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Gary B. Glass, State Geologist

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WYOMING GEO-NOTES
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Cover: Sodium sulfate mined and sold by the Pratt family is stored in this shed, located north of U.S. Highway 26 at Natrona, in Natrona County. See discussion on p. 34.

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MINERALS UPDATE

OVERVIEW

by Gary B. Glass
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In January, 1994, the State's Consensus Revenue Estimating Group (CREG) released a revised forecast of mineral prices and production (as State Geologist, the author is a member of this group). **Tables 1** and **2** and **Figures 1** through **6** summarize CREG's new price and production forecasts for the years 1993 through 1997. CREG's latest (January) estimates of 1993 natural gas production and oil production for 1993 through 1997 are both slightly lower than the estimates they made in October (**Table 2** in *Wyoming Geo-notes No. 40* shows the October forecasts). CREG's latest forecast for oil prices, however, is significantly lower than the October estimate, and reflects a continuing low price paid for Wyoming crude. At the end of the year some producers of sour and(or) heavy Wyoming crude reportedly were receiving considerably less than the posted $10.00 a barrel (**Figure 7**).

Table 1. Average prices paid for Wyoming oil, methane, coal, trona, and uranium (1985-1992) with forecasts to 1997[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	1.90	7.44	41.00	21.00
*1994	12.00	2.00	7.19	41.00	21.00
*1995	12.00	2.11	6.97	41.00	21.00
*1996	12.00	2.23	6.83	41.00	21.00
*1997	12.00	2.34	6.68	41.00	21.00

* Forecast prices by Consensus Revenue Estimating Group (CREG).

[1] Adapted from CREG, Wyoming State Government Revenue Forecast FY94-FY98, January, 1994.

[2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Source: Energy Information Administration, 1985-1992.

[3] Wellhead price in dollars per thousand cubic feet (MCF). Sources: Wyoming State Land and Farm Loan Office, 1989-1992 (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, 1985-1992.

[5] Dollars per ton of trona, not soda ash. Source: Wyoming Department of Revenue, 1985-1992.

[6] Uranium prices in dollars per pound of yellowcake (weighted average price for in-situ and surface-mined uranium). Source: Energy Information Administration, 1985-1990; Geological Survey of Wyoming estimates 1991-1997.

Table 2. Wyoming mineral production (1981-1992) with forecasts to 1997[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	—	—	102.8	11.2	4.6	—	0.05
1982	118.7	465.1	—	—	107.9	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	136.3	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	87.0	884.0	140.0	1.00	202.0	16.2	—	0.8	1.20
*1994	80.9	941.0	140.0	1.00	211.0	16.8	—	0.8	1.25
*1995	75.2	984.0	140.0	1.00	220.4	16.9	—	0.8	1.25
*1996	70.0	1,029.0	140.0	1.00	230.2	17.0	—	0.8	1.25
*1997	65.1	1,076.0	140.0	1.00	240.5	17.1	—	0.8	1.25

*Forecast production by Consensus Revenue Estimating Group (CREG).
[1]Adapted from CREG, Wyoming State Government Revenue Forecast FY94-FY98, January, 1994; [2]Millions of barrels (Source: Wyoming Oil & Gas Conservation Commission, 1981-1992); [3]Billions of cubic feet (primarily methane with some hydrogen sulfide and nitrogen) (Source: Wyoming Oil & Gas Conservation Commission, 1981-1992); [4] Billions of cubic feet. Source: Wyoming Oil & Gas Conservation Commission, 1986-1992; [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 (Sources: Wyoming Department of Revenue, 1981-1987; Wyoming State Inspector of Mines, 1988-1992); [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) (Sources: Wyoming Department of Revenue, 1986-1992; unknown between 1981-1985 because it was only reported as taxable valuation; estimates for 1993-1997 are based on company information); [9]Millions of short tons (Source: Wyoming Oil & Gas Conservation Commission, 1981-1992).

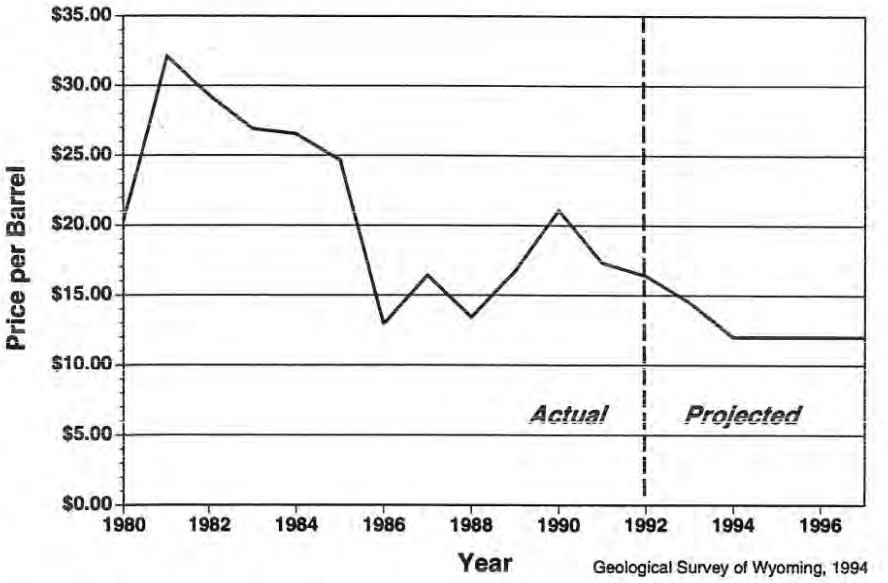

Figure 1. Average prices paid for Wyoming oil (1980 to 1992) with forecasts to 1997.

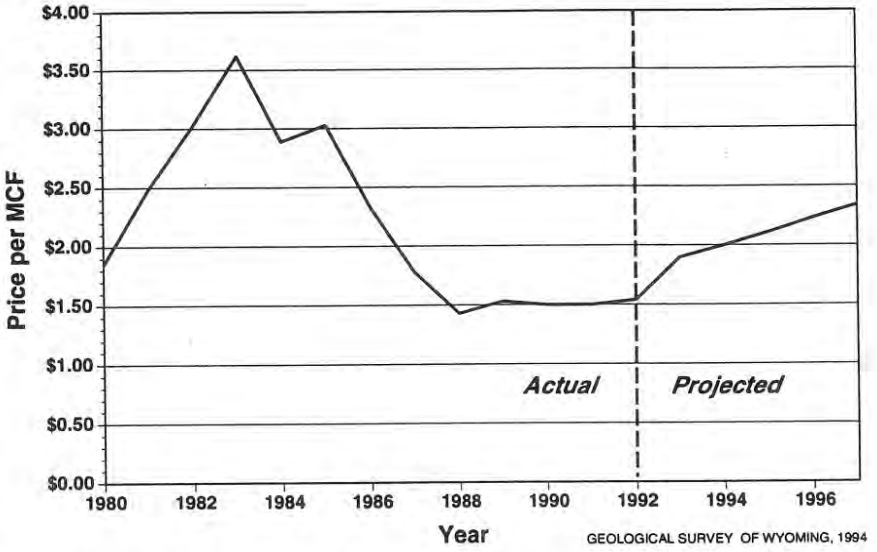

Figure 2. Average prices paid for Wyoming methane (1980 to 1992) with forecasts to 1997.

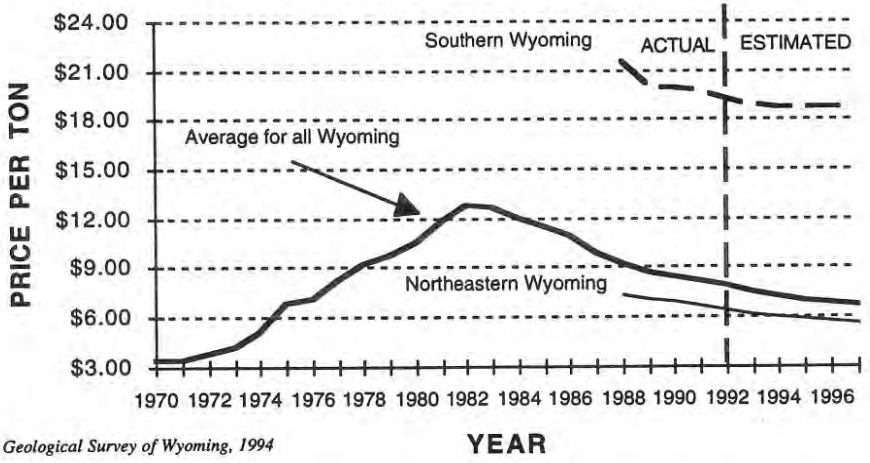

Figure 3. Average prices paid for Wyoming coal (1980 to 1992) with forecasts to 1997. *Data from the U.S. Energy Information Administration (1980-1992) and the Wyoming Consensus Revenue Estimating Group (1993-1997).*

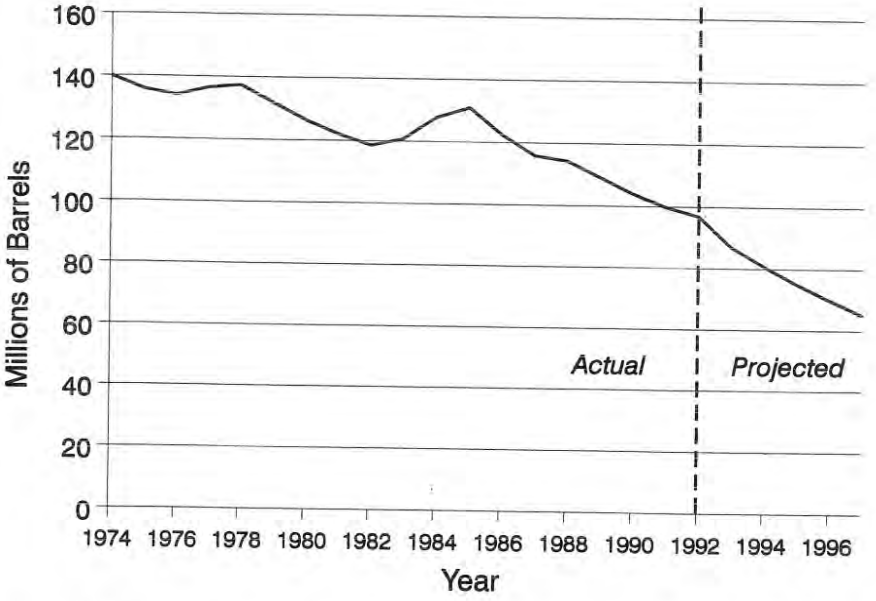

Figure 4. Annual oil production from Wyoming (1974 to 1992) with forecast to 1997.

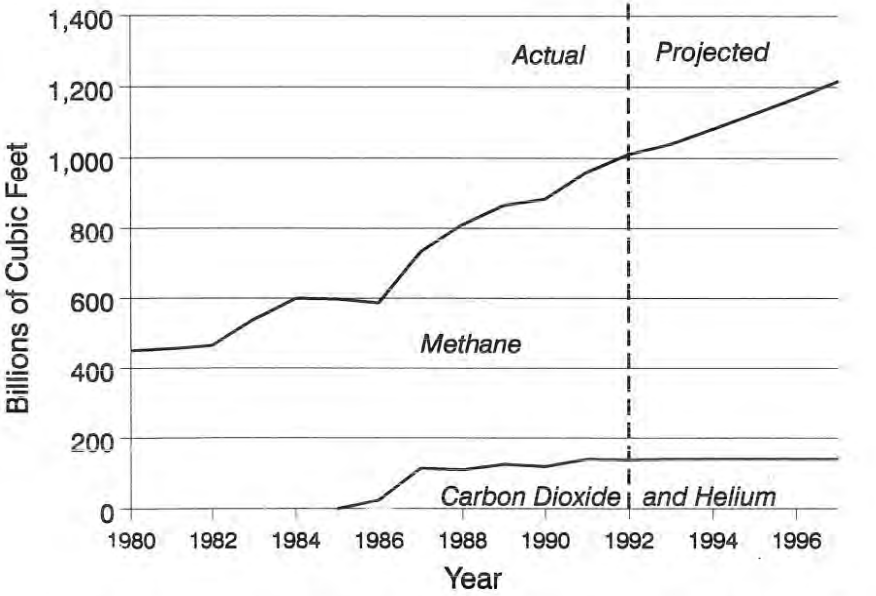

Figure 5. Annual natural gas production from Wyoming (1980 to 1992) with forecasts to 1997.

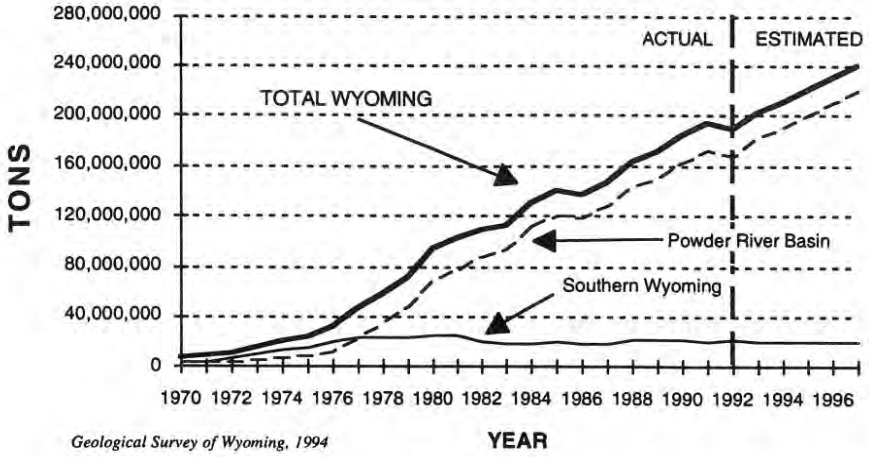

Figure 6. Annual coal production from Wyoming (1970-1992) with forecasts to 1997. *Data from the Wyoming Inspector of Mines (1970-1992) and the Wyoming Consensus Revenue Estimating Group (1993-1997).*

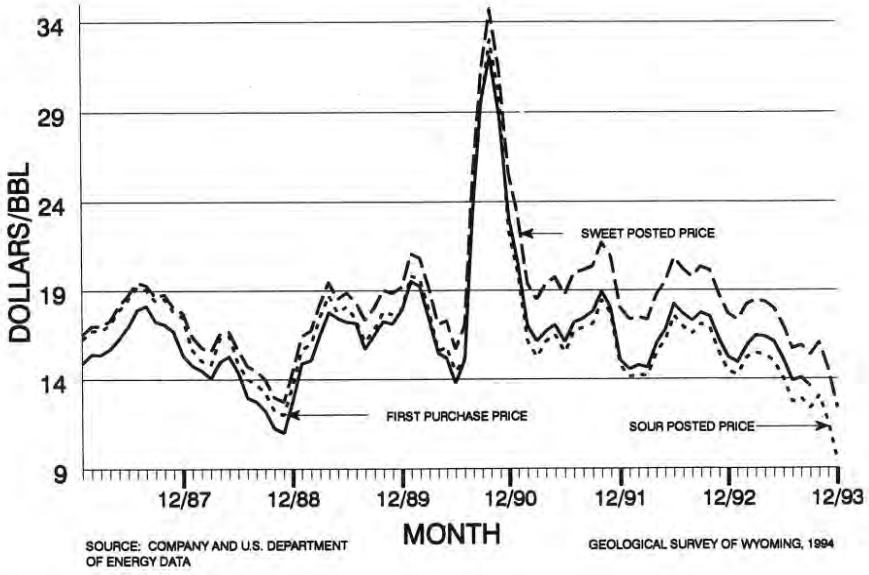

Figure 7. Wyoming posted Sweet and Sour crude prices and first purchase prices averaged by month (1987 to present).

In regard to its oil forecasts, CREG left its 1993 price estimate of $14.50 stand, but it reduced its estimate of the average sales price for a barrel of Wyoming crude to $12.00 for the period 1994 through 1997 (**Table 1** and **Figure 1**). $12.00 is $3.75 per barrel less than the forecast CREG made in October. This average Wyoming price reflects a posted West Texas Intermediate price of about $15.00. Because optimism about oil prices has all but disappeared, the $12.00 price was forecast through 1997. There is little to indicate that the glut of relatively inexpensive foreign oil now on the market will decrease substantially within this time frame. OPEC has shown no sign of lowering their production quotas, nor have they taken any steps to keep their members' production within the existing quotas. Crude from the North Sea, Russia, and possibly Iraq will only exacerbate the situation.

For 1993 and the out years, CREG also reduced its oil production estimates. The estimated 1993 production was reduced by 400 thousand barrels, and the production for the ensuing years was declined at 7% a year, rather than the 6% used in their forecast of October (**Table 2** and **Figure 4**). Oil production is now expected to decline to 65.1 million barrels by 1997. Since oil prices are expected to remain low throughout the forecast period, little new exploration is expected. Similarly, the low prices will make most tertiary recovery projects even more marginal to uneconomical. Consequently, as the existing fields continue to age, production declines will likely accelerate.

The gross production of natural gas (principally methane, carbon dioxide, and helium) is now forecast at 1.025 trillion cubic feet (TCF) for 1993 (**Table 2** and **Figure 5**). This is a decrease of 15 billion cubic feet (BCF) over CREG's forecast made in October. After 1993, production is still forecast to increase 4% a year throughout the forecast period, reaching 1.217 TCF by 1997. With spot gas prices (**Figure 8**) and natural gas futures remaining high, CREG did not change its earlier (October) forecast for gas prices.

In regard to coal, CREG still expects 1993 coal production to reach 202 million tons (**Table 2** and **Figure 6**). Because monthly coal deliveries from Wyoming mines in August and September each set new records, there is a possibility that production in 1993 might have exceeded the current forecast. In fact, an industry organization, called the Wyoming Coal Information Committee, is estimating last year's production at 210 million tons. Some industry officials feel that the flood in the Midwest, the eastern coal strike, and the Federal Clean Air Act Amendments have all had a part in pushing the monthly production in the last five months of 1993 to record highs. Official last quarter production figures for coal, however, will probably not be available before March or April. CREG also did not change its earlier (October) coal price forecasts (**Tables 1** and **3**; **Figure 3**).

The railroads and coal mines that filed suit against an Illinois law, which they felt discriminated against western coal, were handed a victory when a Federal judge declared the law unconstitutional (p. 21). Wyoming had supported, but not joined in the suit.

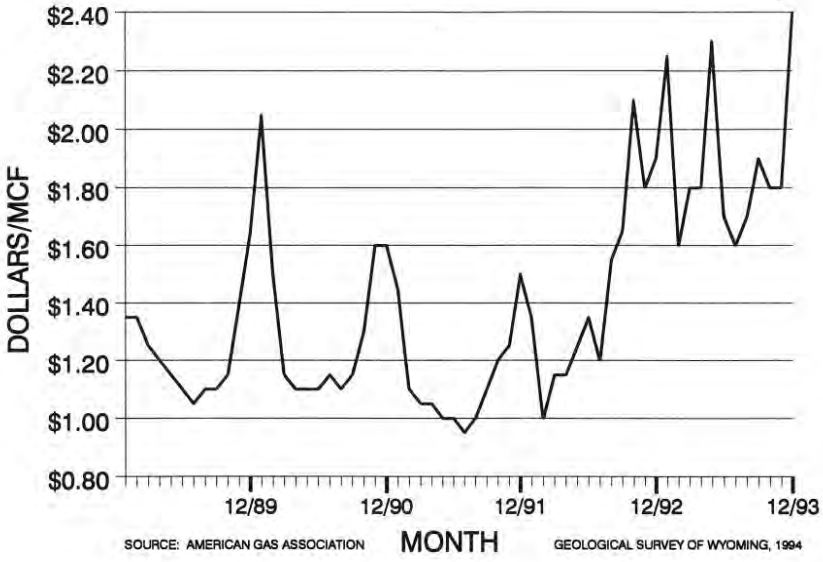

Figure 8. Spot prices for methane at Opal, Wyoming, averaged by month (1989 to present).

Table 3. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1992) with forecasts to 1997.

YEAR	NORTHEASTERN	SOUTHERN	STATEWIDE
1988	**$7.35**	**$21.45**	**$9.16**
1989	**$7.02**	**$19.97**	**$8.63**
1990	**$6.92**	**$19.90**	**$8.43**
1991	**$6.68**	**$19.80**	**$8.09**
1992	**$6.54**	**$19.19**	**$8.14**
1993	**$6.18**	**$18.86**	**$7.44**
1994	**$5.98**	**$18.75**	**$7.19**
1995	**$5.80**	**$18.72**	**$6.97**
1996	**$5.70**	**$18.69**	**$6.83**
1997	**$5.60**	**$18.67**	**$6.68**

In January, the Wyoming Oil and Gas Conservation Commission ruled that 50 million cubic feet of vented carbon dioxide a day from Exxon's La Barge (Shute Creek) gas processing plant would become waste if the average posted price of Wyoming Sweet crude oil remained above $15.00 for three consecutive months. The order followed testimony that there was a market for 120 billion cubic feet of carbon dioxide at the Hartzog Draw oil field in the Powder River Basin. Consequently, they issued an order that would curtail Exxon's venting of

that much carbon dioxide each day until the curtailment equalled 120 billion cubic feet and(or) whenever the price of oil remained below $15.00 for 6 consecutive months.

Two of Exxon's alternatives to curtailing the plant's throughput are (1) to reinject the carbon dioxide into the reservoir or another suitable reservoir and (2) to sell the carbon dioxide to the Hartzog Draw Unit for a tertiary carbon dioxide flood. Exxon has also long considered building its own carbon dioxide pipeline into the Powder River Basin, but that project has been continually postponed. This is the same pipeline that the Wyoming Natural Gas Pipeline Authority had studied and concluded that it should be built because there was a market for carbon dioxide in the Powder River Basin oil fields.

In regard to trona, FMC announced some layoffs and cutbacks in production, principally in their caustic soda line. Solvay, on the other hand, is considering an expansion of its soda ash production. There is some optimism that European tariffs on soda ash might be lowered. That could lead to more export sales from Wyoming (p. 36).

While the section on Industrial Minerals in this issue discusses a new interest in Wyoming's mica deposits, the section on Metals and Precious Stones highlights the continued exploration for diamonds.

Historical production of selected Wyoming mineral commodities are shown in **Table 4.**

Table 4. 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]	
Clay[4]	36.4	59.6	35.9	23.2	1.31	61.1	23.6	---	---	---	
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]	
Decorative Stone	---	---	---	---	---	---	---	---	0.24[7]	1.00[7]	3.50[7]
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]	
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]	
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]	
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]	
Shale[4]	---	20.3	14.7	9.88	103.2	52.1[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]	

Sources: [1]Wyoming Department of Revenue, unless otherwise noted; [2]millions of short tons; [3]includes ballast, scoria, and limestone used for aggregate; [4]thousands of short tons; [5]includes chemical grade limestone used for cement rock, sugar beet refining, and other uses; [6]Wyoming State Inspector of Mines; [7]estimated by Geological Survey of Wyoming; [8]short tons of iron ore used for pigment. [9]short tons of iron ore used as weighting additive in cement. Prepared by Geological Survey of Wyoming, January, 1994.

In this issue of *Wyoming Geo-notes*, there are also descriptions of two, very spectacular, new publications. We prepared and published a 938-page memoir in cooperation with the University of Wyoming's Department of Geology and Geophysics and a host of authors, titled *The geology of Wyoming,* (p. 54). The New Mexico Bureau of Mines and Mineral Resources published the *Atlas of major Rocky Mountain gas reservoirs* through the joint efforts of the state geological surveys of Wyoming, New Mexico, Colorado, and Utah, which were assisted by Barlow & Haun, Inc., Intera-Bergeson, and Methane Resources Group, Ltd. (p. 53). This latter project was partially funded by a grant from the Gas Research Institute and the U.S. Department of Energy.

I also want to personally thank all the individuals and organizations whose efforts went into the preparation and publication of these two landmark publications. I think everyone will agree with me that these were both jobs well done!

OIL AND GAS UPDATE

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

The rig count in Wyoming dropped slightly in the fourth quarter of 1993 (**Figure 9**), after reaching a six-year high of 61 rigs in September, 1993. Considering the very low count in March, April, and May of 1993, the average count for 1993 was fairly high, but still lower than in 1992 (**Figure 10**). Although the rig count for 1994 will most likely drop during the Spring, it should finish the year at as high a level as 1993 because of all the gas development scheduled for southwestern Wyoming. The increase in gas drilling in this area of the State is a result of increased demand and improved prices.

There were 545 well completions in Wyoming during the first 11 months of 1993, compared to 405 during the first 11 months of 1992 (Petroleum Information, 1993). The 299 gas well completions in the first 11 months of 1993 compared to 144 gas well completions in the first 11 months of 1992. The success rate for all wells in the first 11 months of 1993 was 79.6 percent compared to a success rate of 65.7 percent for the first 11 months of 1992.

As a result of the drilling in southwestern Wyoming, BJ Services Co. USA has decided to move its main Wyoming office and 20 employees from Casper to Rock Springs. Other employees will be transferred to Rock Springs from Gillette and Riverton. The company specializes in cementing oil and gas wells and stimulating well production. The expansion and shift of personnel and equipment to this corner of the State makes the Rock Springs area the company's largest operation in the Rocky Mountain region. The company made it clear that it would also still offer services out of Casper.

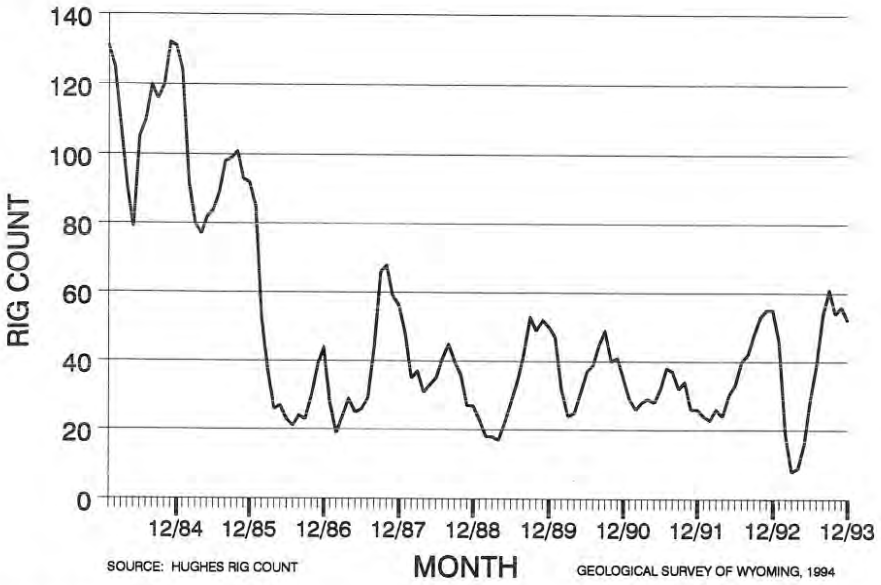

Figure 9. Wyoming daily rig count averaged by month (1984 to present).

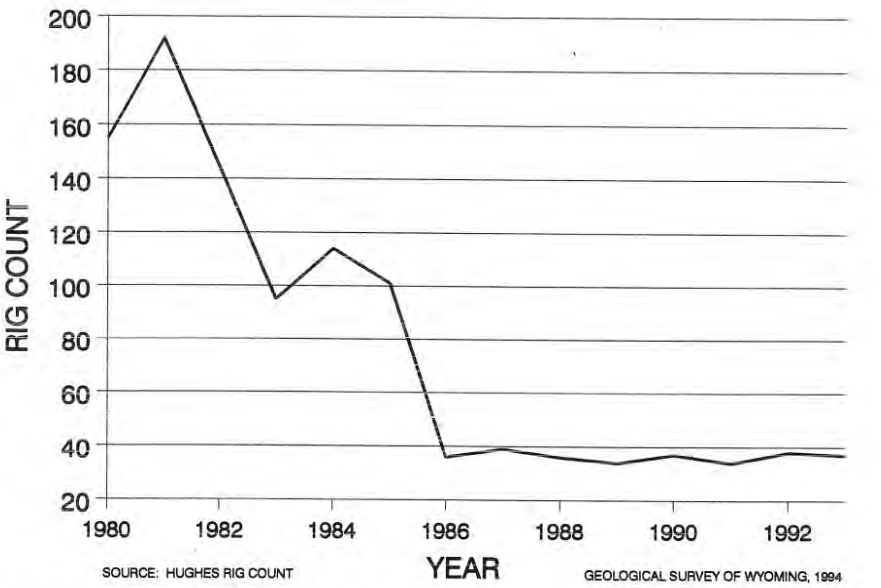

Figure 10. Wyoming daily rig count averaged by year (1980 to 1993).

The spot price for natural gas at Opal, Wyoming, dropped slightly in October, 1993; stayed level in November, 1993; and increased to an all-time high of $2.40 per thousand cubic feet (MCF) in December 1993 (**Figure 8**). The average spot price for 1993 was $1.89 per MCF, compared to an average price of $1.46, $1.19, $1.33, and $1.24 per MCF for 1992, 1991, 1990, and 1989, respectively.

The U.S. Department of Energy (1993) released its 1992 reserve figures for crude oil and natural gas. **Table 5** shows Wyoming's relative ranking in proved reserves of crude oil and natural gas among the top ten states. While Wyoming ranked fourth in crude oil reserves in 1987 and seventh in natural gas reserves in 1987, it has dropped two positions in crude oil reserves and gained three positions in dry natural gas reserves. **Table 6** shows that Wyoming's proved reserves of crude oil are steadily declining while its proved reserves of dry natural gas are remaining at a relatively high level despite increasing production of natural gas over the same time period. These two tables underscore the fact that Wyoming's future is becoming more dependent on natural gas production and less dependent on crude oil production.

The Clinton Administration released its *Domestic Natural Gas and Oil Initiative*. The Initiative contains nearly 50 specific action items that center around creating high technology jobs in the Nation's oil and gas industry, expanding markets for natural gas, and improving coordination among Federal and state regulators and decision makers. It also purports to set into motion a long-range strategy to lessen America's dependence on foreign oil.

The Express Pipeline project (reported in *Wyoming Geo-notes No. 40*, p. 11), which was to bring Canadian crude oil through Wyoming to refineries in the Midwest, has apparently been cancelled. The company reportedly could not secure enough long-term shipper commitments to secure financing.

Table 5. Wyoming's 1992 ranking in proved reserves of crude oil (billions of barrels) and dry natural gas (trillions of cubic feet).

State	Crude Oil[1]	State	Dry Natural Gas[2]
Texas	6.441	Texas	35.093
Alaska	6.022	New Mexico	18.998
California	3.893	Oklahoma	13.926
New Mexico	.757	**Wyoming**	**10.826**
Oklahoma	.698	Louisiana	9.780
Wyoming	**.689**	Kansas	9.681
Louisiana	.668	Alaska	9.638
Kansas	.310	Colorado	6.198
Colorado	.304	Alabama	5.802
North Dakota	.237	California	2.778

Source: U.S. Department of Energy, 1993

Table 6. 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 1992.

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

Source: U.S. Department of Energy, 1993

The U.S. Department of Energy has set January 28, 1994, as the anticipated starting date for the third round of competition in its Oil Recovery Field Demonstration Program. In order to qualify for consideration, an applicant's project must include a reservoir formed either by the downslope movement of dispersed, water-suspended sediment in gravity-driven density currents into deeper parts of ocean basins or by precipitation of fine-grained sediments onto ocean floors.

The oil and gas lease sales held in Wyoming in 1993 were much better than the lease sales held in 1992 in terms of total revenue, parcels sold, and acres leased (**Table 7**).

The U.S. Bureau of Land Management's (BLM's) October sale had a high per-acre bid of $285. The bid was made by EOG Inc. for a 640-acre lease that covers all of section 22, T18N, R92W. The parcel is in the Creston Field area where production is from the Lewis, Mesaverde, and Steele. Caddis Resources Inc. made the sale's second highest per-acre bids of $195 for parcels in sections 2, 4, and 10, T18N, R92W and section 20, T18N, R92W. These parcels are also in the Creston Field area. Flahive Oil & Gas Ltd. paid $178 per acre for a 280-acre tract that covers S/2 section 26 and S/2 NE, SE NW, NE SW, and NW SE section 27, T49N, R72W. The parcel is within a mile of Minnelusa production at Dry Gulch Field.

The State Land and Farm Loan Office's sale in November had a high per-acre bid of $155 for a 82.52-acre lease in N/2 NE section 19, T46N, R98W. The high bid was made by Natural Gas Processing Co. The parcel is in Grass Creek Field and is limited to rights to the Muddy and Lakota formations. The sale's second highest per-acre bid was $117 made by Cramer Oil Co. for an 80-acre lease that comprises E/2 NE section 36, T47N, R71W and is adjacent to Minnelusa production in Big Foot Field.

The December BLM sale's high per-acre bid of $320 was made by Lario Oil & Gas Co. for a 556.23-acre tract that covers portions of section 30, T21N, R112W. The lease is in an area of Frontier production at Whiskey Butte Field. The sale's highest total bid of $264,000 ($150 per acre) was also made by Lario for a 1760-acre lease that covers S/2 N/2 and S/2 section 33 and sections 34 and 35, T24N, R112W. The parcel is near Dakota production at Lincoln Road Field. There were 13 parcels in this sale which sold for $100 or more and in terms of total revenue this sale was the best since February, 1991.

Table 7. Federal and State competitive oil and gas lease sales in Wyoming.

BLM SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1990				
TOTAL	$17,997,133	2,971	1,593	2,169,138	967,293	$18.61	$340.00
			1991				
February	$4,333,861	370	200	275,600	122,225	$35.46	$16,000.00
April	$1,880,742	470	217	332,764	132,278	$14.22	$170.00
June	$2,002,440	490	176	430,576	120,992	$16.55	$275.00
August	$2,005,511	557	211	472,103	120,292	$16.67	$325.00
October	$1,616,314	507	175	397,011	94,899	$17.03	$340.00
December	$1,095,409	421	168	283,408	85,091	$12.87	$1,600.00
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

STATE SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
			1990				
TOTAL	$4,979,094	1,199	732	478,098	380,382	$13.09	$270.00
			1991				
January	$2,050,868	300	295	117,677	115,998	$17.68	$401.00
March	$642,191	197	170	69,652	62,226	$10.32	$110.00
May	$539,556	199	173	79,156	70,081	$7.70	$77.00
July	$396,569	200	124	73,179	52,850	$7.50	$70.00
September	$411,971	200	146	69,025	50,908	$8.09	$260.00
November	$416,730	199	129	71,286	53,847	$7.74	$130.00
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

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

Exploration and Development

Company data and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the fourth quarter of 1993. Activities related to horizontal drilling are discussed in a separate section. The letters preceding discussions below refer to locations on **Figure 11**.

A. Amoco Production completed the two pipelines connecting its Anschutz Ranch East and Painter Complex gas processing plants. One pipeline will transport nitrogen from Painter Reservoir to Anschutz Ranch East and the other pipeline will be available to transport surplus gas from Anschutz Ranch East to the Painter Complex for processing.

B. Wexpro Co. completed several new wells in Church Buttes Field. The 127 Church Buttes well in NE SW section 28, T17N, R112W flowed 5.8 million

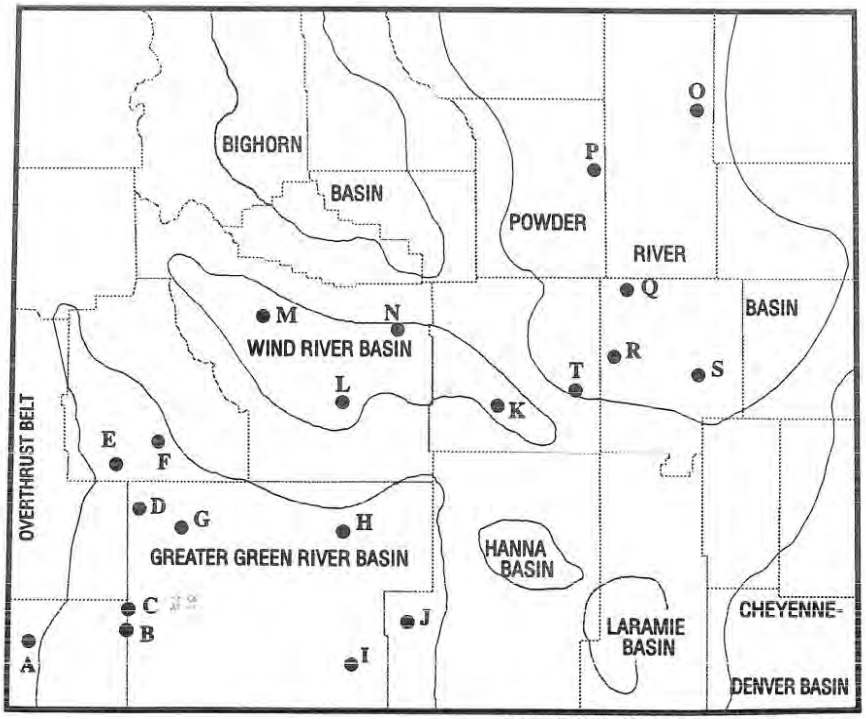

Figure 11. Oil and gas exploration and development activity in Wyoming during the fourth quarter of 1993 (exclusive of horizontal drilling and coalbed methane activities).

cubic feet of gas per day from perforations in the Dakota between 12,888 and 12,934 feet. The 4-3 Haley Federal well in SW NE section 4, T17N, R112W flowed 2.0 million cubic feet of gas per day from perforations in the Dakota between 12,536 and 12,606 feet. The 115 Church Buttes Unit well in SW SW section 1, T17N, R112W flowed 3.7 million cubic feet of gas per day from perforations in the Dakota between 12,684 and 12,780 feet. The 128 Church Buttes Unit well in SW SW section 21, T17N, R112W flowed 2.8 million cubic feet of gas per day from perforations in the Frontier between 12,302 and 12,342 feet.

C. Ten new producing wells were completed in Bruff Field. **Table 8** below summarizes data from these wells.

In *WyomingGeo-notes No. 40* a table of wells completed in Bruff Field during the third quarter of 1993 was inadvertently omitted. The tabulation for those wells is summarized below (**Table 9**).

D. Washington Energy Exploration completed its 40-26 Farson Federal well in SW SW section 26, T24N, R111W. The well produced an average of 3.2 million cubic feet of gas and 16 barrels of condensate per day from perforations in the Frontier in an unreported interval.

E. Enron Oil & Gas completed several new Mesaverde producers in the Big Piney/La Barge area. The 31SE-19 Burley well in NW NE section 19, T28N, R113W flowed 43 barrels of oil and 80 barrels of water per day from perforations between 1,996 and 2,154 feet. The 32SE-19 Burley in SW NE section 19, T28N,

Table 8. Summary of ten new producing wells drilled in the fourth quarter of 1993 in Bruff Field, Sweetwater and Uinta Counties.

OPERATOR	WELL NAME	WELL LOCATION	PROD. RATE	PROD. DEPTH (FT)	FORMATION
WEXPRO	29 BRUFF UNIT	SE NW section 16, T18N, R112W	0.7 MMCFGPD[1]	12,264-12,282	DAKOTA
WEXPRO	30-3 LAWLER FEDERAL	NW NE section 30, T19N, R112W	2.6 MMCFGPD	11,276-11,310	FRONTIER
WEXPRO	24 BRUFF UNIT	NW NW section 16, T18N, R112W	10.0 MMCFGPD	12,146-12,158	DAKOTA
BANNON	3 CHAMPLIN 186 BANNON-F	SW NE section 5, T18N, R112W	3.0 MMCFGPD 152 BCPD[2] 32 BWPD[3]	11,458-11,474 12,046-12,150	FRONTIER DAKOTA
WEXPRO	28-4 LANSDALE FEDERAL	SW SW section 28, T19N, R112W	3.7 MMCFGPD	11,874-11,920	DAKOTA
WEXPRO	12-3 HAGOOD FEDERAL	NW NE section 12, T19N, R112W	1.3 MMCFGPD	11,694-11,744	FRONTIER
WEXPRO	26 BRUFF UNIT	NE SW section 22, T18N, R112W	0.7 MMCFGPD	12,350-12,358	DAKOTA

[1]MMCFGPD equals millions of cubic feet of gas per day.
[2]BCPD equals barrels of condensate per day.
[3]BWPD equals barrels of water per day.

Table 9. Summary of ten new producing wells drilled in the third quarter of 1993 in Bruff Field, Sweetwater and Uinta Counties.

OPERATOR	WELL NAME	WELL LOCATION	PROD. RATE	PROD. DEPTH (FT)	FORMATION
WEXPRO	4-3 LANSDALE FEDERAL	NW NE section 4, T18N, R112W	5.2 MMCFGPD	11,402-11,458	FRONTIER
WEXPRO	12-4 HAGOOD FEDERAL	SW SW section 12, T19N, R112W	1.9 MMCFGPD	11,609-11,644	FRONTIER
WEXPRO	28 BRUFF UNIT	SW NE section 8, T18N, R112W	3.5 MMCFGPD	11,506-11,540	FRONTIER
WEXPRO	22 BRUFF UNIT	NW SW section 8, T18N, R112W	1.9 MMCFGPD	12,092-12,132	DAKOTA
WEXPRO	109 BRUFF UNIT	SE NE section 11, T17N, R112W	1.9 MMCFGPD	12,130-12,180	FRONTIER
WEXPRO	31 BRUFF FEDERAL	NE NE section 20, T18N, R112W	5.0 MMCFGPD	12,370-12,386	DAKOTA
WEXPRO	32-3 PANDO FEDERAL	NE NE section 32, T18N, R112W	1.5 MMCFGPD	12,030-12,068	DAKOTA
WEXPRO	4-4 LANSDALE FEDERAL	NW SW section 4, T18N, R112W	1.7 MMCFGPD	11,462-11,502	FRONTIER
BANNON	3 CHAMPLIN 358 AMOCO B	NE SW section 29, T18N, R112W	1.2 MMCFGPD 1 BCPD	APPROX. 12,600	FRONTIER
BANNON	3 CHAMPLIN 186 BANNON B	NE SW section 7, T18N, R112W	0.8 MMCFGPD 15 BCPD	APPROX. 12,600	FRONTIER

Note: Abbreviations for production rates are explained in Table 8.

R113W flowed ten barrels of oil and two barrels of water per day from perforations between 1,866 and 1,972 feet. The 14NE-20 Burley well in SW SW section 20, T28N, R113W flowed 32 barrels of oil and 32 barrels of water per day from perforations between 1,364 and 1,440 feet. The 14NW-20 Burley in SW SW section 20, T28N, R113W flowed 12 barrels of oil per day from perforations between 1,451 and 1,499 feet.

F. McMurray Oil completed two Mesaverde wells in Jonah Field. During its first month, the 2-8 Jonah Federal well in E/2 NE section 8, T28N, R108W produced an average of 3.0 million cubic feet of gas and 52 barrels of condensate per day from an unreported interval. The 1-7 Jonah Federal well in NE NE section 7, T28N, R108W produced an average of 1.9 million cubic feet of gas and 16 barrels of condensate per day during its first month of production from an unreported interval. McMurray proposes to drill up to 40 additional wells in this area over the next five years if the U.S. Bureau of Land Management (BLM) gives its approval.

G. Texaco Exploration & Production completed its 1 Stage Coach Draw Unit well in C NE section 32, T23N, R107W. The well produced 1.2 million cubic feet

of gas per day during one day of production from an undisclosed interval in the Almond Formation. Texaco now plans to drill up to 60 wells in T22-24N and R107-108W over the next five to seven years. The BLM plans an Environmental Impact Statement (EIS) to address the plan.

H. Presidio Exploration completed its 48 Hay Reservoir Unit well in NW NE section 11, T23N, R97W. The well flowed 3.0 million cubic feet of gas per day from perforations in the Lewis between 9,330 and 9,399 feet.

I. Bass Enterprises Production completed its 1 Polar Bar Unit well in NW SE section 22, T14N, R96W. The well flowed 1.1 million cubic feet of gas and 38 barrels of water per day from perforations in the Almond between 15,214 and 15,352 feet, and it flowed 1.4 million cubic feet of gas and 57 barrels of water per day from perforations in the Lewis between 14,064 and 14,160 feet.

J. The BLM will prepare an EIS for the Creston/Blue Gap Development Project proposed by Snyder Oil and other operators. The project may include the drilling of up to 250 new wells in and adjacent to Barrel Springs, Blue Gap, Fillmore, Creston, and Robbers Gulch fields. The BLM will also prepare an EIS for the Greater Wamsutter Area Natural Gas Project proposed by Union Pacific Resources and other operators. The operators anticipate drilling a minimum of 70 new wells and a maximum of 320 new wells in Standard Draw, Coal Gulch, Wild Rose, and Wamsutter fields.

K. Forest Oil completed its 49 Grieve well in SW NE section 27, T32N, R85W. The well flowed 2.0 million cubic feet of gas per day from an open-hole interval in the Muddy between 6,640 and 6,660 feet.

L. Natural Gas Processing reestablished production in the previously abandoned Mt. Rogers gas field. The 1 Davey well in NE NW section 20, T33N, R94W flowed 720,000 cubic feet of gas per day from the Cloverly between 1,417 and 1,427 feet.

M. Tom Brown, Inc. completed the 12-11 Pavillion Unit well in SW NW section 11, T3N, R2E. The well flowed 2.3 million cubic feet of gas per day from the Fort Union between 5,167 and 5,192 feet.

N. Louisiana Land & Exploration completed its 14 Madden Deep Unit well in NW SE section 2, T38N, R90W. The well flowed 3.6 million cubic feet of gas per day from four intervals in the Fort Union between 9,233 and 9,485 feet.

O. Presidio Exploration completed a new Minnelusa producer in Falcon Ridge Field. The 11-31 Infinity Federal well in NW NW section 31, T50N, R70W produced an average of 74 barrels of oil and 48 barrels of water per day during its first month of production. The interval in the Minnelusa was not reported.

P. Presidio completed a new Shannon producer in Culp Draw Field. The H-106 Culp Draw Unit well in SW NE section 17, T45N, R76W pumped 293 barrels of oil per day from perforations between 9,370 and 9,376 feet.

Q. Presidio also made a new discovery in an unreported Frontier interval. The 33-7 Magnum well in NW SE section 7, T40N, R75W produced an average of 148 barrels of oil per day during its first month of production.

R. Kerr-McGee Corp. completed two new Muddy producers in Sand Dunes Field. The 41-24 Sand Dunes Muddy Unit well in NE NE section 24, T36N, R76W flowed 805 barrels of oil and 656,000 cubic feet of gas per day from perforations between 12,676 and 12,696 feet. The 44-1 Sand Dunes Muddy Unit well in SE SE section 1, T36N, R76W flowed 383 barrels of oil and 451,000 cubic feet of gas per day from perforations between 12,584 and 12,592 feet.

S. Basin Exploration agreed to purchase properties in the Powder River Basin from an undisclosed seller for $14.7 million. The purchase includes 224 producing wells and 119 undeveloped locations primarily in Well Draw and Kaye fields. The properties are credited with approximately 3.8 million barrels of oil equivalent.

T. Nearly all of the processing equipment at Amoco's Casper refinery will be sold, dismantled, and removed by the end of 1996. Duratube Ltd., a United Kingdom firm, will purchase the equipment.

Horizontal Drilling

During the fourth quarter of 1993, the following significant activities related to horizontal drilling occurred. The letters preceding the discussions below refer to locations on **Figure 12**. The discussions are based on company data and on information compiled and published by Petroleum Information.

A. Activity in the Niobrara in the Cheyenne-Denver Basin continues to be strong. Union Pacific Resources completed their 1-H Beartooth 41-7 well drilled from a surface location in NE NE section 17, T15N, R63W to a true vertical depth of 7,643 feet. During its first month of production, the well produced an average of 321 barrels of oil and 74 barrels of water per day from the Niobrara. Union Pacific also reached true vertical depth of 7,464 feet at their 1H Mark 41-15 well drilled from a surface location in C NE NE section 15, T15N, R63W. No other details are available.

B. Activity in Silo Field remains high. Union Pacific Resources completed their 1H Owen 14-9 well, drilled from a surface location in SW SW section 9, T15N, R64W. The well was drilled to a true vertical depth of approximately 7,985 feet and production for the first month averaged 194 barrels of oil and 104 barrels of water per day. Union Pacific also completed their 1-H Marie 41-21 well, drilled from a surface location in NE NE section 21, T16N, R65W, to a true vertical depth of 8,472 feet. The well produced an average of 174 barrels of oil, 76,600 cubic feet of gas, and 347 barrels of water during its first month of production. Berenergy's 1-16H Wyoming-State, which was drilled to a true vertical depth of about 7,930 feet from a surface location in C NE NE section 16, T15N, R64W, produced an average of 164 barrels of oil and 306,000 cubic feet of gas during its first month of production. Exxon Corp. also completed a new

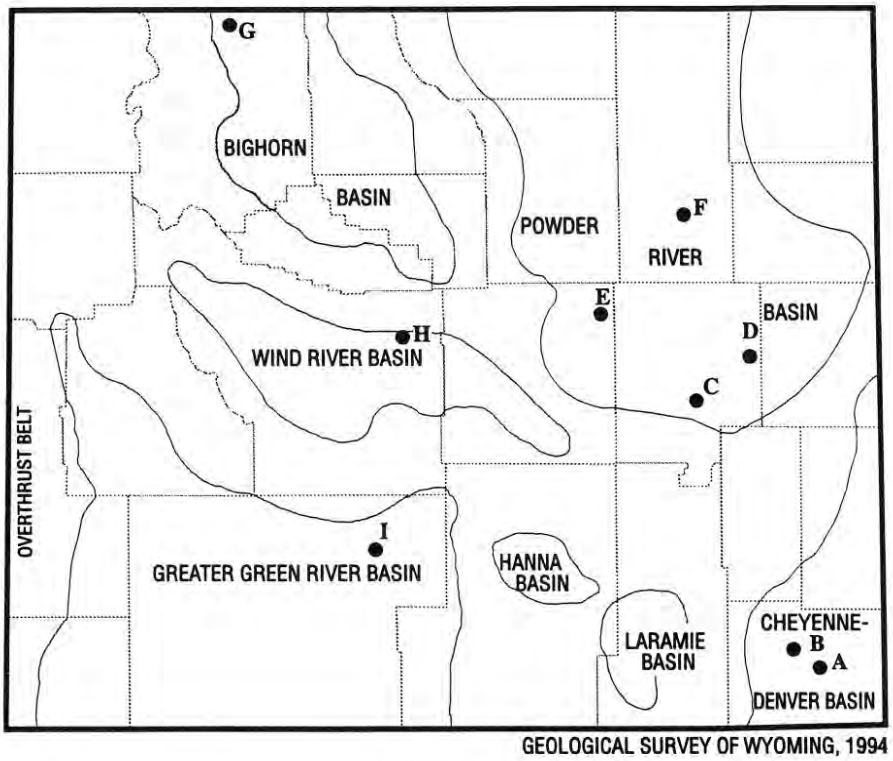

Figure 12. Horizontal drilling activity in Wyoming during the fourth quarter of 1993.

producer. The 1HA Epler Oil Unit well was drilled from a surface location in SW SW section 24, T16N, R65W to a true vertical depth of approximately 8,200 feet. The well averaged 147 barrels of oil and 147,000 cubic feet of gas per day during its first month of production. Wilshire Oil Co. also completed a Niobrara producer. The 1-13H McConnaughey well, drilled from a surface location in SW SW section 13, T16N, R65W to a true vertical depth of 8,165 feet, pumped 203 barrels of oil per day.

C. In the Powder River Basin, Arco Oil & Gas is nearly to true vertical depth of 11,750 feet at their 1H Red Mountain Unit well, drilled from a surface location in NE NW section 35, T33N, R71W. The well will test the Frontier Formation.

D. Meridian Oil Inc. has reached total depth at the 31-15H RE Manning well, drilled from a surface location in SW SE section 31, T35N, R67W to true vertical depth of 9,194 feet in the Turner Sandy Member of the Carlile Shale. The well will evaluate the Turner as well as the Niobrara.

E. EP Operating is drilling its 1H East Flank Unit well from a surface location in SW SW section 30, T39N, R77W to a true vertical depth of 5,000 feet. The well will test an objective in the Niobrara.

F. Conoco Inc. plans to drill its 1H Patroit Unit well from a surface location in NE SW section 24, T45N, R72W. True vertical depth is projected at 8,690 feet and the well will evaluate the Niobrara. Conoco has a location staked for another Niobrara test within a mile of the 1H Patriot Unit well. Conoco is drilling its 1H Patriot Com well from a surface location in SE NW section 30, T45N, R71W to a true vertical depth of 8,650 feet as a test of Niobrara.

G. In the Bighorn Basin, Sierra Energy plans to drill a Frontier Formation test in Badger Basin Field as part of a project partially funded by the Department of Energy. Details on the exact location of the well and true vertical depth of the well have not been released.

H. Meridian Oil began drilling its 1-15H RE Federal-Hanagan well to test the gas potential of the Shannon Sandstone in the Wind River Basin. The well was spudded from a surface location in NW SW section 15, T36N, R91W and is projected to a true vertical depth of 13,750 feet.

I. In the Red Desert area, Amoco Production filed a request with the Wyoming Oil and Gas Conservation Commission for an order to establish a 640-acre horizontal drilling and spacing unit for the Mesaverde. If the unit is approved, Amoco plans to drill a Mesaverde test from a surface location in NW SW section 1, T22N, R96W. No other details are available.

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COAL UPDATE

by Timothy A. Moore
Staff Geologist-Coal, Geological Survey of Wyoming

Wyoming coal deliveries to utilities are once again up over the same period for 1992. Total coal transported to electrical utilities as of September of 1993 is nearly 146 million tons whereas the cumulative total for September 1992 was just over 135 million tons (**Table 10**). Coal production for the month of September 1993, which was over 17,310,000 tons, set a new record for the

amount of coal mined in one month in Wyoming (**Figure 13**). The previous one month record was set in February of 1993. So far, the increase in coal production in 1993 occurred largely from March through May and in September, all of which are historically low volume months. Spot sales for 1993 have been consistently higher than in 1992, averaging over 3 million tons per month for the last four months of available data (June to September, 1993) (**Figure 14A**). Contract coal sales have also been averaging over 13 million tons a month, which is higher than similar periods in 1992 (**Figure 14B**). If these trends continue, Wyoming's coal production for 1993 will probably be slightly higher than the 202 million tons that has been predicted (**Table 11**).

Figure 15 shows the 10 largest purchasers of Wyoming coal and their monthly takes in 1993. PacifiCorp. is by far the largest purchaser. All these utilities buy at least 450,000 tons per month.

Although the flooding in the mid-west this summer did not materially affect transportation of Wyoming coal eastward, there was at least one rather unique problem. In September, a 55,000-ton shipment of Powder River Basin coal moving to the Spanish utility, Endesa, went through the Great Lakes in September instead of down the Mississippi as it normally does. Officials at the Canada Steamship Lines, which handled the Great Lakes shipment, have taken this opportunity to tout the Great Lakes as a viable alternative for regular shipments of Powder River Basin coals to Europe.

As a result of the Clean Air Act Amendments, a number of eastern states have been considering ways to keep their local coal industries viable. In one such example, the state of Illinois passed a law which effectively ordered its utilities to give preference to Illinois coal in their purchases. However, a Federal judge in Illinois has overturned this law citing it as unconstitutional after the state of Illinois was sued by four railroads and two coal companies. The attorney generals of Wyoming and Montana had filed a joint friend-of-the-court brief supporting the suit. The four railroads (Union Pacific, Burlington Northern, Chicago and Northwestern, and Southern Pacific Transportation) along with western coal companies, Arco and Nerco, filed suit against Illinois last July. Amendments to the Clean Air Act require that power plants reduce emissions either by burning lower sulfur coal or by installing stack scrubbers, which remove sulfur from released gases. Meanwhile, the Illinois Commerce Commission has asked the Illinois Attorney General to appeal this decision in the U.S. 7th Circuit Court of Appeals in Chicago.

Developments in western and southwestern Wyoming

Black Butte Coal Company is seeking approval from the Department of Environmental Quality to renew its existing mine permit for the Leucite Hills mine. The mine is located approximately four miles to the north of Point of Rocks in Sweetwater County. The mine, which opened in 1981, has enough reserves

Table 10. Monthly coal deliveries from Wyoming mines[1].

	1989 Monthly	1989 Cumulative	1990 Monthly	1990 Cumulative	1991 Monthly
JAN	14,283,020	14,283,020	15,059,530	15,059,530	14,960,450
FEB	11,488,140	25,771,160	13,328,290	28,387,820	15,480,110
MAR	14,124,330	39,895,490	14,535,270	42,923,090	16,278,870
APR	13,489,450	53,384,940	14,155,470	57,078,560	14,820,240
MAY	13,149,170	66,534,110	13,882,590	70,961,150	14,589,790
JUN	12,948,350	79,482,460	13,649,070	84,610,220	14,007,600
JUL	14,043,350	93,525,810	15,368,280	99,978,500	16,451,090
AUG	15,428,210	108,954,020	16,046,910	116,025,410	15,940,620
SEP	13,795,760	122,749,780	15,166,020	131,191,430	15,314,490
OCT	14,523,480	137,273,260	15,244,760	146,436,190	14,810,510
NOV	14,507,130	151,780,390	15,569,280	162,005,470	14,783,000
DEC	13,527,880	165,308,270	14,479,970	176,485,440	16,716,630
Total Tonnage Reported		**165,308,270**		**176,485,440**	
Total Tonnage Not Reported		**5,831,734**		**7,521,261**	
Total Tonnage Produced[2]		**171,140,004**		**184,006,701**	

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

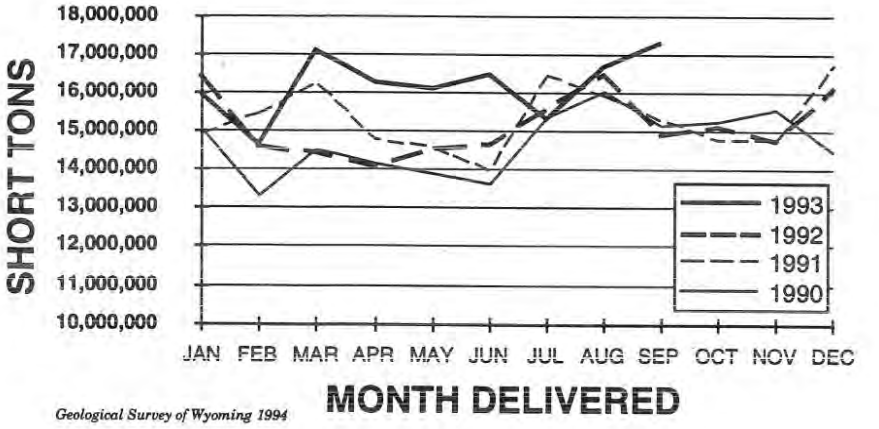


Figure 13. Reported deliveries from Wyoming coal mines. *(From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Table 10. *continued*

1991 Cumulative	1992 Monthly	1992 Cumulative	1993 Monthly	1993 Cumulative
14,960,450	16,407,150	16,407,150	15,931,150	15,931,150
30,440,560	14,604,480	31,011,630	14,646,090	30,577,240
46,719,430	14,429,650	45,441,280	17,112,970	47,690,210
61,539,670	14,063,060	59,504,340	16,259,770	63,949,980
76,129,460	14,518,590	74,022,930	16,085,470	80,035,450
90,137,060	14,655,600	88,678,530	16,473,920	96,509,370
106,588,150	15,592,050	104,270,580	15,296,480	111,805,850
122,528,770	16,467,100	120,737,680	16,682,090	128,487,940
137,843,260	14,878,150	135,615,830	17,310,330	145,798,270
152,653,770	15,122,820	150,738,650		
167,436,770	14,757,230	165,495,880		
184,153,400	16,096,150	181,592,030		
184,153,400		**181,592,030**		**145,798,270**
9,710,406		**7,878,226**		
193,863,806		**189,470,256**		

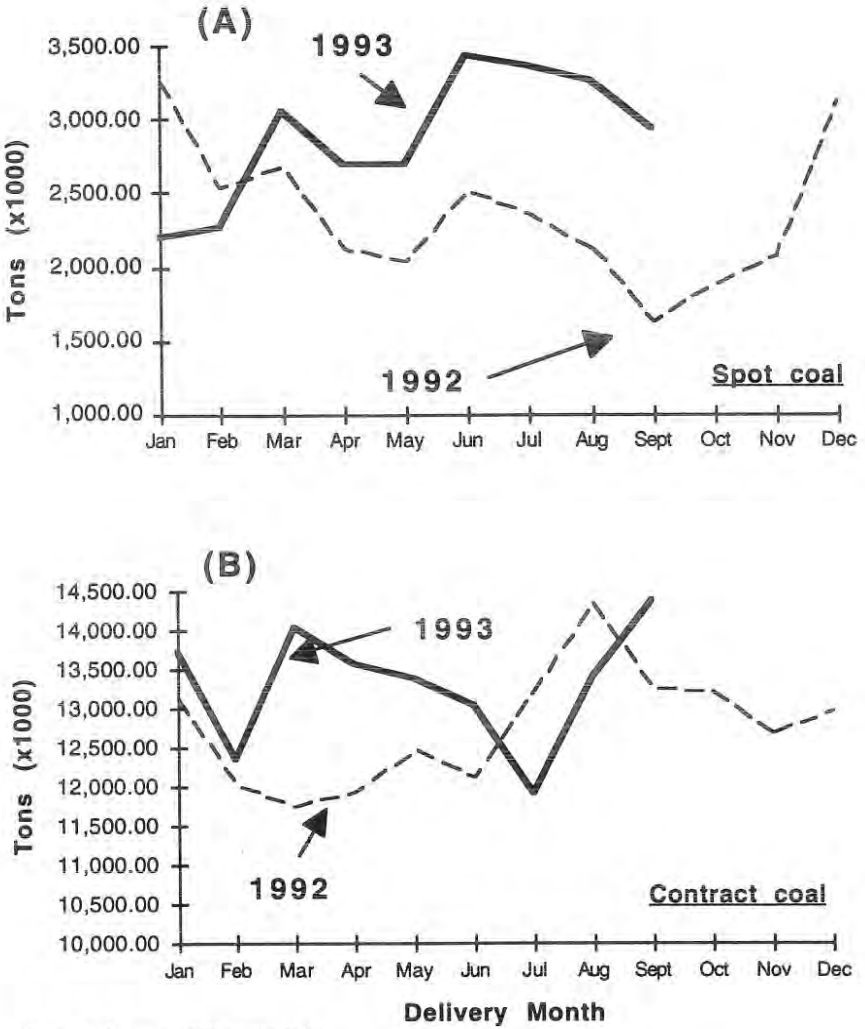
for it to continue operation until 2003. This mine has also been chosen as one of the main coal suppliers in 1994 for the nearby Jim Bridger power plant.

As reported in *Wyoming Geo-Notes No. 40*, the FMC Corporation (FMC) coke plant near Kemmerer in the Hams Fork Coal Field (**Figure 16**) has been testing the viability of drying and briquetting coal. Successful runs on subbituminous coals from both Skull Point and the Powder River Basin have resulted in this technology being marketed world wide. FMC and Coal Drying Technologies Inc. (CDT) recently signed an agreement that will allow CDT to exclusively license a portion of FMC's Form Coke technology as it relates to drying and briquetting low-rank coals.

Developments in the Powder River Basin

In the Montana portion of the basin, Decker Coal Co. recently signed a three-year, one million ton per year contract with Mississippi Power in Pascagoula, Mississippi.

Billings-based Wesco Resources and Seattle-based Washington Energy, Inc. have announced plans to build a new 122-mile-long railroad that would cut about 160 miles off the current route from the Decker mine area in Montana to upper Midwest utilities. The proposed Tongue River Railroad currently has reached no agreement with the Burlington Northern railroad to share its trackage beyond the new railroad.



Geological Survey of Wyoming 1994

Figure 14. Monthly coal deliveries from Wyoming for 1992 and 1993. (A) Coal sold on the spot market and (B) coal sold on contract. *(From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Table 11. Coal production in millions of tons (1984-1992) with forecasts to 1997.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994*	1995*	1996*	1997*
Campbell County	106.8	113.9	111.0	122.3	135.7	143.8	154.7	164.9	159.6	172.3	180.9	189.9	199.4	209.1
Converse County	3.3	3.6	4.8	5.1	5.7	6.1	7.9	8.2	8.5	9.2	9.7	10.2	10.6	11.0
Sheridan County	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.2	0.1	M	M	M	M	M
Carbon County	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.7	4.1	4.3	4.3	4.3	4.3	4.3
Sweetwater County	8.9	13.2	12.9	11.8	12.2	12.0	11.9	11.4	12.6	11.4	11.4	11.4	11.4	11.4
Lincoln County	4.1	4.3	4.0	3.8	4.9	4.8	4.7	4.4	4.6	4.7	4.7	4.7	4.7	4.7
Hot Springs County	M	M	M	M	M	M	0.1	0.1	M	M	M	M	M	M
Total Wyoming	130.7	140.7	135.6	146.4	163.5	171.1	183.9	193.9	189.5	202.0	211.0	220.5	230.4	240.5
Annual Change	14.2%	7.1%	-3.8%	7.4%	10.5%	4.4%	7.0%	5.2%	-2.3%	6.2%	4.3%	4.3%	4.3%	4.2%
Low-priced coal[1]		6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%	57%	62%

* Estimated by Geological Survey of Wyoming, January 1994. [1]Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under $5.00. M means minor tonnage (less than 0.1 million tons).

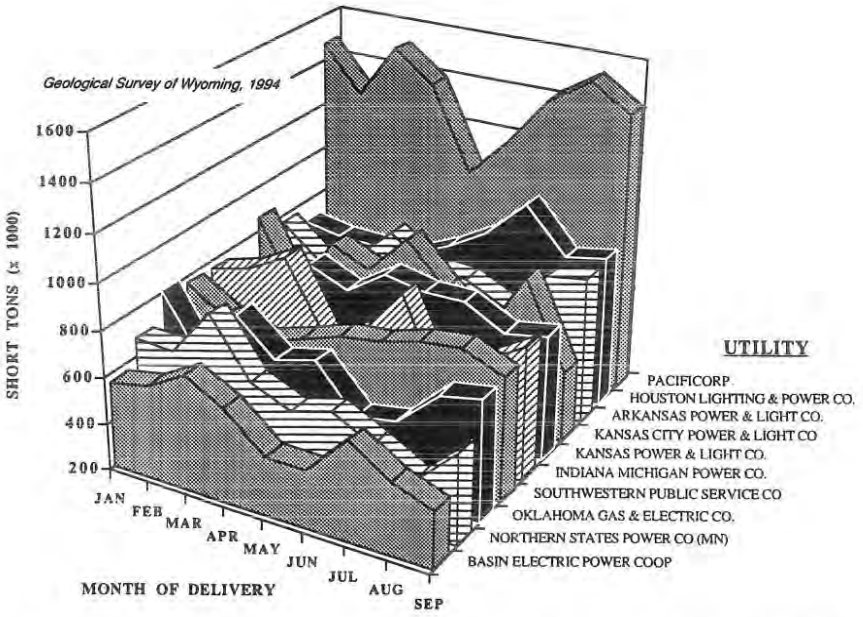


Figure 15. Top ten utilities based on their consumption of Wyoming coal during the first three quarters of 1993 (*from COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities*).

Northern Indiana Public Service Co. (NIPSCO), which has been blending Powder River Basin (PRB) coal with Illinois Basin coal in its Bailly generating station during a coal strike, may continue using a PRB blend for economic reasons even after the strike ends. Spokepersons for NIPSCO note that not only is the approximately $4.00 per ton PRB coal less expensive than its Illinois Basin counterpart, but NIPSCO is also getting more competitive transportation rates.

A new coal crusher at the Wyodak coal mine suffered major damage when a fire swept through the five-story structure in mid-November. The fire burned for two and a half hours before it was brought under control by firefighters. The crusher is being built for a new part of the coal mine located near the Wyodak power plant, which is owned by PacificCorp and Black Hills Power and Light.

Amax's Eagle Butte mine just north of Gillette has applied for a lease on 184 million tons of Federal coal adjacent to its mine permit area. This expansion will extend the life of the mine by 10 years.

In another lease modification, the Caballo mine has filed an application so as to not bypass one million tons of coal adjacent to their present mine. The area is less than 20 acres.

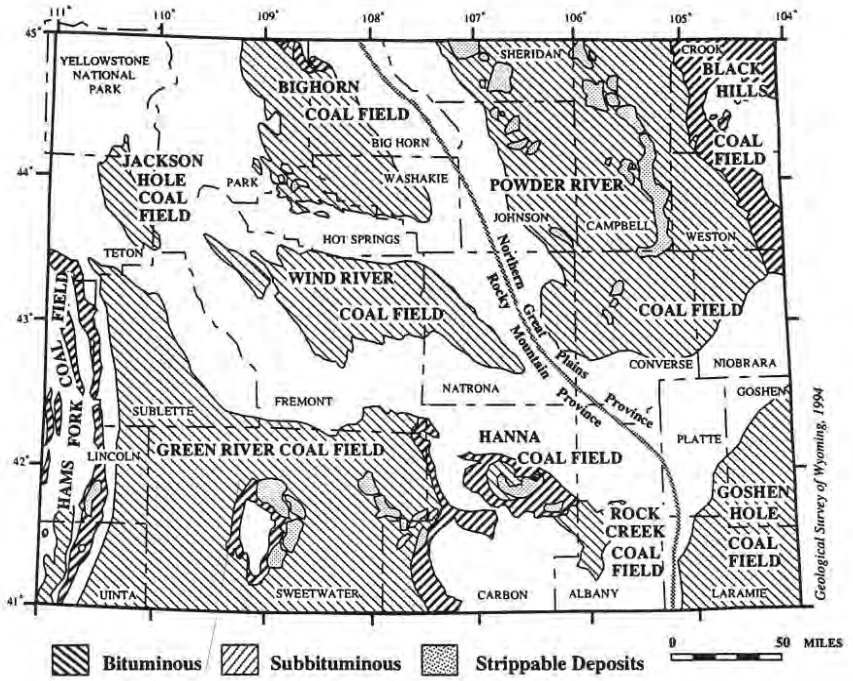


Figure 16. Coal fields of Wyoming.

The U.S. Bureau of Land Management also allowed Northwestern Resources, a subsidiary of Montana Power Co., to combine a new and an old lease into a "logical mining unit." With this ruling, Northwestern announced that it would start its proposed Rocky Butte mine in Campbell County before the end of the decade.

From a coal regulatory standpoint, the U.S. Bureau of Land Management has announced that it is reviewing its rules on "leasing by application", "due diligence", and the formation of "logical mining units."

Contracts

New coal contracts, test burns, solicitations, and spot sales for the fourth quarter of 1993 are summarized in **Table 12**. Of note, is the test burn of Powder River Basin coal by New England Electric Power Co., which - like Georgia Power's recent contract - may signal yet another in-road for Wyoming coal into eastern markets as a result of the Clean Air Act Amendments.

Table 12. Recent activity involving coal producers in Wyoming during the fourth quarter of 1993.

Utility	Power Plant	Coal Mine or Region	Activity	Tonnage	Comments
Commonwealth Edison	N.D.	Jacobs Ranch	T	N.D.	
Hastings NE Utility Dept.	N.D.	Powder River Basin	So	0.1-0.3 million t	
Houston Lighting & Power	Parish		So	2.5 million t	Will solicit western coals including Powder River Basin coal mines
		Powder River Basin	So	2.5 million t/y	
IES Industries		Belle Ayr	Sp	0.4-0.6 million t	
Lower Colorado River Authority	Fayette Power Project	Jacobs Ranch	Sp	1,581,000 t	FOB mine price is $4/t.
		Caballo	Sp	295,000 t	FOB mine price is $3.50/t
	Fayette Power Project No. 3 unit	Caballo Rojo	C	5.75 million t	This is tonnage is to be delivered over a 5-year period.
Midwest Power Systems	Neal North	Hanna Basin	So	500,000 t	
	Neal North Units 1, 2 and 3	Powder River Basin	So	0.8-1.5 million t	
Minnesota Power & Light	N.D.	Spring Creek, Belle Ayr, Black Thunder	So	N.D.	
Mississippi Power Co. (MPC)	Daniel	Powder River Basin	C		Contract still being negotiated.
New England Power	Salem Harbor N.D.	North Antelope Rochelle	T T	7,000 t 14,000 t	
Northern Indiana Public Service	Bailly Michigan City Bailly	Shoshone Shoshone Caballo Rojo	C C Sp	80,000 t 50,000 t 22,000 t	

Table 12. Recent activity involving coal producers in Wyoming during the fourth quarter of 1993 *(Continued)*.

Utility	Power Plant	Coal Mine or Region	Activity	Tonnage	Comments
Northern Indiana Public Service	Dean H. Mitchell	Caballo Rojo	Sp	33,000 t	
		Cordero	Sp	33,000 t	
		Caballo Rojo	Sp	77,000 t	
	Michigan City	Shoshone	C	70,000 t	
		Black Thunder	Sp	55,000 t	
		Black Thunder	Sp	50,000 t	
Omaha Public Power District	Nebraska City	Belle Ayr or Eagle Butte	Sp	1.5 million t	A short-term contract for 1994.
	North Omaha	Buckskin	Sp	1 million t	
PacifiCorp	Dave Johnston	Caballo Rojo	Sp	up to 0.3 million t	
		Cordero	Sp	up to 0.4 million t	
		Caballo	Sp	up to 0.3 million t	
		North Rochelle	Sp	up to 25,000 t	
		Glenrock	C	2.5 million t	
	Jim Bridger	Swanson	C	132,000 t	
		Black Butte	C	200,000 t	For first half deliveries in 1994.
		Jim Bridger	C	5.2 million t	
Portland OR General Electric	Boardman	Caballo Rojo	Sp	800,000 t	To be supplied during the first half of 1994.
Southwestern Public Service	Harrington	Rochelle	Sp	1.2-1.3 million t	
TU Electric	Monticello	Belle Ayr	T	N.D	
West Texas Utility	Oklaunion	Belle Ayr & Eagle Butte	Sp	300,000 t	
Wisconsin Power & Light	Columbia No.1	North Antelope	Sp	0.4-0.45 million t	
	Columbia No.2	Caballo Rojo	Sp	800,000 t	
	Columbia No.2	Amax Coal Co.	Sp	800,000 t	
	Edgewater 3 & 4 units	North Antelope or Rochelle	Sp	700,000 t	

N.D.=no data available; C = Contract coal; T = test burn; Sp =spot coal; So =solicitation; t =short ton; t/y =short ton per year.

Coalbed Methane

Although there was no significant developments and(or) drilling for coalbed methane in Wyoming in the last quarter of 1993, Metfuels, Inc. continued to develop its project in the Hanna Coal Field (**Figure 16**).

INDUSTRIAL MINERALS AND URANIUM UPDATE

by Ray E. Harris
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General

According to the U. S. Bureau of Mines, Wyoming ranks 10th in nonfuel mineral production and 5th in industrial mineral production. All of the nonfuel minerals in production in Wyoming are classified as industrial minerals (Peterson, 1993).

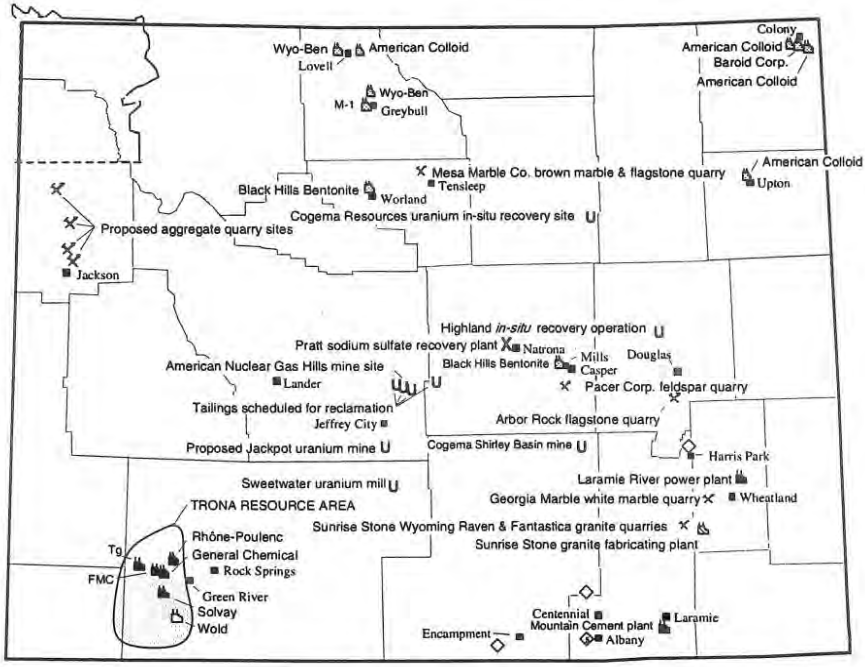
Production statistics for uranium and many industrial mineral commodities produced in Wyoming, are available in spreadsheet and graph form from the Industrial Minerals and Uranium Section of the Geological Survey of Wyoming. These statistics cover the years 1920 through the present. Also available are the price histories of selected commodities, in current dollars. The spreadsheets contain the best available production and price data, including data from the U.S. Bureau of Mines, the Atomic Energy Commission, the former Wyoming State Board of Equalization, the Wyoming Ad Valorem Tax Division, the Wyoming Department of Revenue, and the Wyoming State Inspector of Mines. Graphs of historic production for bentonite, sodium sulfate, and mined trona are included in this issue of *Wyoming Geo-notes*. Others will be included in future issues, until statistics for all the commodities have been presented.

Aggregate (Construction)

During the fourth quarter of 1993, the production of construction aggregate and other construction materials declined seasonally.

In October, Casper Concrete Co. asked the Casper City Council to allow the mining of gravel from land along the north shore of the North Platte River just west of Bryan Stock Trail. Permission is pending.

In December, a plan to use construction aggregate sources from within Grand Teton National Park for in-park construction projects was presented for public comment. The proposal includes quarrying gravel (river rock) from the Pilgrim and Spread Creek drainages; the Snake River alluvial plain, near the



EXPLANATION

- Quarries and mines
- Potential quarry sites, Medicine Bow National Forest
- Plants or refineries
- Plants or refineries under construction
- Proposed plant or refinery
- Bentonite mill
- X Sites of miscellaneous mineral production
- U Uranium activities
- Localities mentioned in text

Figure 17. Industrial minerals and uranium activities in Wyoming during the fourth quarter of 1993.

Jackson Hole Airport; and near Signal Mountain (**Figure 17**). Because construction aggregate is such a low-cost commodity, the cost of transporting the material to a point of use is often greater than the cost of the material at its source. According to the plan, using in-park aggregate sources for in-park highway and other construction projects can save the National Park Service (NPS), and ultimately U.S. taxpayers, over $25,000,000 over the next 20 years. All of these savings are in transportation costs to haul aggregate from sources outside of the park.

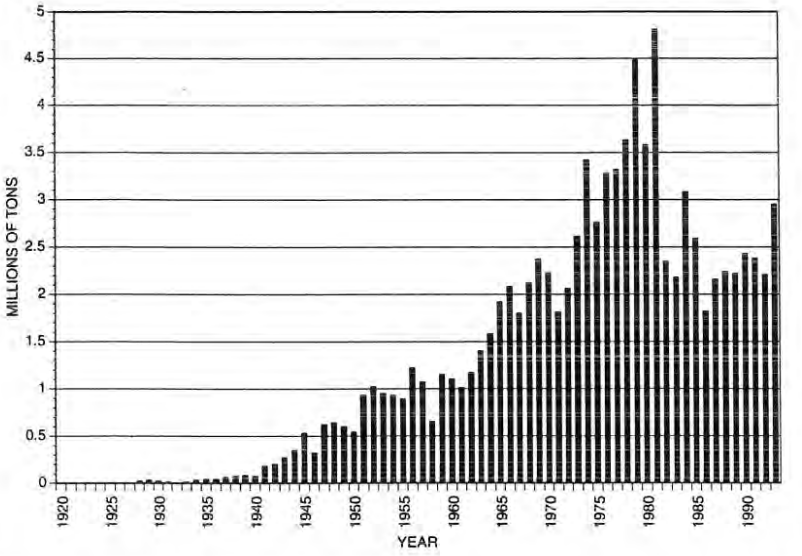


Figure 18. Historical bentonite production from Wyoming (1920- 1993) (*1993 production is an estimate by the Geological Survey of Wyoming*).

Bentonite

The production of bentonite in Wyoming continues to recover after a significant decline in production after 1981 (**Figure 18**). 1993 production which is estimated at about three million tons, could be the highest level of production in the last nine years. Before 1990, most bentonite was used in oil well and other drilling muds. The strength of the current recovery lies in the increased use of bentonite for foundry casting molds and environmental containment.

Bentonite has been produced in Wyoming since the turn of the century. Before 1940, however, only small amounts were produced. The increase in oil well drilling during World War II fueled the growth of bentonite production, which continued more or less steadily until the early 1980s (**Figure 18**). Currently, bentonite is refined at ten mills, five in the Bighorn Basin, four in the Black Hills, and one at Mills in Natrona County (**Figure 17**).

In late 1993, Baroid Corporation signed a letter of intent to acquire the bentonite mining operations of Bentonite Corporation from Bentonite Corp.'s parent company, Tremont Corp. Bentonite Corp., which operates a mill at Colony, in Crook County, mines bentonite from several pits in the Black Hills, and leases bentonite property in the Bighorn Basin (**Figure 17**). This change in ownership should not affect overall Wyoming bentonite production.

The Town of Mills has annexed the property owned by Black Hills Bentonite Corp. This annexation gave Black Hills access to the municipal water supply, and thereby allows for increased production of bentonite from the mill on that site. Black Hills mines bentonite from several pits near Kaycee and Casper and produces bentonite products at the mill in Mills (**Figure 17**).

Decorative stone

The production of black granite (actually an amphibolite) at Sunrise Stone Company's Wyoming Raven quarry and the pink and gray swirled granite (more specifically a gneiss) at the adjoining Fantastica quarry in Albany County (**Figure 17**) continues. Construction has begun on the fabricating plant located southwest of the junction of Tunnel Road and Wyoming Highway 34 (**Figure 17**). The fabricating plant will be inside a previously constructed metal building at this site.

Near Tensleep, in Washakie County (**Figure 17**), Mesa Marble Co. has shipped a few loads of flagstone and fieldstone for use as fireplace facing, sidewalks, patio flooring, and landscaping rock. This material is a Triassic dolomitic limestone and dolomite, and comes in colors ranging from dark brown through tan to grey to greenish grey. Also, beneath the flagstone is a thick zone of brown marble (actually a dolomite) that can be produced as a uniform brown block or a wood-grained block. In the future, Mesa hopes to quarry blocks of this rock for counter tops and other uses.

Arbor Rock Company, a division of Western Aggregates, has reopened an old flagstone quarry south of Douglas (**Figure 17**). In the past, this buff to light-brown flagstone was quarried and used locally for sidewalks and facing. Now, the flagstone is shipped to the Denver area.

The Geological Survey of Wyoming has recently identified eight potential granite and quartzite decorative stone and aggregate quarry sites in the Medicine Bow National Forest as part of a grant from the U.S. Forest Service. The sites are just north of Harris Park; north of Centennial in the Medicine Bow Mountains; in the Medicine Bow Mountains just west of Albany, Albany County (5 sites); and west of Encampment in the Sierra Madre (**Figure 17**). Industry has already shown interest in the five sites near Albany and the site west of Encampment.

Feldspar

Pacer Corp. continues to produce a light beige feldspar from its quarry on Casper Mountain (**Figure 17**). Most of this production is sold for decorative aggregate. No recent production figures, however, are available for the Pacer quarry. Nationally, 175,195 short tons of feldspar were mined in 1993. Most feldspar is used in the manufacture of glass and ceramics (Potter, 1993).

Wyoming has large resources of high-quality silica sand, soda ash, and limestone, as well as feldspar, all of which are used in the manufacture of glass.

Mica

Mica is the name for a group of silicate minerals characterized by an ability to be split into thin sheets. Before the early 1950s, sheets of primarily muscovite, one type of mica, were used in windows that were subject to high heat, such as furnace windows. Since synthetic materials have in large part replaced sheet mica for these uses, mica production in the U.S. has been relatively minor. Recently, however, flake mica (small flakes formerly discarded by the producers of sheets) has seen increased use in joint cement, pearlescent additives to paint, and other uses (Davis, 1993). In 1993, a couple of producers inquired of the Geological Survey of Wyoming about potential sources of mica. This summer should see some limited exploration for sources of mica, primarily in the Laramie Mountains, Medicine Bow Mountains, and the Hartville uplift.

Sodium sulfate

Small amounts of sodium sulfate (Na_2SO_4) have been produced in Wyoming almost continuously since the 1920s (**Figure 19**). Most sodium sulfate is currently used in phosphate-free detergents. Other uses include paper process-

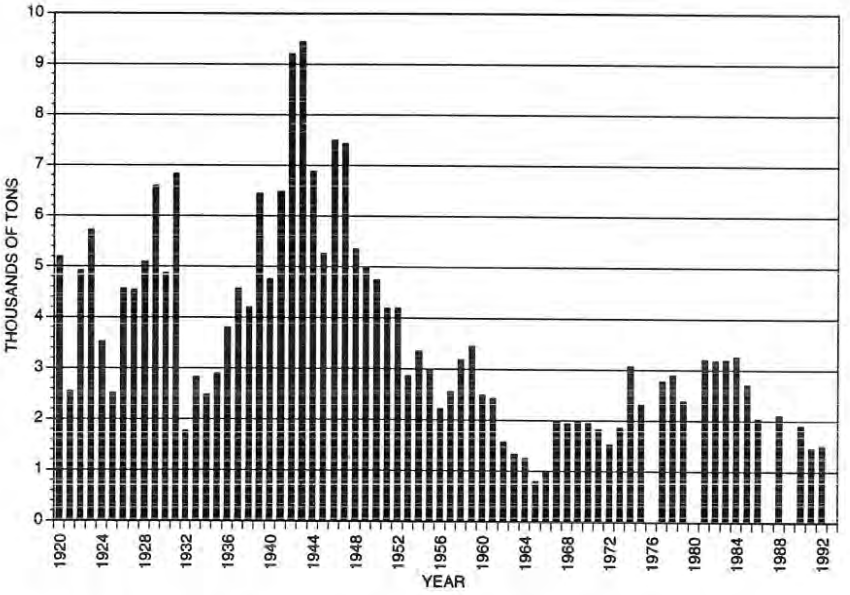


Figure 19. Historical sodium sulfate production from Wyoming (1920-1992).

ing, textile finishing, and other minor uses (Kostick, 1993). Sodium sulfate from Wyoming is currently produced from the Pratt soda lakes at Natrona, northwest of Casper (**Figure 17**). At this locality, the material is dredged and pumped from the soda lakes and dried at the large shed located near U.S. Highway 26 at Natrona. It is shipped to consumers in the Chicago, Illinois, area. Production peaked during World War II, but about 2,000 short tons have been produced annually since the mid-1950s by the Pratt family. Earlier, the Gill family produced sodium sulfate from the Gill lakes in northern Albany County.

Trona

Natural trona is mined in Wyoming from five underground operations west of Green River and refined into soda ash and other sodium compounds at five refineries (**Figure 17**).

In 1946, trona was discovered in Wyoming in core from an oil and gas well drilled near Westvaco, the current site of the FMC mine and soda ash processing plant. FMC began production in 1950. Stauffer Chemical (now Rhône-Poulenc) began production in 1963, General Chemical in 1968, Texasgulf (now Tg Soda Ash) in 1975, and Tenneco (now Solvay) in 1982 (**Figure 20**). Wold Trona is proposing a sixth facility to begin production in the last half of this decade. The

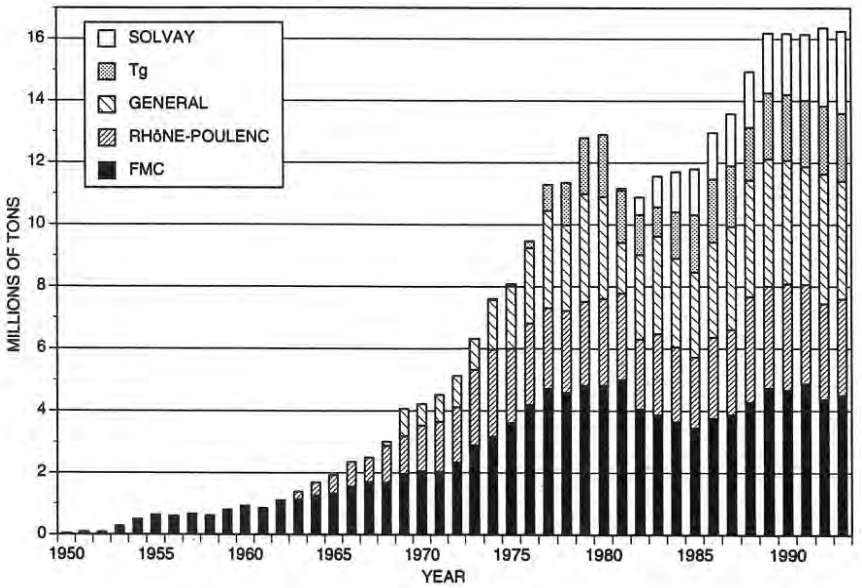


Figure 20. Historical trona production from Wyoming (1950-1993) (*1993 production is estimated*).

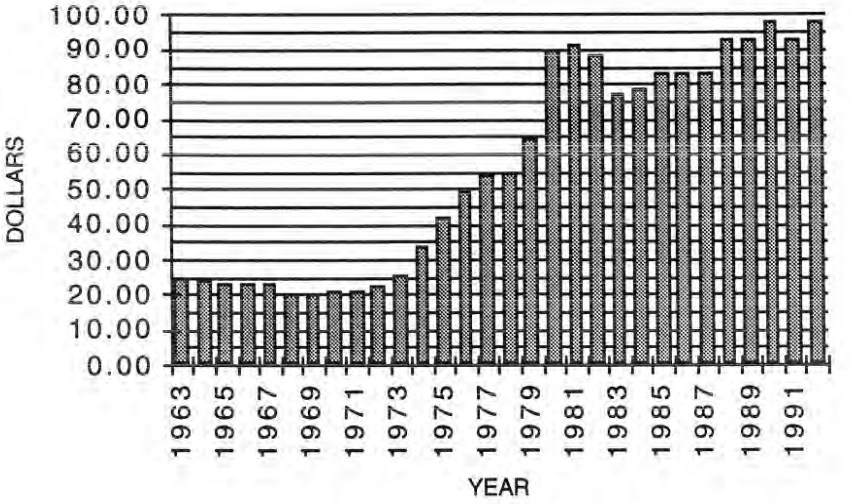


Figure 21. Historical summary of year-end prices for Wyoming soda ash (*FOB Green River, Wyoming*).

mining of trona and the production of soda ash and other sodium compounds should increase in the future. Trona mining currently accounts for over two-thirds of the valuation of nonfuel minerals produced in Wyoming. Historical soda ash prices are shown in **Figure 21**.

Wold Trona continues to go forward with plans for a new trona mine and refinery. According to John Wold, expanding markets will justify the new operation. Wold plans to produce a 97 to 98 percent pure soda ash product, named benetron.

On August 1, 1993, the United Steelworkers Union began a strike against General Chemical, one of the five producers. This strike was resolved on December 1, 1993, and full production has resumed.

In a move that will expand international markets for Wyoming soda ash, European representatives to the International Conference on Tariffs and Trade at Geneva, Switzerland, have agreed to reduce European tariffs on soda ash by 50 percent. If signed, this agreement will significantly increase the competitiveness of Wyoming soda ash in Europe, and offer opportunities for additional sales to that area. Exports to Europe have recently been declining, following a peak in early 1992, according to the U. S. Bureau of Mines (Kostick and Arguelles, 1993).

Partly in response to the declining export market, which some see as only temporary, and a steady decrease in the market for caustic soda, on December 26, 1993, FMC announced that it was laying off 90 employees and cutting back

caustic soda production beginning in January, 1994. The layoffs amount to about 10 percent of its workforce. FMC had announced some possible expansion plans in early 1993, but there has been no recent statement from the company regarding those plans.

In December, Solvay announced a possible expansion of its plant. The company, which has already expanded its production by 600,000 short tons per year, is considering another 700,000 short tons per year expansion. Earlier in 1993, Solvay announced that it was stopping its production of caustic soda, and transferred 10 employees to other parts of the plant.

In response to concerns regarding an apparent lowering of atmospheric visibility in the Green River Basin, Solvay is aiding efforts by the Air Quality Division of the Wyoming Department of Environmental Quality, to determine if there is a decrease in visibility. And if there is, what may be causing it.

Uranium

The NUEXCO spot market uranium prices presented here give information about the relative prices of yellowcake and price trends. These prices are not necessarily the figure at which yellowcake is sold. Add-ons and other factors increase the sale price of uranium compounds. Other price indicators are higher than the NUEXCO spot market price. Also, in July, NUEXCO adjusted its prices to reflect international price levels. Currently, NUEXCO is reporting adjusted and unadjusted prices, both are presented in **Table 13**.

Table 13. NUEXCO spot market price of yellowcake from October 1992 to November 1993 (end-of-month price in current dollars).

Month	UNADJUSTED PRICE	ADJUSTED PRICE
Oct. 1992	$8.00	
Nov. 1992	7.90	
Dec. 1992	7.85	
Jan. 1993	7.65	
Feb. 1993	7.60	
Mar. 1993	7.45	
Apr. 1993	7.10	
May 1993	7.00	
Jun 1993	7.00	
Jul 1993	6.90	10.00
Aug 1993	6.90	10.00
Sep 1993	6.90	10.20
Oct 1993	6.90	10.15
Nov 1993	6.90	9.90
Dec 1993	7.00	9.85

Uranium in Wyoming is produced at Power Resources' Highland in-situ facilities north of Glenrock in Converse County and at Cogema Resources' recently purchased Irigary Ranch and Christiansen Ranch properties near the Pumpkin Buttes (**Figure 17**). In-situ production from these latter two properties began in 1994. Cogema Resources was formerly known as Pathfinder Mines, a subsidiary of COGEMA, a French corporation.

The Green Mountain Mining Venture (GMMV), a joint venture between Kennecott Energy and U. S. Energy Corp., is developing its Jackpot underground uranium mine on the south slope of Green Mountain, south of Jeffrey City. Recently, the GMMV purchased the former UNOCAL Sweetwater mill (**Figure 17**). In November, the U.S. Bureau of Land Management decided the GMMV must submit an Environmental Impact Statement for the mine. GMMV had been hoping to begin operations under a much simpler, less costly, and less time-consuming Environmental Assessment.

Two companies are examining ways to use their abandoned open pit uranium mines as repositories for low-level radioactive waste. Cogema Resources (formerly Pathfinder Mines) applied for a permit in early 1993 to put 800,000 short tons of low-level waste into its Shirley Basin pit. The Wyoming Department of Environmental Quality (DEQ) rejected this proposal, but did grant approval for 20,400 short tons of low-level waste. In November, American Nuclear received permission from the DEQ to put 10,000 cubic yards (approximately 21,900 short tons) of uranium tailings and other types of mining waste into a pit in the Gas Hills.

Four uranium mill tailings sites in Fremont County are scheduled for reclamation under the Energy and Water Appropriations Bill signed by the President in early December. This bill approved $40,000,000 for the cleanup of uranium mill tailings at 13 sites nationwide. The Wyoming localities are Western Nuclear's Split Rock mill north of Jeffrey City, the former Federal-American mill in the Gas Hills, Umetco's East Gas Hills mill, and Pathfinder's Lucky Mc mill in the West Gas Hills (**Figure 17**). The tailings funded for cleanup at these sites are those generated during the U.S. Atomic Energy Commission's buying program, which ceased in 1965.

A proposed uranium trade agreement between the U.S. and Russia has been given mixed reviews by the uranium industry. Under the proposed agreement, Russian uranium can be sold in the U.S. at low prices, providing the purchasers also purchase an equal amount of uranium from domestic producers. According to an article in the Casper Star-Tribune (December 28, 1993), while some industry officials derided the agreement as detrimental to the already suffering U.S. uranium industry, others lauded the agreement as a step in increasing domestic sales.

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METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel
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Diamonds

Continuing exploration for diamonds in both Colorado and Wyoming has involved as many as a dozen companies from the U.S., Australia, and Canada. Articles in the Denver Post (July 25th, 1993), the Los Angeles Times (October 3rd, 1993), and the International California Mining Journal (Hausel, 1994), have described the recovery and exploration for diamonds that is occurring in the Colorado-Wyoming State Line district south of Laramie, Wyoming.

Successful diamond recovery hs continued along the state line from a group of kimberlites (and associated alluvial deposits) known as the Kelsey Lake intrusives. In a press release by Redaurum Red Lake Mines Limited (RRLML) of Toronto (August 24, 1993), it was reported that a bulk sample of the two largest Kelsey Lake kimberlites yielded a total of 58.3 carats of gem and industrial diamonds.

The results from recent bulk samples of alluvial material associated with the Kelsey Lake kimberlites were also very encouraging. RRLML reported in a press release (November 4, 1993) that the Kelsey Lake joint venture with Colorado Diamond Corporation recovered the largest reported diamond from the Colorado-Wyoming State Line diamond district, to date. The gemstone weighed 6.2 carats! Another alluvial sample yielded a 1.1 carat gemstone.

According to the November press release, the Kelsey Lake project has now produced 268 diamonds larger than 2 mm from kimberlite and associated alluvium. Of these, 60% are gem quality and 25% weigh more than one carat. The project manager of the joint venture, the Colorado Diamond Corporation, has advised RRLML that it will construct a larger recovery plant during the 1993-94 winter in preparation for a 100,000-tonne trial mining program to commence in the Spring of 1994.

Diamonds recovered from the Schaffer-Aultman kimberlite intrusives north of the Kelsey Lake kimberlites in the early 1980s, also included several gemstones, as well as a 0.86 carat gem (Hausel, 1993a). Fleck Resources is currently exploring this area. To date, more than 100,000 diamonds have been recovered by various companies from the Colorado-Wyoming State Line district south of Laramie (McCallum, 1991).

Southern Wyoming, especially, is receiving a lot of activity as a follow-up to studies by the Geological Survey of Wyoming. The Survey identified approximately 300 heavy mineral anomalies in more than 1,600 stream-sediment samples collected in the Laramie, Medicine Bow, and Seminoe Mountains. The anomalous samples yielded pyrope garnet, chromian diopside, and/or picroilmenite - all minerals that originated in the earth's mantle. Similar

anomalies were also identified in the Green River Basin of southwestern Wyoming.

Jelm Mountain district

The Jelm Mountain district, along the southeastern flank of the southern Medicine Bow Mountains of southeastern Wyoming, has had a notorious past involving fraud related to several historical mining ventures (Duncan, 1990). Geologically, the district lies within a favorable succession of Proterozoic volcanogenic metamorphic rocks known as the Green Mountain terrane. In similar rocks of the Sierra Madre and Laramie Range to the west and east of the Medicine Bow Mountains, volcanogenic massive sulfides and a copper-gold porphyry have been identified. The Geological Survey of Wyoming began a study of this district during the past field season as a follow-up to an inquiry by Red Mountain Mining Company.

Preliminary mapping by the State Survey shows the belt to consist of an isoclinally folded metamorphosed succession of amphibolite grade gneisses and schists. Samples collected from various prospects in the district yielded 26 parts per million (ppm) to 1.39% Cu, none to 0.1% Pb, 29 ppm to 0.43% Zn, none to 4.0 ounce per ton (opt) Ag, and none to 0.07 opt Au (**Table 14**). The samples collected to date verify the presence of localized zones of anomalous copper, lead, zinc, silver, and gold.

Rattlesnake Hills

During the 1993 field season, the author mapped approximately 40 square miles of previously undifferentiated Archean rocks of the Rattlesnake Hills supracrustal terrane in the Granite Mountains, 50 miles west of Casper. Prior

Table 14. Geochemical analyses of rock samples from the Jelm Mountain district (*analyses by Robert W. Gregory, Geological Survey of Wyoming*).

Sample no.	Cu	Pb (ppm)	Zn	Ag (ppm)	Au (ppm)
JM1-93	0.63%	9.7	286 ppm	nd	nd
JM2-93	889 ppm	989	103 ppm	51.0	0.7
JM3-93	65 ppm	116	884 ppm	1.9	nd
JM4-93	36 ppm	24	201 ppm	137.0	nd
JM5-93	26 ppm	8.3	59 ppm	nd	nd
JM6-93	904 ppm	276	0.43%	5.8	nd
JM7-93	32 ppm	nd	29 ppm	nd	nd
JM8-93	0.38%	62	80 ppm	3.0	nd
JM9-93	0.21%	12	87 ppm	nd	nd
JM10-93	1.39%	16	110 ppm	12.0	nd
JM11-93	0.18%	955	184 ppm	88.0	2.3

nd = not detected

to this study, very little geological information had been published on this terrane.

Economic interest in the Rattlesnake Hills had been minor until significant gold anomalies were independently identified by the Geological Survey of Wyoming in 1982 (Hausel and Jones, 1982), and by American Copper and Nickel Company in 1983 (John T. Ray, personal communication). Currently, three companies are involved with gold projects in this area.

The Rattlesnake Hills supracrustal belt consists of refolded Archean metamorphic rocks intruded by several Tertiary (42 Ma) alkalic plugs and dikes (Pekarek, 1977). The Precambrian belt is dominated by a thick metagreywacke succession with chemistries similar to those reported for the South Pass (Condie, 1967; Hausel, 1987; 1991) and the Seminoe Mountains greenstone belts (Hausel, 1993b). Many of the metagreywacke beds are relatively alumina-rich which made them favorable for the production of alumino-silicate porphyroblasts during prograde metamorphism. X-ray diffraction patterns of some porphyroblasts indicate the presence of cordierite.

The metagreywacke succession contains a two to five-thousand-foot thick metatholeiitic volcanic complex of metagabbro, metabasalt, and uncommon graphitic schist. This complex hosts the Lost Muffler vein with a strike length of nearly 1.5 miles. The vein is localized near or along the contact between the metatholeiites and metagreywackes, and consists of quartz, metachert, minor jasperoid, and sulfides. Sulfides include pyrite and uncommon galena. Assays of vein material (samples LMP82-1, LMP82-2, LMP82-3, LMP82-4, RH1-92, RH2-92, RH3-92, RH44-92, RH21-93, and RH23-93) range from <0.2 to 2.0 ppm Ag, <5 parts per billion (ppb) to 7.55 ppm Au, 38 ppm to 0.04% Cu, 11 ppm to 0.13% Pb, and <0.010 ppm to 0.021 ppm Hg (**Table 15**).

The metagreywacke succession is structurally underlain by 2,500 feet of metavolcanics dominated by well-preserved pillow metabasalts and amphibolites with minor intercalated ultramafics and intermediate metavolcanics. In the vicinity of three Tertiary alkalic plugs - Goat Mountain, Sandy Mountain, and an unnamed plug in sections 23, 24, and 25, T32N, R88W, the metatholeiites and metagreywackes have been brecciated and are locally gossaniferous.

Samples of brecciated Precambrian rock along the flanks of the Tertiary plugs (samples RH20-92, RH22-92, RH29-92, RH8-93, RH13-93, and RH14-93) yielded <5 ppb to 925 ppb Au, and 37 ppm to 0.14% Cu (**Table 15**). Some samples yielded anomalous arsenic (25 ppm to 1.65% As) and mercury (0.012 ppm to 0.078 ppm Hg). Samples of a breccia vein within this disrupted succession yielded 92 ppb to 367 ppb Au (samples RH23-92, RH31-92, RH32-92, and RH33-92). The Tertiary volcanics which disrupted the Precambrian rocks are also anomalous in gold. Composite chip samples of volcanic rock collected along the flank of Sandy Mountain (samples RH19-93A and RH20-93) yielded 44 ppb and 370 ppb Au, respectively (**Table 15**).

Table 15. Geochemical analyses of rock samples from the Rattlesnake Hills district (*analyses by Bondar-Clegg*).

sample no	Ag	Au	Zn	As	Sb	Cu	Pb	Hg
RH1-92	1.2	114	35	88	38.6	38	197	<0.01
RH2-92	1.8	21	90	124	2	432	1307	<0.01
RH3-92	2	52	59	20	1.4	123	61	0.021
RH9-92	<0.2	8	33	75	3.3	57	16	<0.01
RH11-92	0.9	26	25	213	1.8	614	<2	0.139
RH13-92	1.1	29	253	110	1.6	423	9	0.013
RH15-92	0.2	157	18	1080	11	263	41	<0.01
RH18-92	0.5	16	53	68	4.6	22	11	<0.01
RH20-92	1.2	925	12	16500	8.2	524	42	0.028
RH22-92	0.6	<5	37	91	1.5	37	16	0.012
RH23-92	0.2	92	4	131	0.4	125	8	0.372
RH29-92	0.5	300	-	-	-	-	-	-
RH30-92	1.8	<5	-	-	-	-	-	-
RH31-92	<0.2	367	52	4720	2.5	835	12	0.101
RH32-92	1.7	109	4	8820	3.1	37	<2	<0.01
RH33-92	0.56	164	17	543	0.8	163	55	0.083
RH35-92	<0.2	800	-	-	-	1000	-	-
RH36-92	0.28	300	-	-	-	-	-	-
RH37-92	<0.2	5000	-	-	-	-	-	-
RH43-92	<0.2	<5	-	-	-	-	-	-
RH44-92	1.5	10	-	-	-	-	-	-
RH3-93A	<0.2	<5	34	-	-	49	7	-
RH6-93	<0.2	28	42	290	7	285	17	0.043
RH8-93	<0.2	103	78	222	6	128	67	0.04
RH9-93	11	-	-	-	-	-	-	-
RH13-93	<0.2	9	297	36	8	62	11	0.078
RH14-93	<0.2	29	95	25	7	1369	14	0.015
RH19-93A	<5	370	<200	345	11	-	-	-
RH20-93	<5	44	<200	103	4.1	-	-	-
RH21-93	<0.2	31	309	95	<5	167	13	<0.010
RH23-93	<0.2	<5	137	<5	7	130	11	<0.010
LMP82-1	-	7550	-	-	-	-	-	-
LMP82-2	-	4460	-	-	-	-	-	-
LMP82-3	1.03	1030	-	-	-	-	-	-
LMP82-4	-	1370	-	-	-	-	-	-

"-" means not detected; all values in parts per million (ppm).

The mafic metamorphic rocks are underlain by a succession dominated by metasedimentary rocks containing banded iron formation, metapelite, and amphibolite. Samples of the banded iron formation (RH30-92, RH37-92, and RH9-93) yielded <5 ppb to 5.0 ppm Au (**Table 15**). Other iron formation samples collected for whole rock analysis yielded 15.62% to 64.74% Fe_2O_3 with 23.13% to 79.12% SiO_2.

The supracrustals lie in contact with gneiss along the southwestern flank of the belt which has been fractured and rehealed producing a stockworks-like network of veinlets. A sample of the iron-stained gneiss (RH36-92) yielded 300 ppb Au (**Table 15**).

The preliminary results verify the presence of anomalous gold in Archean structures as well as in the Tertiary volcanics, breccias, and jasperoids in the district. Further work will be directed at sampling placers and paleoplacers in the district.

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1993)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.5	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.1	billion barrels
Remaining Reserve Base (January 1, 1993)		
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.37	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.17	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1993)		
Discovered (Includes 20.1 trillion cubic feet (TCF) of methane[1] and 122.0 TCF of CO_2[3])	141.1	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,848.3	trillion cubic feet
Remaining Reserve Base (January 1, 1993)		
Measured reserves (Proved reserves) (Includes 11.3 TCF of methane[2] and 60.6 TCF of CO_2[3])	71.9	trillion cubic feet

COAL

Remaining Resources (January 1, 1993)		
Identified and Hypothetical (Discovered)	1,428.2	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,459.7	billion tons
Remaining Reserve Base (January 1, 1993)		
Demonstrated strippable (Measured and indicated reserve base)	26.6	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	69.1	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, 1993, U.S. crude oil, natural gas, and natural gas liquids reserves: 1992 Annual Report, October, 153 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.

GEOLOGIC MAPPING AND STRATIGRAPHY

by Alan J. Ver Ploeg
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DENVER CORE CENTER WILL HOUSE WYOMING DRILL SAMPLES

The U.S. Geological Survey's Core Research Center in Denver, Colorado, recently acquired a major collection of drill cuttings and chip samples from American Stratigraphic (Amstrat). The collection totals nearly 230 million feet of samples from over 50,000 wells located in 25 states. The addition will supplement the Core Research Center's current inventory of over 1.4 million feet of core. Personnel of the Core Research Center are currently sorting and shelving the collection and hoped to have the samples available for examination by January 1994. The Core Research Center is also building a new cuttings observation room. The room will be equipped with individual cubicles, tables, microscopes, UV boxes, chemicals, vented hood, and sink, etc. The facility should be completed and opened for public use in June, 1994. According to latest estimates, the Core Research Center houses 2,840 sets of core and 18,389 sets of drill cuttings from Wyoming wells.

The U.S. Geological Survey has no funding to offset the $250,000 cost of incorporating the Amstrat samples into the Core Center. As a result, a committee for preservation of the samples has been formed to raise funds to help cover the costs. A tax deductible contribution to help save this collection can be made to:

RMAG Cuttings Preservation Account
Rocky Mountain Association of Geologists
730 17th Street, Suite 350
Denver, CO 80202

NEW PALEONTOLOGICAL FINDS IN WYOMING

During the past field season, a team from the Museum of the Rockies worked on the excavation of a relatively well-articulated *Diplodocus* north of Shell, Wyoming (**Figure 22**). This plant-eating dinosaur was found beneath the famous "Big Al" site (Jurassic Morrison Formation) where a complete, articulated *Allosaurus* was excavated by a team from this museum in the summer of 1991 (See *Wyoming Geo-notes No. 32*, p. 40-41). Team members feel the

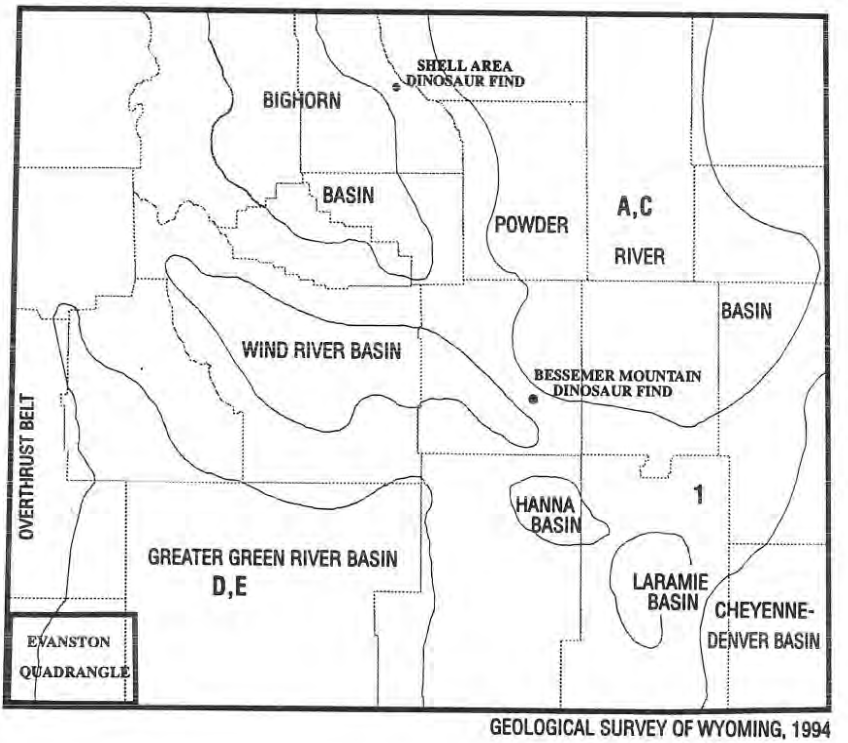

Figure 22. Index to selected geologic activities and recently released maps and reports on Wyoming geology.

meat-eating *Allosaurus* may have come to feed on the plant eating *Diplodocus*, which may have been embedded in a muddy area and unable to escape. Some *Allosaurus* teeth were found near the remains of the *Diplodocus*, supporting this theory.

A recent study contracted by Rissler & McMurry Construction Company in the vicinity of their limestone mine on Bessemer Mountain near Casper, (**Figure 22**) identified 13 sites with well preserved vertebrate fossils. Michael Leite, who conducted the study, indicated that the fossils were primarily from one species of nothosaurs, a reptilian group specialized for aquatic propulsion similar to the more advanced plesiosaurs. The fossils were found in the Alcova Limestone Member of the Triassic Chugwater Formation (205-240 million years before present). Leite's findings, plus five previous sites found, brings the total to 15 in the area. The nothosaur remains in the Alcova Limestone represent the only

known occurrences of these reptiles in the New World. They are well known from numerous localities in Europe and China. Leite recommends that the sites be excavated and that the fossils be housed in a museum where they would be available for research. Rissler & McMurry's mine plan provides for the removal of significant fossils and for monitoring of the future quarrying activities so that new discoveries can be reported and safely removed.

NEW JOURNAL ARTICLES ON WYOMING GEOLOGY

Two new articles on Wyoming geology appeared in the November issue of *Geology*. Chamberlain, and others (1993) discuss deformation of the Archean Wyoming province in the southeastern portion of Wyoming. The belt of rocks described in this article provides evidence for the reactivation of a block of Archean crust which was uplifted during the development of the Cheyenne belt collision zone approximately 1.8 billion years ago. The second article, written by Heller, and others (1993), examines subtle topographic uplifts which occurred throughout the Rocky Mountain area during middle and late Mesozoic time. The authors discuss the causes and the prediction of these types of features along with their effect on the stratigraphic record of that time.

Both of these articles are listed below and the study area for the first article is indicated by a "1" on the accompanying index map (**Figure 22**). The second article refers to Wyoming and the Rocky Mountain area in general.

1. Chamberlain, K.R., Suresh, C.P., Frost, B.R., and Snyder, G.L., 1993, Thick-skinned deformation of the Archean Wyoming province during Proterozoic arc-continent collision: Geology, v. 21, p. 995-998.

Heller, P.L., Beekman, F., Angevine, C.L., and Cloetingh, S.A.P.L., 1993, Cause of tectonic reactivation and subtle uplifts in the Rocky Mountain region and its effect on the stratigraphic record: Geology, v. 21, p. 1003-1006.

NEW U.S. GEOLOGICAL SURVEY GEOLOGIC MAP OF SOUTHEAST WYOMING

The U.S. Geological Survey recently published a new, color, 30' X 60', geologic map covering a portion of southeast Wyoming including Evanston. The map is 1:100,000-scale. There are now four 30' X 60' quadrangles completed in Wyoming (see Figure 25 in *Wyoming Geo-notes No. 39*, p. 50, for the location of the previous three). This new publication is listed below and shown on the index map in **Figure 22**.

1. Dover, J.H., and McGonigle, J.W., 1993, Geologic map of the Evanston 30' X 60' Quadrangle, Uinta and Sweetwater Counties, Wyoming: U.S. Geological Survey Miscellaneous Investigation Map I-2168, scale 1:100,000.

NEW U.S. GEOLOGICAL SURVEY PUBLICATIONS ON WYOMING GEOLOGY

The U.S. Geological Survey recently released five new reports on the geology and hydrology of Wyoming. Four of the reports emphasize work on the stratigraphy of Wyoming, focusing on the Triassic rocks of the Powder River Basin; Cambrian through Mississippian rocks of the Powder River Basin; Baxter Shale, Blair Formation, and Rock Springs Formation on the Rock Springs uplift; and the Fox Hills Sandstone, Lewis Shale, and Lance Formation in southwest Wyoming. The two Powder River Basin reports are a product of the U.S. Geological Survey's Evolution of Sedimentary Basins - Powder River Basin Project. The fifth report deals with characteristics of fluvial systems in Wyoming.

Each of these reports is listed below and the study area is located geographically on the accompanying index map (**Figure 22**).

A. Johnson, E.A., 1993, Depositional history of Triassic rocks in the area of the Powder River Basin, northeastern Wyoming, and southeastern Montana: U.S. Geological Survey Bulletin 1917-P, 30 p.

B. Lowham, H.W., and Smith M.E., 1993, Characteristics of fluvial systems in the plains and deserts of Wyoming: U.S. Geological Survey Water Resources Investigations Report 91-4153, 57 p.

C. Macke, D.L., 1993, Cambrian through Mississippian rocks of the Powder River Basin, Wyoming, Montana, and adjacent areas: U.S. Geological Survey Bulletin 1917-M, 174 p.

D. Roehler, H.W., 1993, Coastal sedimentation along a segment of the interior seaway of North America, Upper Cretaceous Baxter Shale, and Blair and Rock Springs Formations, Rock Springs uplift, southwest Wyoming: U.S. Geological Survey Bulletin 2051, 31 p.

E. Roehler, H.W., 1993, Stratigraphy of the Upper Cretaceous Fox Hills Sandstone and adjacent parts of the Lewis Shale and Lance Formation, east flank of the Rock Springs uplift, southwest Wyoming: U.S. Geological Survey Professional Paper 1532, 57 p.

GEOLOGIC HAZARDS IN WYOMING

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EARTHQUAKES IN WYOMING, 1991-1993

Between 1991 and 1993, Wyoming experienced 37 earthquakes with magnitudes greater than 2.8. There were 21 such earthquakes in 1993 (**Table 16, Figure 23**), 9 in 1992 (**Table 17, Figure 24**), and 7 in 1991 (**Table 18, Figure 25**). In addition, a few earthquakes that occurred in neighboring states were also felt in Wyoming. Numerous other small earthquakes occurred in the State, especially in the Yellowstone National Park area, but they were generally not felt. Fortunately, little earthquake-related damage has occurred in Wyoming over the last three years. Summaries of these 37 earthquakes as well as others near Wyoming are presented below. The earthquake information was obtained from the National Earthquake Information Center in Golden, Colorado, and the U.S. Bureau of Reclamation in Denver, Colorado.

Table 16. 1993 earthquakes in or adjacent to Wyoming (magnitudes $\geq$ 2.8).

Date	Magnitude	Latitude	Longitude	Description
1-02-93	3.5	44.902N	110.962W	Yellowstone National Park. No damage.
2-25-93	3.9	44.932N	106.062W	Northeastern Sheridan County. No damage reported.
3-7-93	3.1	44.546N	110.904W	Yellowstone National Park. No damage reported.
3-10-93	3.2	43.399N	106.617W	Seventeen miles west of Midwest. No damage reported.
3-30-93	3.4	44.577N	111.185W	Hebgen Lake area (Montana). No damage reported.
4-1-93	3.1	43.624N	110.196W	Eastern Teton county. No damage reported.
4-14-93	3.3	44.813N	110.972W	Yellowstone National Park. No damage reported.
6-01-93	3.8	42.28 N	107.521W	Bairoil area. Felt as Intensity III at Bairoil. No damage reported.
6-10-93	2.9	44.93 N	111.003W	Yellowstone National Park. No damage reported.
6-30-93	3.0	42.985N	105.373W	Fifteen miles north of Douglas. No damage reported.
7-23-93	3.7	42.478N	105.703W	South-central Converse County. Felt as Intensity IV in the Laramie Peak area. Slightly felt in Laramie. No damage reported.
8-05-93	3.3	44.818N	110.992W	Yellowstone National Park. No damage reported.
8-19-93	3.7	44.803N	110.941W	Yellowstone National Park. No damage reported.
8-23-93	3.1	43.576N	109.921W	Northwest Fremont County, north of Fish Lake Mountain. No damage reported.

Table 16. 1993 earthquakes (Continued).

Date	Magnitude	Latitude	Longitude	Description
8-23-93	3.0	42.033N	106.837W	Seminoe Reservoir area. No damage reported.
9-04-93	2.9	42.308N	110.247W	Calpet area (northwest of La Barge). No damage reported.
10-10-93	3.7	42.421N	105.868W	Northern Albany County. Felt in Garrett area. No damage reported.
10-10-93	3.1	43.289N	110.973W	Northern Lincoln County, north of Alpine. No damage reported.
11-16-93	3.5	43.884N	107.384W	Ten miles south of Tensleep. No damage reported.
11-26-93	3.8	43.487N	110.180W	Eastern Teton County, near Sunday Peak. No damage reported.
12-13-93	3.5	42.3 N	105.5 W	Northern Albany County southern Converse County area. No damage reported.
12-28-93	4.7	43.493N	110.192W	Eastern Teton County, near Sunday Peak. Felt as Intensity II-III at Jackson, Dubois, Hudson, Lander, and Rock Springs. Felt as Intensity III-IV at Darwin Ranch.

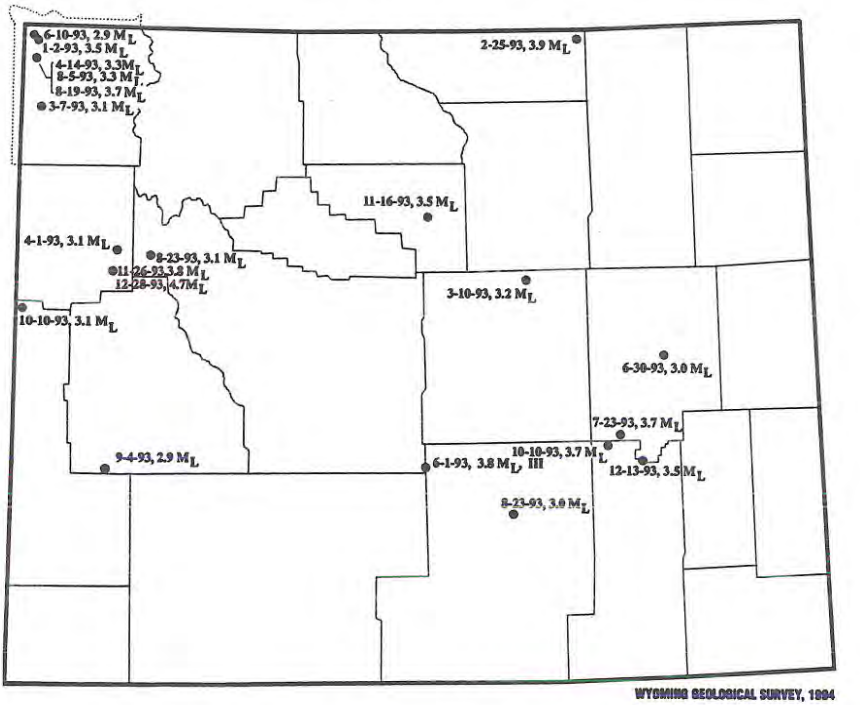


Figure 23. Map of 1993 earthquake epicenters in Wyoming (M_L =magnitude).

Table 17. 1992 earthquakes in or adjacent to Wyoming (magnitude ≥ 2.8).

Date	Magnitude	Latitude	Longitude	Description
1-31-92	2.8	43.020N	108.947W	Fort Washakie area. Felt at Lander. No damage reported.
2-22-92	2.9	44.324N	106.317W	East of Buffalo. No damage reported.
4-04-92	4.0	43.832N	111.078W	Eastern Idaho, near Alta. Felt as Intensity III at Moose and Wilson. Also felt in Idaho at Ashton, Driggs, Rexburg, Victor, Tetonia, and St. Anthony, and in Wyoming at Alta and Jackson. No damage reported.
7-20-92	3.7	44.55 N	110.308W	Yellowstone National Park. Felt in parts of the Park. No damage reported.
8-31-92	3.6	43.825N	107.041W	Bighorn Mountains near Mayoworth. Felt in Barnum and Kaycee. No damage reported.
9-24-92	3.7	43.706N	110.387W	Mount Leidy area in central Teton County. No damage reported.
10-10-92	4.0	42.822N	108.277W	Approximately twenty miles east of Lander. Felt as Intensity III at Hudson and Lander. No damage reported.
11-03-92	3.0	42.74 N	104.389W	Lusk area. Felt as Intensity V at Lusk and Intensity II at Manville. No damage was reported.
11-10-92	4.8	43.07 N	111.366W	Eastern Idaho, west of the Star Valley in Wyoming (Not shown on map). Felt as Intensity V at Wayan, Idaho, and at Grover, and Alpine, Wyoming. Felt as Intensity IV at Afton, Bedford, Etna, Smoot, and Thayne. No significant damage was reported.
11-10-92	4.9	43.09 N	111.418W	Eastern Idaho, west of the Star Valley in Wyoming (Not shown on map). Felt as Intensity V at Wayan, Idaho and Grover, Wyoming. Felt as Intensity IV at Alpine, Freedom, and Thayne, Wyoming. Felt as Intensity III at Afton, Etna, and Fairview, Wyoming. No significant damage was reported.
11-11-92	4.4	43.002N	111.470W	Eastern Idaho, west of the Star Valley in Wyoming (not shown on map). Felt as Intensity V at Wayan, Idaho. Felt as Intensity II at Alpine and Freedom, Wyoming.
11-16-92	3.4	43.017N	111.533W	Eastern Idaho, west of Alpine, Wyoming (not shown on map). Felt as Intensity V at Wayan, Idaho. Felt as Intensity III at Alpine, Wyoming.
12-28-92	3.2	44.678N	110.994W	Yellowstone National Park. No damage reported.
12-28-92	3.0	33.702N	110.958W	Yellowstone National Park. No damage reported.

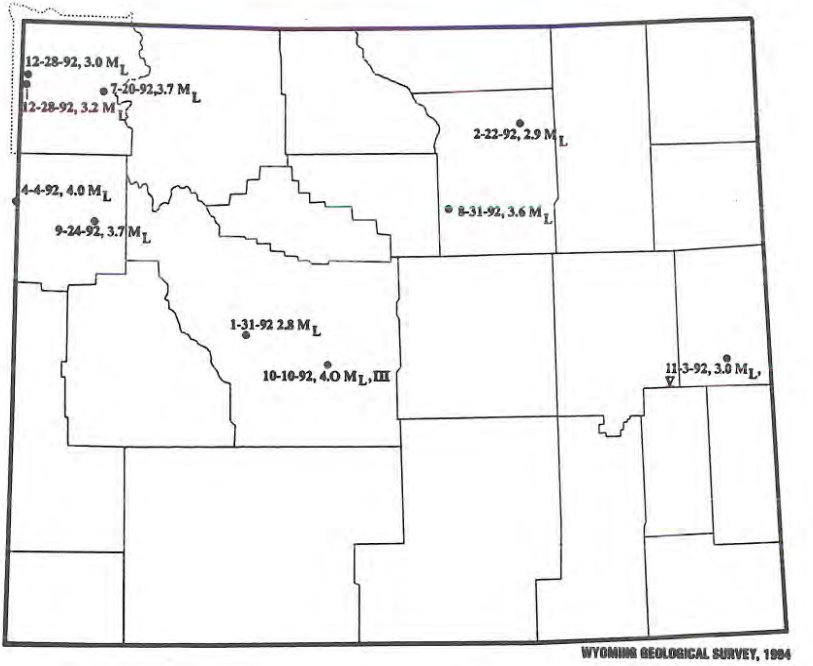


Figure 24. Map of 1992 earthquake epicenters in Wyoming (M_L =magnitude).

Table 18. 1991 earthquakes in or adjacent tot Wyoming (magnitudes ≥ 2.8).

Date	Magnitude	Latitude	Longitude	Description
2-12-91	3.1	44.795N	111.109W	Hebgen Lake area (Montana). No damage reported.
2-12-91	3.1	44.795N	111.110W	Hebgen Lake area (Montana). No damage reported.
4-13-91	3.0	42.031N	106.857W	Seminoe Reservoir area. No damage reported.
4-19-91	2.9	42.07 N	106.856W	Seminoe Reservoir area. No damage reported.
8-07-91	3.5	43.501N	108.86 W	Owl Creek Mountains area. Felt inThermopolis. No damage reported.
8-14-91	3.0	43.368N	110.669W	Jackson area. No damage reported.
9-30-91	3.2	43.478N	110.235W	Gros Ventre Range. No damage reported.
11-18-91	3.0	42.737N	111.121W	Eastern Idaho, west of Afton, Wyoming. No damage reported.
12-18-91	3.1	41.936N	106.917W	Seminoe Reservoir area. No damage reported.
12-29-91	3.0	44.767N	110.817W	Yellowstone National Park. No damage reported.

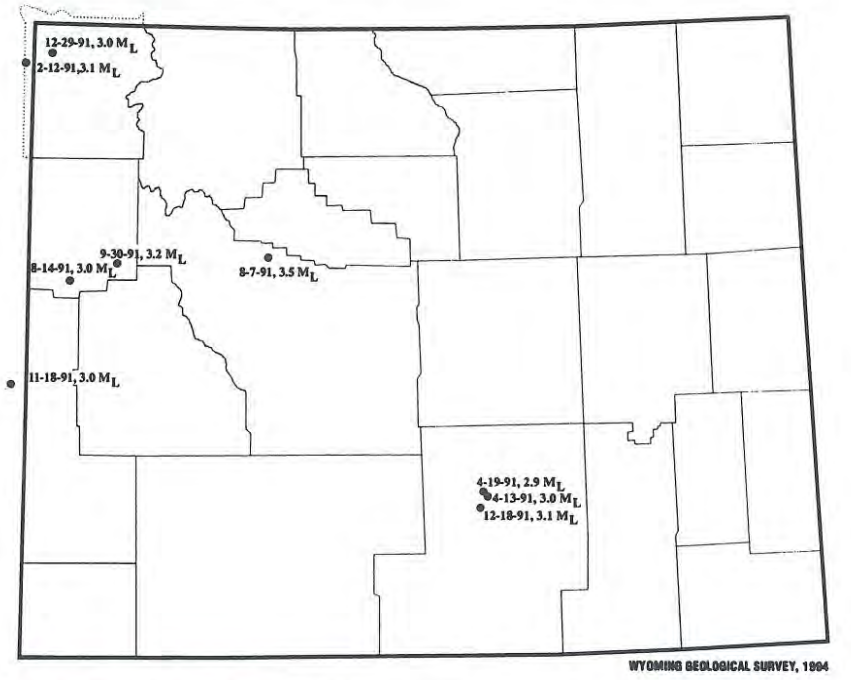


Figure 25. Map of 1991 earthquake epicenters in Wyoming (M_L =magnitude).

NEW ROCKY MOUNTAIN GAS ATLAS AVAILABLE

The Geological Survey of Wyoming announces the publication of the *Atlas of major Rocky Mountain gas reservoirs*. The 17"x22" atlas contains over 200 pages and includes descriptions of 66 major gas plays in Wyoming, Colorado, New Mexico, and Utah as well as sections on coalbed methane, low-BTU gas, sequence stratigraphy, and engineering analyses of typical reservoirs. Color plates illustrate the age and lithology of the reservoirs in each state, the major tectonic elements and major pipelines in the four-state area, and the stratigraphic relationships in the most productive gas basins of the four states. A computer database contains geologic, engineering, and production information for each of 861 reservoirs with cumulative gas production greater than 5 billion cubic feet. The database and sequence stratigraphy references are included on floppy disks.

The atlas, which was jointly prepared by the state geological surveys of Wyoming, Colorado, New Mexico, and Utah, also contains major contributions from Barlow & Haun, Inc., Intera-Bergeson, Inc., and Methane Resources Group, Ltd. The atlas, which was partially funded by the Gas Research Institute and the U.S. Department of Energy, was published by the New Mexico Bureau of Mines and Mineral Resources. The publication is a valuable resource for exploration and production companies, gas pipeline and processing companies, gas investors, gas consumers, and geologists and engineers in all phases of the natural gas industry.

The Wyoming portion of the atlas contains descriptions of the Wind River and Wasatch, Fort Union, Almy, Lance, Lewis and Fox Hills, Mesaverde, Cody, Frontier, Muddy, Bear River, Dakota/Fall River, and Phosphoria plays as well as Rocky Mountain foreland structure plays in the Powder River, Bighorn, Wind River, and Greater Green River basins and Thaynes, Weber, Madison/Mission Canyon, and Bighorn plays in the Thrust Belt. Some plays shared with other states are covered in other sections of the atlas.

The *Atlas of major Rocky Mountain gas reservoirs* is available over-the-counter from the Geological Survey of Wyoming in Laramie. The price is $99.75 per copy. For mail and phone orders, contact the New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico, 87801 or phone (505) 835-5410.

NEW BOOK ON THE GEOLOGY OF WYOMING HONORS TWO DISTINGUISHED WYOMING GEOLOGISTS

Two well-known geologists from Laramie, Dr. Donald L. Blackstone, Jr., and Dr. J. David Love, have recently been honored for their contributions to Wyoming geology by the dedication of a new two-volume book. The book, entitled *Geology of Wyoming*, was prepared and published through a cooperative effort of the Geological Survey of Wyoming and the Department of Geology and Geophysics at the University of Wyoming.

Dr. Blackstone has worked on the geology of Wyoming and the Rocky Mountain area since the 1930s. His Ph.D. thesis on the structural geology of the Pryor Mountains of southern Montana and northern Wyoming remains the definitive work for that area. Dr. Blackstone has been a teacher and scientist at the University of Wyoming since 1946. After retiring in 1974 from a teaching career that spanned four decades, he remains quite active today as an Emeritis Professor. As a leading authority on the structural geology of the Rocky Mountains, he continues to publish and give talks on his research. Dr. Blackstone's field mapping and structural geology courses are legendary

among several generations of University of Wyoming geology students. He has received the University of Wyoming's highest award for teaching and research as well as an honorary Doctor of Laws degree from the University.

Dr. Love has been working on the geology of Wyoming since the 1930s. His Ph.D. thesis is considered a classic, cornerstone work on the geology of the southern Absaroka Mountains. His outstanding career with the U.S. Geological Survey, which began in Wyoming in 1942, has continued past his official retirement in 1987. Dr. Love is known for his authorship of both the 1955 and 1985 geologic maps of Wyoming, for his mapping and geologic investigations in Jackson Hole and the Tetons, and for numerous definitive geologic reports on nearly every part of Wyoming. Dr. Love still maintains an office in Laramie and spends every summer in the field in northwestern Wyoming. He is a distinguished alumnus of the University of Wyoming and also holds an honorary Doctor of Laws degree from the University.

The new publication, Memoir 5 of the Geological Survey of Wyoming, consists of two hardbound volumes totalling 938 pages plus a map pocket containing 7 oversize plates, a stratigraphic nomenclature chart, a basement configuration map of the State, and a highway geologic map of Wyoming. Thirty-two technical papers, authored by geoscientists at the University of Wyoming, the Geological Survey of Wyoming, and other orgainzations or institutions, appear in the two volumes, along with dedications to Dr. Blackstone and Dr. Love.

The publication is currently available over-the-counter or by mail from the Department of Geology and Geophysics, University of Wyoming, Box 3006, University Station, Laramie, Wyoming 82071, Phone (307) 766-3386. A flyer listing the articles contained in the publication plus an order form can be obtained from the above address or from the Geological Survey of Wyoming in Laramie.

CALENDAR OF EVENTS

Society of Organic Petrology, 11th Annual Meeting, September 25-30, 1994, Jackson, Wyoming. Information: Ron Stanton, U.S. Geological Survey, 956 National Center, Reston, VA 22092, phone (703) 648-6462, FAX (703) 648-6419, E-mail rstanton @ ncrds.vsgs.er.gov. In cooperation with the Coal Section of the Geological Survey of Wyoming.

International Industrial Minerals Forum, 32nd Annual Meeting, May 1996, Laramie, Wyoming. Information: Ray Harris, Geological Survey of Wyoming, Box 3008, University Station, Laramie, WY 82071, phone (307) 766-2286, FAX (307) 766-2605.

National Association of State Boards of Geology, Annual Meeting, October 9-14, 1995, Jackson Lake Lodge. In cooperation with the Wyoming Board of Registration for Professional Geologists, phone (307) 766-2490.

Association of Earth Science Editors, Annual Meeting, September 17-20, 1995, Jackson. In cooperation with the Geological Survey of Wyoming. Contact: Richard W. Jones, (307) 766-2286.

NEW PUBLICATIONS OF THE GEOLOGICAL SURVEY OF WYOMING

*Geology of Wyoming, dedicated to Donald L. Blackstone, Jr., and J. David Love, edited by A.W. Snoke, J.R. Steidtmann, and S.M. Roberts: Memoir 5, 1993.- $75.00 plus postage and handling. **Please note:** this is currently available only through the Department of Geology and Geophysics, University of Wyoming, P.O. Box 3006, University Station, Laramie, Wyoming 82071. Phone (307) 766-3386.

*Guide to the geology, mining districts, and ghost towns of the Medicine Bow Mountains and Snowy Range Scenic Byway, by W.D. Hausel: Public Information Circular 32, 1993.-$10.00

*Sixtieth Annual Report of the Geological Survey of Wyoming, Fiscal Year 1993, by G.B. Glass and S.G. Bruhnke.-free.

Precambrian basement map of Wyoming: outcrop and structural configuration, by D.L. Blackstone, Jr.: Map Series 43, 1993.- $5.00 (folded only).

Occurrences of radioactive elements in Lincoln County, Wyoming, by R.E. Harris, J.K. King, and W.D. Hausel: Open File Report 93-2, 1993.-$4.00.

Occurrences of radioactive elements in Hot Springs County, Wyoming, by R.E. Harris, J.K. King, and W.D. Hausel: Open File Report 93-3, 1993.-$3.00.

Occurrences of radioactive elements in Sheridan County, Wyoming, by R.E. Harris, J.K. King, and W.D. Hausel: Open File Report 93-4, 1993.-$3.00.

*Changing idealogies in Wyoming coal petrography, by J.C. Shearer: Reprint 55, 1994.-$3.00.

*Mining history and geology of some of Wyoming's metal and gemstone districts and deposits, by W. Dan Hausel: Reprint 56, 1994.-$3.00.

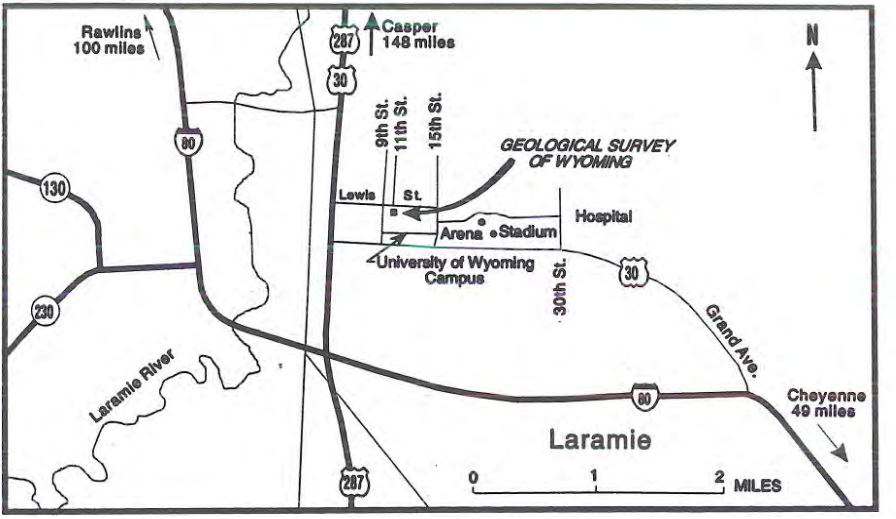
*The Geological Survey of Wyoming now sells the *Atlas of major Rocky Mountain gas reservoirs*, a publication jointly prepared by the State Geological

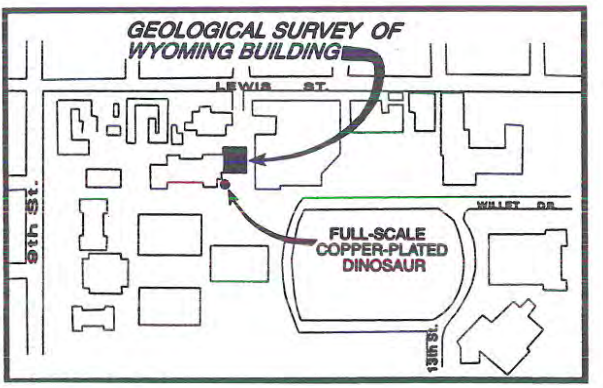
Surveys of New Mexico, Colorado, Utah, and Wyoming, and published by the New Mexico Bureau of Mines and Mineral Resources - $99.75. At the Geological Survey of Wyoming, this publication is only available for over-the-counter sales. Mail orders, prepaid, must be sent to the New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico 87801. Phone (505) 835-5410 (Price includes postage and handling).

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

Except for Memoir 5, *The Geology of Wyoming*, and the *Atlas of major Rocky Mountain gas reservoirs*, order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper Wyoming.

GEOLOGICAL SURVEY OF WYOMING
LOCATION MAPS





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