Wyoming Geo-notes

Number 45

Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
February, 1995

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 $10.00) or as single copies at $3.00 each. Two-year subscriptions are accepted.

People with disabilities who require an alternative form of communication in order to use this publication should contact the Editor, Wyoming State Geological Survey at (307) 766-2286. TDD Relay operator 1(800) 877-9975.

Printed on 50% recycled fiber paper. 600 copies printed by Pioneer Printing and Stationery Company, Cheyenne, Wyoming.

Cover: This skull cast of *Tyrannosaurus rex* measures 4.5 feet high and 6 feet long and is now on display at the University of Wyoming's Geological Museum in Laramie. In 1990, a crew from the Museum of the Rockies discovered the skull in eastern Montana. See related discussion on page 46.

Table of Contents

MINERALS UPDATE

OVERVIEW

Gary B. Glass
State Geologist, Wyoming State Geological Survey

By January 1995, the Wyoming's Consensus Revenue Estimating Group (CREG) had enough production and price information for 1994 that it revised some of its October forecasts. As a member of CREG, the Wyoming State Geological Survey assisted in making these revisions.

Based on monthly average prices published by the U.S. Energy Information Administration and posted prices through December 15th, CREG increased its 1994 estimated oil price to $13.58 a barrel- an increase of 33 cents a barrel from its October forecast (**Figures 1** and **2** and**Table 1**). Its forecast average price for 1995 through 1998 was left unchanged at $13.50 a barrel.

Production, however, did not track the increase in average price nor the earlier forecast. Consequently, while CREG's January forecast still shows oil production continuing to decline (**Table 2**), the rate of decline was increased by another two percent to a yearly decline of 10% (**Figure 3**). This compares with an actual 8.8% rate of decline between 1992 and 1993. As mentioned in *Wyoming Geo-notes No. 44*, the accelerating rate of decline is a consequence of low oil prices, which have not only reduced exploration and discoveries, but have also led to the earlier abandonment of wells as well as to fewer new secondary waterfloods and almost no new tertiary recovery projects.

Forecast natural gas prices for 1994 and 1995 were lowered once again. CREG reduced their earlier forecasts to $1.56 per thousand cubic feet (MCF) or nine cents lower than their October forecast (**Table 1** and **Figure 4**). This is equivalent to the average 1994 spot sale price at Opal, Wyoming. **Figure 5** shows that the high spot sale prices that characterized late 1992, 1993, and early 1994 declined to about $1.20 in October and ended the year at only $1.60, which was rather similar to what happened to pre-1993 prices. Mild weather and full storage by suppliers were cited as reasons for the softening market in 1994. The forecasts for 1996 through 1998, however, were left at $1.65/MCF.

As a result of this softened market, CREG again lowered its forecast for natural gas production, though not substantially. This January revision still shows record setting production through 1998 (**Figure 6** and **Table 2**). The annual rate of increase in production, however, was reduced to two percent, rather than the 3.6% previously forecast.

No changes were made in the October forecast for coal prices (**Figure 7** and **Tables 1** and **3**). In the last quarter of 1994, spot sale prices continued to show signs of edging higher. Some newly available information may allow better estimates of the average spot sale prices by the next issue of *Wyoming Geo-notes*.

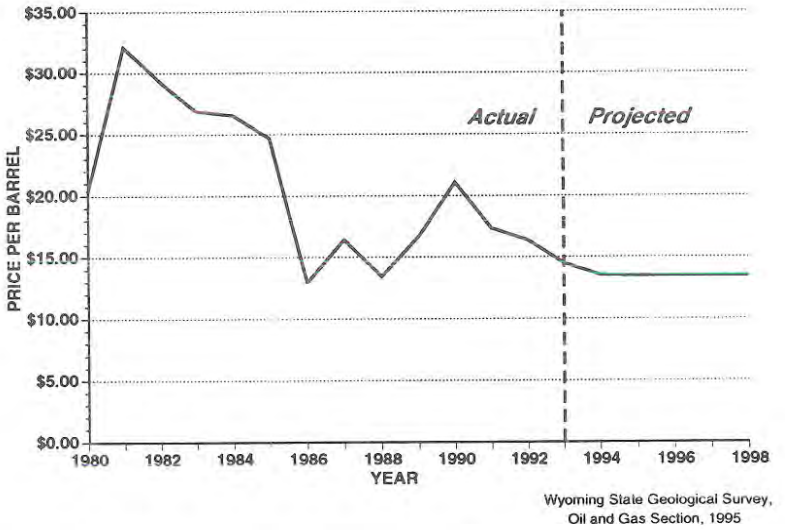


Figure 1. Average prices paid for Wyoming oil (1980 to 1993) with forcasts to 1998.

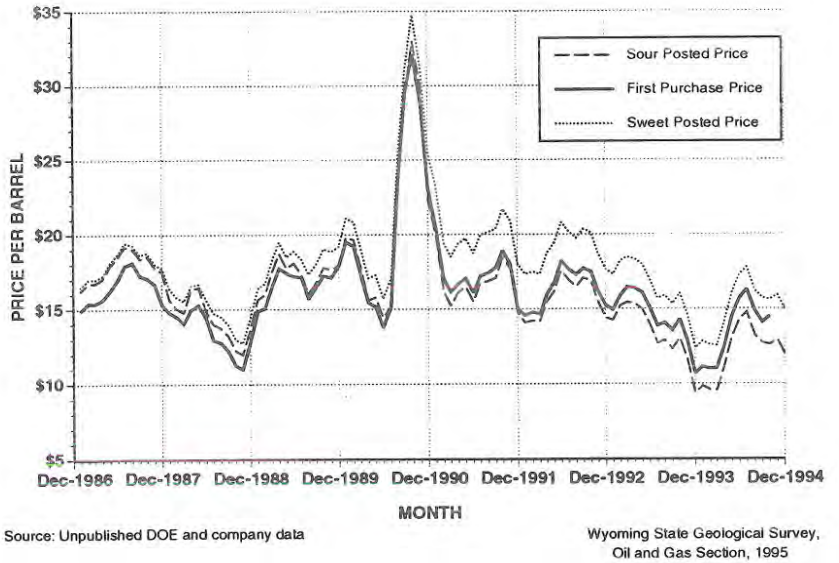


Figure 2. Wyoming posted Sweet and Sour crude oil prices and first purchase prices averaged by month (1987 to present).

Table 1. Average prices paid for Wyoming oil, methane, coal, trona, and uranium (1985-1993) with forecasts to 1998[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]	Uranium[6]
1985	24.67	3.03	11.36	35.18	36.82
1986	12.94	2.33	10.85	34.80	52.45
1987	16.42	1.78	9.80	36.56	43.55
1988	13.43	1.43	9.16	36.88	25.77
1989	16.71	1.58	8.63	40.76	22.09
1990	21.08	1.59	8.43	41.86	21.16
1991	17.33	1.46	8.09	44.18	21.00
1992	16.38	1.49	8.14	44.50	21.00
1993	14.50	1.81	7.32	40.08	21.00
*1994	13.58	1.56	6.70	39.00	21.00
*1995	13.50	1.56	6.54	40.00	21.00
*1996	13.50	1.65	6.43	40.00	21.00
*1997	13.50	1.65	6.31	40.00	21.00
*1998	13.50	1.65	6.19	40.00	21.00

* Forecast prices by Consensus Revenue Estimating Group (CREG).
[1] Adapted from CREG, Wyoming State Government Revenue Forecast FY95-FY98, January, 1995.
[2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1993.
[3] Wellhead price in dollars per thousand cubic feet (MCF). Sources: Wyoming State Land and Farm Loan Office, 1989-1993 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments).
[4] Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1993.
[5] Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1993.
[6] Uranium prices in dollars per pound of yellowcake (weighted average price for in-situ and(or) surface-mined uranium). Source: Energy Information Administration, 1985-1990; Wyoming State Geological Survey estimates 1991-1998.

CREG's October forecast of coal production was also left unchanged in January (**Figure 8** and **Table 2**). Production is still expected to increase by at least 12% in 1994. In January of 1995, a preliminary estimate released by the Wyoming Mining Association set 1994 production at 237 million tons or 2 million tons more than CREG's estimate of 235 million tons. The State Inspector of Mines, however, has not yet released his official production figures.

It remains to be seen if demand related to the 1990 Amendments to the Clean Air Act coupled with transportation capabilities will result in larger annual production increases than currently forecast. CREG is currently estimating a yearly 4.5% increase between 1995 and 1998. Our breakdown of the CREG forecast by county also remains unchanged (**Table 4**).

There were no changes made to the October price and production forecasts for trona and uranium (**Tables 1** and **2**). Early in 1995, however, FMC Corp. announced that it would proceed with a planned $45 million expansion of its trona mining and refining facilities in southwestern Wyoming. The company said the decision to move forward with this phase of a larger proposed expansion effort was not only related to a contract involving a new use for soda ash, but also an expected growth in export markets (see also the **Industrial Minerals and Uranium Update**).

Table 2. Wyoming mineral production (1981-1993) with forecasts to 1998[1].

Calendar Year	Oil[2]	Natural Gas[3]	Carbon Dioxide[4]	Helium[5]	Coal[6]	Trona[6]	Mined Uranium[7]	In-situ Uranium[8]	Sulfur[9]
1981	122.1	455.4	—	—	102.7	11.2	4.6	?	0.05
1982	118.7	465.1	—	—	108.0	10.9	2.1	?	0.07
1983	120.9	539.8	—	—	112.2	11.6	3.0	?	0.57
1984	127.8	600.1	—	—	130.7	11.7	1.6	?	0.71
1985	131.0	597.9	—	—	140.4	11.8	0.6	?	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.2	0.04	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.2	0.06	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	0.3	1.16	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	0.1	1.07	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	0.2	1.1	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	0.4	1.1	1.18
1992	96.8	871.5	139.2	1.05	189.5	16.4	0.1	1.2	1.20
1993	89.0	912.8	140.8	1.06	209.9	16.0	—	1.1	1.14
*1994	78.0	926.4	142.5	1.07	235.0	16.0	—	1.1	1.20
*1995	70.2	947.8	142.5	1.07	245.5	16.4	—	1.1	1.20
*1996	63.2	969.6	142.5	1.07	256.5	16.8	—	1.1	1.20
*1997	56.9	991.9	142.5	1.07	267.9	17.1	—	1.1	1.20
*1998	51.2	1,014.6	142.5	1.07	279.9	17.1	—	1.1	1.20

*Forecast production by Consensus Revenue Estimating Group (CREG).
[1]Adapted from CREG, Wyoming State Government Revenue Forecast FY95-FY98, January, 1995. [2]Millions of barrels (Source: Wyoming Oil & Gas Conservation Commission, 1981-1993); [3]Billions of cubic feet (primarily methane with some hydrogen sulfide and nitrogen) (Source: Wyoming Oil & Gas Conservation Commission, 1981-1993); [4] Billions of cubic feet. Source: Wyoming Oil & Gas Conservation Commission, 1986-1993; [5]Billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5%; [6]Millions of short tons (Source: Wyoming State Inspector of Mines, 1981-1993); [7]Millions of short tons of uranium ore (not yellowcake) (Source: Wyoming Department of Revenue, 1981-1992); [8]Millions of pounds of yellowcake (U_3O_8) (Source: Wyoming Department of Revenue, 1986-1993; unknown between 1981-1985 because it was only reported as taxable valuation); [9]Millions of short tons (Source: Wyoming Oil & Gas Conservation Commission, 1981-1993).

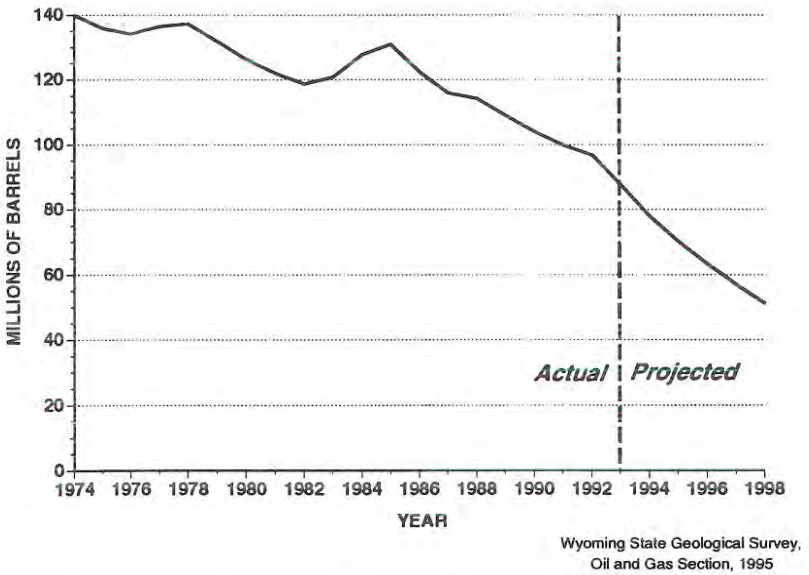


Figure 3. Annual oil production from Wyoming (1974 to 1993) with forecasts to 1998.

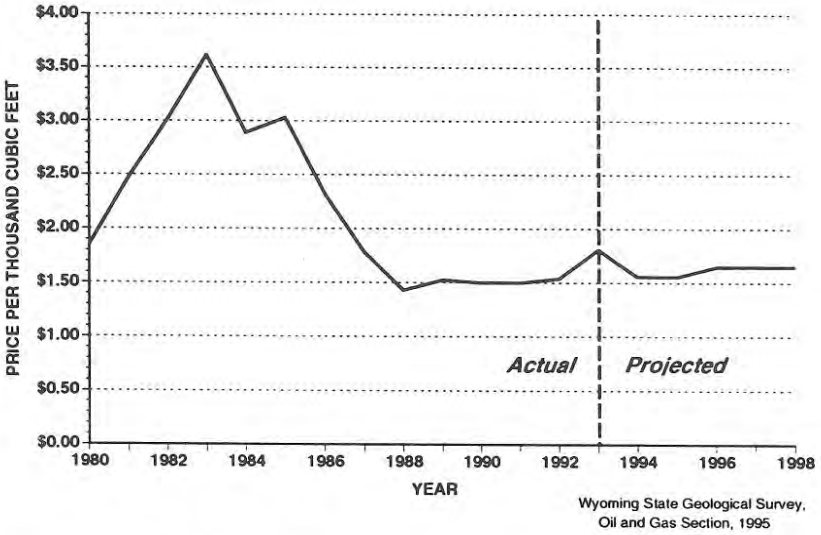


Figure 4. Average prices paid for Wyoming methane (1980 to 1993) with forecasts to 1998.

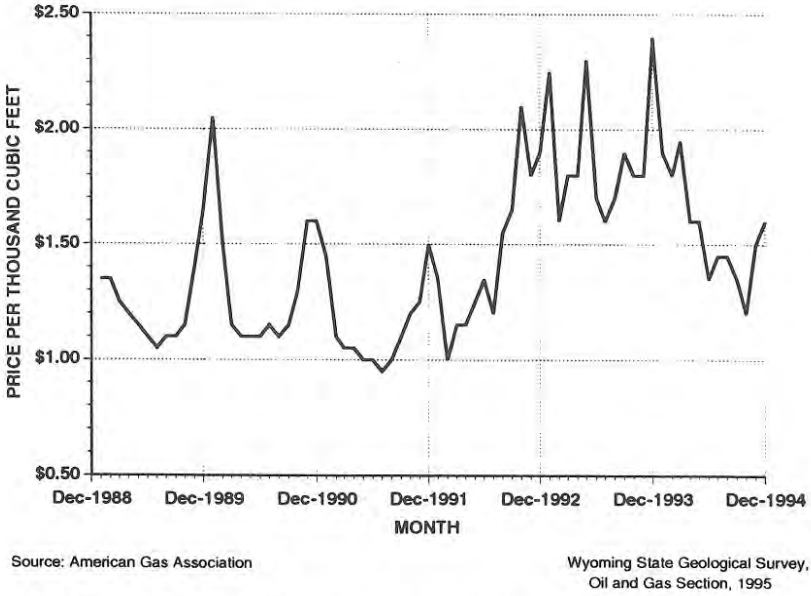


Figure 5. Spot prices for methane at Opal, Wyoming, averaged by month (1989 to present).

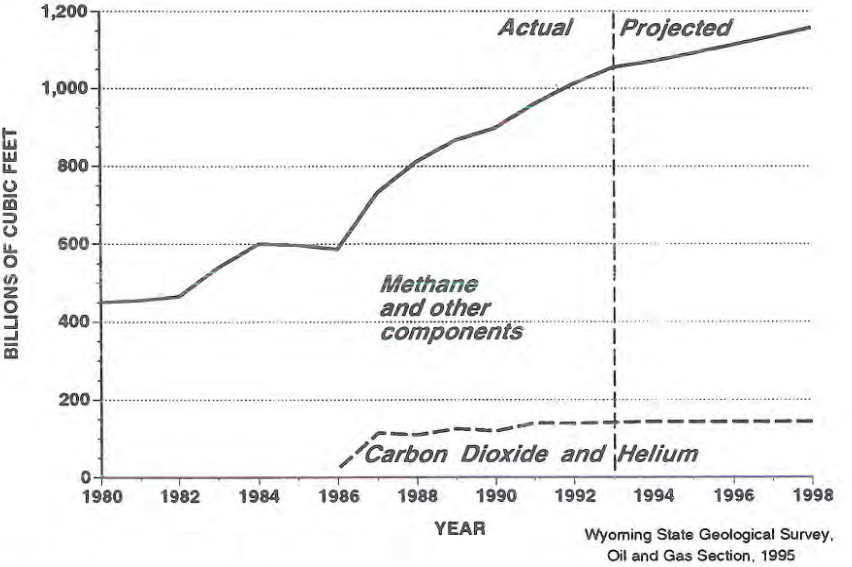


Figure 6. Annual natural gas production from Wyoming (1980 to 1993) with forecasts to 1998.

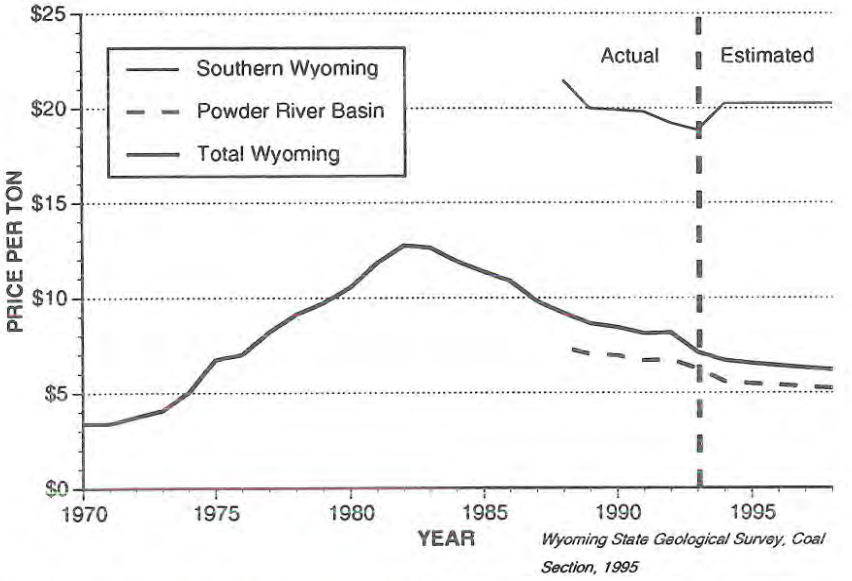


Figure 7. Average prices paid for Wyoming coal (1980 to 1993) with forecasts to 1998. Data from U.S. Energy Information Administration (1980-1993) and the Wyoming Consensus Revenue Estimating Group (1994-1998).

Table 3. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Statewide (1988-1993) with forecasts to 1998[1].

YEAR	NORTHEASTERN	SOUTHERN	STATEWIDE
1988	$7.35	$21.45	$9.16
1989	$7.02	$19.97	$8.63
1990	$6.93	$19.90	$8.43
1991	$6.69	$19.80	$8.09
1992	$6.74	$19.19	$8.14
1993	$6.24	$18.82	$7.32
1994	$5.58	$20.45	$6.70
1995	$5.47	$20.45	$6.54
1996	$5.39	$20.45	$6.43
1997	$5.30	$20.45	$6.31
1998	$5.23	$20.45	$6.19

[1]Source of Statewide data for 1988-1993 is the Energy Information Administration of the U.S. Department of Energy; forecasts for 1994-1998 are from the Wyoming Consensus Revenue Estimating Group. Regional breakdowns are estimated by the Wyoming State Geological Survey.

A few days later, the Casper Star-Tribune carried a story about Natrona Resources Inc.'s proposed new sodium bicarbonate and soda ash plant slated for construction in the Piceance Basin of northwestern Colorado. According to Natrona Resources, their proposed operation would extract nahcolite by solution mining techniques with the initial plant in operation by 1998. Nahcolite is a naturally occurring sodium bicarbonate. In addition, Wold Trona is already working on permits for its new trona and soda ash operation planned for the Green River Basin of Wyoming. They hope to have their plant operational by the fall of 1996.

The **Industrial Minerals and Uranium Update** in this issue provides production summaries for twelve minor industrial mineral commodities that are or were mined in Wyoming. **Table 5** provides historical production for some selected mineral commodities.

ABOLISHMENT OF THE USGS AND USBM?

Both the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) are targeted for abolishment as part of a Congressional initiative called its "Contract with America". While the elimination of these agencies could be in total, their abolishment could also be accomplished with a shift of their personnel and functions to other organizations. The latter approach, however, would not net the cost savings that the advocates of this proposal want. As a bottom line, there is definitely a concerted effort to eliminate these two science and technology agencies.

Although an amendment to abolish these agencies was rejected in 1994, Representative John R. Kasich (Ohio), the sponsor of that legislation, has

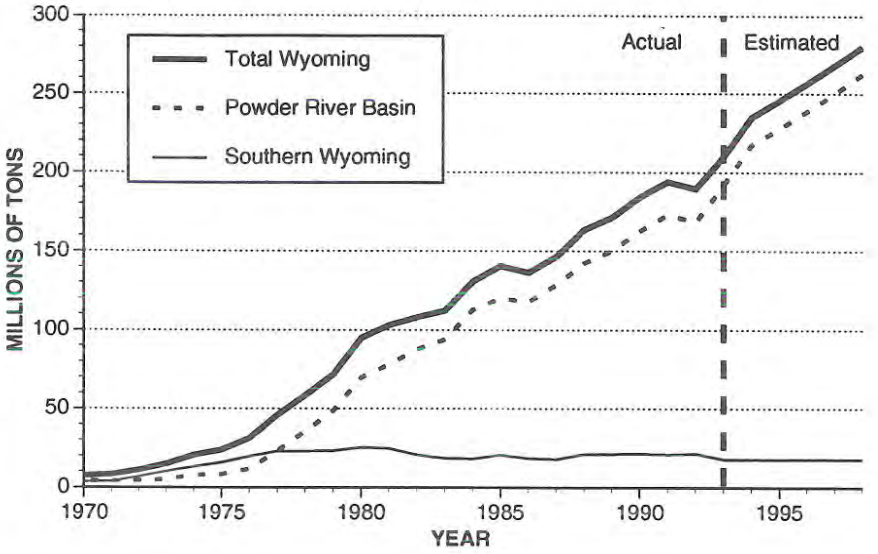


Figure 8. Annual coal production from Wyoming (1970-1993) with forecasts to 1998. Data from the Wyoming State Inspector of Mines (1970-1993) and Wyoming Consensus Revenue Estimating Group (1994-1998).

become the Chairman of the House Budget Committee and is in a much better position to get the bill passed this year. The Clinton Administration has made it clear that it does not favor abolishment of these two agencies.

While individual State Geological Surveys provide similar information, products, and services, of necessity their emphases are much more parochial in scope than the USGS and USBM. In addition, State Surveys often build on the geoscience research, technology, and information that has traditionally been provided by these two Federal agencies. Much of this research far exceeds the scope and financial resources of individual states.

Individuals and organizations, which use the products and services of these two Federal agencies are rallying support to temper this extreme course of action. As a State agency that has always benefitted by the work and publications of these two agencies, we join with others in urging Congress not to eliminate the USGS or the USBM.

The geoscience community's views are well stated in this quote from the American Geological Institute's January 1995 issue of *Geotimes*:

> *Geoscience research and information play vital roles in an ever-growing range of societal problems. Federal investments in geoscience research and information continue to pay enormous dividends.*

Table 4. Coal production (1984 to 1993) with forecast to 1998 (millions of tons).

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[1]	1995[1]	1996[1]	1997[1]	1998[1]
Campbell County	113.9	111.0	122.3	135.7	143.8	154.7	164.9	159.6	181.9	203.7	212.8	222.3	232.2	242.6
Converse County	3.6	4.8	5.1	5.7	6.1	7.9	8.2	8.5	10.2	11.4	11.9	12.5	13.0	13.6
Sheridan County	2.4	1.4	1.2	0.9	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Carbon County	3.3	1.5	2.2	4.1	4.3	4.5	4.7	4.1	4.4	4.9	5.2	5.4	5.6	5.9
Sweetwater County	13.2	12.9	11.8	12.2	12.0	11.9	11.4	12.6	9.2	10.3	10.7	11.2	11.7	12.3
Lincoln County	4.3	4.0	3.8	4.9	4.8	4.7	4.4	4.6	4.1	4.6	4.8	5.0	5.2	5.4
Hot Springs County	M	M	M	M	M	0.1	0.1	M	M	M	M	M	M	M
Total Wyoming	140.7	135.6	146.4	163.5	171.1	183.9	193.9	189.5	209.9	235.0	245.5	256.5	267.9	279.9
Annual Change	7.7%	-3.6%	8.0%	11.7%	4.6%	7.5%	5.4%	-2.3%	10.8%	12.0%	4.5%	4.5%	4.5%	4.5%
Low-priced coal[2]	6%	7%	8%	10%	20%	25%	33%	35%	47%	54%	58%	60%	62%	65%

[1]Forecast by the Wyoming State Geological Survey, January, 1995. [2]Estimated percentage of total production that was 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. M means minor tonnage (less than 0.1 million tons).

Table 5. Production history of selected Wyoming mineral commodities[1].

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Bentonite[2]	2.18	3.08	2.59	1.82	2.16	2.24[6]	2.22[6]	2.43[6]	2.38[6]	2.21[6]	2.53[6]
Clay[4]	36.4	59.6	35.9	23.2	1.31	---	---	---	---	---	---
Decorative Aggregate[2]	0.07	0.08	0.09	0.07	0.06	0.07[7]	0.06[6]	0.06[6]	0.07[6]	0.07[6]	0.08[6]
Decorative Stone[10]	---	---	---	---	---	---	---	---	24[7]	100[7]	168.0[6]
Dolomite[2]	0.66	0.86	0.87	0.81	0.46	0.19[6]	0.15[6]	0.21[6]	0.23[6]	0.20[6]	---
Gypsum[2]	0.33	0.33	0.35	0.41	0.35	0.36[6]	0.42[6]	0.44[6]	0.42[6]	0.43[7]	0.43[7]
Iron Ore	2.48[2]	---	---	---	---	---	40[8]	40[8]	---	---	250[7,9]
Leonardite[4]	---	---	---	---	---	minor[6]	38.9[6]	41.7[6]	22.9[6]	37.0[6]	39.0[6]
Limestone[2, 5]	0.56	0.65	0.32	0.33	0.32	0.64	0.60[6]	0.48[6]	0.49[6]	0.52[6]	0.63[6]
Construction Aggregate[2, 3]	6.72	8.31	6.40	5.01	4.12	3.15	6.46[6]	7.73[6]	8.62[6]	8.11[6]	10.6[6]
Shale[4]	---	20.3	14.7	9.88	103.2	52.2[6]	15.6[6]	43.5[6]	158.2[6]	113.3[6]	---
Sodium Sulfate[4]	3.19	3.25	2.71	2.03	---	2.10[6]	---	1.9[6]	1.5[6]	1.5[6]	1.5[6]

Sources: [1]Wyoming Department of Revenue, unless otherwise noted; [2]millions of short tons; [3]includes ballast, scoria, and limestone used for aggregate; [4]thousands of short tons; [5]includes chemical grade limestone used for cement rock, sugar beet refining, and other uses; [6]Wyoming State Inspector of Mines; [7]estimated by Wyoming State Geological Survey; [8]short tons of iron ore used for pigment; [9]short tons of iron ore used as weighting additive in cement; [10] short tons. Prepared by Wyoming State Geological Survey, January, 1995.

OIL AND GAS UPDATE

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

The rig count in Wyoming was not as high in the fourth quarter of 1994 as anticipated (**Figure 9**), and the average daily rig count for the year dropped to 34 from 37 in 1993 (**Figure 10**). High storage volumes and a very mild winter combined to hold down spot prices and production of both oil and natural gas. There was also much less development drilling for natural gas this year than expected because of the weak market. The U.S. Bureau of Land Management's approval of a large number of infill-drilling projects, coupled with near-record lease sales in 1994, indicate that the natural gas industry in Wyoming is in a good position to respond to market conditions as they improve.

The U.S Department of Energy (1994) has released its 1993 reserve estimates for crude oil and natural gas. **Table 6** shows Wyoming's relative

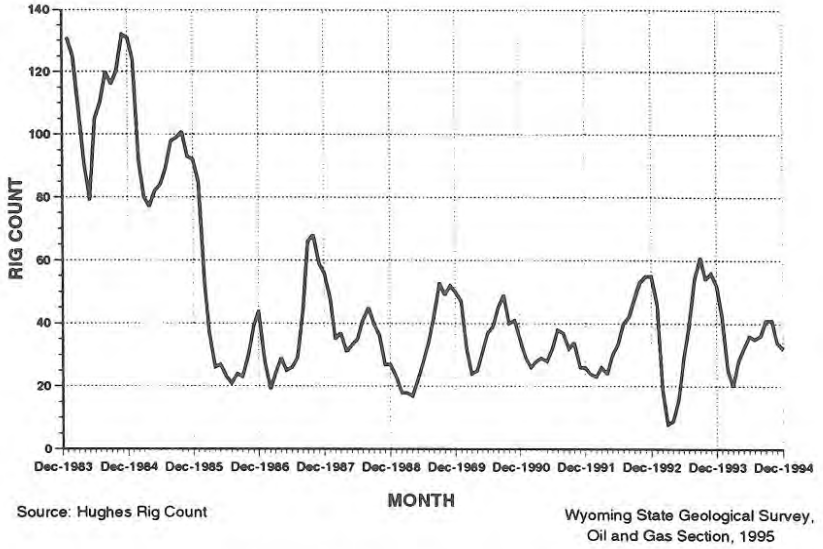


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

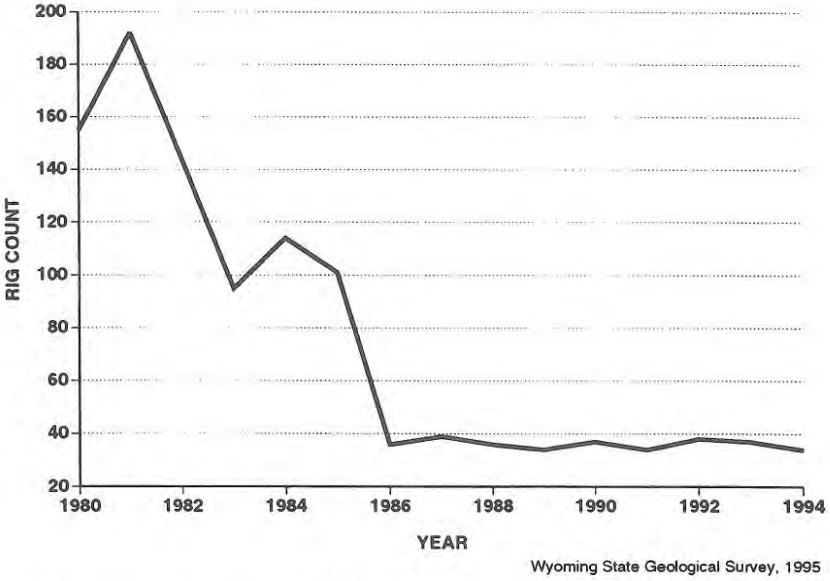


Figure 10. Average daily rig count for Wyoming, averaged by year [based on Hughes Rig Count (1980-1994)].

ranking among the top ten states in proved reserves of crude oil and natural gas. While Wyoming ranked fourth in crude oil reserves and seventh in natural gas reserves in 1987, it has dropped to seventh in crude oil reserves and increased to fourth in natural gas reserves. **Table 7** shows that Wyoming's proved reserves of crude oil are declining steadily while its proved reserves of dry natural gas are remaining at a relatively high level despite increased production of natural gas over the same time period. These two tables underscore the fact that Wyoming's future economic health will be more dependent on natural gas production and less dependent on crude oil production. A survey by Arthur Andersen & Co. showed that 90 percent of the surveyed domestic oil and gas companies believe there are significant natural gas reserves yet to be discovered in the U.S. while only 41 percent of the surveyed companies believe there are significant oil reserves yet to be discovered in the U.S.

Although crude oil production in Wyoming is declining, oil production from stripper wells (those that produce less than 10 barrels per day) rose 45 percent in 1993 to nearly 9.3 million barrels from 7,660 wells. This compares to production of almost 6.4 million barrels in 1992 from 3,126 wells. At first glance, the increase in stripper production may look like good news; however, the increased stripper production is from wells that were recently producing more than 10 barrels of oil per day, but have now dropped below tthose higher production levels. The increase in stripper production is signaling increased declines in Wyoming's crude oil production as wells in many of the State's mature fields continue to produce less oil each year.

A recent report by the U.S. Department of the Interior (1994) shows that in 1993 Wyoming received more Federal mineral royalties than any other state. Wyoming received $187 million as its share; New Mexico was second with $135.1 million. Oil and gas production and lease sales accounted for more than

Table 6. Wyoming's 1993 ranking in proved reserves of crude oil (billions of barrels) and dry natural gas (trillions of cubic feet).

State	Crude Oil	State	Dry Natural Gas
Texas	6.171	Texas	34.718
Alaska	5.775	New Mexico	18.619
California	3.764	Oklahoma	13.289
New Mexico	.707	**Wyoming**	**10.933**
Oklahoma	.680	Alaska	9.907
Louisiana	.639	Kansas	9.348
Wyoming	**.624**	Louisiana	9.174
Colorado	.284	Colorado	6.722
Kansas	.271	Alabama	5.140
Utah	.228	California	2.682

Source: U.S. Department of Energy, 1994

Table 7. Comparison of Wyoming's proven reserves of crude oil (billions of barrels) and dry natural gas (trillions of cubic feet) for the years 1979 through 1993.

Date	Crude Oil	Dry Natural Gas
1979	.841	7.526
1980	.928	9.100
1981	.840	9.307
1982	.856	9.758
1983	.957	10.227
1984	.954	10.482
1985	.951	10.617
1986	.849	9.756
1987	.854	10.023
1988	.815	10.308
1989	.825	10.744
1990	.794	9.944
1991	.757	9.941
1992	.689	10.826
1993	.624	10.933

Source: U.S. Department of Energy, 1994

55 percent of Wyoming's 1993 distribution. Since 1920, when the distribution of Federal mineral royalties was instituted, Wyoming has received $3.05 billion. This total is more than any other state and is 37 percent of the total distribution to all states. Oil and gas production and lease sales have accounted for 80 percent of the historic distribution to Wyoming.

Conoco Inc. and Marathon Oil have agreed to exchange oil and gas properties in Wyoming. Conoco will acquire Marathon's interests in Bruff, Fabian Ditch, and Elk Basin fields. Conoco will also acquire about 2,000 non-productive acres in the Greater Green River Basin. Marathon will receive Conoco's interests in Circle Ridge, Frannie, North Danker, Sunshine North, Gebo, Elk Basin, and Elk Basin South fields.

Lease sales in Wyoming did well this quarter (**Table 8**). The total revenue for the November State Land and Farm Loan sale was higher than that for any State sale in the last several years and the December Federal sale also had higher total revenue than any U.S. Bureau of Land Management (BLM) sale in the last several years. The total revenue for the year from four State sales and six Federal sales was over $30 million. Total revenues from lease sales were highest in 1985 and 1988, respectively. Twelve sales in 1988 generated a total of nearly $34 million and 13 sales in 1985 generated a record total of almost $40 million. The heaviest leasing activities at the sales in the fourth quarter of 1994 were about equally divided among southwestern Wyoming and the Powder River Basin (**Figures 11**, **12**, and **13**). Federal leases in the Wind River Basin and Bighorn Basin were also in relatively high demand (**Figures 11** and **12**).

The BLM's October sale had a high per-acre bid of $11,200. The bid was made by Prima Oil & Gas Co. for an 80-acre lease in W/2 NE section 32, T37N, R86W. The tract is less than a mile east of a subthrust Lance discovery that was recently completed by Barrett Resources Corp. The second highest per-acre bid of $190 was made by Union Pacific Resources Co. for a 960.13-acre parcel covering all of section 6 and parts of sections 8 and 22, T20N, R113W. The lease is over two miles from Frontier gas and condensate production at Whiskey Butte Field. There were a total of 28 leases at this sale that drew bids of $50 or more per acre.

Table 8. Federal and State competitive oil and gas lease sales in Wyoming.

FEDERAL SALES (BUREAU OF LAND MANAGEMENT)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1990				
TOTAL	$17,997,133	2,971	1,593	2,169,138	967,293	$18.61	$340.00
			1991				
TOTAL	$12,934,277	2,815	1,147	2,191,462	675,777	$19.14	$16,000.00
			1992				
February	$940,581	342	126	213,469	67,205	$14.00	$210.00
April	$331,199	355	109	229,407	58,951	$5.62	$112.00
June	$425,183	314	86	168,230	37,701	$11.28	$220.00
August	$1,395,060	335	109	196,800	54,530	$25.58	$230.00
October	$657,029	351	73	259,482	43,843	$14.99	$2,500.00
December	$1,029,888	425	161	366,880	102,248	$10.07	$280.00
TOTAL	$4,778,940	2,122	664	1,434,268	364,478	$13.11	$2,500.00
			1993				
February	$1,637,233	464	246	346,357	155,272	$10.54	$220.00
April	$2,116,184	478	259	351,465	177,989	$11.89	$220.00
June	$1,415,793	463	179	351,130	86,435	$16.38	$390.00
August	$1,877,405	462	262	374,274	208,495	$9.00	$400.00
October	$2,636,127	458	247	367,281	186,274	$14.15	$285.00
December	$3,259,266	444	276	275,435	180,879	$18.02	$320.00
TOTAL	$12,942,008	2,769	1,469	2,065,942	995,344	$13.00	$400.00
			1994				
February	$3,909,085	442	290	374,969	237,761	$16.44	$160.00
April	$4,248,182	498	278	369,657	201,690	$21.06	$275.00
June	$3,759,282	480	270	417,447	233,664	$16.09	$325.00
August	$5,100,550	439	294	323,410	217,157	$23.49	$255.00
October	$4,703,706	492	341	411,117	269,003	$17.49	$11,200.00
December	$5,386,789	617	367	479,930	290,384	$18.55	$390.00
TOTAL	$27,107,594	2,968	1,840	2,376,530	1,449,659	$18.70	$11,200.000

STATE SALES (STATE LAND AND FARM LOAN OFFICE)

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1990				
TOTAL	$4,979,094	1,199	732	478,098	380,382	$13.09	$270.00
			1991				
TOTAL	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
			1992				
January	$138,165	200	96	72,027	37,840	$3.65	$65.00
March	$200,000	200	114	70,294	41,034	$4.88	103.00
May	$208,166	200	93	60,687	28,605	$7.28	$230.00
November	$200,407	199	116	74,747	43,134	$4.65	$87.00
TOTAL	$745,738	799	419	277,755	150,613	$4.95	$230.00
			1993				
March	$601,400	200	137	74,940	54,723	$10.99	$400.00
May	$362,840	200	141	82,388	56,770	$6.39	$90.00
September	$505,587	200	141	80,428	56,845	$8.89	$225.00
November	$510,290	200	143	73,517	53,801	$9.48	$155.00
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
			1994				
March	$917,380	200	169	84,571	73,061	$12.56	$170.00
May	$802,688	200	141	75,523	54,199	$14.81	$205.00
September	$586,083	200	149	83,143	61,675	$ 9.50	$190.00
November	$998,001	200	148	88,542	66,217	$15.07	$142.00
TOTAL	$3,304,152	800	607	331,779	255,152	$12.95	$205.00

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

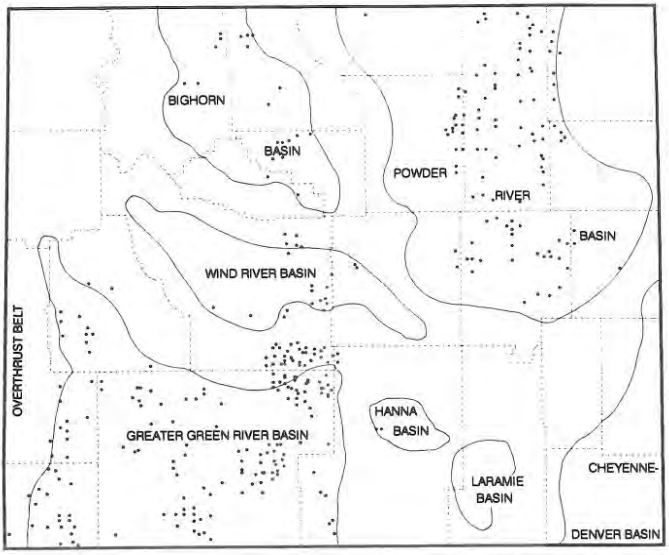


Figure 11. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the October, 1994, sale.

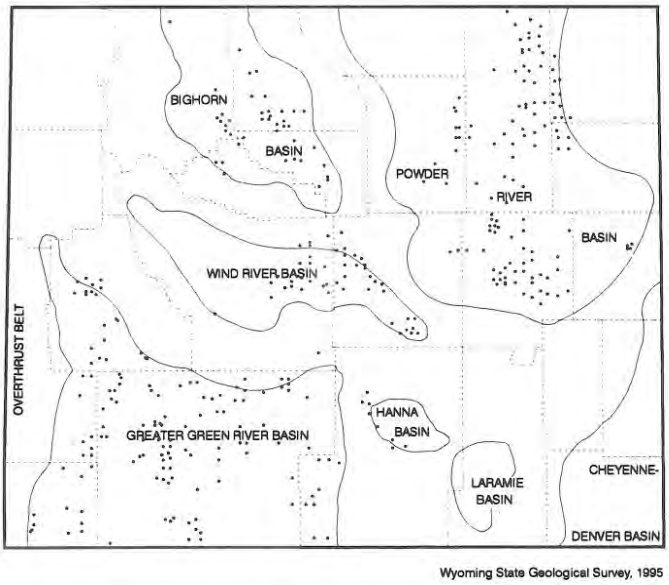


Figure 12. Locations of Federal oil and gas tracts leased by the U.S. Bureau of Land Management at the December, 1994, sale.

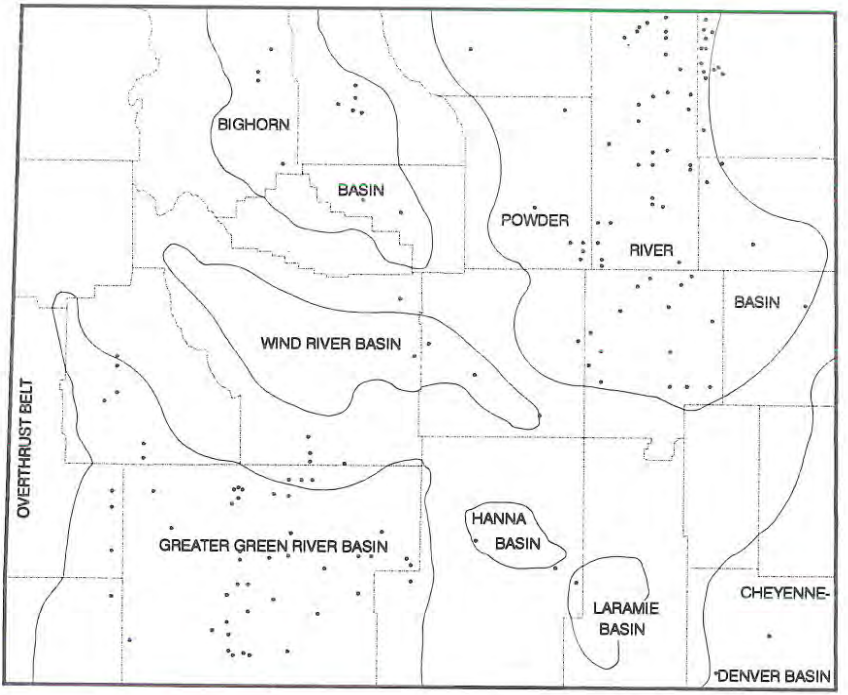


Figure 13. Locations of State oil and gas tracts leased by the State Land and Farm Loan Office at the November, 1994, sale.

The BLM's sale in December had a high per-acre bid of $390. The bid was made by Richardson Production Co. for a 621.98-acre lease in parts of sections 16, 17, 20, 22, and 29, T33N, R71W. The lease is one to three miles from the abandoned La Prele Field discovery well that produced oil and gas from the Teapot and Parkman. Petral Exploration LLC paid $265 per acre for a 933.80-acre lease that covers parts of section 17 and 18, T23N, R110W. The lease is about one mile southwest of Four Mile Gulch Field, which produces from the Frontier and Dakota. Petral also paid $265 per acre for a 612.92-acre lease that covers most of section 7, T23N, R110W. The lease is also within a mile of Frontier and Dakota production at Four Mile Gulch Field. A total of 31 parcels sold for $50 or more per acre at this sale.

The State Land and Farm Loan Office's sale in November had a high per-acre bid of $142 for a 640-acre lease that covers all of section 36, T22N, R94W. The bid was made by Snyder Oil Corp. and the lease is just over a mile south of Almond gas production at Siberia Ridge Field. David Holwegner made the sale's second high per-acre bid of $123 for a 320-acre parcel that covers E/2 section 16, T33N, R71W. Vastar Resources has drilled two horizontal tests of the Niobrara and Frontier within two miles of this lease. David Holwegner also made

the sale's third highest bid of $119 per acre for a 640-acre lease that covers section 16, T21N, R93W. The lease is a little over a mile from Mesaverde and Lewis gas production at Five Mile Field. A total of nine parcels received bids of $50 or more at this sale.

Exploration and Development

Company data, news releases, and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the third quarter of 1994. The numbers preceding discussions below refer to locations on **Figure 14**.

1. The Wahsatch [sic] gathering system is in operation and Amoco Production is processing around 75 million cubic feet of natural gas per day from Yellow Creek Field near Evanston, Wyoming, and from a nearby field in Utah. The gas has an average hydrogen sulfide concentration of 14.9 percent. The company is processing the gas at its Whitney Canyon gas plant.

2. Chevron USA set production casing to 12,120 feet at its 33-7 Ross wildcat well in NW SE section 7, T30N, R110W. The well was drilled to test the Ericson and Rock Springs and reportedly produced gas through perforations between 11,204 and 11,771 feet. The well is about 12 miles east of Almy and Mesaverde production at Star Corral Field. No other details on the well are available.

Chevron also set production casing at its 33-16 Billy wildcat well in NW SE section 16, T31N, R111W. The 12,354-foot wildcat produced gas during tests of the Ericson and Rock Springs; however, no other details are available. In addition, Chevron set production casing at its 23-31 Paradise-Federal well in NE SW section 31, T31N, R109W. The 12,770-foot wildcat is scheduled to test the Fort Union and the Lance.

3. Snyder Oil permitted three new wildcat wells near Jonah Field. Two of the tests will be drilled in section 15, T29N, R107W and the other will be drilled in section 36, T28N, R108W. The wells are scheduled to test the Lance and Mesaverde and will be drilled to depths that vary between 11,550 and 13,100 feet.

4. BTA Oil Producers completed a new gas well in Sinkhole Field. During the first month of production, the 2 Bravo Unit well in C NW section 10, T23N, R99W flowed an average of 2.1 million cubic feet of gas and 94 barrels of condensate per day from an undisclosed interval in the Lewis.

5. Presidio Exploration completed its third Lewis producer in Strike Field. During its first month of production, the 40-7 Strike Unit well in C SE section 7, T22N, R95W flowed 956,000 cubic feet of gas, 152 barrels of condensate, and 10 barrels of water per day from an undisclosed interval in the Lewis.

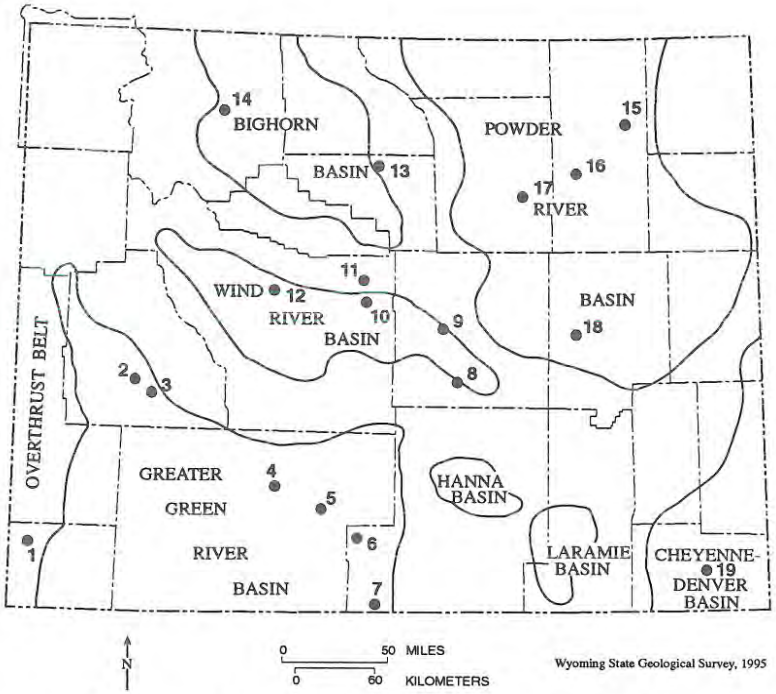


Figure 14. Oil and gas exploration and development activities in Wyoming during the fourth quarter of 1994 (exclusive of coalbed methane activities).

6. Williams Field Services plans to double the capacity of its new Echo Springs gas processing plant, which opened in the Spring of 1994. The company has applied for a new emissions permit from the Wyoming Department of Environmental Quality. The plant currently processes 120 million cubic feet of gas per day, but plans to process 240 million cubic feet of gas per day by October, 1995, if the proposal is approved.

7. EOG Inc. completed two new wells in the Robbers Gulch/Blue Gap Field area. The 2-7 Robbers Dog well in NW NW section 7, T14N, R91W flowed an average of 2.5 million cubic feet of gas, 15 barrels of condensate, and six barrels of water per day during its first month of production from an undisclosed interval in the Mesaverde. During its first month of production, the 3-7 Robbers Dog well in SE SW section 7, T14N, R91W flowed 748,000 cubic feet of gas, five barrels of condensate, and 15 barrels of water per day from an undisclosed interval in the Mesaverde.

8. Forest Oil completed a new producer in Grieve Field. The 50 Grieve well in NW SE section 27, T32N, R85W flowed 3.0 million cubic feet of gas per day from the Muddy between 6,475 and 6,520 feet.

9. Barrett Resources is drilling the first offset to the company's recent discovery. The 4 Cave Gulch-Federal well in SW SW section 29, T37N, R86W is projected to 8,800 feet to evaluate a subthrust section of the Lance. The discovery well, the 1 Cave Gulch-Federal in NE NE section 31, T37N, R86W is currently producing 9.7 million cubic feet of gas and 116 barrels of oil per day from a Lance interval between 6,302 and 6,306 feet. Prima Oil & Gas paid $11,200 per acre for an 80-acre lease in W/2 NE section 32, T37N, R86W at the October Federal lease sale.

10. At Madden Field, Louisiana Land & Exploration recompleted a well in the Mesaverde between 15,983 and 15,996 feet that flowed 5.0 million cubic feet of gas and 15 barrels of water per day. The 1-2 Joyce well in SE SW section 2, T38N, R90W originally was completed in the Sussex between 16,870 and 16,990 feet.

11. Louisiana Land & Exploration dedicated a new $62 million gas processing plant. In January, the Lost Cabin plant is scheduled to begin processing sour gas from two Madison Limestone wells at Madden Field. These two wells, which were completed between 23,000 and 24,000 feet, established the deepest commercial gas production in the Rocky Mountain Region. The new plant can process 50 million cubic feet of gas per day.

12. Tom Brown Inc. completed its 43-10 Tribal-Pavillion well in NE SE section 10, T3N, R2E in the Fort Union between 5,324 and 5,486 feet. The well flowed 2.2 million cubic feet per day.

13. Marathon Oil will redrill a well in Hidden Dome Field. Plans are to horizontally redrill the 5H OPC2 well from a surface location in SE SE section 31, T48N, R90W. Marathon plans to commingle Tensleep production from the existing vertical hole with Tensleep production from the open hole-lateral. Depth of the Tensleep production is between 4,595 and 4,666 feet.

14. Marathon also plans to redrill the 20H Sidney well from a surface location in SW NW section 5, T51N, R100W. The true vertical depth of the well will be approximately 3,300 feet and it will test the Tensleep Sandstone.

15. EOG Inc. completed a new Muddy producer. Its 2-18 K-M Federal well in SE SE section 18, T51N, R71W pumped an average of 47 barrels of oil and four barrels of water during its first month of production. No other details are available.

16. Apache Corp. reentered and drilled a lateral leg in the Sussex from a surface location in NE NE section 33, T47N, R75W. True vertical depth is about 8,325 feet. This is the first time that the Sussex has been horizontally drilled in Wyoming.

17. Celsius Energy recovered about 1,500 feet of gas cut oil with the water cushion during a drillstem test of the Tensleep between 14,772 and 14,881 feet. After the test, Celsius set pipe to 15,091 feet at its 1 Mantis Unit well in NW SW section 30, T44N, R78W. No other details are available.

18. Samson Resources Co. acquired Nutcracker and Sand Dunes fields from Oryx Energy Co. The Wyoming properties were part of a $40 million deal between the two companies.

19. Union Pacific Resources will evaluate a horizontal section of the Niobrara with its 1H Sego Lily 14-5 well to be drilled from a surface location in SW SW section 5, T14N, R64W. The vertical depth of the test will be about 8,075 feet. Wilshire Oil will drill its 1-3H Messenger well from a surface location in NE NE section 3, T15N, R65W to a true vertical depth of 8,063 feet. The well will test a horizontal section of the Niobrara on the southwestern flank of Silo Field. Silo Field produced nearly 1.6 million barrels of oil in 1993. Nearly all of this production came from lateral sections drilled in the Niobrara. And Consolidated Industrial Services Inc. has begun treating salt water from Silo Field. The company's plant removes sodium chloride, barium, strontium, iron, and sulfates from about 100,000 gallons of water produced at Silo Field every day.

References cited

U.S. Department of Energy, 1994, U.S. crude oil, natural gas, and natural gas liquids reserves: 1993 Annual Report: Washington, D.C., 155 p.

U.S. Department of the Interior, 1994, Mineral revenues 1993: Report on receipts from Federal and Indian lands: Denver, CO, 126 p.

COAL UPDATE

P. Daniel Vogler
Staff Geologist-Coal, Wyoming State Geological Survey

The 20,572,120 tons of coal delivered in August set a new monthly delivery record from Wyoming mines (**Table 9** and **Figures 15** and **16**). In addition, the 12.96% increase in delivered coal from July-August is the second highest month-to-month increase in the last three years. This record month also corresponds with the implementation of a deferred rail maintenance agreement that the Burlington Northern, Chicago & NorthWestern, and Union Pacific railroads negotiated in late August and early September to help accelerate rail shipments.

As reported in *Wyoming Geo-notes No. 44* (p. 21), Burlington Northern and Union Pacific are investing large amounts of capital in upgrading track serving the Powder River Basin. Recently, Burlington Northern completed a 10.2-mile segment of double track from Bill to Logan for an estimated $12 million. Burlington Northern has also announced that it will open more double track from Walker to Shawnee for an additional $12 million. This latter line is jointly owned by Burlington Northern and Chicago & NorthWestern railroads although Burlington Northern is responsible for maintaining and dispatching trains over the line.

Illinois Power has recently purchased 500 tons of sulfur dioxide (SO_2) allowances from the Wyoming-based Dave Johnston plant for an estimated $7-10 million. An "allowance" under the 1990 Amendments to the Clean Air Act is equal to one ton of SO_2. If a utility is exceeding the Phase I compliance limit of 1.2 lbs of SO_2/million Btu, it can buy or otherwise obtain "allowances" from other utilities that are not exceeding the compliance limit. If a non-compliant utility can acquire enough allowances to offset the amount it exceeds the compliance limit, that utility becomes compliant. Currently, the Jim Bridger and Wyodak plants in Wyoming are also under the compliance limit and are expected by many to sell allowances in the future. The deadline for compliance with Phase I is November 15, 1995.

Developments in the Powder River Basin

In the Montana portion of the basin, different interests joined together and have apparently succeeded in preventing the renewal of the mine permit for the Montco mine, which has been undeveloped since 1984. Montco is owned by Wesco Energy and a Washington Energy subsidiary, partners in the Tongue River Railroad which is planned to run from the Decker area mines to Miles City.

As reported in *Wyoming Geo-notes No. 44* (p. 23), Kennecott applied for an air quality permit that would allow construction of a coal processing plant at its Cordero mine site. Kennecott has also applied for a "fast track" permitting process from the Industrial Siting Division of the Department of Environmental Quality. With a "fast track" permit, Kennecott could begin construction of the coal processing plant in the spring of 1995 and finish in the fall of 1996. The Kennecott plant will use the PURON process to condense and dry coal from the Cordero mine, enhancing the Btu and lowering the moisture content of the coal. Kennecott is also planning a second plant at or near its Spring Creek mine in Montana. Officials from Kennecott believe that the process could boost Spring Creek's production to 13 millions tons annually.

The Wyoming Department of Environmental Quality (DEQ) granted a Torrington company a deminus exemption for solid waste storage, allowing construction of a coal unloading facility in south Torrington. The facility will clean and reclaim coal that has spilled from coal train derailments on nearby railroad trackage. An average coal train derailment consists of 80-100 tons of coal

Table 9. Coal deliveries by month from Wyoming mines[1].

	1991 Monthly	1991 Cumulative	1992 Monthly	1992 Cumulative
JAN	14,960,450	14,960,450	16,407,150	16,407,150
FEB	15,480,110	30,440,560	14,604,480	31,011,630
MAR	16,278,870	46,719,430	14,429,650	45,441,280
APR	14,820,240	61,539,670	14,063,060	59,504,340
MAY	14,589,790	76,129,460	14,518,590	74,022,930
JUN	14,007,600	90,137,060	14,655,600	88,678,530
JUL	16,451,090	106,588,150	15,592,050	104,270,580
AUG	15,940,620	122,528,770	16,467,100	120,737,680
SEP	15,314,490	137,843,260	14,878,150	135,615,830
OCT	14,810,510	152,653,770	15,122,820	150,738,650
NOV	14,783,000	167,436,770	14,757,230	165,495,880
DEC	16,716,630	184,153,400	16,096,150	181,592,030
Total Tonnage Reported		**184,153,400**		**181,592,030**
Total Tonnage Not Reported		**9,710,406**		**7,878,226**
Total Tonnage Produced[2]		**193,863,806**		**189,470,256**

[1] Source: COALDAT Marketing Reports by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities
[2] Source: State Mine Inspector's Annual Reports

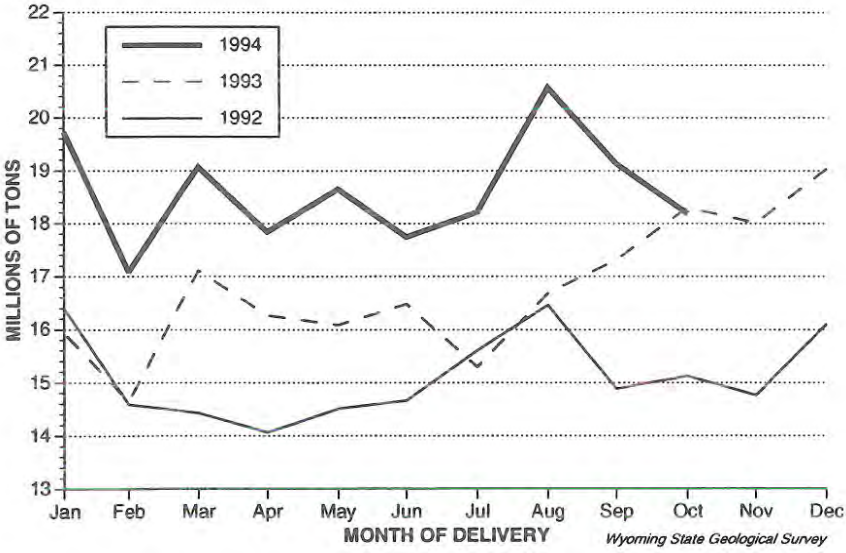


Figure 15. Reported deliveries from Wyoming coal mines (1992 through October, 1994). (From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).

Table 9. *continued*

1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative
15,931,150	15,931,150	19,326,770	19,326,770
14,646,090	30,577,240	17,171,910	36,498,680
17,112,970	47,690,210	19,178,990	55,677,670
16,259,770	63,949,980	17,839,110	73,516,780
16,085,470	80,035,450	18,652,290	92,169,070
16,473,920	96,509,370	17,741,480	109,910,550
15,296,480	111,805,850	18,213,540	128,124,090
16,682,090	128,487,940	20,572,120	148,696,210
17,310,330	145,798,270	19,129,450	167,825,660
18,300,070	164,098,340	18,189,260	186,014,920
18,007,970	182,106,310		
19,034,530	201,140,840		
	201,140,840		**186,014,920**
	8,784,986		
	209,925,826		

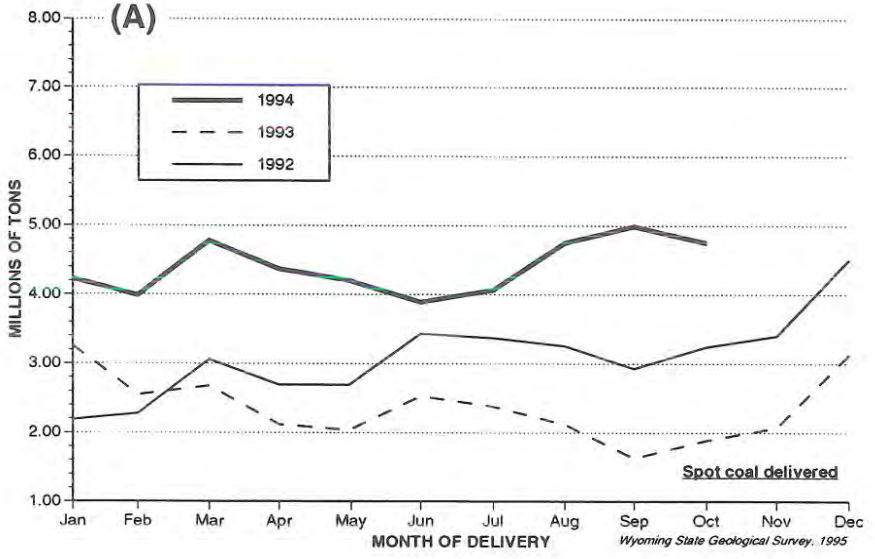
according to DEQ statistics. There have been two derailments in the Powder River Basin since the fall of 1994.

In December, a fire at the Fort Union mine, near Gillette, damaged conveyor belts that ran to two on-site coal storage silos. Apparently the fire did not reach the 5,100 tons of coal stored in the silos. There were no injuries reported.

The September issue of the U.S. Bureau of Land Management's (BLM's) *Wyoming Issues* fact sheet shows that three lease by applications (LBAs) were pending in the Powder River Basin. BLM issued an Environmental Assessment (EA) on the Eagle Butte LBA in July, but they had not issued a Decision Record. If they approve the sale, it may be in 1995. Public review of the EA for the Antelope LBA ended in October. A decision should be made in 1995 with a sale possible in 1996. The schedule for the North Roundup LBA is due in late 1995. BLM notes that an Environmental Impact Statement may be needed for this LBA.

Developments in western and southwestern Wyoming

Arch Mineral Corp. has recently announced that its Seminoe No. 2 mine will reopen in mid-1995. According to company officials, recent contracts will allow them to recover a few hundred thousand tons of coal over a limited time.



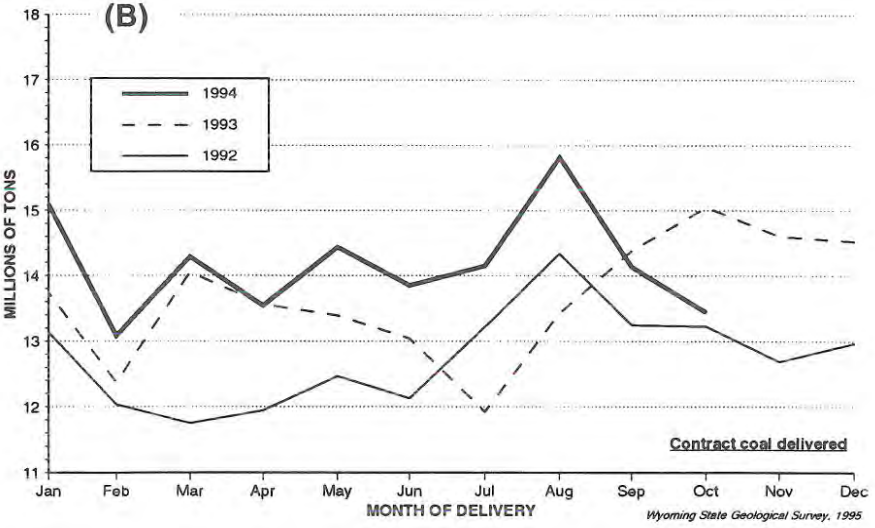


Figure 16. Monthly coal deliveries from Wyoming (1992 through October, 1994). (A) Coal sold on the spot market and (B) coal sold on contract. (From COALDAT Marketing Report by Resource Data International, Inc. compiled from the FERC Form 423 filed monthly by electric utilities).

The September issue of the U.S. Bureau of Land Management's (BLM's) *Wyoming Issues* fact sheet shows that no schedule has been set for the lease by application for the Carbon County Underground Gasification Project.

Contracts

The Lower Colorado River Authority accepted Jacobs Ranch's (Kerr-McGee) bid of $4.44 a ton freight-on-board (F.O.B.) for its recent 300,000-ton spot coal solicitation to be delivered in 1995. Other bids received were:

1) Caballo Rojo - $4.30/ton F.O.B.
2) Rochelle - $5.25/ton F.O.B.
3) Caballo - $4.39/ton F.O.B.
4) Cordero - $4.30/ton F.O.B.

Springfield [MO] City Utilities received the following bids from their Fall 1994 solicitation for 600,000 tons to their Southwest plant. The bids received were:

1) Caballo Rojo - $4.00/ton F.O.B.
2) Black Thunder - $5.09/ton F.O.B.
3) Antelope - $5.10/ton F.O.B.
4) Rochelle/North Antelope - $5.13/ton F.O.B.

Grand Island [NE] Electric Department has awarded Caballo Rojo a coal contract for one million tons to be delivered to its Platte plant through 1997. The price was $4.05/ton F.O.B. This contract supersedes a previous agreement with Cordero for $3.50/ton F.O.B.

New coal contracts, test burns, solicitations, and spot-sales for the fourth quarter of 1994 are summarized in **Table 10** and located on **Figure 17**.

Coalbed Methane

The comment period on the American Oil and Gas Lighthouse Project, ended in November. For this project, American Oil and Gas proposes drilling 200 coalbed methane wells, targeting Ft. Union Formation coals in a 200-square-mile area north of Wright and near Reno Junction. During the comment period, new ground-water data was obtained and incorporated into a hydrologic model. The Environmental Assessment should be released early in 1995.

Table 10. Activities involving coal producers in Wyoming during the fourth quarter of 1994[1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	Central & Southwest Services	various plants[2]	Powder River Basin coal	So	4,700,000 t	
2.	Commonwealth Edison	various plants	Jacobs Ranch, Black Thunder, Caballo, Rochelle	C	2,500,000 t	
3.	Dairyland Electric Power Cooperative	Alma & Genoa	Caballo	C	500,000 t	As-needed supplemental contract.
4.	Grand Island [NE] Electric	Platte	Caballo Rojo	C	roughly 1,000,000 t	$4.05/ton F.O.B.
5.	Hastings [NE] Utility Department	Hastings	Black Thunder/Coal Creek	C	50,000-200,000 t	
6.	Lower Colorado River Authority	Fayette Power Project Units 1 & 2	Jacobs Ranch	C	1,880,000 t	$4.44/ton F.O.B.
7.	Midwest Power Systems	Council Bluffs	Caballo/Rawhide	C	1,200,000-1,400,000 t	3-year term.
		Neal Units 1, 2, & 3	Medicine Bow	C	600,000 t	One-year term.
8.	Northern Indiana Public Service Co. (NIPSCO)	Michigan City	Shoshone	C	90,000 t	October-November.
		Dean H. Mitchell	Belle Ayr	C	36,000 t	November.
			Caballo Rojo	C	24,000 t	November.
		Schahfer	Cordero	C	72,000 t	November.
			Black Thunder	C	240,000 t	October-November.
			Shoshone	C	103,000 t	October-November.
9.	Omaha Public Power District	Nebraska City	Clovis Point	Sp	400,000 t	
		North Omaha	Rawhide	Sp	500,000 t	

Table 10. Activities involving coal producers in Wyoming during the fourth quarter of 1994[1] *(continued)*.

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
10.	PacifiCorp Electrical Generation [WY]	Jim Bridger	Black Butte	Sp Sp	500,000 t 500,000 t	First-half delivery. Second-half delivery.
11.	PacifiCorp Electrical Generation [WA]	Centralia	Buckskin	C	N.D.	As needed supplemental contract.
12.	Portland [OR] General Electric	Boardman	Rochelle Black Thunder Black Butte	C Sp Sp	1,000,000 t 500,000 t 200,000 t	One-year term. Second-half delivery. First-quarter delivery.
13.	San Antonio Public Service Board	Spruce & Dealy	Hanna Basin	So	250,000-500,000 t	
14.	Springfield [MO] City Utilities	Southwest	Powder River Basin coals	So	600,000 t	
15.	Texas Municipal Power Agency	Gibbons Creek	Caballo Rojo	T	N.D.	
16.	West Texas Utilities	Oklaunion	Rawhide	Sp	500,000 t	

[1]Data obtained from : Coal Week, trade journals, periodicals, FERC database, and personal contacts.
[2]This solicitation is for: West Texas Utilities' Central Power & Light, and Public Service of Oklahoma's plant.
N.D. =no other data available; C =contract coal; T =Test burn; Sp =Spot coal; So =solicitation; t =short ton; t/y =short tons per year.

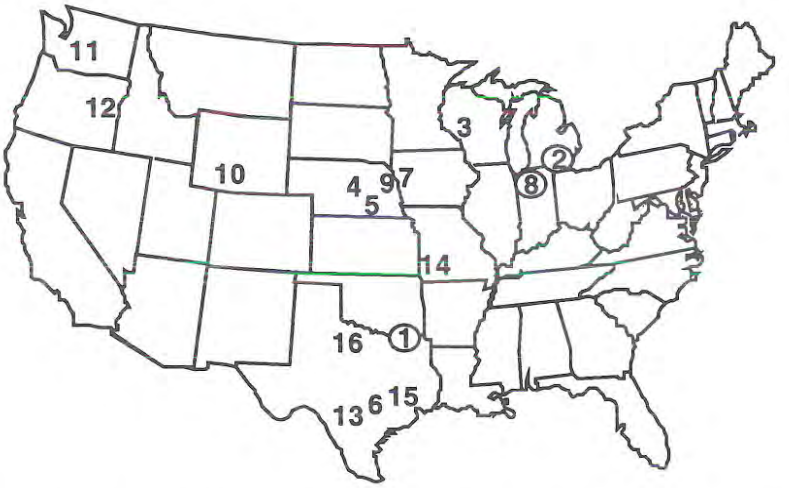


Figure 17. Coal marketing activities related to Wyoming in the fourth quarter of 1994. [*Numbers correspond to those in Table 10; circled numbers denote more than one plant in an area*].

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

The production histories (1921 to the present) of all industrial mineral commodities and uranium produced in Wyoming are available in spreadsheet and graph form from the Industrial Minerals and Uranium Section of the Wyoming State Geological Survey. Also available are recent price histories for selected commodities, in current dollars. Spreadsheets and graphs were prepared from the best available production data, including the former Wyoming State Board of Equalization, the Wyoming Ad Valorem Tax Division of the Wyoming Department of Revenue, the Wyoming State Inspector of Mines, the U.S. Bureau of Mines, the U.S. Atomic Energy Commission (now the U.S. Department of Energy), as well as individual company data. The production histories of common clay, shale, cement rock, decorative aggregate, decorative stone, feldspar, graphite, leonardite, silica sand, mined sulfur, recovered sulfur, and vermiculite are included in table form in this issue of *Wyoming Geo-notes* (**Table 11**). The production and selected price histories of bentonite, gypsum,

Table 11. Production records of some minor industrial commodities produced in Wyoming. (All figures in short tons. Data from the Wyoming Department of Revenue and Wyoming State Inspector of Mines unless otherwise noted).

YEAR	Marl[1]	Shale[2]	Decorative Aggregate[3]	Decorative Stone	Graphite	Silica Sand	Sulfur (mined)	Sulfur (recovered)	Vermiculite	Feldspar[4]	Leonardite	Common Clay
1921	---	---	---	---	---	---	---	---	---	---	---	5,000
1922	---	---	---	---	---	---	---	---	---	---	---	---
1923	---	---	---	15	---	---	---	---	---	---	---	1,637
1924	---	---	---	---	---	---	---	---	---	---	---	2,390
1925	---	---	---	---	---	---	158	---	---	---	---	2,480
1926	---	---	---	---	50	500	175	---	---	---	---	2,436
1927	---	---	---	---	---	483	---	---	---	---	---	3,088
1928	---	---	---	---	---	---	---	---	---	---	---	4,011
1929	---	---	---	---	---	---	---	---	---	---	---	4,536
1930	---	---	---	---	---	---	---	---	---	---	---	4,920
1931	---	---	---	---	---	---	---	---	---	---	---	6,243
1932	---	---	---	---	---	---	---	---	---	---	---	4,351
1933	---	---	---	---	---	---	---	---	---	---	---	2,290
1934	---	---	---	---	---	---	---	---	---	---	---	5,788
1935	---	---	---	---	---	---	---	---	---	---	---	6,418
1936	---	---	---	---	---	---	---	---	---	---	---	6,195
1937	---	---	---	---	---	---	---	---	---	---	---	8,163
1938	---	---	---	---	---	---	---	---	---	---	---	8,971
1939	---	---	---	---	---	---	---	---	---	---	---	8,598
1940	---	---	---	---	---	---	---	---	---	---	---	9,662
1941	152,175	---	---	---	---	---	---	---	31	---	---	9,866
1942	161,293	---	---	---	---	---	---	---	---	---	---	8,611
1943	135,428	---	---	---	---	---	---	---	---	4,456	---	7,334
1944	110,584	---	---	---	---	---	---	---	45,006	25,068	---	5,893
1945	103,235	---	---	---	---	---	---	---	300	19,067	---	7,242
1946	160,575	---	---	---	---	---	---	---	375	22,783	---	10,162
1947	191,554	---	---	---	---	---	---	---	1,500	23,293	---	11,043
1948	195,033	---	---	---	---	---	---	---	65	16,297	---	11,880
1949	201,674	---	---	---	---	---	1,222	---	1000	3,298	---	12,942
1950	181,543	---	---	---	---	---	725	---	15	---	---	13,808
1951	182,835	---	---	---	---	---	80	---	---	2,051	---	14,070
1952	190,939	---	---	---	---	---	100	---	180	---	---	12,760

Table 11. Production records of some minor industrial commodities produced in Wyoming. (All figures in short tons. Data from the Wyoming Department of Revenue and Wyoming State Inspector of Mines unless otherwise noted). *(Continued).*

YEAR	Marl[1]	Shale[2]	Decorative Aggregate[3]	Decorative Stone	Graphite	Silica Sand	Sulfur (mined)	Sulfur (recovered)	Vermiculite	Feldspar[4]	Leonardite	Common Clay
1953	179,784	---	---	---	---	---	---	---	2,203	1,704	---	13,950
1954	174,000	---	---	---	---	---	---	---	---	956	---	13,995
1955	192,419	---	---	---	---	---	2,057	---	---	---	---	16,471
1956	186,946	---	---	---	---	---	300	---	---	1,370	---	17,315
1957	193,806	138,702	---	---	---	---	375	---	---	482	---	15,270
1958	195,899	178,992	---	---	---	---	469	---	---	3,064	---	11,646
1959	204,185	216,506	---	---	---	---	586	---	---	---	---	14,042
1960	163,628	248,038	---	---	---	---	---	---	---	252	---	27,269
1961	157,874	196,194	---	---	---	---	---	---	---	---	---	39,215
1962	166,617	129,810	---	---	---	---	---	---	---	433	---	56,646
1963	166,704	61,618	---	---	---	---	---	---	---	---	---	59,293
1964	148,361	39,923	1,490	---	---	---	---	---	---	490	---	57,186
1965	145,985	---	6,456	---	---	---	---	---	---	---	---	60,030
1966	127,253	---	25,608	---	---	---	---	---	---	---	---	51,431
1967	115,021	---	10,366	---	---	---	---	---	---	---	---	40,172
1968	159,529	---	13,006	---	---	---	---	---	---	---	---	42,141
1969	161,793	---	20,330	---	---	---	---	---	---	---	3,579	60,831
1970	195,786	157,322	25,327	---	---	---	---	---	---	7,967	---	31,876
1971	195,242	164,226	35,635	---	---	---	---	---	---	---	---	59,844
1972	183,355	161,314	39,161	---	---	---	---	---	---	2,577	---	32,096
1973	192,251	163,919	61,650	---	---	---	---	---	---	2,588	---	79,314
1974	200,410	147,899	68,383	---	---	---	---	---	---	2,161	---	55,493
1975	191,357	128,566	56,400	---	---	---	---	---	---	2,033	---	43,781
1976	200,740	149,331	57,800	---	---	---	---	---	---	3,548	---	47,017
1977	192,957	---	75,000	---	---	---	---	---	---	3,977	---	56,468
1978	337,657	---	78,000	---	---	---	---	---	---	3,080	---	37,417
1979	342,168	---	74,000	---	---	---	---	---	---	206	---	39,184
1980	381,786	---	52,000	---	---	---	---	---	---	200	---	41,996
1981	538,883	---	49,978	---	---	---	---	50,000	---	25	---	23,220
1982	338,840	---	48,367	---	---	---	---	70,000	---	172	---	15,702
1983	393,647	---	67,397	---	---	---	---	570,000	---	---	---	36,445
1984	468,390	20,345	83,037	---	---	---	---	710,000	---	---	---	59,638

Table 11. Production records of some minor industrial commodities produced in Wyoming. (All figures in short tons. Data from the Wyoming Department of Revenue and Wyoming State Inspector of Mines unless otherwise noted). *(Continued).*

YEAR	Marl[1]	Shale[2]	Decorative Aggregate[3]	Decorative Stone	Graphite	Silica Sand	Sulfur (mined)	Sulfur (recovered)	Vermiculite	Feldspar[4]	Leonardite	Common Clay
1985	---	14,662	86,449	---	---	---	---	800,000	---	---	---	35,917
1986	---	9,878	74,083	---	---	---	---	760,000	---	---	---	23,222
1987	---	103,209	64,948	---	---	---	---	1,190,000	---	---	---	1,310
1988	---	52,172	no data	---	---	---	---	1,060,000	---	---	7	---
1989	---	15,618	61,405	---	---	---	---	1,170,000	---	---	38,871	---
1990	---	43,510	61,086	---	---	---	---	1,040,000	---	---	41,674	---
1991	---	158,232	69,685	24[5]	---	---	---	1,180,000	---	---	22,865	---
1992	---	113,295	69,423	100[5]	---	---	---	1,200,000	---	---	36,992	---
1993	---	---	81,192	168	---	---	---	1,140,000	---	---	38,999	---

[1]Calcareous rock used as an additive in cement.
[2]Shale used as siliceous additive in cement.
[3]Includes marble, serpentine, quartz, and feldspar.
[4]Used as a major ingredient in the manufacture of ceramics, glass, and dental appliances.
[5]Estimated by the Wyoming State Geological Survey.

limestone (chemical grade), phosphate, sodium sulfate, and trona have already been presented in previous issues of *Wyoming Geo-notes*. Future issues will include statistics on construction aggregate and uranium production.

In the following discussions, the locations of mines, quarries, plants, etc. are shown on **Figure 18**.

Aggregate (Construction)

The production of construction aggregate in Wyoming slows seasonally with the decline in outdoor construction during the winter. However, there are plans for some new quarries early in 1995. A limestone aggregate quarry is scheduled to open near Laramie to provide large amounts of rock for a major reconstruction of Interstate 80 between the Curtis Street interchange in Laramie and the Summit.

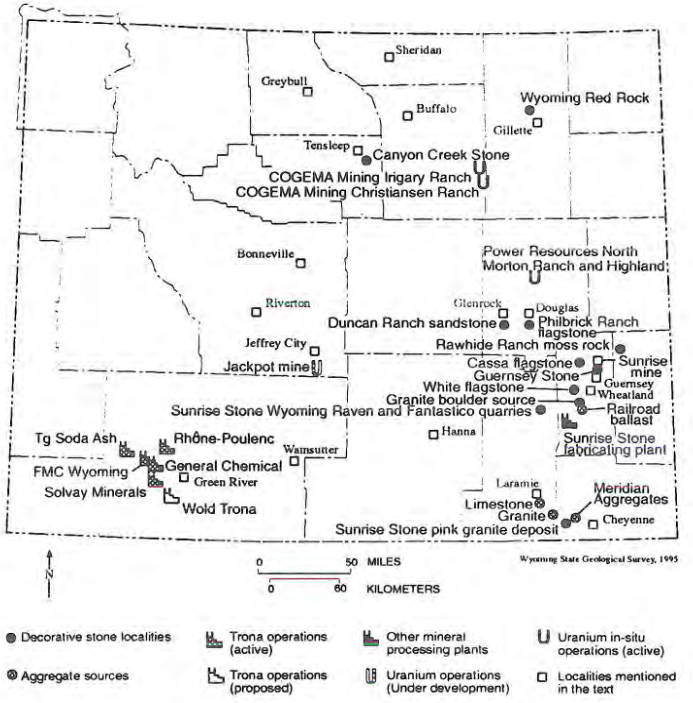


Figure 18. Industrial minerals and uranium activities in Wyoming during the fourth quarter of 1994.

Meridian Aggregates, located at Granite, west of Cheyenne in Laramie County, is still the largest producer of construction aggregate in Wyoming. It produces railroad ballast and a variety of sized aggregate for general construction needs. Meridian recently sold rip rap to the University of Wyoming and to Laramie for use in its runoff collecting basins. The quarried material is a granitic gneiss of Precambrian age. Meridian has also provided a few boulders for decorative landscaping for schools and other locations in Laramie and Cheyenne.

Contract negotiations and permitting are in progress for a proposed ballast quarry along the Burlington Northern Railroad in Platte County. In 1990, the Wyoming State Geological Survey investigated the use of this site for ballast and prepared an in-house report on it. Like the Meridian quarry, the rock at this site is a granitic gneiss of Precambrian age.

In October, Monroc Inc. purchased Big Horn Ready Mix, Inc., of Greybull. Big Horn operated four ready-mix concrete plants in northwestern Wyoming. Monroc, Inc., which is based in Salt Lake City, Utah, operates 18 ready-mix facilities in Utah, Idaho, and Wyoming, in addition to the newly purchased Wyoming plants, and it is a major user of local construction aggregate. Monroc also markets prestressed and precast concrete products.

Decorative stone

The production of cut and polished pieces of Wyoming Raven, a black granite (actually an amphibolite), and Fantastico (a multicolored gneiss), continues at Sunrise Stone's quarry in Albany County and its fabricating plant in Platte County. The plant currently has enough orders to keep it operating at full capacity for most of 1995. Contracts include stone for Bill Gates' (Microsoft executive) new house in the Seattle, Washington area; cornerstones for a group of churches in the south; and stone for Taiwan, where it will be introduced into the Far East market. Some of the stones shipped to Taiwan may be used in buildings in mainland China as well. Sunrise is also negotiating with the Taiwan buyers for the opening of a pink granite quarry southeast of Laramie.

The production of buff-colored flagstone from a quarry on the Lawrence Philbrick property south of Douglas has at least temporarily ceased. Some of that stone was shipped last year to Disney World, in Orlando, Florida. White flagstone (sandstone) from near Glendo and white flagstone (limestone) from west of Wheatland were shipped to Colorado during the last quarter of 1994.

In November red quartzite boulders covered with green moss were shipped from the Rawhide Ranch in northwestern Goshen County. Western Aggregates, of Boulder, Colorado, sold this decorative stone to buyers in the Colorado Front Range area.

Abbott Construction is beginning the shipment of more than one hundred truckloads of pink granite boulders, some of them twelve feet long. These

boulders were quarried from the Fred McGuire Ranch in Platte County for a buyer in Aspen, Colorado. Until recently, they had been stockpiled south of Wheatland. The quarry site has already been reclaimed.

Canyon Creek Stone continues to develop its flagstone and brown marble quarry southeast of Tensleep, in Washakie County. Material from this operation has been used on buildings in the Jackson, Wyoming, and Big Sky, Montana, areas. Canyon Creek is still planning to construct a processing plant at the quarry site.

Wyoming Red Rock, of Gillette, is producing and shipping several varieties of decorative aggregate throughout the region. The product for which the company is named is clinker or scoria, which is baked and fused shale. This is the bright red to red-orange to black rock that forms resistant layers capping buttes and mesas in the northern Powder River Basin, particularly in the Gillette, Sheridan, and Buffalo areas. Clinker was produced by the baking and partial melting of shales that overlaid burning coal beds.

Because pink is a popular color in Florida for houses and other decorations, Guernsey Stone, has shipped some pink marble aggregate to Florida for use in landscaping, roofing granules, driveways, or other uses. Although Guernsey Stone primarily sells construction aggregate, it reports greatly increased sales of all colors of its decorative stone. Guernsey Stone is a division of Peter Kiewit and is located just north of Guernsey, Wyoming.

A deposit of buff, apricot, and pink sandstone on the Duncan Ranch south of Glenrock was investigated by the Wyoming State Geological Survey. The area contains a number of abandoned quarries in which there are many quarried dimensional blocks still present. These quarries supplied cut stone for the Chicago & NorthWestern Railroad early this century. Many of the original stone culverts constructed with this rock are still in service. Negotiations are currently under way for the reactivation of these quarries and the production of dimensional blocks.

Iron oxide (Industrial)

Shipments of iron oxide from tailings at the Sunrise mine in northeastern Platte County have ceased and the operator's permit has been revoked by the Wyoming Department of Environmental Quality. About 500 tons of this material had been shipped to the cement plant north of Fort Collins, Colorado, for use as a weighting and strengthening additive.

Trona

Trona is mined in Wyoming at five locations west of Green River, Wyoming, and refined into soda ash and a variety of sodium-based products at the mine sites. A sixth facility is under development. Soda ash is used primarily in the

manufacture of glass, and also in products such as baking soda, toothpaste, and chemicals for treating paper and water. Ninety percent of the soda ash produced in the U.S. comes from Wyoming; the remaining ten percent is produced from surface deposits of trona in California. Most of the soda ash produced in the rest of the world is manufactured synthetically from salt, limestone, and other ingredients.

Because it is much cheaper to produce soda ash from mined trona, many other countries have established trade barriers to protect their domestic soda ash industries from competition with U.S. soda ash. With the passage of the General Agreement on Tariffs and Trade (GATT), some of these barriers may be reduced, which could lead to significant increases in the sale of Wyoming products. Officials at the trona plants report that they are optimistic about the eventual increase in the export market, but they warn that the changes may be slow.

As a result of GATT, in October, the Japanese ambassador indicated that both flat glass and soda ash would see increased sales there, increasing market opportunities for sales of these U.S. products.

In a related issue, the Wyoming State Geological Survey has reported that all of the raw materials necessary to produce glass are found in Wyoming. These include silica sand, soda ash, limestone, and feldspar. Glass production is also energy-intensive, and Wyoming has low energy costs. Currently, the Laramie Economic Development Corporation is sponsoring a study by the University of Wyoming to determine the costs and feasibility of a glass plant in Albany County.

Following Union Pacific Railroad's cut in soda ash freight rates, BTI Inc., laid off about half of its work force. BTI had been trucking soda ash to the Burlington Northern Railroad at Bonneville, northeast of Riverton for nine years.

Uranium

In 1993, the most recent year for which there is published information, there was a little good news, and a lot of bad news in the domestic uranium industry. The U.S. Energy Information Administration (EIA) noted that uranium inventories, which are the amount of processed uranium stored by utilities for use as nuclear fuel, declined in 1993 for the tenth year in a row. These stocks were extremely large following the cessation of nuclear plant construction in the early 1980s. Because inventories are being depleted, utilities must buy more uranium to fuel existing nuclear power plants.

In 1993, U.S. utilities purchased 31.2 million pounds of U_3O_8 at an average price of $11.97 per pound. New purchase contracts, however, were let for 3.6 million pounds at an average price of $9.36 per pound U_3O_8 (EIA, 1994a), indicating that the price of U_3O_8 declined in 1993. Of the 31.2 million pounds of

U_3O_8 used in the U.S., 21 million pounds were purchased from foreign sources at an average price of $10.53 per pound (EIA, 1994a).

Consequently in 1993, U.S. production of mined and processed U_3O_8 declined 46% from 1992 levels while employment in the uranium mining industry declined 44% (EIA, 1994a). Also in 1993, uranium production ceased in New Mexico, historically the nation's number one producer. Florida and Wyoming, respectively, now produce the most uranium with production also reported from Texas and Nebraska.

Another EIA report noted that the existing 109 nuclear power plants in the U.S. were producing 21.9% of the nation's electricity. This represented an increase from 20.1% during the same period in 1993 (EIA, 1994b).

In November the U.S. Departments of State, Energy, and Defense jointly announced the details of a U.S. purchase of weapons-grade uranium from Kazakhstan. Six hundred kilograms were purchased and shipped to the Oak Ridge facility in Tennessee. The Secretary of Energy initially said the material would be converted to nuclear fuel within a few months. Later, officials of the Department of Energy said that a special conversion plant might have to be constructed, and that electric utilities might not be interested in putting up the capital for such construction. While weapons-grade uranium contains more than 90% of the fissionable isotope $_{235}U$ fuel for nuclear power plants only contains about 3% $_{235}U$.

In December, the Tennessee Valley Authority (TVA), announced it was cancelling any further construction of non-operable nuclear power plants throughout the country. COGEMA Mining, which operates two in-situ recovery fields in Johnson County, and Power Resources, which operates an in-situ uranium recovery operation at the Highland site in Converse County, said that the TVA decision won't affect their operations (**Figure 18**). Much of the uranium production (yellowcake) from Wyoming is sold under contract to foreign purchasers. Kennecott Energy, the developers of the Jackpot deposit on Green Mountain south of Jeffrey City, also said that the TVA decision will not affect their plans.

References cited

Energy Information Administration [EIA], 1994a, Low-priced imports depress U.S. uranium production: Press Release EIA-94-15, 1p.

Energy Information Administration [EIA], 1994b, Nuclear energy: Monthly Energy Review, November, p. 103.

METALS AND PRECIOUS STONES UPDATE

W. Dan Hausel
Senior Economic Geologist, Wyoming State Geological Survey

Diamonds

In the fourth quarter of 1994, diamond testing was reported at the Kelsey Lake, Sloan, and Chicken Park kimberlites in the Colorado-Wyoming State Line district. Exploration activities for diamonds were also reported at several locations in the Laramie Mountains of eastern Wyoming and in the Green River Basin of southwestern Wyoming.

In the Green River Basin, exploration was reported in the Leucite Hills north of Rock Springs and near Cedar Mountain south of Green River. The Leucite Hills enclose one of the largest lamproite fields in the world, and the Cedar Mountain area contains scattered anthills with the kimberlitic indicator minerals pyrope garnet and chromian diopside. Although exploration results are unknown, several claims were recently staked in this region.

In the Laramie Mountains of southeastern Wyoming and in the Front Range of northern Colorado, exploration activity was reported at several locations. Near Sybille Canyon in the central Laramie Mountains, two kimberlite intrusives were reportedly discovered by an exploration geologist from Colorado. The intrusives were found during follow-up reconnaissance on several kimberlitic heavy mineral anomalies discovered by the Wyoming State Geological Survey and reported in Hausel and others (1988).

At another locality several miles south of Sybille Canyon in the Eagle Rock-Happy Jack area east of Laramie, the source of 35 kimberlitic heavy mineral anomalies previously identified by the Wyoming State Geological Survey (Hausel and others, 1988) was explored by First Choice Industries from Canada. According to the *Northern Miner* (December 26, 1994), geophysical testing by First Choice Industries identified magnetic and resistivity anomalies in the vicinity of the heavy mineral anomalies. Similar geophysical anomalies were previously identified in association with kimberlite in the State Line district and the Sybille Canyon area (Hausel and others, 1979; 1981). First Choice started drilling at their discovered anomalies.

Four angle holes have been drilled on the geophysical targets, but no kimberlite has been intersected. The company plans to continue with detailed

sampling of stream sediments on all drainages and topographic depressions in the area in an attempt to find the source of the indicator minerals.

Several miles south of the First Choice Industries prospect, diamond recovery from the Kelsey Lake kimberlites in the Colorado-Wyoming State Line district south of Tie Siding, Wyoming, remained impressive. The property, which is controlled by the Diamond Company, NL-Redaurum joint venture, consists of a cluster of eight diamondiferous kimberlite pipes, less than a stone's throw south of the Wyoming border. These pipes have yielded more than 600 diamonds from bulk samples. The recovered diamonds have included more than 60% gemstones including the two largest diamonds (weighing 6.2 and 14.2 carats) found in the district. Both of these stones are high-quality gems. Alluvial deposits on the Wyoming side of the border have also yielded diamonds. It is not know from which state the two largest diamonds were recovered.

According to the *Northern Miner* (December 12, 1994), the results are sufficiently encouraging that Redaurum has entered into an agreement to acquire the remaining 75% interest in the Kelsey Lake properties. According to the *Northern Miner*, the company will proceed with the construction of a 250,000-tonne-per-year diamond extraction plant in 1995. The mill will be designed to facilitate prefeasibility studies and trial mining.

Exploration and diamond testing were also reported on the Sloan 1 and 2 diamondiferous kimberlites and the Chicken Park kimberlites in Colorado. These intrusives lie nearly 10 miles south of the Kelsey Lake kimberlites.

Silver Crown district

Compass Minerals Exploration USA/Australia continued its feasibility studies on drill core recovered from the Copper King mine in the Silver Crown district in southeastern Wyoming. The Copper King deposit is a low-grade, disseminated, copper-gold deposit. Further exploration and development will depend on the metallurgical tests. A company decision is expected anytime.

Encampment district

The Wyoming State Geological Survey recently made a brief reconnaissance examination of the region surrounding the historic Charter Oak mine in the Encampment district of the Sierra Madre. The property is located 6.5 miles northwest of Encampment on Puzzler Hill. Puzzler Hill is an ultramafic massif with scattered mineralization.

Hand specimen samples collected in the field are dominantly pyroxenite and ultramafic schist. Samples of the host rocks collected for petrographic and geochemical studies include a sample of pyroxenite (CO1-94) and a sample of actinolite-chlorite schist (CO5-94). Both magnesian-rich rocks are typical of ultramafic rocks (**Table 12**).

Table 12. Whole-rock analyses of samples from the Charter Oak mine area.

Oxide[1]/Element[2]	Sample CO1-94	Number CO5-94
SiO_2	45.5	48.75
TiO_2	0.59	0.44
Al_2O_3	8.48	8.57
Fe_2O_3	11.76	12.09
MnO	0.17	0.19
MgO	19.39	16.43
CaO	8.01	6.65
Na_2O	0.83	0.79
K_2O	0.07	0.09
P_2O_5	0.05	<0.03
Cr_2O_3	0.35	0.28
LOI	3.59	4.24
TOTAL	98.79	98.52
Au (ppb)	3	14
Pt (ppb)	8	<5
Pd (ppb)	15	8
Cu (ppm)	159	248
Ni (ppm)	343	178
Co (ppm)	29	28

[1]Weight percent.

[2]Parts per billion (ppb) or parts per million (ppm).

Other samples collected from a small group of mines and prospects in the massif contained anomalous metal values. A limonite-stained breccia sample (CO2-94) from a mine dump contained anomalous copper, nickel, platinum, palladium, and silver (**Table 13**). Samples of massive specular and earthy hematite with copper carbonate, minor bornite, and chalcopyrite in chlorite-actinolite-talc schist from the Charter Oak mine dump (CO3-94 and CO4-94) yielded anomalous copper and gold. Near the Charter Oak mine dump, a sample of quartz breccia cemented by sideritic limonite with fuchsite (CO6-94) was poorly mineralized (**Table 13**).

According to early reports, the Charter Oak mine was located on a northerly-trending, easterly-dipping vein on the east side of a broad synform in granite-gneiss, schist, and diorite country rock. The vein reportedly contained iron- and copper-sulfides, which also impregnated the fractured country rock. Chalcopyrite, chalcocite, bornite, and azurite were identified in a gangue of quartz, jasperoid, schistose wall rock, calcite, and chalcedony (Spencer, 1904). Some high-grade gold was also reported on the property (Beeler, 1905).

Early reports indicated that the mineralized zone was traced two miles on the surface and varied in width from 14 feet at the Charter Oak shaft to 100 feet elsewhere. Where the mineralized structure was widest, the ore apparently consisted of quartz stringers mixed with low-grade material. Beeler (1906) reported that an open cut near the top of Puzzler Hill exposed a "huge ledge of mineralized diorite" stained with copper-carbonate. According to Armstrong (1970), the Charter Oak ores also carried as much as 4 to 5% cobalt although this was not verified during the present study. The Charter Oak shaft was sunk to a depth of 488 feet (Beeler, 1905), with more than 1,570 feet of shafts and tunnels (Beeler, 1906).

In addition to the mineralization at the Charter Oak, scattered gossans in the massif suggest that the mineralization is widespread, but erratic.

Table 13. Assays from the Puzzler Hill massif (analyses by Bondar-Clegg).

Sample No	Cu (%)	Ni (ppm)	Co (ppm)	Cr (ppm)	Au (ppb)	Pt (ppb)	Pd (ppb)	Ag (ppm)	Pb (ppm)	Zn (ppm)
CO2-94	4.43	>20,000	831	244	95	828	4,042	2.9	57	55
CO3-94	3.52	66	27	71	7718	<5	11	3.8	10	14
CO4-94	2.39	127	82	64	9862	<5	14	6.6	9	9
CO6-94	0.01	162	21	294	14	<5	5	<0.1	-	-

Note: % = percent by weight; ppm = parts per million; and ppb = parts per billion.

Gold in southern Wyoming

In 1991 and 1992, the author, Gordon Marlatt of Laramie, and Eric Nielsen from Nebraska discovered several precious metal occurrences in southern Wyoming. The discoveries included placer gold in a few gravel pits and in several streams draining the northeastern Medicine Bow Mountains, anomalous silicified zones at Quaking Asp Mountain and Black Butte near Rock Springs, and silver anomalies in coal in the Kemmerer coal mining district of western Wyoming. The results of the study were recently published as Wyoming State Geological Survey Open File Report 94-2, *Study of metals and precious stones in southern Wyoming*, by W. Dan Hausel, Gordon Marlatt, Eric Nielsen, and Robert Gregory.

South Pass

Based on encouraging results from last summer's drilling program, Carissa Mining (VSE) announced they will proceed with the next phase of drilling on the Carissa shear zone in the South Pass greenstone belt on the southern margin of the Wind River Range. The company will invest approximately $250,000 in drilling in 1995.

Ore reserve calculations in 1993 showed probable reserves of about 100,000 tons grading 0.368 ounce per ton (opt) in the existing mine workings. The 1994 program outlined additional gold mineralization both east and west of the mine, and at depth below the present workings. Some reported drill intersections included 1.09 opt over 24 feet, 0.05 opt over 15 feet, and 0.15 opt over 9.5 feet (*Northern Miner*, January 9, 1995, p. 14).

Mineral Reports

The Wyoming State Geological Survey has developed an extensive file of unedited and unpublished reports known as Mineral Reports. These reports contain a variety of topical information including geological maps and assay data. They are available for examination at the Survey's office in Laramie. Copies of the various reports can be purchased for the cost of photocopying, plus postage. Contact W. Dan Hausel for further information.

Two recent Mineral Reports of interest include: *Diamonds, kimberlites, lamproites, and related rocks in the United States*, Mineral Report MR94-2, 50 pages, and *Preliminary report on copper, lead, zinc, and molybdenum in Wyoming*, Mineral Report MR95-1, 200 pages.

References cited

Armstrong, J.R., 1970, Grand Encampment 1898-1912: High Country Treasure: Rawlins Newspaper, Inc., Rawlins, Wyoming, 19 p.

Beeler, H.C., 1905, Mining in the Grand Encampment copper district, Carbon and Albany counties, Wyoming (2nd edition): Office of the State Geologist, Cheyenne, Wyoming, 31 p.

Beeler, H.C., 1906, A brief report on the Charter Oak-Puzzler groups near Encampment, Carbon County, Wyoming: Geological Survey of Wyoming Mineral Report MR06-73, 10 p.

Hausel, W.D., McCallum, M.E., and Woodzick, T.L., 1979, Exploration for diamondiferous kimberlite: an evaluation of exploration techniques: Geological Survey of Wyoming Report of Investigations 19, 29 p.

Hausel, W.D., Glahn, P.R., and Woodzick, T.L., 1981, Geological and geophysical investigations of kimberlite in the Laramie Range, southeastern Wyoming: Geological Survey of Wyoming Preliminary Report 18, 13 p.

Hausel, W.D., Sutherland, W.M., and Gregory, E.B., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 11 p., 5 sheets.

Spencer, A.C., 1904, Copper deposits of the Encampment district, Wyoming: U.S. Geological Survey Professional Paper 25, 107 p.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1994)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.4	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.0	billion barrels
Remaining Reserve Base (January 1, 1994)		
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.12	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	3.92	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1994)		
Discovered (Includes 20.1 trillion cubic feet (TCF) of methane[1] and 122.0 TCF of CO_2[3])	140.0	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,847.2	trillion cubic feet
Remaining Reserve Base (January 1, 1994)		
Measured reserves (Proved reserves) (Includes 10.9 TCF of methane[2] and 60.4 TCF of CO_2[3])	71.3	trillion cubic feet

COAL

Remaining Resources (January 1, 1994)		
Identified and Hypothetical (Discovered)	1,428.0	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,459.5	billion tons
Remaining Reserve Base (January 1, 1994)		
Demonstrated strippable (Measured and indicated reserve base)	26.4	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	68.9	billion tons

TRONA

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

URANIUM

Remaining Resource (December 31, 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, 1994, U.S. crude oil, natural gas, and natural gas liquids reserves: 1993 Annual Report, 155 p.

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

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

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

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

[7] Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 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.

SURFICIAL GEOLOGIC MAPS COMPLETED

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

Surficial geologic maps and bedrock geologic maps are usually quite different. Surficial geologic maps show bedrock where it is well exposed with the rest of the map showing surficial landforms and the materials or deposits associated with the landforms. Bedrock geologic maps, however, primarily show bedrock, even when the bedrock is covered by shallow surficial deposits. On bedrock geologic maps surficial deposits are usually only shown when they are thick enough to entirely mask the underlying bedrock, or when they are extensive or unique enough to merit inclusion. In this regard, some bedrock geologic maps can be rather misleading, as they may give the impression that most of the surface of Wyoming is composed of well exposed outcrops of bedrock. In reality, a significant portion of the surface of the State is composed of erosional or depositional landforms and their associated materials. Much of the near-surface bedrock has been weathered and is covered with a thin cover of bedrock residuum.

In late 1993, the Geologic Hazards Section at the Wyoming State Geological Survey began mapping the surficial geology of the State. Using aerial photography, existing mapping, and limited field checking, the State was quickly mapped at a scale of 1:100,000. The 100,000-scale maps were then used to create a somewhat simplified 1:500,000-scale statewide map. The first draft of this map is now complete.

The mapped landforms and deposits include alluvium, bench and terrace deposits, mesas and structural terraces, colluvium, eolian features and deposits, landslides, residuum, slopewash, clinker, hot spring deposits, karst features, grus, and bedrock. Playa lake deposits and mined-out areas are shown when they are large enough to depict at a scale of 1:500,000. Map classifications are composed of single or multiple features or deposits. For example, many hillsides are covered by a combination of slopewash, colluvium, and residuum, designated by the letters s, c, and r, respectively. On the map, that combination of deposits is labeled scr, crs, rsc, etc. with the order of the letters dependent upon their relative abundance. In total, over 500 classifications were used on the map.

This 1:500,000-scale map will first be used for a project on the vulnerability of aquifers to agricultural contamination. This project was discussed in *Wyoming Geo-Notes No. 43* (p. 44-45). The Wyoming Water Resources Center, the project leader on the aquifer vulnerability study, is currently in the process of digitizing and annotating the classified areas on the map. Once in a digital form, the map will be relatively easy to update and modify. The 1:100,000-scale maps, when refined, will be useful in siting facilities, homes, roads, or other structures.

For further information on surficial geologic maps of Wyoming, contact Jim Case or Laura Larsen at the Wyoming State Geological Survey.

GEOLOGIC MAPPING AND STRATIGRAPHY

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

COLOR GEOLOGIC MAPS PUBLISHED FOR AREA EAST OF TENSLEEP, WYOMING

The Wyoming State Geological Survey recently published two new 1:24,000-scale color geologic maps for the southern Bighorn Mountains, southeast of Tensleep. The maps are titled *Geologic map of the Monument Hill Quadrangle, Washakie and Johnson Counties, Wyoming,* and *Geologic map of the Beartrap Meadows Quadrangle, Johnson County, Wyoming,* the maps were prepared by the author and Phillip L. Greer. These maps have been designated Wyoming State Geological Survey Map Series 44 and 45, respectively, and represent the first two color geologic maps revised and published as part of the southern Bighorn Mountains mapping project (**Figures 19** and **20**). Another eight preliminary geologic maps have been completed as Open File Reports in this portion of the southern Bighorn Mountains (**Figure 20**).

The Geologic Mapping Section initiated this mapping project in 1984 to provide new geologic mapping for an area that, with the exception of a few thesis maps, was last mapped by N. H. Darton in 1906 at 1:250,000-scale. In addition, the area serves as a major recharge area for the Paleozoic aquifers on both sides of the southern Bighorn Mountains. These maps, along with those currently in preparation, should aid in locating water well sites as well as understanding the ground-water hydrology of this area. The maps also include information relating to potential sand and gravel resources.

The mapped area contains rocks ranging from Cambrian Flathead Sandstone (over 500 million years old) to Triassic/Permian Goose Egg Formation (over 220 million years old). These rocks are capped in some areas by the relatively young Oligocene White River Formation (24-37 million years in age). Both maps also contain portions of the Big Trails fault system, an oblique-slip structural feature.

Field examination of this fault system on the Beartrap Meadows Quadrangle revealed a graben of Pennsylvanian Tensleep Sandstone, bordered on the west and east by Mississippian Madison Limestone. While the Big Trails fault had little apparent vertical offset on it, the graben was down-dropped into the fault approximately 300 feet. Nearly 1.5 miles south of this graben, a horst of Cambrian Gallatin Limestone is mapped wedged between Ordovician Bighorn Dolomite. Again, while there was very little vertical offset on the Big Trails fault, the horst of Gallatin Limestone had been forced upward about 200 feet. Both of these features lend support to the theory that movement on the Big Trails fault

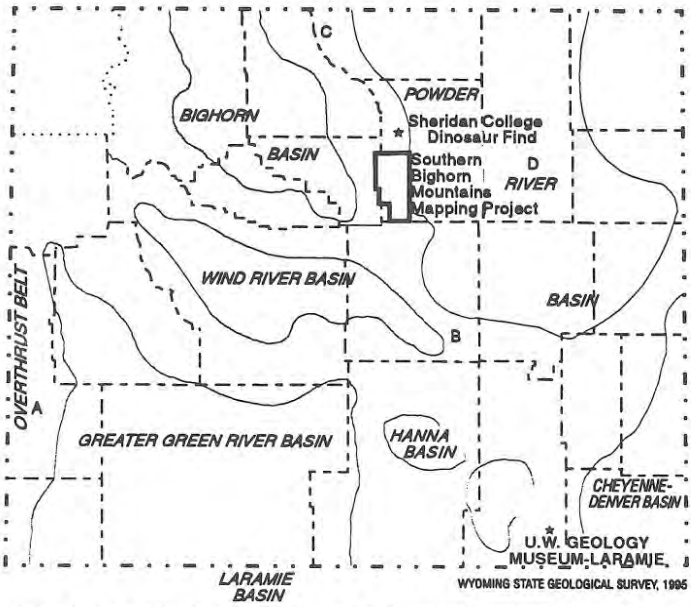


Figure 19. Index to selected geologic activities and recently released maps and reports on Wyoming geology.

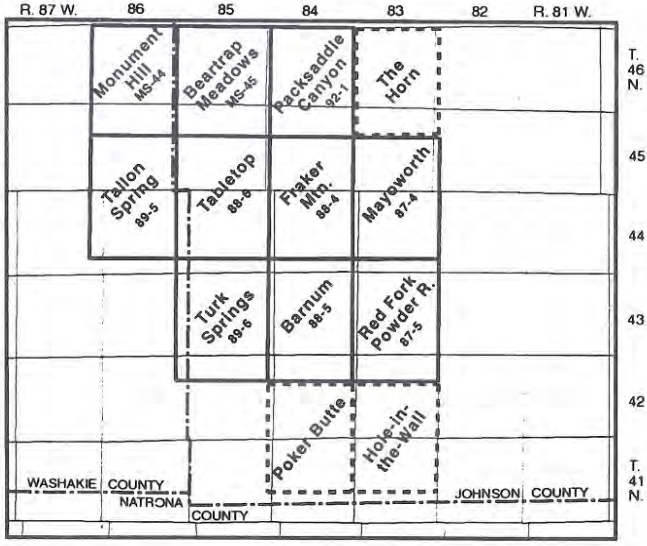


Figure 20. Geologic quadrangle maps of the southern Bighorn Mountains available from the Wyoming State Geological Survey. (Open file maps are annotated with the year and number of each map, i.e., 88-5; maps in progress are dashed). MS indicates Map Series.

was primarily horizontal or strike-slip in this area. The graben could have been created by a minor releasing bend in the fault and the horst by a minor restraining bend. These sorts of features are common to oblique-slip faults, and there are several other examples of these types of features farther to the south on this fault.

RECENT PALEONTOLOGICAL DEVELOPMENTS

The Director of the University of Wyoming's Geological Museum, Brent Breithaupt, recently announced the aquisition of a skull cast of *Tyrannosaurus rex*. Crews of the Museum of the Rockies uncovered the skull in 1990 in eastern Montana. This fiberglass skull cast is 55 inches high, 59 inches long, and contains 58 teeth. It was recently on display immediately below the neck of the *Apatosaurus* in the museum. By the end of January, the cast will be moved to a permanent spot. The Museum has sponsored a variety of fund raising events in 1994 to pay for this new addition. One ongoing fund raising effort includes the sale of beautifully crafted pewter pins depicting the *Tyrannosaurus rex* skull. The pins are designed and produced by artist Michael Holland of Montana and are available for $20.00 each from the Geological Museum.

After the skull is moved to its new location, the Geological Museum will hold a T-rex celebration to commemorate the 30th anniversary of the completion of the museum's life-sized copper-plated *Tyrannosaurus*. This dinosaur replica was built by famed Wyoming geologist Samuel H. Knight and stands adjacent to the museum building.

Tyrannosaurus rex, which was the largest carnivorous dinosaur, flourished in the western interior of North America during the Late Cretaceous about 70 million years ago. Remains have been collected from the Lance and Hell Creek Formations of Wyoming and Montana. The first skeleton of a *Tyrannosaurus* was discovered in northeastern Wyoming, and it now resides at the British Museum of Natural History in London.

In a related note, Breithaupt announced that the University of Wyoming's Geological Museum in Laramie (**Figure 19**) has become a separate entity from the Department of Geology and Geophysics. Breithaupt serves as director of this now separate program.

Michael Flynn, head of the Geology Department at Sheridan College, recently reported the discovery of a nearly complete dinosaur skeleton in a quarry on State land south of Buffalo, Wyoming (**Figure 19**). The skeleton represents a probable juvenile *Diplodicus*, a plant-eating dinosaur from the Upper Jurassic Morrison Formation of at least 138 million years ago. The articulated skeleton is nearly 50% uncovered at this point thanks to the efforts of Flynn and 15 Sheridan College students who began excavation of the

skeleton in November. The excavated portion of the dinosaur has been covered with approximately three feet of sand on canvas to protect it from winter weather. Flynn hopes to resume excavation efforts sometime this spring. Previous discoveries in this quarry revealed incomplete and inarticulated specimens in a poorer state of preservation. As a result, Flynn is greatly encouraged by this most recent find.

As a result of pressure from the general public, the geoscience community, and Congress, the U.S. Forest Service retracted proposed regulations that would have created sweeping new restrictions on collecting fossils, minerals, and rocks on National Forest lands. Current rules prohibit excavating, damaging, or removing vertebrate fossils or removing any paleontologic resources from National Forest lands for commercial purposes without a special use permit. The proposed rule change would have prevented even casual surface collecting of rocks and invertebrate fossils. There currently is no consistent policy for management of fossils on Federal lands. In 1992, Senator Max Baucus from Montana introduced legislation to create a more uniform approach to management of vertebrate fossils on Federal lands, but that bill died in committee. There are apparently one or two new paleontology bills that have been or will be introduced in 1995.

NEW REPORTS DETAILING THE STRATIGRAPHY AND STRUCTURAL GEOLOGY OF WYOMING

Four recent papers have dealt with the geology of Wyoming. Burtner (1994) discusses thermochronology of Lower Cretaceous source rocks in the Idaho-Wyoming portion of the Idaho-Wyoming-Utah thrust belt. Sampling of source rocks and the resulting analyses allow for new interpretations of the thermal history of these source rocks. Gaussian curvature analyses are used by Lisle (1994) in the detection of zones of abnormal strain in structural features, specifically Goose Egg dome near Casper. A Gaussian curvature map can be used to predict areas of abnormal strain or high fracture densities in petroleum producing structures. McConnell (1994) uses kinematic modelling to look at basement-involved fault-propagation folds in the northern Bighorn Basin and Bighorn Mountains of Wyoming. Another product of the ongoing evolution of sedimentary basins study was recently released by the U.S. Geological Survey. Robbins (1994) details the results of his gravity and aeromagnetic studies completed in the Powder River Basin of Wyoming, Montana, and South Dakota.

Each of these reports is listed below and the study area is located on the accompanying index map (**Figure 19**).

A. Burtner, R.L., Nigrini, A., and Donelick, R.A., 1994, Thermochronology of Lower Cretaceous source rocks in the Idaho-Wyoming thrust belt: American Association of Petroleum Geologists Bulletin, v. 78, no. 10, p. 1613-1636.

B. Lisle, R.J., 1994, Detection of zones of abnormal strains in structures using Gaussian curvature analysis: American Association of Petroleum Geologists Bulletin, v. 78, no. 12, p. 1811-1819.

C. McConnell, D.A., 1994, Fixed-hinge, basement-involved fault-propagation folds, Wyoming: Geological Society of America Bulletin, v. 106, p. 1583-1593.

D. Robbins, S.L., 1994, Gravity and aeromagnetic studies of the Powder River Basin and surrounding areas, southeastern Montana, northeastern Wyoming, and western South Dakota: U.S. Geological Survey Bulletin 1917-R, 17 p.

ROCKHOUND'S CORNER

W. Dan Hausel, Senior Economic Geologist,

Wyomingite, which is possibly the rarest rock in the world, was initially described in the Leucite Hills northeast of Rock Springs, Wyoming, in 1897. Technically, Wyomingite is a peralkaline ultrapotassic volcanic rock that consists of volcanic glass with the primary minerals leucite, diopside, and phlogopite (many of the glittering minerals seen in Wyomingite are phlogopite mica). In 1940, Wyomingite was also recognized in West Kimberley, Western Australia, where it was given the name Fitzroyite. Two similar rocks found in the Leucite Hills are orendite and madupite.

Wyomingite, orendite, and madupite are all very rare rock types that are part of a group of rocks collectively known as lamproites. Lamproite is similar to kimberlite, which is also considered one of the rarest rock types found on the earth's surface. For example, the total volume of the known kimberlites in the world is on the order of only 1,200 cubic miles; and that of lamproite is less than 25 cubic miles (the total volume of Wyomingite would be even less).

Wyomingite was first considered as a possible source of potassium for fertilizer. In fact, lamproite is currently mined for fertilizer in Woodson County, Kansas. However, the mining of lamproites for fertilizer could be a mistake in that some of these rocks are known to have a much greater value. For instance, nearly every olivine lamproite found in the world contains diamond. This

includes the olivine lamproites at the Crater of the Diamonds State Park in Murfreesburo, Arkansas; at Majhgawan, India; and at Argyle, Western Australia. The Majhgawan lamproite was the first primary host rock ever mined for diamonds, and the Argyle lamproite is the richest diamondiferous rock in the world with an average grade of 680 carats per 100 tonnes (many diamond mines in South Africa average only about 10 carats per 100 tonnes). Some rare diamonds mined at Argyle, known as Argyle pinks, sell for 1,000,000 Australian dollars per carat!

Diamonds, however, have not yet been identified in the Leucite Hills of Wyoming. Samples of Wyomingite are available at the Wyoming State Geological Survey Building in Laramie.

1995 WGA FIELD CONFERENCE

The 1995 Wyoming Geological Association Field Conference on the geology and mineral resources of the Green River Basin and nearby regions is starting to take shape. The conference, which is scheduled for August, is co-chaired by Rod DeBruin and W. Dan Hausel of the Wyoming State Geological Survey. Interested parties can contact either chairman for information.

Papers and talks submitted for consideration at the conference include:

"Three-dimensional depth imaging of seismic data to help delineate petroleum reservoirs in southwestern Wyoming", by A.K. Benson.

"The Laramide orogeny and associated lithostratigraphic units, southwestern Wyoming", by H.A. Boyd.

"Timing of the Laramide rise of the Uinta Mountains, Utah, and Colorado", by M.D. Bradley.

"The oldest known bat skeletons: The unique record from the Eocene Epoch Green River Formation of western Wyoming", by B.H. Breithaupt.

"Factors influencing differential natural gas production from the Upper Cretaceous Almond Formation, Wamsutter arch area, Sweetwater and Carbon Counties, Wyoming", by G.E. Christiansen and R.S. Martinsen.

"Cements and in-situ widths of natural fractures, Almond Formation, Green River Basin, Wyoming", T.L. Dunn and R.C. Surdam.

"Exploration and development of the coal fields of southwest Wyoming", by A.D. Gardner.

"Industrial minerals of southwestern Wyoming", by R.E. Harris.

"Quaking Asp Mountain, an epithermal system south of Rock Springs", by W.D. Hausel.

"Lamproites and related anomalies in the Green River Basin", by W.D. Hausel, W.M. Sutherland, and R.W. Gregory.

"Kimberlitic indicator minerals in anthills and paleoconglomerates of the southern Green River Basin, Wyoming", by T.E. McCandless, W.P. Nash, and W.D. Hausel.

"Preliminary report on the geology and gold mineralization of the Rattlesnake Hills", by W.D. Hausel.

"The 1872 diamond hoax", by Sandy Stahl and W.D. Hausel.

"A review of the components and controls on basin centered gas in the Greater Green River Basin, southwestern Wyoming", by M.L. Hendricks.

"Mesaverde exploration objectives in the Red Desert and Washakie Basins, southwestern Wyoming", by M.L. Hendricks.

"Whitney Canyon-Carter Creek field—A synergistic geologic and engineering analysis", by J.D. Hunt and D.E. McGarry.

"Relating fractures in the eastern Greater Green River Basin to oil and gas fields: Integrating field measurements, linear features, and digital geologic data using Geographic Information Systems concepts", by Cheryl Jaworowski.

"Wyoming: The soda ash capital of the world", by D.S. Kostick.

"Estimates of recoverable gas from basin-centered gas accumulations in the Greater Green River Basin, Wyoming, Colorado, and Utah", by B.E. Law, J.W. Schmoker, and R.A. Crovelli.

"Wyoming trona: An overview", by R.T. Leigh.

"Stresses and fractures in the Green River Basin predicted from basin-margin tectonic interactions", by J.C. Lorenz.

"Stratigraphy, sedimentology, and gas potential of the Almond Formation, eastern Washakie Basin, Wyoming", by R.S. Martinsen, G.E. Christiansen, and R.C. Surdam.

"Review of coal and coal gas resources of the Greater Green River Basin", by A.R. Scott, Roger Tyler, D.S. Hamilton, and Naijiang Zhou.

"The impact of reservoir heterogeneity on fluid flow in the Tensleep Sandstone of the Bighorn Basin", by M.A. Shebl and R.C. Surdam.

"Index to horizontally drilled wells in Wyoming", by W.W. Stewart and D.F. Cardinal.

"Oil and gas exploration activity maps of the Moxa Arch (I and II) and eastern Washakie Basin: update of maps published in the 1992 Oil and Gas Fields of the Greater Green River Basin Symposium", by W.W. Stewart and others.

"The impact of unitization of Federal lands on the oil and gas industry in Wyoming", by Dean Stilwell and Roger Miller.

"Pressure regime in the Upper Cretaceous shales and sandstones in the Washakie Basin, Wyoming", by R.C. Surdam, Z. Jiao, and J. Liu.

"Stratigraphic and facies relationships within the Late Cretaceous Frontier Formation, Rock Springs uplift, southwestern Wyoming", by C.J. Ware and F.G. Etheridge.

"Stratigraphic plays of the 1950's on the Wamsutter arch: Discovery of Desert Springs, Patrick Draw, and West Desert Springs fields", by R.J. Weimer.

"Effects of diagenesis on petrophysical properties of reservoir rocks", by Peigui Yin and R.C. Surdam.

NEW PUBLICATIONS OF THE WYOMING STATE GEOLOGICAL SURVEY

*Sixty-first Annual Report of the Wyoming State Geological Survey (for Fiscal Year 1994), by Gary B. Glass and Susanne G. Bruhnke: 1995.-free upon request.

Wyoming Geomaps (second printing), by Sheila Roberts: Educational Series 1 (second printing), 1989.-$7.00.

*Geologic map of the Monument Hill Quadrangle, Johnson and Washakie Counties, Wyoming, by A.J. Ver Ploeg and P.L. Greer: Map Series 44, 1995.-$5.00.

*Geologic map of the Beartrap Meadows Quadrangle, Johnson County, Wyoming, by A.J. Ver Ploeg and P.T. Greer: Map Series 45, 1995.-$5.00.

*Study of metals and precious stones in southern Wyoming, by W.D. Hausel: Open File Report 94-2, 1994.-$10.00 (xerox copies only).

Knightia postcard (3rd printing): 1988.-$0.25 each or 5 for $1.00.

Tyrannosaurus rex postcard (2nd printing): 1990.-$0.25 each or 5 for $1.00.

Geologic map of Wyoming postcard: 1994.-$0.25 each or 5 for $1.00.

Organics and the Rockies—Field Guide, edited by R.M. Flores, K.I. Mehring, R.W. Jones, and T.L. Beck: Public Information Circular 33, 1994.-$15.00.

*Decorative stones of the Medicine Bow National Forest, by R.E. Harris: Public Information Circular 34, 1994.-$1.50.

Economic geology of the Seminoe Mountains mining district, Carbon County, Wyoming, by W.D. Hausel: Report of Investigations 50, 1994.-$8.00.

*Phosphate rock resources of the Wind River Indian Reservation, Wyoming, by R.P. Sheldon: Reprint 57, 1982.-$5.00 (xerox copy only).

*Evaluation of bentonite and gold resources on the Wind River Indian Reservation, Wyoming, by C.A. Roberts, J.B. Worthington, and L.G. Nonini: Reprint 58, 1983.-$12.00 (xerox copy only).

*Evaluation of coal resources on the Wind River Indian Reservation, Wyoming, by J. Gersic and E.K. Peterson: Reprint 59, 1983.-$8.00 (xerox copy only).

*Bentonite resources in the Winkleman Dome-Bighorn Ridge, Arapahoe Reservoir, and Blue Ridge areas on the Wind River Indian Reservation, Wyoming, by J. Gersic, and J.B. Worthington: Reprint 60, 1984.-$10.00 (xerox copy only).

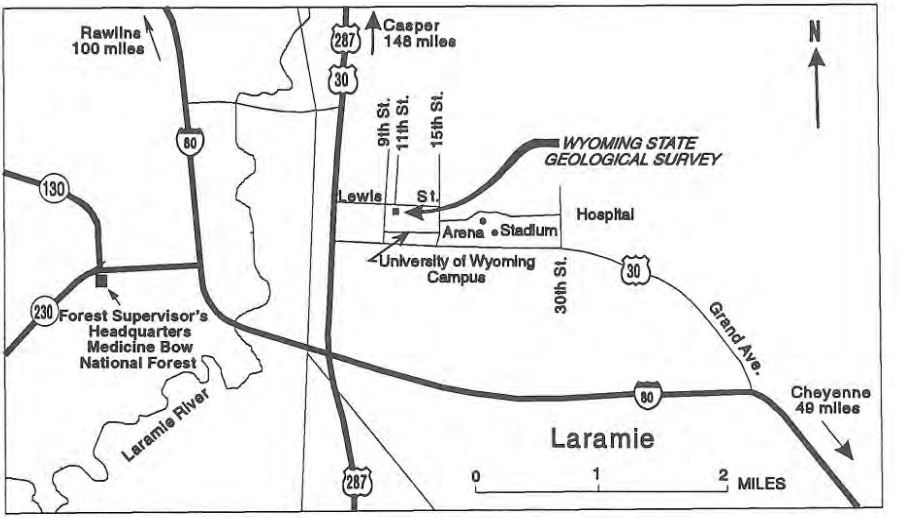
*Sand/gravel, gypsum, and iron resources on the Wind River Indian Reservation, Wyoming, by J. Gersic and L.G. Nonini: Reprint 61, 1985.-$12.00 (xerox copy only).

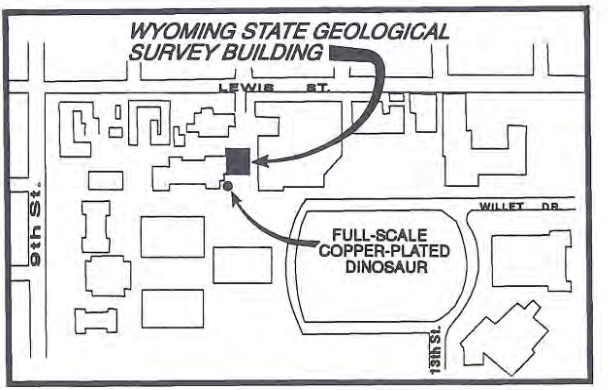
---

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

The Wyoming State Geological Survey sells the *Atlas of Major Rocky Mountain Gas Reservoirs*, a publication prepared by the New Mexico Bureau of Mines and Mineral Resources, the Colorado Geological Survey, the Utah Geological Survey, and the Wyoming State Geological Survey -$99.75. Available over-the-counter or PREPAID, by mail from the Wyoming State Geological Survey in Laramie. Checks, for this publication only, should be made to: New Mexico Bureau of Mines and Mineral Resources or NMBMMR. (Price includes postage and handling.)

WYOMING STATE GEOLOGICAL SURVEY
LOCATION MAPS





ORDER FORM

Send this order and make checks payable to:

Wyoming State Geological Survey
Box 3008, University Station
Laramie, Wyoming 82071-3008

Your name, address, zip:

_____

_____

_____

_____

_____

Larger orders sent U.P.S. which requires a street address.

May we contact you about your order?

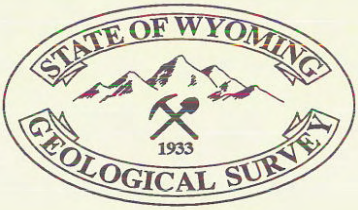
_____

(4/94) Prices are subject to change.

Quantity	Publication Number	Publication Title	Price	Total Price

*No postage charged on prepaid orders unless otherwise specified. If ordering **Memoir 5,** postage for shipping each copy is: $5.00 (Wyoming), $10.00 (other U.S. States), and $20.00 (International, including Canada).

Rolled maps ($1.50 each tube)	
WYOMING RESIDENTS ADD 6% SALES TAX (or furnish proof of exempt status)	
TOTAL ENCLOSED*	


STATE OF WYOMING
1933
GEOLOGICAL SURVEY