953	6,114	0	0	26,485,275
1982	19,015,683	384,578	472,330	0	0	0	19,872,591
1983	17,297,232	353,974	537,941	0	0	0	18,189,147
1984	17,968,567	121,175	889,710	0	0	186,973	19,166,425
1985	15,816,484	79,518	408,906	0	0	236,186	16,541,094
1986	8,340,540	0	0	0	0	194,651	8,535,191
1987	6,850,053	0	0	0	0	0	6,850,053
1988	2,532,519	0	0	0	0	998,132	3,530,651
1989	24,219	15,907	149,813	0	0	1,554,251	1,774,190
1990	40,715	109,293	12,389	0	0	1,024,530	1,186,927

Data sources:

[1] Minerals Management Service Annual Reports, 1981-1990.
[2] State Land and Farm Loan Office's Annual Reports, 1979-1991.
[3] Derived by subtraction of State and Federal production from total.
[4] Annual Reports, Wyoming State Mine Inspector and Wyoming Department of Revenue.



Sources: MMS and State Land and Farm Loan Office

Geological Survey of Wyoming, 1992

Figure 15. Annual Wyoming coal production arranged by coal ownership (1979 to 1990).

Developments in western and southwestern Wyoming

The fourth quarter of 1991 saw little new activity in the coal fields of western and southwestern Wyoming. Lion Coal Company's Swanson underground coal mine east of Rock Springs did ship some spot coal to the Jim Bridger power plant northeast of Point of Rocks. Coal delivery reports indicate that Lion Coal Company delivered coal to the power plant through December, 1991. In 1990, the Swanson mine produced about 107,000 tons of coal and employed 53 workers. This is one of two underground mines on the Rock Springs uplift that supplied coal to the Bridger plant. The Swanson mine and Arch of Wyoming's Pilot Butte underground mine north of Rock Springs both produce bituminous coals with relatively high heat values (over 10,500 Btu/pound on an "as-received" basis). Both mines are mining coals from the Upper Cretaceous Rock Springs Formation.

Developments in the Hanna Coal Field

During the fourth quarter, Arch of Wyoming (a subsidiary of Arch Mineral Corporation) furnished Wisconsin Power and Light Company (WPL) with an unspecified amount of coal for testing in the utility's cyclone boiler plants. Coal from Arch's Medicine Bow mine was burned without blending at undisclosed power plants operated by WPL.

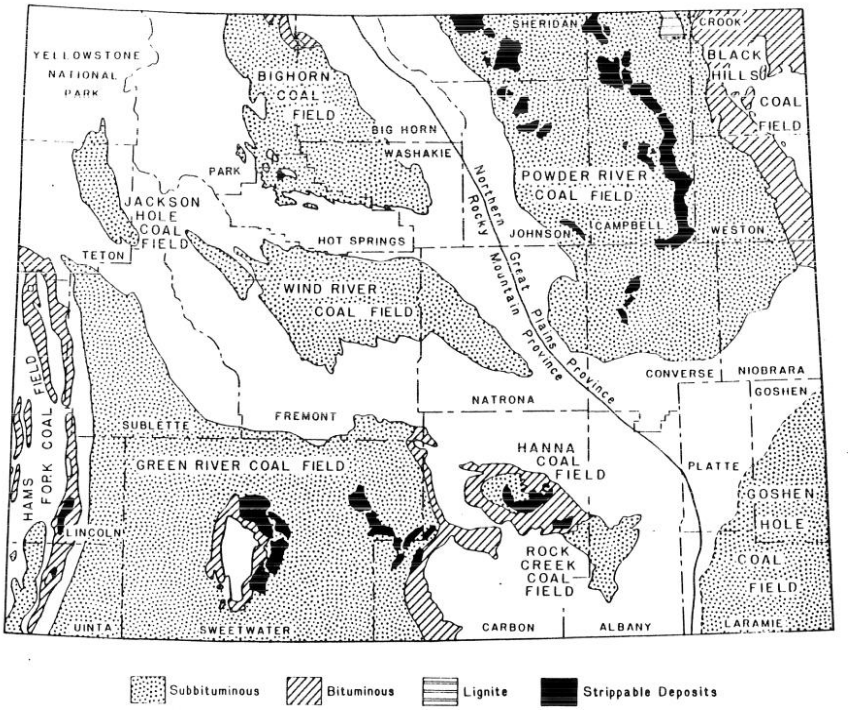


Figure 16. Index map of Wyoming coal fields and strippable coal deposits.

Arch of Wyoming's 1.2-million-ton-per-year contract with Kansas Power and Light Company's (KPL's) Lawrence and Tecumseh, Kansas, power plants expired at the end of December, 1991. KPL had solicited bids for a new two-year contract to replace this expired tonnage. In January, 1992, Arch's Medicine Bow mine, which supplied the coal on the expired contract, was awarded a new contract by KPL.

Developments in the Powder River Coal Field

In mid-December, 1991, Marigold Land Company of Birmingham, Alabama, purchased Mobil Coal Producing, Inc. from its parent company, Mobil Corporation (*Wyoming Geo-notes No. 32*, p. 26). Marigold Land Company is partially owned by Drummond Company, Inc., a mining company that operates coal mines in Alabama. Drummond was listed by the National Coal Association as the 30th largest coal company in the U.S. in 1989 with production of 8.1 million tons. The purchase price was not disclosed, but the sale did include the Caballo Rojo mine and its 400 to 500 million tons of reserves, an administrative and coal sales office in Denver, and the mine office and staff of about 150 employees. The mine is the

first one operated by Marigold Land Company. While the mine name will remain the same, Marigold will change the mine operator's name from Mobil Coal Producing, Inc. to Caballo Rojo, Inc.

A recent contract dispute between Triton Coal Company, a subsidiary of Shell Mining Company, and an Oklahoma electric utility company, Western Farmers Electric Cooperative (WFEC), was settled in Federal court in late October. WFEC had sued Triton in an attempt to end a 15-year, 1.08-million-ton-per-year coal supply contract for coal deliveries from Triton's Buckskin mine to WFEC's Hugo, Oklahoma, generating plant. A U.S. District Court jury found in favor of Triton Coal Company and upheld the contract, which expires in 1996. WFEC claimed that the contract's escalated price of $15 per ton F.O.B. the mine constituted a financial hardship because similar quality coal was currently available to them at about $10 per ton less than the escalated contract price. Because the contract evidently contained no price reopeners or renegotiation clauses in the event of market changes, but did contain escalation clauses, WFEC was unable to avoid paying a higher price. The jury concluded that WFEC had no hardship, that Triton had negotiated the contract in good faith, and that WFEC had to continue taking coal under the current contract. As part of the lawsuit, several rulings on accounting and invoicing issues were decided, which resulted in Triton paying $750,000 to WFEC.

A final settlement in the Whitney Benefits, Inc. lawsuit over unminable coal in an alluvial valley (*Wyoming Geo-notes No. 30,* p. 30 and *No. 31*, p. 23) was reached in October, 1991. The U.S. Supreme Court let stand the $160 million that a U.S. Court of Appeals awarded to Whitney Benefits, Inc. and Peter Kiewit Sons Company. The U.S. Government had made a final appeal of the award to the Supreme Court, but the Court declined to hear final arguments in the case. Peter Kiewit Sons and Whitney Benefits have sued one another in arguments over who should get what in the settlement. In early January, a U.S. District Court judge in Cheyenne delayed any decisions on the case pending a ruling by the U.S. Court of Claims.

The K-Fuels project underway near Gillette (*Wyoming Geo-notes No. 29,* p. 23) apparently has a new financial partner, ThermoChem, Inc. of Maryland. If the U.S. Department of Energy (DOE) approves the merger, ThermoChem would invest $30 million it received from the fourth round of DOE's Clean Coal Technology Program in the K-Fuels project. ThermoChem had originally planned to construct a $40 million coal gasification plant in Oregon. The plant was to use coal fines from Wyoming, but because of prohibitive transportation costs to move the fines to Oregon, ThermoChem decided instead to merge with K-Fuels. With the merger, they could obtain coal fines on site and construct their gasification plant near the K-Fuels plant.

Meanwhile, Heartland Fuels Corporation, a sister corporation of Wisconsin Power and Light Company and an 80 percent partner in K-Fuels, agreed to provide $44 million to the project if the DOE approves the ThermoChem/K-Fuels merger. If all the needed funding is obtained, construction of a combination K-

Fuels product plant and a coal gasification plant near Gillette would commence. The Fort Union coal mine would furnish the raw coal for the plant.

Coal contracts - Powder River Coal Field

Coal purchasing activities during the fourth quarter of 1991 were more numerous than those in the third quarter as many utilities announced their coal purchases for 1992. Both spot and short term contracts were announced. In addition, only three test burns of coal from this coal field were announced during the fourth quarter.

New coal contracts and sales are summarized below:

A) Cordero Mining Company (a subsidiary of Sun Coal Company) and Grand Island, Nebraska, Electric Department have renewed a coal supply contract for the Platte, Nebraska, power plant (no. 6, Figure 17). The Cordero mine will supply 0.1 to 0.55 million tons of coal from November, 1991, through October, 1992, at a delivered price of $11.45 per ton and an F.O.B. mine price of $4.70 per ton. The generating plant burns an average of 0.3 million tons of coal per year.

B) Caballo Rojo, Inc. (formerly Mobil Coal Producing, Inc.) will supply 0.6 million tons of spot coal from their Caballo Rojo mine to several electric generating

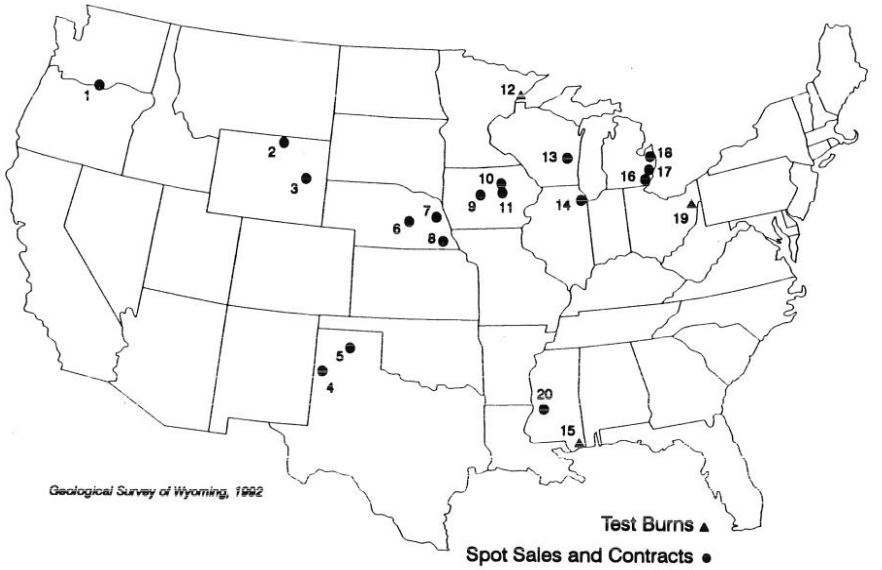


Figure 17. Index map of coal contracts and sales activities involving Wyoming coal mines, noted during the fourth quarter of 1991.

plants operated by Iowa Electric Light and Power Company. This coal sale is a one-year extension of last year's contract (*Wyoming Geo-notes No. 30*, p. 37), which allowed for the purchase of additional, optional tonnages for 1992. As with last year's contract, about 0.3 million tons will probably go to the Sutherland, Iowa, plant (no. 9, Figure 17); the remaining tonnage will probably go to both the Prairie Creek (no. 10, Figure 17) and the Sixth Street (no. 11, Figure 17) power plants near Cedar Rapids, Iowa.

C) Big Horn Coal Company, a subsidiary of Peter Kiewit Sons, will supply 5,650 tons of stoker coal from the Big Horn No. 1 mine north of Sheridan to the Veterans Administration Medical Center in Sheridan (no. 2, Figure 17). The announced price of the coal, as delivered by truck, was $19.50 per ton. The length of the contract was not announced.

D) North Antelope Coal Company's North Antelope mine in southern Campbell County will supply 0.8 million tons of coal to Wisconsin Power and Light Company's (WPL's) Columbia Unit 2 generating plant (no. 13, Figure 17) during 1992. North Antelope Coal Company is an operating unit of Powder River Coal Company, a subsidiary of Peabody Holding Company.

E) Carter Mining Company, a subsidiary of Exxon Coal and Minerals, will also supply 0.154 to 0.3 million tons of coal to WPL's Columbia Unit 2 plant (no. 13, Figure 17). This coal is expected to fill the utility's spot coal needs for the Columbia Unit 2 in 1992.

F) Nerco Coal Company's Antelope mine and Rochelle Coal Company's Rochelle mine will each supply 0.35 million tons of spot coal to three Michigan power plants operated by Detroit Edison. This additional 0.7 million tons of coal will supplement the 1.0 million tons of spot coal which Detroit Edison already purchased from Nerco and Rochelle for 1992 (*Wyoming Geo-notes No. 32*, p. 28). The additional coal will be burned at the Monroe, River Rogue, and St. Clair power plants (nos. 16, 17, and 18, respectively, Figure 17).

G) Caballo Rojo, Inc. (formerly Mobil Coal Producing, Inc.) furnished 0.1 to 0.15 million tons of spot coal to Portland General Electric Company's Boardman, Oregon, generating plant during the last two months of 1991 (no. 1, Figure 17). This spot coal sale supplemented an earlier sale of 0.35 million tons from the Caballo Rojo mine to the Boardman plant (*Wyoming Geo-notes No. 31*, p. 24). The coal from the Caballo Rojo mine originates on Burlington Northern Railroad (BN) and terminates on the Union Pacific Railroad (UP). Decker Coal Company's West Decker, Montana, coal mine north of Sheridan, Wyoming, recently won a contract to supply Boardman with 0.9 million tons of spot coal during the first half of 1992.

H) Amax Coal Company will furnish 0.8 million tons of coal to Omaha Public Power District's North Omaha and Nebraska City, Nebraska, power plants (nos. 7 and 8, respectively, Figure 17). Coal from the Belle Ayr mine will be supplied via BN rail lines during the last three quarters of 1992. An additional 0.1 million tons of coal is optional under this agreement.

I) Rochelle Coal Company, an operating unit of Powder River Coal Company (a subsidiary of Peabody Holding Company) will supply 0.8 to 1.35 million tons of spot coal to Southwestern Public Service Company's (SWPSC's) Harrington, Texas, power plant (no. 5, Figure 17) and 0.1 to 0.45 million tons of spot coal to SWPSC's Tolk, Texas, power plant (no. 4, Figure 17). The coal will be delivered in 1992 by BN (to the Tolk plant) and by BN and the Santa Fe Railway (to the Harrington plant).

J) Caballo Rojo, Inc. (formerly Mobil Coal Producing, Inc.) signed a one-year contract with Pacificorp Electric Generation Company (a subsidiary of Pacificorp) to supply 1.2 million tons of coal in 1992 to the Dave Johnston generating plant near Glenrock (no. 3, Figure 17). The coal will come from the Caballo Rojo mine; transportation details for the coal deliveries were not announced.

K) During the last two months of 1991, an unspecified coal supplier in this coal field supplied 85,000 tons of coal to Consumers Power Company of Jackson, Mississippi (no. 20, Figure 17). The plant or plants that used the coal were not announced.

L) Caballo Rojo, Inc.'s (formerly Mobil Coal Producing, Inc.'s) Caballo Rojo mine also supplied a total of 0.143 million tons of spot coal to Northern Indiana Public Service Company's Mitchell, Indiana, power plant (no. 14, Figure 17).

Coal purchased for test burns is summarized below:

M) Venture Fuels, a coal brokerage company, will supply 15,000 tons of test coal to LTV Steel Company's Taconite Harbor, Minnesota, power plant (no. 12, Figure 17). Venture Fuels is a partnership between Nerco Coal Company and Midwest Energy Resources Company. The coal would come from either Nerco's Spring Creek, Montana, mine or the Antelope mine in Wyoming and would be blended with equal amounts of Eastern low-sulfur coal in one of three 75-MW units at the plant. LTV Steel Company restarted one unit at the power plant in July, 1991, after a 10-year shutdown. The other two units at the plant will be brought into service in the near future. The steel company will eventually only use coal from the Powder River Coal Field. Shipments could begin this spring.

N) Peabody Holding Company is currently supplying 40,000 tons of test coal to LTV Steels' Taconite Harbor plant from either the North Antelope or the Rochelle mines (no. 12, Figure 17).

O) Caballo Rojo, Inc.'s (formerly Mobil Coal Producing, Inc.'s) Caballo Rojo mine is also supplying 20,000 tons of test coal to LTV Steel's Taconite Harbor plant (no. 12, Figure 17).

P) In October, Mobil Coal Producing, Inc. furnished 12,000 tons of test coal to Ohio Edison's Burger, Ohio, power plant (no. 19, Figure 17). The Caballo Rojo coal was blended with other Eastern coals at the plant. The actual sale was

arranged by Mobil's eastern coal vendor, Coal Network, Inc. and transportation was arranged by Coal Transit, Inc., an affiliate of Coal Network, Inc.

Q) Nerco Coal Company will furnish 0.16 million tons of test coal to Mississippi Power Company's Daniel, Mississippi, power plant (no. 15, Figure 17). The deliveries began in December of 1991 and will continue through February. The coal is from either the Spring Creek, Montana, or the Antelope mine and will be burned without blending with other coals. Southern Company Services, the fuel procurement agent for Mississippi Power Company, arranged the coal purchase.

References cited

Chadwick, John, 1991, World coal: Mining Magazine, v. 165, no. 4 (October, 1991), p. 211, 213-214.

Minerals Management Service, 1991, Mineral revenues 1990 - Report on receipts from Federal and Indian leases: U.S. Department of the Interior, 128 p.

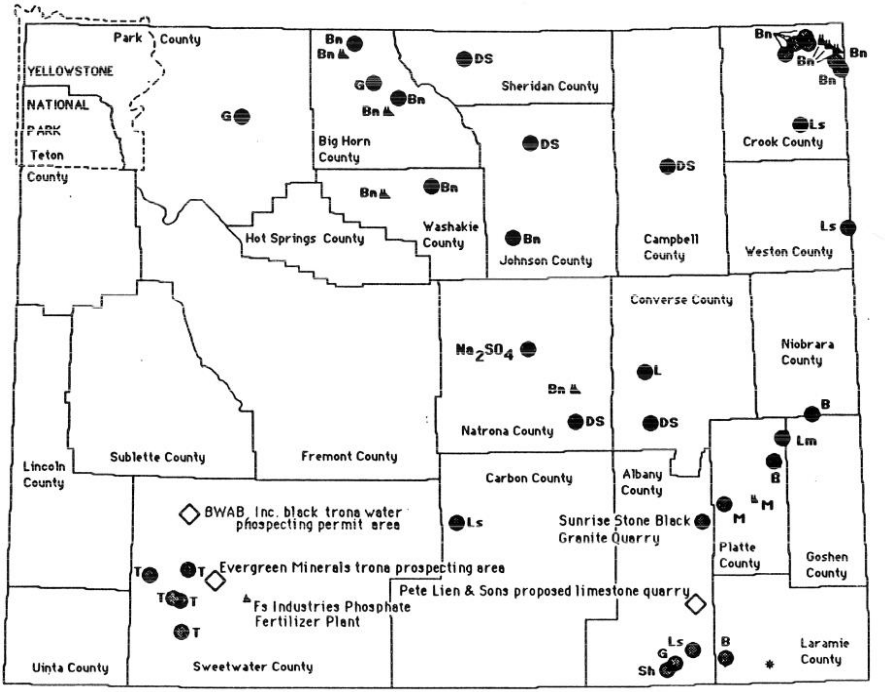
INDUSTRIAL MINERALS AND URANIUM UPDATE

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

Summary

Usually, the fourth quarter of a calendar year is marked by few new developments by the industrial minerals and uranium producers in Wyoming. The fourth quarter of 1991 was no exception. Of note, however, were the sale of Chevron Chemical Company's fertilizer plant in Rock Springs (see Fertilizer) and an increase in exploration for trona (see Trona).

In 1991, industrial minerals and construction materials produced in Wyoming were bentonite, construction aggregate (which includes sand and gravel, crushed rock, and railroad ballast), decorative aggregate, decorative stone, leonardite, chemical grade limestone, gypsum, shale, sodium sulfate, and trona (Figure 18). Also, uranium production continued at Wyoming's one uranium mine and one in-situ recovery operation (Figure 19).



EXPLANATION

⊗	Active mines or quarries
	Aggregate (construction)[1]
B	Ballast
Ls	Limestone (aggregate)
	Aggregate (decorative)
M	Marble
Bn	Bentonite
DS	Stone (decorative)
G	Gypsum
L	Leonardite
Lm	Limestone (chemical)
Sh	Shale
$NaSO_4$	Sodium sulfate
T	Trona
◇	Prospects or proposed mines or quarries
	Plants or mills

[1]Does not include temporary sand and gravel pits

Figure 18. Index map of industrial mineral and construction material activities in Wyoming.

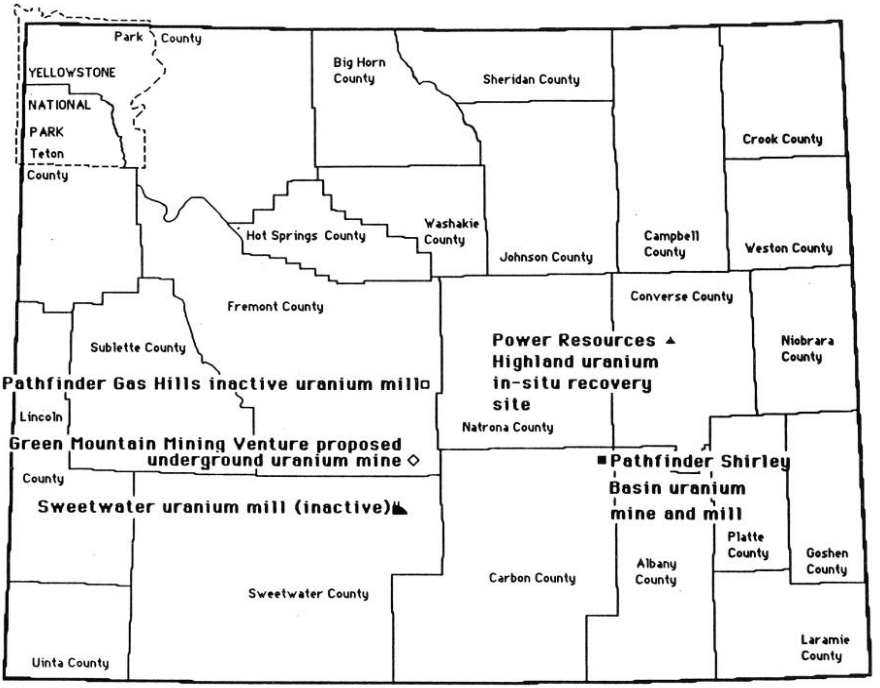


Figure 19. Uranium activities in the fourth quarter of 1991.

Construction aggregate

The U.S. Congress passed the 1991 highway appropriations bill in the 4th quarter of the year. Because this bill includes funds for increased construction of highways in Wyoming, the demand for aggregate used for road base, sub-base, and surfacing should be greater in 1992 than in 1991. Highway construction in Wyoming slowed in the last quarter of 1991 due to a lack of appropriated Federal highway funds and the onset of winter.

The production of railroad ballast in Wyoming should show a large increase from 1990 to 1991 although production figures have not been published. According to company representatives, Meridian Minerals' ballast quarry at Granite, Wyoming, west of Cheyenne, is increasing ballast sales to both the Union Pacific and Burlington Northern Railroads.

Lamb Construction's ballast quarry, south of Lusk at Bald Butte, reopened in 1991 and produced ballast for a ballast and tie replacement project of the Chicago and Northwestern Railroad (C&NW). This quarry last operated in 1985 during construction of the C&NW line from Morrill, Nebraska, to the coal fields of the

Powder River Basin. Both Meridian's and Lamb's quarries produce ballast from Precambrian quartzofeldspathic gneiss. In addition, Guernsey Stone at Guernsey produces a small amount of light-duty ballast from a Precambrian dolomite.

The U.S. Bureau of Mines (1991b) reported that domestic sales of sand and gravel for construction aggregate in the third quarter of 1991 were 13.5 percent less than sales from the corresponding period in 1990. This figure indicates a general slowdown in the construction industry in the third quarter of 1991. Although the U.S. Bureau of Mines does not report production figures for crushed stone sold for construction purposes, crushed stone production should have mirrored that of sand and gravel.

Decorative aggregate

A small amount of decorative aggregate from the Luhr pit east of Guernsey (Figure 18) was sold to the Wal-Mart Corporation in Denver for resale as landscape rock. This material is sized, natural gravel, which is known as "river rock". In past years, the Luhr pit has also intermittently provided construction aggregate.

Decorative stone

Sunrise Stone continues to quarry a black "granite" at the Kennedy Ranch site in northern Albany County (Figure 18). The quarried rock is actually a Precambrian amphibolite. At the quarry site, a normally thin amphibolite layer has been folded upon itself into a large uniform deposit.

Sunrise hopes to increase production of this decorative stone to about four blocks per week. The blocks are shipped by rail from Wheatland to a cutting and finishing facility operated by Fagan Marble and Granite in western Arkansas. There, the blocks are cut into slabs and tiles which are polished for use as decorative stone facing , flooring, and tile.

The Geological Survey of Wyoming (GSW) continues to assist Sunrise Stone by studying the geology of the black amphibolite quarry site. As a result of these geologic investigations, which are supported by a grant from Sunrise Stone, the GSW has identified and delineated many tons of this black decorative stone that appear to be minable with little waste.

The GSW also received notification at the end of December that the U.S. Forest Service might award it a grant for the purpose of locating decorative stone in southeastern Wyoming, especially on or near National Forest land. Project details and the amount of the award are not yet final.

Fertilizer

Chevron Chemical Company is in the process of selling its fertilizer plant southeast of Rock Springs (Figure 18), to a joint venture between Farmland

Industries, of Kansas City, Missouri, and J.R. Simplot of Boise, Idaho. The sale should be completed and the sale documents signed in early 1992. The two joint venture partners will have equal shares in the management of the plant. The venture is called FS Industries. FS said that the operation of the plant will not change significantly, and the number of employees (about 250) and the annual production of fertilizer (350,000 - 400,000 short tons) will remain the same. Each of the new partners owns phosphate fertilizer operations elsewhere. J.R. Simplot operates a phosphate mine and fertilizer plant in Idaho, and Farmland operates a phosphate mine and fertilizer plant in Florida. The Rock Springs plant uses fertilizer mined north of Vernal, Utah, (shipped to the plant by slurry pipeline) and sulfur recovered from natural gas produced in Wyoming.

Limestone

Plans for a chemical-grade limestone quarry and lime plant near Laramie are on hold. Tests at the quarry site, 11 miles northeast of Laramie (Figure 18), delineated high-quality limestone suitable for the production of calcined lime, but the anticipated market for the lime has not developed. Pete Lien & Sons, the developer, is waiting for a better market before proceeding with the opening of the quarry and the construction of a lime plant.

Sulfur

Sulfur is produced in the United States by two methods: mined sulfur (Frasch sulfur), and sulfur produced from the refining of natural gas and petroleum (recovered sulfur). According to the U.S. Bureau of Mines (1991a), Wyoming was second in the Nation in 1990 in recovered sulfur production, behind Texas, and third in overall sulfur production, behind Texas and Louisiana. Some of this sulfur is processed into sulfuric acid (H_2SO_4) an industrial chemical with a wide variety of uses. Pure sulfuric acid sells for $75 to $85 per ton liquid F.O.B. ocean ports. Less pure (smelter grade) sulfuric acid sells for $48 per ton liquid F.O.B. smelter (*Chemical Marketing Reporter*, Dec. 2, 1991). However, the sales price of sulfuric acid is dropping very fast due to competition from the sale of sulfuric acid recovered from coal-fired power plant emissions. As a result of the new Clean Air Act Amendments, there will be even more sulfuric acid recovered from power plants. Consequently, the price may fall below $10 per ton liquid according to David Ramsey of Peridot Chemicals of New Jersey. This price drop may not only decrease the amount of Wyoming sulfur sold for the production of sulfuric acid, but also decrease the overall amount of sulfur sold from Wyoming.

Trona

Five companies mine trona and manufacture a variety of products from refined trona (soda ash) at five locations west of Green River in Sweetwater County (Figure 18). Production continues to increase as new and upgraded facilities are constructed at these sites (*Wyoming Geo-notes No. 31*, p. 30, and *Wyoming Geo-notes No. 32*, p. 32).

BWAB, Inc., of Denver is exploring for black trona water south of Farson (*Wyoming Geo-notes No. 32*, p. 32). Also, in the last quarter of 1991, Evergreen Enterprises, of Casper, Wyoming, submitted an exploration program for trona to the U.S. Bureau of Land Management. Evergreen's exploration program is for an area to the north and west of Green River, south and east of the Rhône-Poulenc mine and plant area (Figure 18). This increase in exploration is a result of the increased demand for sodium products produced from trona.

In October, Japanese trade representatives announced that Japan will drop its four percent tariff on imported U.S. soda ash. This development could result in an increase in sales of U.S. soda ash to Japan. Japan is currently the largest importer of American soda ash, buying 22% of American exports, all of which come from Wyoming.

Uranium

The NUEXCO spot market price for uranium increased to $7.40 in November, 1991, up from October's price of $7.25 per pound of yellowcake. By the end of the fourth quarter, the NUEXCO spot market price had increased to $8.75 per pound.

In Wyoming, uranium is still produced by conventional open pit mining and milling at the Shirley Basin mine, operated by Pathfinder Mines in northeastern Carbon County, and by in-situ recovery methods at the Highland site, owned by Power Resources, in the southern Powder River Basin in Converse County (Figure 19). Pathfinder in early 1992, however, announced that it planned to close the Shirley Basin mine.

In October, the Wyoming Environmental Quality Council rejected Pathfinder Mines self-bond for reclamation at the company's two uranium mining operations in the state, the active mine in the Shirley Basin and the inactive mines and mill in the Gas Hills (Figure 19). The Wyoming Environmental Quality Council later accepted the self-bond of the parent company, COGEMA-France.

In December, Green Mountain Mining Venture (GMMV) announced that it was planning to buy the closed Sweetwater uranium mill from UNOCAL. GMMV is composed of Kennecott Minerals, based in Salt Lake City, and U.S. Energy-Crested Corp. of Riverton. This venture has been studying the feasibility of opening an underground uranium mine at Green Mountain, south of Jeffrey City. The Sweetwater mill closed in 1983 and is located about 25 miles south of the proposed mine (Figure 19). In 1982, it was the largest operating uranium mill in Wyoming.

Also in December, the Fremont County Commissioners voted to apply for a $100,000 grant from the U.S. Department of Energy (DOE) to study the feasibility of constructing a Monitored Recoverable Storage site (MRS) in Wyoming. An MRS is a temporary storage site for spent fuel rods used by nuclear power plants. The fuel rods would be transported to an MRS site in virtually indestructible containers, which provide radiation shielding. They would be stored at the MRS in similar containers. In early 1992, the DOE awarded a grant to Fremont County.

References cited

U. S. Bureau of Mines, 1991a, Sulfur in 1990: U.S. Bureau of Mines Mineral Industry Surveys, April 22, 1991, 6 p.

U. S. Bureau of Mines, 1991b, Crushed stone and sand and gravel in the third quarter of 1991: U.S. Bureau of Mines Mineral Industry Surveys, November 25, 1991, 7 p.

METALS AND PRECIOUS STONES UPDATE

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

Discoveries of large metal deposits along Wyoming's southern and northern borders should increase exploration for metal deposits in Wyoming during the upcoming 1992 field season. In addition, the Geological Survey of Wyoming completed the initial phase of its study of several atypical geological environments that might host gold in southern Wyoming. A second phase of this project will begin in the spring of 1992.

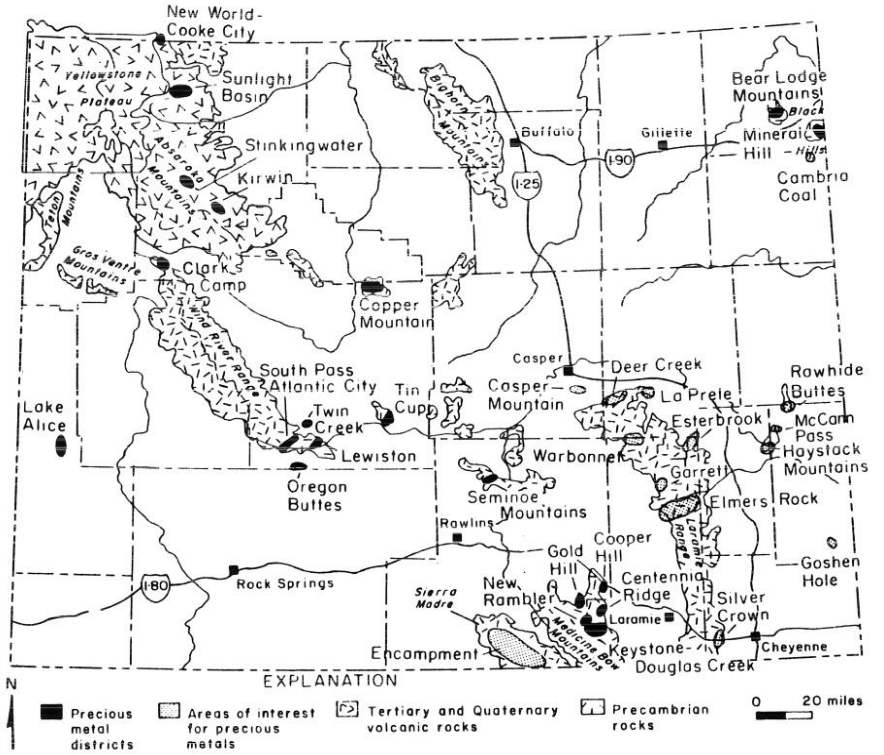
Absaroka Mountains

The Casper Star-Tribune (Nov. 3, 1991) reported that Crown Butte Mines, a subsidiary of Noranda Exploration, plans to develop a gold mine in the New World mining district in Montana (Figure 20). The southern border of the New World mining district borders with Wyoming (Hausel, 1989, p. 16-18). According to the newspaper article, the deposit, which is located 3 miles northeast of Cooke City, hosts an estimated 2.2 million ounces of gold. The estimated reserves are worth about a half billion dollars at current gold prices. Because of the location of the proposed mine, Crown Butte may employ some people from the Cody area.

South of this region in Wyoming, other companies are reportedly exploring for porphyry copper-silver-gold mineralization and metasomatic gold-silver replacement deposits. However, no major discoveries have been reported in this area.

Bear Lodge Mountains

The Bear Lodge Mountains in Crook County in northwestern Wyoming form a Tertiary alkalic complex that intrudes Phanerozoic sedimentary rocks (Figure 20). This complex has received a fair amount of exploration interest for disseminated gold during the past few years (*Wyoming Geo-notes No. 29*, p. 31-32). The *Engineering and Mining Journal* (April, 1991) reported that Coca Mines Inc. increased the resource estimate of their Sundance property in the Bear Lodge Mountains to 8.2 million short tons of ore, averaging 0.02 ounce per ton of gold. Metallurgical testing indicated only a 70% recovery.



Geological Survey of Wyoming, 1992

Figure 20. Principal metal districts and mineralized regions of Wyoming.

Encampment district, Sierra Madre

During the 1991 field season, there was intensive exploration for zinc, silver, and gold by more than one mining company in the Encampment district of the southern Sierra Madre of southern Wyoming (Figure 20). The exploration activities in this area of Wyoming have been confined to geochemical sampling and aerial magnetic surveys. Whereas, a short distance across the border in Colorado, a major mining company has been drilling a zinc-silver massive sulfide (?) deposit over the past few years.

The Geological Survey of Wyoming (GSW) began a study of the historic mines and prospects in the Sierra Madre last summer (*Wyoming Geo-notes No. 32*, p. 36). One of the mines examined was the Copper Giant mine located a few miles west of Encampment. Eric V. Sorg of Laramie led the GSW to this mine because of its historical significance. History indicates that Wild Bill Cody was the principal investor in the development of the mine (Eric V. Sorg, personal communication, 1991).

The Copper Giant was developed along the North Fork of the Encampment River where an adit appears to have been cut several hundred feet into the hillside. The mine dump consists of waste material with no visible ore. The four samples collected for gold and silver analyses included quartz breccia cemented by pyrite, hematite-stained quartz, fractured quartz filled with specular hematite, and limonite-stained quartz. Three of the samples yielded no detectable gold (minimum detection limit=0.05 ppm Au). The fourth sample only had 0.09 ppm Au (0.0026 ounce per ton). Two of the four samples contained no detectable silver (minimum detection limit=0.1 ppm Ag). The other two had only traces of silver, assaying 0.12 ppm (0.003 ounce per ton) and 0.99 ppm Ag (0.029 ounce per ton). These samples were not assayed for base metals because they contained no visible ore minerals with the exception of pyrite. There was no evidence of copper mineralization anywhere on the property.

Another property investigated by the GSW was the Kurtz-Chatterton mine on Copper Creek south of Encampment. This proved to be a very interesting property with copper mineralization associated with veins, breccia veins, and stockworks over a distance of at least 3,500 feet and widths of 600 to 800 feet (Figure 21). The deposit is hosted in altered zones of the Sierra Madre granite (quartz monzonite?) with secondary (?) biotite, muscovite, and propylitic mineral assemblages. Petrographic studies of the alteration assemblages are planned.

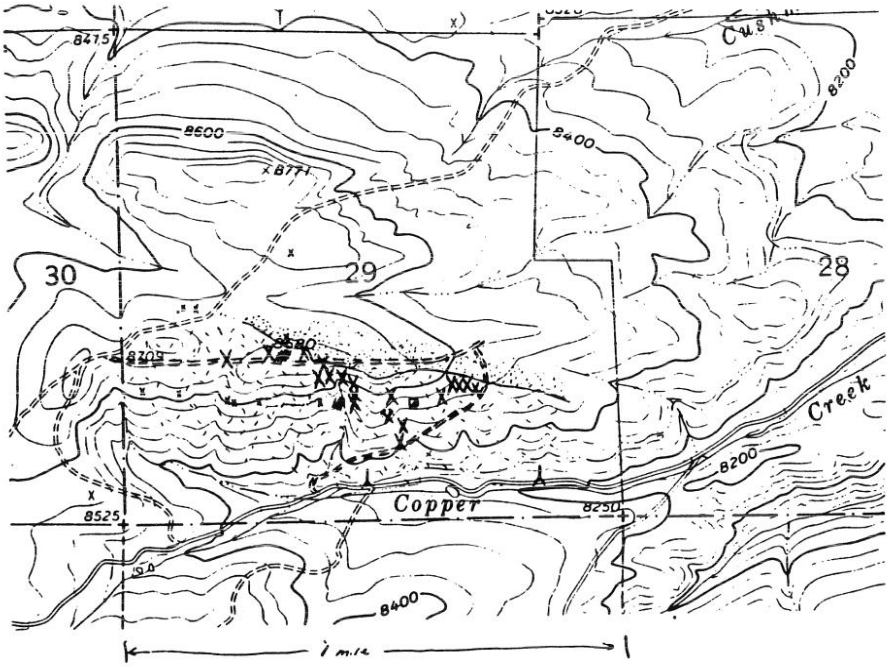
Samples collected by the GSW contain abundant primary and secondary copper minerals including pyrite. Historic reports indicate that by 1901 more than 1,700 feet of tunnel and several hundred feet of drifts had been dug on the property and that the ore ran from 10 to 20 percent copper with some gold and silver (Hausel, 1989, p. 156). Numerous samples were collected by GSW geologists in 1991, but no assays are yet available. It appears that some of the samples will carry several percent copper.

Sheep Mountain, Medicine Bow Mountains

In May of 1991, the author examined a copper mine in the Sheep Mountain area along the eastern flank of the Medicine Bow Mountains (*Wyoming Geo-notes No. 31*, p. 33). Prior to this field investigation, this previously unnamed mine was not listed in the records of the Geological Survey of Wyoming. For discussion's sake, the mine will be referred to as the Sheep Mountain mine.

The mine lies in a saddle between two drainages in a heavily forested area in sec. 15, T14N, R77W, and it was developed by a shaft (presently caved). The size of the mine dump suggests the shaft could be a few hundred feet deep with several hundred feet of drifts.

Several samples were collected from the dump including some malachite-stained hypidiomorphic granite with minor amounts of fluorite. This granite has been referred to as Sherman Granite (Proterozoic). Other samples included quartz breccia and fractured quartz, cemented by various ore minerals including ilsemannite ($MoO_8 \cdot xH_2O$), molybdenite, chalcopyrite, chalcocite, bornite, minor cuprite, and traces of copper sulfate (?). Five samples (SPM3-91 through SPM7-



EXPLANATION

X	Prospect pit exposing mineralized rock
x	Prospect pit-no mineralized rock
⚒	Open cut in mineralized rock
◪	Shaft in mineralized rock
⟋	Adit in mineralized rock
▩	Mineralized gossan
▩	Sierra Madre granite (Proterozoic)
▩	Quartzite (Proterozoic)

Figure 21. Reconnaissance map of the Kurtz-Chatterton copper mine, Encampment Quadrangle, Sierra Madre, Wyoming (sec. 29, T14N, R84W).

91) were assayed showing good concentrations of copper and anomalous silver, lead, and molybdenum (Table 8) (Hausel, 1991a).

Table 8. Assay results of samples from the mine dump at the Sheep Mountain mine, (sec. 15, T14N, R77W) in the Sheep Mountain area of the Medicine Bow Mountains, southwestern Wyoming (Hausel, 1991a).

Sample #	Au(ppb)	Ag(ppm)	Cu(%)	Pb(ppm)	Zn(ppm)	Mo(ppm)
SPM3-91	52	16.3	>2.0	192	<1	870
SPM4-91	6	5.0	>2.0	672	60	99
SPM5-91	10	23.2	>2.0	47	<1	114
SPM6-91	40	26.8	>2.0	—	—	—
SPM7-91	13	23.8	>2.0	83	<1	—

South Pass-Atlantic City district

Consolidated McKinney Resources, Inc. of Canada recently sold the Carrisa mine in the South Pass greenstone belt in the southern Wind River Range to Hol-Lac Gold Mines (Figure 20). Hol-Lac Gold Mines is a shell company, dating back to 1937, which is being reactivated with funding from Europe (Mel de Quadros, personal communication, 1991). The Carrisa property was drilled by Consolidated McKinney in 1989 with favorable results which led up to the purchase agreement by Hol-Lac. Historic production from the mine is reportedly between 50,000 to 180,500 ounces of gold (Hausel, 1991b, p. 43).

In the same general region, the *Engineering and Mining Journal* (Sept. 1991, p. 14) reported that Goldstake Explorations, Inc. and Sawatch Gold Placers had begun an extensive drilling project on a 6.5-mile-long paleoplacer south of Atlantic City in the South Pass greenstone belt. They have proposed drilling 100 holes. The deposit, which occurs at depths of only 40 to 70 feet, has the potential for more than one million ounces of gold.

Southern Wyoming

The first phase of a reconnaissance study of several different geological environments that might host precious metals and diamonds was completed during the 1991 field season. A grant from Union Pacific Resources to the Geological Survey of Wyoming (GSW) made the study possible.

Several gold anomalies were outlined during the project in a number of different areas in southern Wyoming. Some of the areas examined for gold included the Cooper Hill mining district in the Medicine Bow Mountains (*Wyoming*

Geo-notes No. 32, p. 34-35), coal and clinker deposits in the Rock Springs area, coal deposits near Walcott Junction, titaniferous sandstone deposits in the Rock Springs uplift, sand and gravel deposits at several localities in southern Wyoming, and a large silicified zone south of Rock Springs. Samples of lamproite from the Leucite Hills northeast of Rock Springs were collected and examined for possible diamond mineralization and for its peridot (olivine) quality.

The overall project was very successful and the GSW identified numerous gold anomalies where none had been identified before. The results are scheduled for publication as an open file report during the early part of 1992.

References cited

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

Hausel, W.D., 1991a, Sheep Mountain copper mine, Medicine Bow Mountains, Wyoming: Geological Survey of Wyoming Mineral Report MR91-1, 5 p.

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

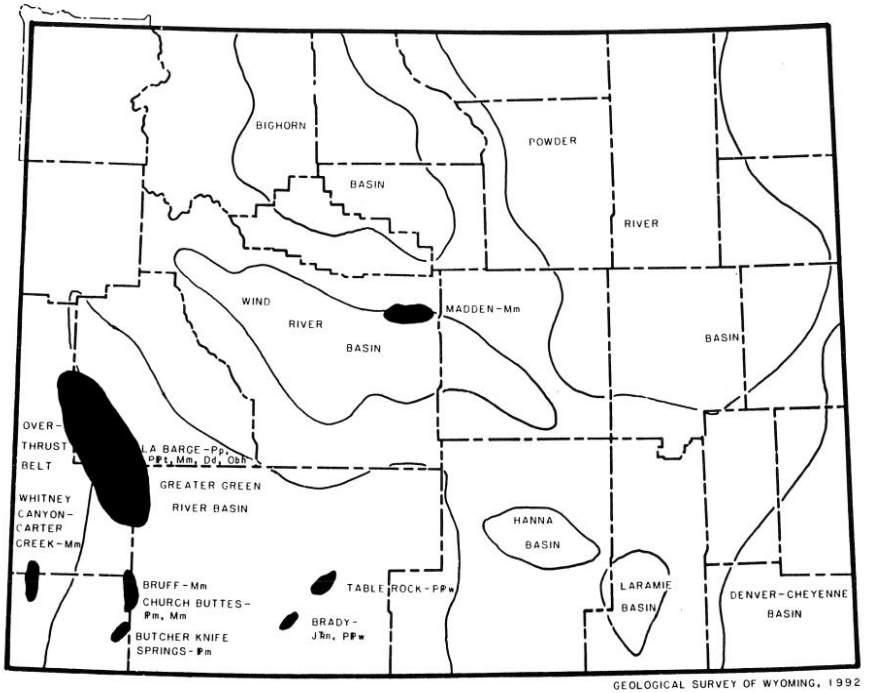
CARBON DIOXIDE RESOURCES IN WYOMING

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

In Wyoming, significant carbon dioxide resources have been discovered in reservoirs of Paleozoic age at La Barge, Bruff, Church Buttes, and Butcher Knife Springs fields on the Moxa arch in the Greater Green River Basin (Figure 22). Table Rock and Brady fields in the eastern Greater Green River Basin, Whitney Canyon -Carter Creek Field in the Overthrust Belt, and Madden Field in the Wind River Basin also have reservoirs that contain significant volumes of carbon dioxide.

A new report by the Geological Survey of Wyoming provides estimates of original, remaining, and recoverable identified and undiscovered resources of carbon dioxide in these and other reservoirs in Wyoming (De Bruin, 1991). Based on this report, the original resources of carbon dioxide in these and other reservoirs are estimated to have been 153.89 trillion cubic feet (Table 9). After cumulative production of 0.63 trillion cubic feet is subtracted, Wyoming has remaining carbon dioxide resources of 153.26 trillion cubic feet (through December 31, 1990). These remaining carbon dioxide resources consist of 60.715 trillion

cubic feet of recoverable identified resources, 61.345 trillion cubic feet of marginal and subeconomic identified resources, 15.60 trillion cubic feet of recoverable undiscovered resources, and 15.60 trillion cubic feet of marginal and subeconomic undiscovered resources (Table 9).



KEY TO FORMATION NAMES

JURASSIC-TRIASSIC
JTRn Nugget Sandstone

PERMIAN
Pp Phosphoria Formation

PERMIAN-PENNSYLVANIAN
PPw Weber Sandstone
PPt Tensleep Sandstone

PENNSYLVANIAN
Pm Morgan Formation

MISSISSIPPIAN
Mm Madison Limestone

DEVONIAN
Dd Darby Formation

ORDOVICIAN
Obh Bighorn Dolomite

Figure 22. Oil and gas fields in Wyoming with significant resources of carbon dioxide.

Table 9. Original and remaining resources of carbon dioxide in Wyoming[1].

	Identified		Undiscovered	Total	
	Original	Remaining[2]	Remaining[2, 3]	Original	Remaining[2]
Recoverable	61.345	60.715	15.60	76.945	76.315
Marginal and Subeconomic	61.345	61.345	15.60	76.945	76.945
Total	122.69	122.06	31.20	153.89	153.26

[1]All volumes are in trillions of cubic feet.
[2]Resources remaining after December 31, 1990.
[3]In this case, the remaining resources are the same as the original resources.

Of the remaining 122.06 trillion cubic feet of identified resources of carbon dioxide, most are concentrated at La Barge anticline (Table 10). La Barge has 117.38 trillion cubic feet of the State's total remaining identified resources, most of which are in the Madison Limestone.

Most of the estimated 15.60 trillion cubic feet of recoverable undiscovered resources and the estimated 15.60 trillion cubic feet of marginal and subeconomic undiscovered resources are in Paleozoic formations below a depth of 15,000 feet in the Greater Green River Basin.

The most important use for carbon dioxide produced in Wyoming is in some enhanced oil recovery (EOR) projects. These are EOR projects that inject carbon dioxide to recover additional oil left behind in reservoirs. Normally between 60 and 70 percent of the original oil is left in a reservoir after primary and secondary operations are completed. When carbon dioxide is introduced into an appropriate oil reservoir, it swells the oil and reduces its viscosity, improves relative permeability to ease the flow of oil, extracts light crude oil components, and adds solution gas-drive energy to the reservoir. All these effects help to recover an additional portion of the original oil that otherwise would be left in the reservoir.

Since September, 1986, Exxon has produced carbon dioxide-rich natural gas from the Madison Limestone at the La Barge anticline. Sixty-six percent of this natural gas is carbon dioxide. After the carbon dioxide is separated from methane and other gases, a contracted portion of it is transported by pipeline to Rangely Field in Colorado and to Lost Soldier and Wertz fields in central Wyoming. At these three fields, conventional carbon dioxide floods are recovering additional oil. Some of the separated carbon dioxide is also sold for use in huff 'n' puff wells, which are treated using a cyclic, carbon dioxide, stimulation process.

Reference cited

De Bruin, R.H., 1991, Wyoming's carbon dioxide resources: Geological Survey of Wyoming Open File Report 91-6, 20 p.

Table 10. Remaining identified resources of carbon dioxide in Wyoming by field and formation[1, 2].

Field	Formation								
	Madison Limestone	Bighorn Dolomite	Tensleep Sandstone	Phosphoria Formation	Weber Sandstone	Morgan Formation	Nugget Sandstone	Darby Formation	Total
La Barge	111.26	5.28	0.38	0.39				0.07	117.38
Bruff	0.43								0.43
Church Buttes	1.89					0.22			2.11
Butcher Knife Springs						0.01			0.01
Whitney Canyon-Carter Creek	0.14								0.14
Table Rock	0.37				0.04				0.41
Brady					0.19		0.44		0.63
Madden	0.95								0.95
Total	115.04	5.28	0.38	0.39	0.23	0.23	0.44	0.07	122.06

[1]All volumes are in trillions of cubic feet.
[2]Resources remaining after December 31, 1990.

Table 11. Mineral resource and reserve base estimates for Wyoming.

PETROLEUM		
Remaining Resources (January 1, 1991)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.7	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.3	billion barrels
Remaining Reserve Base (January 1, 1991)		
Measured reserves (Proved reserves) (Includes 0.79 billion barrels of oil, 0.66 billion barrels of gas liquids, and 0.10 billion barrels of condensate)	1.55	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.35	billion barrels
NATURAL GAS		
Remaining Resources (January 1, 1991)		
Discovered (Includes 21 trillion cubic feet (TCF) of methane[1] and 122.1 TCF of CO_2[3])	143.1	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,850.3	trillion cubic feet
Remaining Reserve Base (January 1, 1991)		
Measured reserves (Proved reserves) (Includes 10.4 TCF of methane[2] and 60.7 TCF of CO_2[3])	71.1	trillion cubic feet
COAL		
Remaining Resources (January 1, 1991)		
Identified and Hypothetical (Discovered)	1,428.6	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,460.1	billion tons
Remaining Reserve Base (January 1, 1991)		
Demonstrated strippable (Measured and indicated reserve base)	27.0	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	69.5	billion tons
TRONA		
Original Resources (1990 estimate)		
Trona	81.0	billion tons[8]
Mixed trona and halite	52.7	billion tons[8]
Total	133.7	billion tons
URANIUM		
Remaining Resource (December 31, 1989)	1.99	billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1989)		
Uranium oxide recoverable at $30.00 per pound	66	million pounds[9]
OIL SHALE		
Original Resources (January 1, 1981)		
Identified (Discovered)	320	billion barrels of shale oil[10]

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

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

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

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

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

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

[7] Geological Survey of Wyoming, January, 1992. (Modified from Berryhill, H.L., Jr. and others, 1950), Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.

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

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

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

GEOLOGIC MAPPING AND STRATIGRAPHY

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

NEW MAP COMPLETED

The Geological Survey of Wyoming (GSW) recently completed work on a new preliminary 1:24,000-scale geologic map of the Packsaddle Canyon Quadrangle located northwest of Kaycee, Wyoming, in the southern Bighorn Mountains (Figure 23). The map is titled, *Preliminary geologic map of the Packsaddle Canyon Quadrangle, Johnson County, Wyoming*, and was released as Open File Report 92-1. This map represents the tenth geologic quadrangle map completed as part of the southern Bighorn Mountains mapping project.

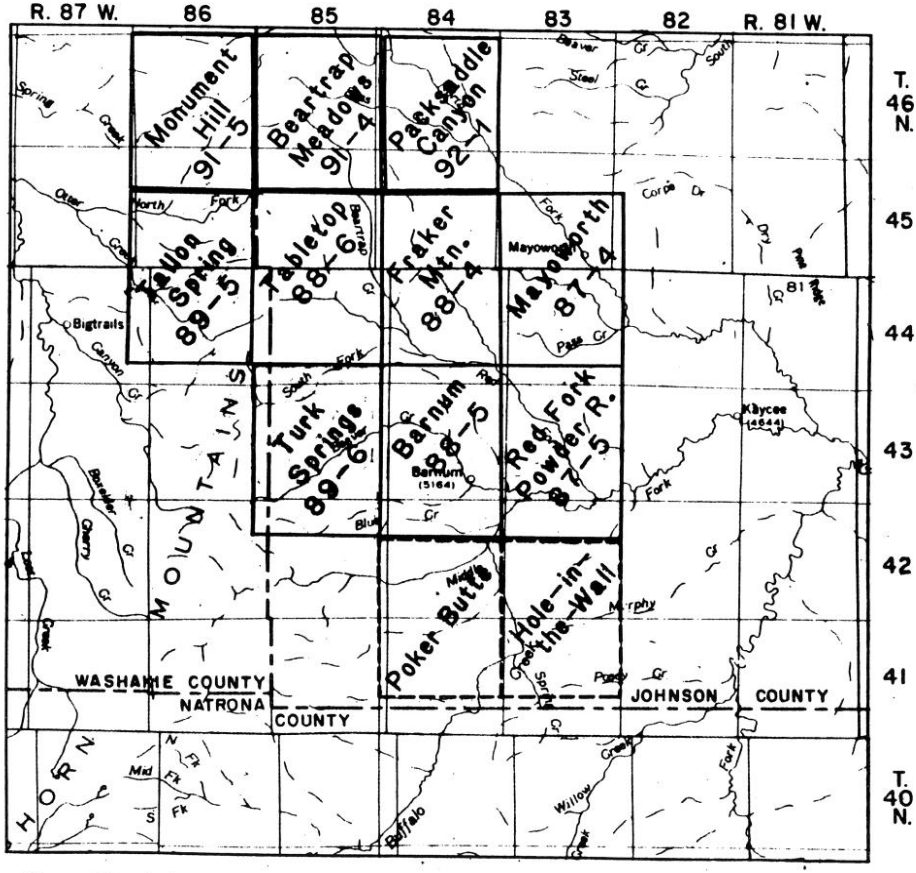


Figure 23. Index map to mapping by the Geological Survey of Wyoming in the southern Bighorn Mountains.

The Packsaddle Canyon Quadrangle contains sedimentary rocks ranging from the Tertiary White River Formation to the Cambrian Flathead Sandstone. The northeast portion of the map contains a segment of the Horn, an uplifted and faulted feature predominantly made up of Precambrian basement rocks. The majority of outcrops west of the Horn fault are Paleozoic rocks dipping toward the east at about 8° to 12° and striking north/south. Some Jurassic, Triassic, and Permian outcrops occur in the syncline immediately adjacent to the Horn fault.

The quadrangle contains several interesting structural features. The predominate feature is the Horn fault, which outlines the western boundary of the Horn uplift. Previous workers, including Hose (1955), Case (1957), and Palmquist (1961), mapped the Horn uplift and interpreted the Horn fault as a steep, near vertical, reverse fault. Palmquist (1961) defines the Horn structure as a block faulted, vertically uplifted feature.

The GSW's preliminary work associated with mapping the quadrangle suggests that the Horn is a compressional feature. The Horn fault, on the southwest facing margin, appears to dip at a much lower angle, more consistent with compressional features. In this interpretation, the Horn is an anticlinal fold, which is asymmetrical to the west. It is faulted on the west side with the upthrown block overriding the synclinal axis toward the southern end of the structure. This overridden synclinal axis reappears in the folded sediments immediately south of the Horn structure.

Other structural features include the Fraker Mountain anticline. This structure trends north/south on the west side of the quadrangle, projecting north from the Fraker Mountain Quadrangle, located to the south. This fold is asymmetrical to the west, plunging and disappearing toward the north end of the Packsaddle Canyon Quadrangle. In addition, two previously unidentified faults were mapped trending southwest off the northwest corner of the Horn structure. The more significant of the two faults trends southwest, turning south and merging into the Fraker Mountain anticline. This fault is downthrown to the north and west and extends for at least four miles.

Two other quadrangles (Poker Butte and Hole-in-the-Wall) were mapped this past field season and are currently awaiting final compilation. They will be released as open file reports in early 1992.

GREYBULL DINOSAUR SITE

Brent Breithaupt, curator of the University of Wyoming's Geology Museum, recently announced that next field season he and others will return to the site of the significant dinosaur find near Greybull. Breithaupt and personnel from the Museum of the Rockies, removed a complete sub-adult *Allosaurus* skeleton from the site last fall (*Wyoming Geo-notes No. 32*, p. 40-41). The paleontological group is hopeful that they can find additional fossils in the area.

In a related note, U.S. Bureau of Land Management officials have proposed that the area surrounding the discovery site be designated an area of critical environmental concern.

STRIKE-SLIP MOVEMENT ON BIG TRAILS FAULT SYSTEM

Adam Norris and An Yin of the Department of Earth and Space Sciences, University of California at Los Angeles, recently presented results of their study of the interaction of the Casper Arch fault, Owl Creek fault, and Big Trails fault at the southern end of the Bighorn Mountains. Their presentation was a poster session at the annual meeting of the Geological Society of America in San Diego in late October of 1991 (Norris and Yin, 1991). The research involved systematic mapping and kinematic studies of the three fault systems with emphasis on the Big Trails fault. This research indicates the Big Trails fault is a right-normal oblique-slip fault, totalling 1.5-2.5 kilometers of vertical slip with the west side down and 2.5-3.5 kilometers of right slip displacement. Slickensides or striations measured in the central portion of the fault plunge 32° toward the northeast, indicating oblique slip. The fault plane dips 75-80° toward the west. Also, numerous NW-trending folds were noted along the fault. All these features are consistent with oblique-slip or strike-slip fault models.

The results of this research are in agreement with the work and interpretations developed by the Geologic Mapping Section of the Geological Survey of Wyoming (GSW). The GSW's interpretations were derived from mapping done along the Big Trails fault as part of the southern Bighorn Mountains mapping project in 1987, 1988, 1989, and 1990. Previous articles by the GSW *(Wyoming Geo-notes No. 24*, p. 31-33 and *Wyoming Geo-notes No. 28*, p. 41-42) outline some of the evidence found as a result of this field mapping.

References cited

Case, L.E., 1957, General geology of the Horn fault region, Bighorn Mountains, Wyoming: Unpublished M:S. thesis, State University of Iowa, 87 p.

Hose, R.K., 1955, Geology of the Crazy Woman Creek area, Johnson County, Wyoming: U.S. Geological Survey Bulletin 1027-B, 118 p.

Palmquist, J.C., 1961, Petrology and structure of the Horn area, Bighorn Mountains, Wyoming: Unpublished Ph.D. dissertation, State University of Iowa, 188 p.

Norris, A. and Yin, A., 1991, Evolution of an intraplate triple junction during the Laramide orogeny, southern Bighorn Mountains, Wyoming (abs.): Geological Society of America Abstracts with Programs, v. 23, p. A133.

EARTHQUAKE RESEARCH IN WYOMING

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

In 1990 and 1991, many activities related to earthquakes were expanded in Wyoming. Significant progress has been made with educational activities, research on active faults, the National Earthquake Hazards Reduction Program (NEHRP), and possible recommendations related to the Uniform Building Code. Summaries of these activities are presented below.

EDUCATIONAL ACTIVITIES

The State of Wyoming and the Federal Emergency Management Agency (FEMA) conducted numerous educational seminars or presentations on earthquakes in Wyoming from November 1, 1990, to November 1, 1991. In November, 1990, a presentation on *Geologic Hazards and Seismic Risk in Wyoming* was given to the Wyoming Public Employees Association. Later in November, a presentation on *Seismic Hazards in the United States, with an Emphasis on Wyoming* was given to the Wyoming Society of Professional Engineers.

On May 2-4, 1991, FEMA, in cooperation with the Geological Survey of Wyoming (GSW), the University of Wyoming, and the Wyoming Department of Education, sponsored a *Train-the-trainer* workshop on *Tremor Troop, Earthquakes, A Teacher's Package for K-6.* The workshop, which was conducted in Jackson, Wyoming, was well attended by educators from Wyoming and surrounding states. On August 15-16, 1991, FEMA sponsored a *Multi-hazard Workshop* in Thermopolis, Wyoming. August 16, 1991, was devoted to an earthquake and seismic risk seminar in addition to a review of NEHRP. Representatives from many of the cities and counties in Wyoming were present at the conference. On August 26-27, 1991, the Wyoming Emergency Management Agency sponsored a class on *Earthquake Hazard Mitigation for Utility Lifeline Systems* in Riverton, Wyoming. Instructors at the course had been previously trained at FEMA's Train-the-trainer course at the Emergency Management Institute in Emmitsburg, Maryland. On October 23, 1991, a presentation on *Seismic Risk and Hazards in Wyoming* was given at the annual meeting of the Wyoming Conference of Building Officials, which was held in Casper, Wyoming. At that meeting, the need for upgrading portions of Wyoming from Seismic Risk Zone 3 to Seismic Risk Zone 4 was discussed.

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP)

In December, 1990, the Geological Survey of Wyoming, with assistance from the Wyoming Emergency Management Agency and the Wyoming State Engineer's Office, prepared Wyoming's application to establish eligibility for participation in the Earthquake Program (44 CFR, Part 361, The EP Rule). The application was approved by FEMA. In early 1991, the Geological Survey of Wyoming provided

input for the development of FEMA's guidelines for newly eligible states under the National Earthquake Hazards Reduction Program (NEHRP). Refer to *Wyoming Geo-notes No. 30*, page 62, for further information.

In early 1991, Wyoming requested and was provided with the portion of FEMA's earthquake library that had been in storage due to space limitations. The Geological Survey of Wyoming (GSW) and the Wyoming Emergency Management Agency have prepared an indexed bibliography on all earthquake-related reports, books, and articles now available at the GSW. Currently, over 900 listings are in the bibliography. The GSW hopes to incorporate its earthquake library into the University of Wyoming library system. Contact Jim Case at the GSW for further information on this important resource.

RESEARCH ON ACTIVE FAULTS

Known and suspected active faults are shown on Figure 24. Of primary interest are faults that have been active in the Quaternary (the last two million years). Research has continued on the Teton, Rock Creek, and Greys River fault systems in Wyoming.

Dr. Bob Smith and John Byrd at the Department of Geology and Geophysics, University of Utah, have continued their research on the Teton fault (Figure 24) with funding assistance from the National Park Service and the Geological Survey of Wyoming. In the past year, the following observations were made:

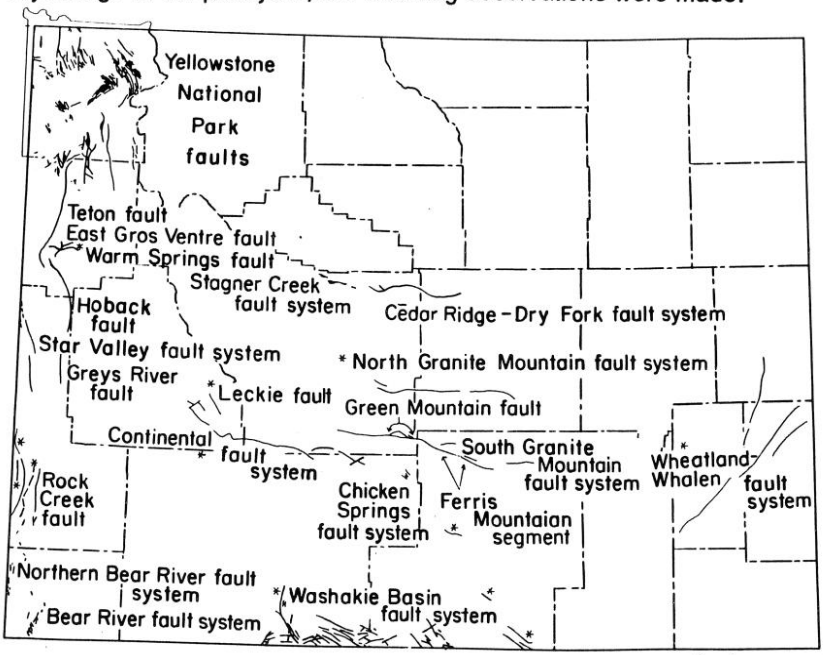


Figure 24. Suspected active faults in Wyoming.

1) Recent investigations indicate that the Teton normal fault may consist of two segments, a 42-km-long southern segment and a 13-km-long northern segment. Previously, a three-segment model was postulated. The three-segment model was based upon a change in fault strike and near-surface dip in the central portion of the southern segment. It has been determined that such a change would not necessarily stop the propagation of a rupture along the fault (Byrd and Smith, personal communication, 1991).

2) Recent trenching and dating of the southern segment of the Teton fault indicates that a scarp with a net tectonic displacement of 4.1 meters at the mouth of Granite Canyon was formed as a result of two prehistoric earthquakes. The earliest event, with 2.8 meters of net tectonic displacement, occurred 7,175 ± 100 radiocarbon years before present. The most recent event, with 1.3 meters of net tectonic displacement, occurred 4,224 ± 65 to 6,155 ± 75 years before present (Byrd, 1991, personal communication). The 2.8 meters of displacement may have been the product of a Ms 7.2 ± 0.3 event, and the 1.3 meters of displacement may have been the product of a Ms 6.9 ± 0.3 event. Considering that a return period ranging from 800 to 3,600 years has been suggested for the fault system, researchers still believe the Teton fault is beyond the expected return for a large event.

Dr. Jim McCalpin, formerly at the Department of Geology, Utah State University, obtained funding from the National Science Foundation to map and trench two Quaternary normal faults in western Wyoming. The following observations were made:

1) The Rock Creek fault (Figure 24), located near Fossil Butte National Monument (20 miles west of Kemmerer, Wyoming), was trenched in June, 1991. The fault system, which is composed of a series of down-to-the-west normal faults, is approximately 24 miles long. The main fault scarp, which is seven meters high, was trenched near Cook Canyon. At least two faulting events occurred subsequent to the deposition of valley-bottom alluvium (McCalpin, personal communication, 1991). The alluvium is apparently no older than 15 thousand years. Average displacement per event is an estimated 3.5 meters.

2) The Greys River fault (Figure 24) is located approximately 25 miles east of Afton, Wyoming. The fault system, which is composed of a series of down-to-the-west normal faults, is approximately 25 miles long. It is located east of the north-south trending segment of the Greys River in Lincoln County, Wyoming. The fault system was trenched where it crosses the valley of Sheep Creek in T33N, R116W. Multiple alluvial terraces are displaced by fault scarps of varying heights at the Sheep Creek site. Three trenches were excavated at the site. The northern and central trenches cut across a 10-meter-high scarp fronted by a 12-meter-wide, 2-meter-deep graben. There was weak evidence for two colluvial wedges at those trench sites (McCalpin, personal communication, 1991). The northern trench revealed evidence of two large displacement events. The southern trench cut a 2-meter-high scarp on a younger terrace. Excavation revealed a 4-meter displacement (McCalpin, personal communication, 1991). McCalpin estimates that two surface

faulting events have occurred since deposition of major Quaternary valley fill. Each event was accompanied by approximately 4 meters of vertical displacement.

3) Radiocarbon samples from the trenches are being dated. For further information, contact Dr. Jim McCalpin at GEO-HAZ Consultants in Estes Park, Colorado.

UNIFORM BUILDING CODE (UBC)

Because of new information derived from recent investigations into the prehistoric activity of fault systems in western Wyoming, the Geological Survey of Wyoming (GSW) is investigating whether or not the Uniform Building Code (UBC) Seismic Zone map for western Wyoming should be modified. Specifically, the GSW is concerned that the existing information may indicate that portions of Teton and Lincoln Counties should be updgraded from Seismic Zone 3 to Seismic Zone 4. Seismic Zone 4 is in part defined as having a 90% probability of not exceeding a horizontal acceleration of 30% g or greater in a 50-year period (100% probability of exceedance in a 475-year period).

The Teton fault system, in Teton County and the Star Valley fault system in Lincoln County (Figure 24) are both capable of generating Magnitude 7.5, Intensity X events. At present, little is known about the subsurface configuration of either fault system. Assuming a 45° dip to the subsurface fault plane and a zone of seismogenic rupture that initiates approximately 2 km below the surface, a simplified model of potential horizontal accelerations can be developed. Using ground motion curves generated by Kenneth Campbell (Campbell, 1987), the Teton and Star Valley fault systems may both be capable of generating horizontal accelerations as high as 70% g. The effect of surficial materials on site amplification has not been determined.

The probabilities of exceeding 30% g on either fault system have not been determined. However, the estimated recurrence interval for a major event on the Teton fault is between 800 and 3,600 years. As mentioned earlier in this article, the University of Utah has determined that the southern segment of the Teton fault experienced movement 7,175 ± 100 radiocarbon years ago and 4,224 ± 65 to 6,155 ± 75 years ago. The maximum expected recurrence interval on the Teton fault system has been exceeded by over 600 years.

The estimated recurrence interval for a major event on the Star Valley fault is between 2,500 and 6,400 years. Three faulting events have been described on that system near Afton, Wyoming (McCalpin, 1990): The earliest event, dated at 14,000-15,500 years before present had a net throw of 4 meters. The second event, dated at 8,100 years before present, had a net throw of 4 meters; and the latest event, dated at 5,500 years before present, had a net throw of 3 meters. Because 5,500 years have elapsed since the latest event, the expected recurrence interval has either been nearly met or exceeded. Due to the relationship between the expected recurrence intervals and the dates of the most recent events for both the Teton and Star Valley fault systems, the probabilities of a major

event occurring on either system may be cause for concern. It is unknown at the present time if the probabilities are at a level that will warrant a change from Seismic Zone 3 to Seismic Zone 4.

References cited

Campbell, K.W., 1987, Predicting strong ground motion in Utah *in* Gori, P.L. and Hays, W.W., editors, Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah: U.S. Geological Survey Open File Report 87-585, 1,380 p.

McCalpin, J., 1990, Latest Quaternary faulting in the Northern Wasatch to Teton Corridor (NWTC): Final Technical Report to U.S. Geological Survey, Contract No. 14-08-001-G1396, 42 p.

WYOMING BOARD OF PROFESSIONAL GEOLOGISTS

On December 5, 1991, the Wyoming Board of Professional Geologists voted to adopt its proposed rules with some modifications. These rules, which became effective in late January, 1992, are the rules under which the Board will operate as it administers the licensing law for geologists seeking to use the title of "professional geologist" in Wyoming, pursuant to Wyoming Statutes 33-41-101 through 33-41-121.

The Board also set the first year's registration fees for a professional geologist at $94 and for a geologist-in-training at $47. By February 1992, approximately 3,000 geologists had requested applications to register as "professional geologists" in Wyoming. The "grandfather period" for registration expires at midnight on June 30, 1992. After that date, individuals will have to take an examination if they wish to be registered as a "professional geologist" in the State or if they want to be certified as a geologist-in-training.

A geologist or a qualifying geology student lacking four years experience may "grandfather" in as a geologist-in-training by applying before midnight, June 30, 1992. In this case, individuals accepted as geologists-in-training will avoid having to take the geologist-in-training examination.

The first applications were mailed out at the end of December. To receive information about registration in Wyoming, send your name, address, and phone number to:

Wyoming Board of Professional Geologists
P.O. Box 3008, University Station
Laramie, Wyoming 82071

or call Patricia Kessler at (307) 766-2286.

REORGANIZATION PLAN FOR THE GEOLOGICAL SURVEY

It now appears that there will be no proposed reorganization plan for the Geological Survey of Wyoming introduced in the 1992 Legislative Session.

NEW PUBLICATIONS

*Index to U.S. Geological Survey topographical maps of Wyoming, available from the Geological Survey of Wyoming, 1:1,000,000, 1992, $2.00 folded.

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

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

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

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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.

PLEASE NOTE THAT PRICES FOR SURVEY PUBLICATIONS WILL BE INCREASING IN APRIL, 1992.

— 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
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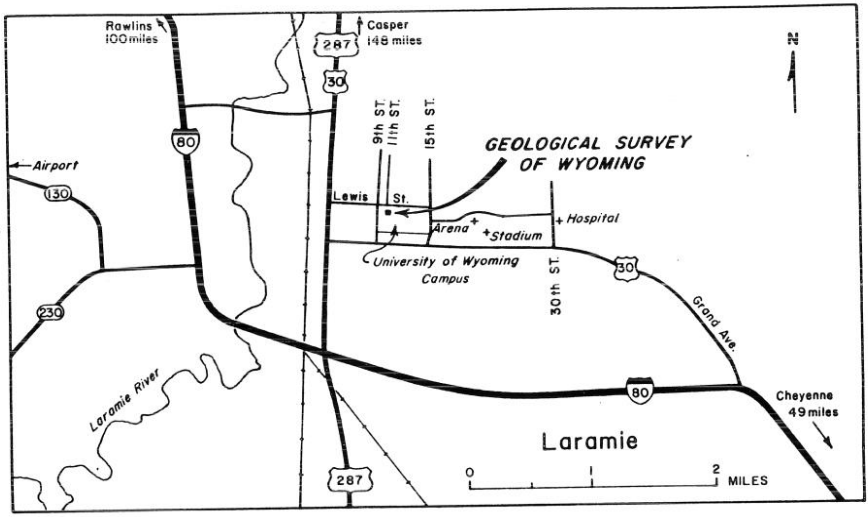

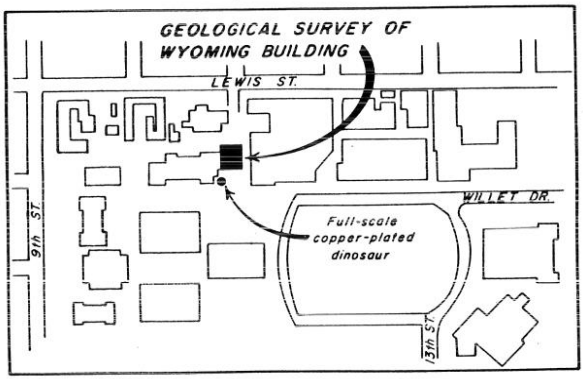

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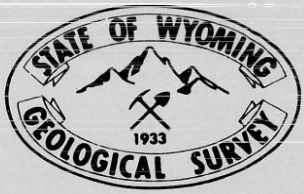
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