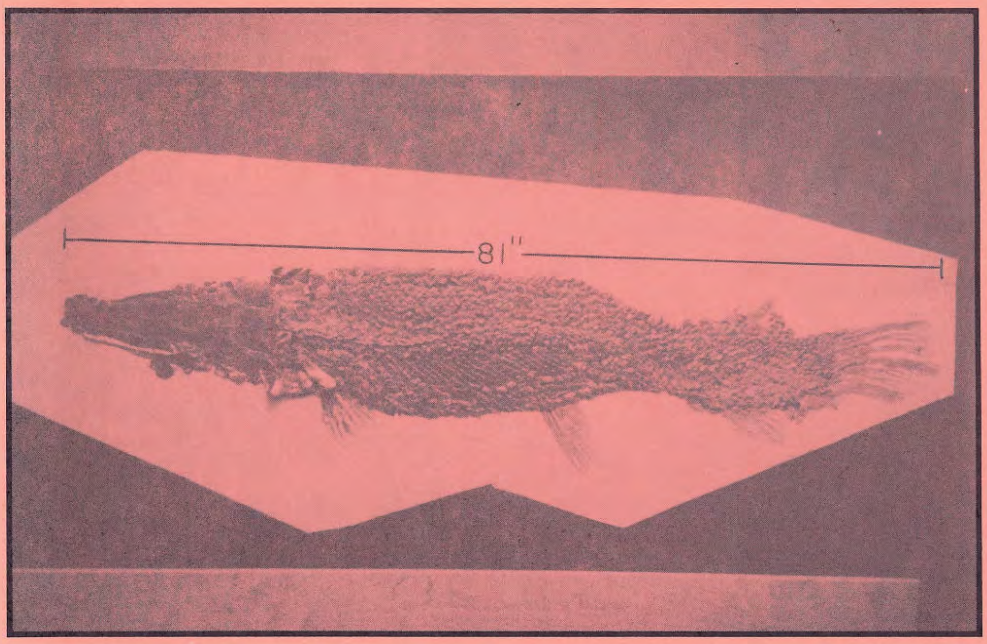
Wyoming Geo-notes

Number 43



Wyoming State Geological Survey
Gary B. Glass, State Geologist

Laramie, Wyoming
August, 1994

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WYOMING GEO-NOTES
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Cover: This is now the world's largest, complete, fresh-water, fossil fish. This gar (*Lepisosteus atrox*) measures 81 inches in length and would have had a live weight of about 225 pounds. It was discovered in the Eocene Green River Formation (50 million years old) at a commercial fossil quarry on State land near Kemmerer. Crews from Western Paleontological Laboratories volunteered to prepare it after they found it in 1992. The gar has just been put on display at the Geology Museum on the University of Wyoming campus in Laramie.

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MINERALS UPDATE

OVERVIEW

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

Let me start this quarterly overview by thanking the Heads of the Oil and Gas, Coal, Industrial Minerals and Uranium, and Metals and Precious Stones Sections for the invaluable assistance they give me. They answer my endless questions, they provide interim production and price information, and they prepare and(or) provide the data for the tables and figures that appear in each **Overview**. Without their help, the **Overview** would be immeasurably harder to write. Thanks also to Peggy Hopkins and Kim Mehring, who have assembled and formatted the recent issues of *Wyoming Geo-notes*, and to Phyllis Ranz who has created some of the computerized graphs.

The strong showing of coal production in the first quarter of this year has prompted an upward revision in our forecast coal production. We now estimate that coal production will at least increase to 220 million tons in 1994, an increase of 5% or 10.1 million tons over 1993 (**Table 1** and **Figure 1**). For comparison, coal production in the first quarter of 1994 has already exceeded last year's first quarter production by more than 16%. The new forecast is based on a resumption of traditional seasonal variations in monthly production for the remainder of 1994. This normal seasonal variation was not seen in 1993, however, as production increased steadily throughout most of the third and fourth quarters (see **Figures 13** and **14** on p. 20 and 22).

There are also several things happening that by the next issue of this quarterly could cause us to forecast 1994 coal production closer to 227 million tons or an 8% increase. Most notably there is an increase in demand at the same time that supply is tightening. In the former case, there is already an apparent increase in demand for low-sulfur western coal in response to the 1990 Amendments to the Clean Air Act. Twelve additional power plants started using Wyoming coal in 1993, and a report on the utilities in the Illinois Basin market area stated that 33% of those utilities affected by the Clean Air Act amendments would switch to low-sulfur western coal or use it for blending (p. 19 in the **Coal Update**).

In regard to supply, a recent survey of permitted capacities of coal mines in Wyoming shows that the mines are only at 52% of their maximum permitted capacity (see **Table 7** on p. 23). There is, however, a strong indication that the existing coal mines are at or near their online capacities. The time lag needed to expand online capacities will likely encourage utilities to take the maximum tonnages allowable in flexible contracts on the off chance that the greater tonnages might not be available when they are needed. Under these conditions, the record spot sale tonnages of the first quarter of 1994 are also not all that

Table 1. Wyoming mineral production (1981-1993) 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	—	—	102.7	11.2	4.6	—	0.05
1982	118.7	465.1	—	—	108.0	10.9	2.1	—	0.07
1983	120.9	539.8	—	—	112.2	11.6	3.0	—	0.57
1984	127.8	600.1	—	—	130.7	11.7	1.6	—	0.71
1985	131.0	597.9	—	—	140.4	11.8	0.6	—	0.80
1986	122.4	563.2	23.8	0.15	135.4	13.0	0.2	0.04	0.76
1987	115.9	628.2	114.2	0.86	146.5	13.6	0.2	0.06	1.19
1988	114.3	700.8	110.0	0.83	163.6	14.9	0.3	1.16	1.06
1989	109.1	739.0	126.1	0.94	171.1	16.2	0.1	1.07	1.17
1990	104.0	777.2	119.9	0.90	184.0	16.2	0.2	1.1	1.04
1991	99.8	820.0	140.3	1.05	193.9	16.2	0.4	1.1	1.18
1992	96.8	871.5	139.2	1.05	189.5	16.4	0.1	1.2	1.20
1993	87.7	910.1	140.8 est.	1.06 est.	209.9	16.0	—	1.1	1.20 est.
*1994	80.9	941.0	140.0	1.00	220.0	16.8	—	1.1	1.25
*1995	75.2	984.0	140.0	1.00	231.0	16.9	—	1.1	1.25
*1996	70.0	1,029.0	140.0	1.00	243.0	17.0	—	1.1	1.25
*1997	65.1	1,076.0	140.0	1.00	255.0	17.1	—	1.1	1.25

*Forecast production by Consensus Revenue Estimating Group (CREG) [Coal forecast revised by Wyoming State Geological Survey, July 1994].
[1]Adapted from CREG, Wyoming State Government Revenue Forecast FY94-FY98, January, 1994; [2]Millions of barrels (Source: Petroleum Information, 1993; Wyoming Oil & Gas Conservation Commission, 1981-1992); [3]Billions of cubic feet (primarily methane with some hydrogen sulfide and nitrogen) (Source: Petroleum Information, 1993; 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 (Source: Wyoming State Inspector of Mines, 1981-1993); [7]Millions of short tons of uranium ore (not yellowcake) (Source: Wyoming Department of Revenue, 1981-1992); [8]Millions of pounds of yellowcake (U_3O_8) (Sources: Wyoming Department of Revenue, 1986-1993; unknown between 1981-1985 because it was only reported as taxable valuation); [9]Millions of short tons (Source: Wyoming Oil & Gas Conservation Commission, 1981-1992).

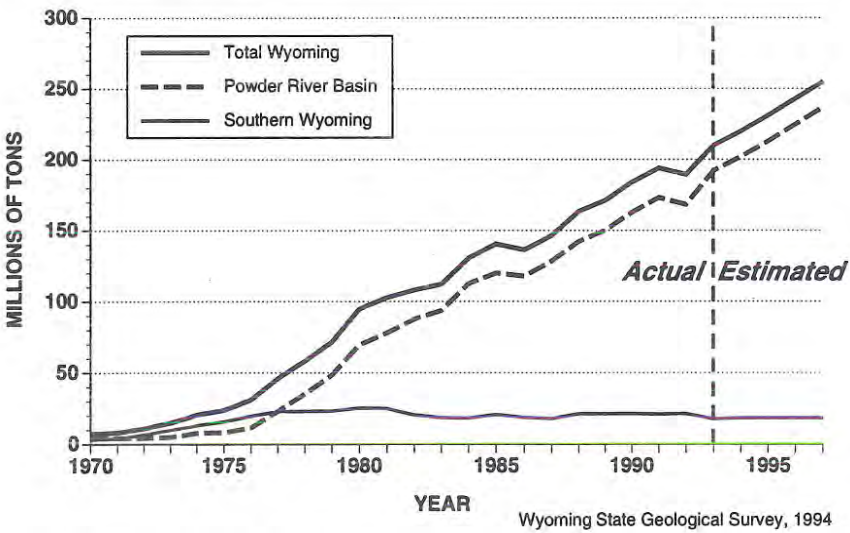


Figure 1. Annual coal production from Wyoming (1970-1993) with forecasts to 1997. *Data from the Wyoming Inspector of Mines (1970-1993) and the Wyoming State Geological Survey (1994-1997).*

surprising. Purchases may also increase as buyers hedge against higher prices likely to occur in a tighter market. The bottom line is that the new forecast tonnages between 1994 and 1997 may well be underestimated.

There is also some concern that rapidly expanding demand for Wyoming coal could be limited by the existing rail capacity, especially in the Powder River Basin. Fortunately, the coal hauling railroads have and are spending millions of dollars each year on maintenance, improvements, and expansions. There may, however, be a need to accelerate these efforts.

Natural gas production, on the other hand, is tracking well with the production forecast shown in **Table 1** and **Figure 2**. Production of 275 billion cubic feet (BCF) of natural gas through the first quarter of 1994 compares with 258 BCF in the same quarter of last year. While natural gas production should set another record in 1994, there has been concern expressed by some natural gas producers that the proposed Altamont gas pipeline from Canada to Opal would not only displace Wyoming gas, which is currently going into the Kern River Pipeline, but also decrease the price. The major concern is that there is not a large enough California market for the anticipated increase in supply that would come with the Altamont line. In a recent natural gas marketing conference held in Denver, however, there was some optimism that other markets are materializing (p. 11 in the **Oil and Gas Update**). And not everyone is certain that the Altamont line will be built in the foreseeable future.

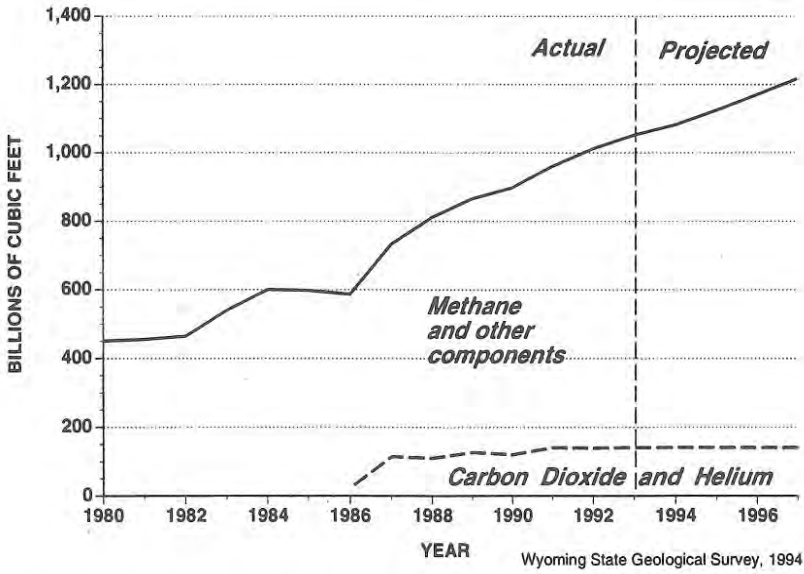


Figure 2. Annual natural gas production from Wyoming (1980 to 1993) with forecasts to 1997.

Oil production is also following the forecast shown in **Table 1** and **Figure 3**. Comparing this year's first quarter production with that of last year, production is 1.6 million barrels less, or down 7%.

In regard to prices, there is an indication that the tightening supply of coal in the Powder River Basin of Wyoming has translated into some higher prices. An interruptable contract discussed in the **Coal Update** (p. 25) included accepted bids of $5.25 to $4.25 per ton. Our current estimates of coal prices, however, were not changed for this issue of *Wyoming Geo-notes* (**Tables 2** and **3** and **Figure 4**).

Although spot sale prices for natural gas at Opal fell in the first and second quarters (**Figure 5**), they started back up in the third quarter. The average spot price for the first six months of 1994, however, was $1.70 per thousand cubic feet, which compares with $1.91 in 1993. Natural Gas Futures, on the other hand, are currently holding at about $2.00 for the remainder of the year. The only forecast natural gas price in **Table 2** and **Figure 6** that was changed since the last issue of *Wyoming Geo-notes,* is the average price in 1993. It has been reduced by nine cents.

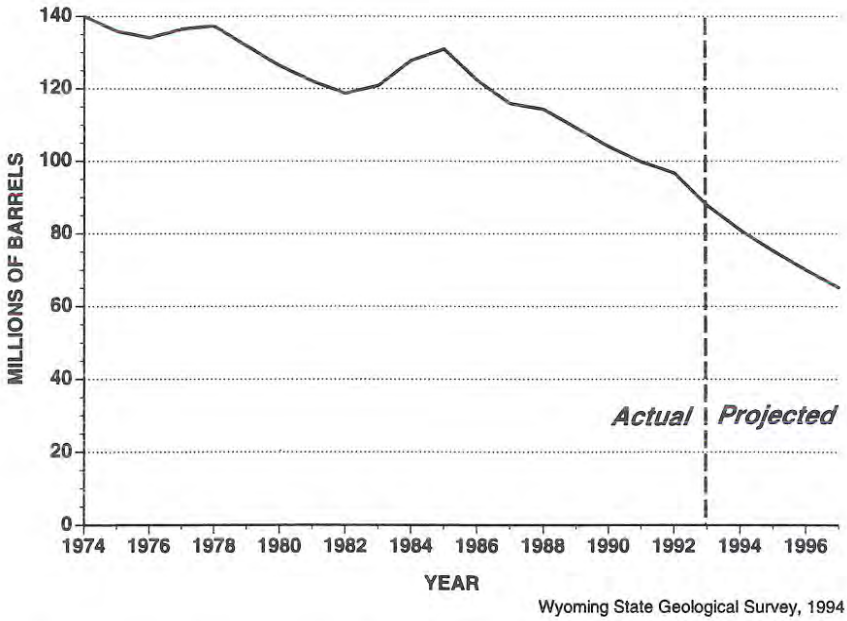


Figure 3. Annual oil production from Wyoming (1974 to 1993) with forecast to 1997.

Table 2. Average prices paid for Wyoming oil, methane, coal, trona, and uranium (1985-1993) 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	14.55	1.81	7.44 est.	41.00 est.	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, 1985-1993.
[3] Wellhead price in dollars per thousand cubic feet (MCF). Sources: Wyoming State Land and Farm Loan Office, 1989-1993 (derived from State royalty payments); Minerals Management Service, 1985-1988 (derived from Federal royalty payments).
[4] Dollars per short ton (weighted average price for coal mined by surface and underground methods). Source: Energy Information Administration, 1985-1992.
[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(or) surface-mined uranium). Source: Energy Information Administration, 1985-1990; Wyoming State Geological Survey estimates 1991-1997.

Table 3. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole (1988-1993) 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 est.	$18.86 est.	$7.44 est.
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

Falling oil prices, which leveled off in the first quarter, improved in the second quarter, providing some hope that the predicted average of $12.00/barrel in 1994 might be exceeded (**Figures 7** and **8** and **Table 2**). For the first six months of 1994, the first purchase price of Wyoming crude averaged $12.70, compared to $15.82 last year. Here again, Sweet Crude Futures provide some optimism since they are currently holding above $18.00/barrel for the remainder

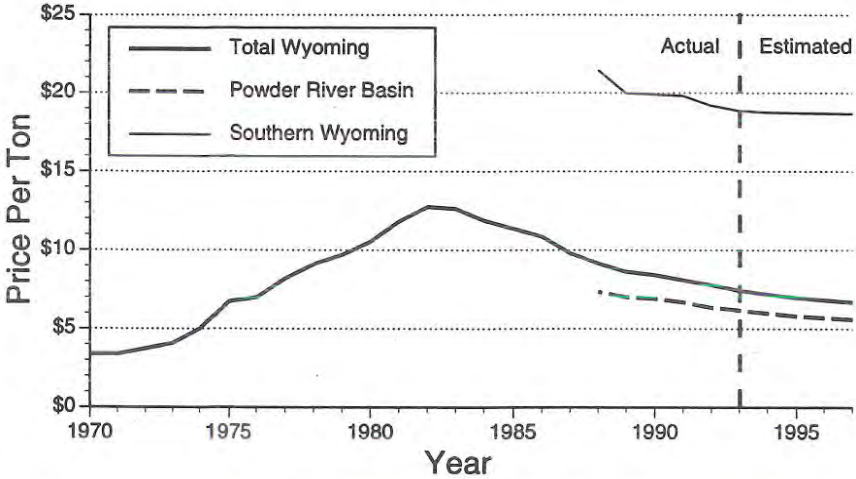


Figure 4. Average prices paid for Wyoming coal (1980 to 1992) with forecasts to 1997. *Data from the U.S. Energy Information Administration (1980-1992) and the Wyoming Consensus Revenue Estimating Group (1993-1997).*

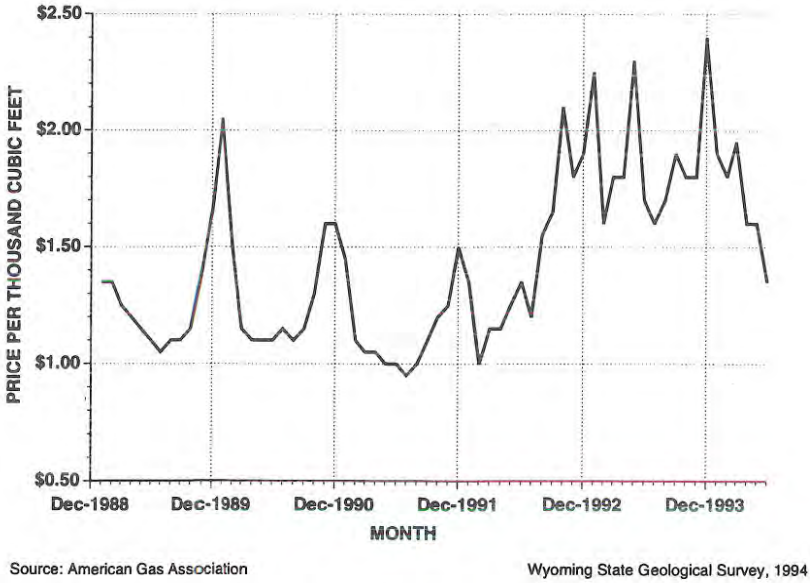


Figure 5. Spot prices for methane at Opal, Wyoming, averaged by month (1989 to present).

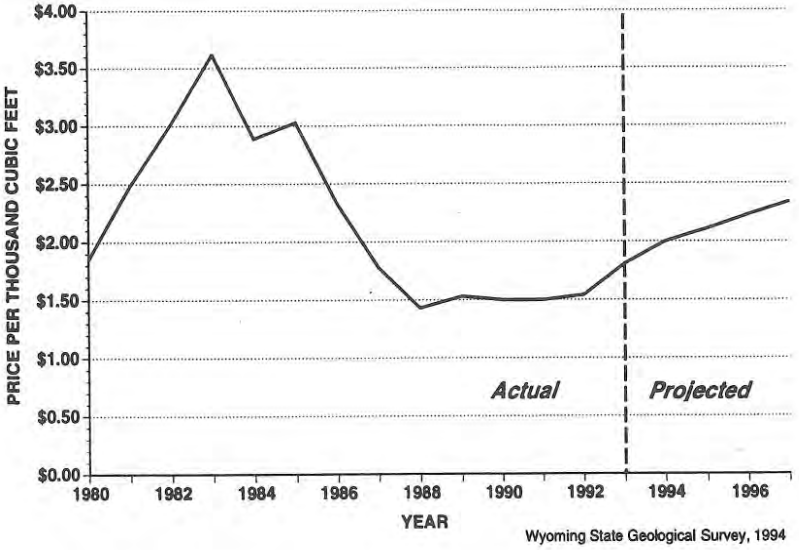


Figure 6. Average prices paid for Wyoming methane (1980 to 1993) with forecasts to 1997.

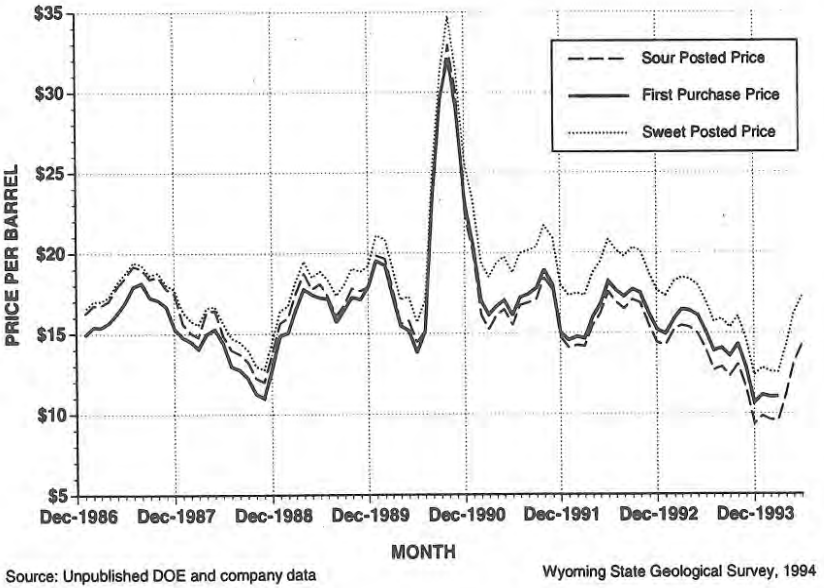
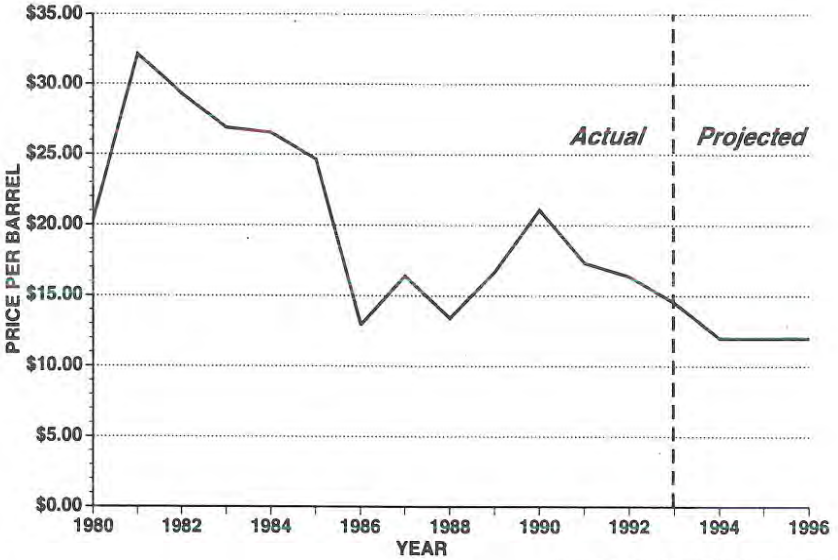


Figure 7. Wyoming posted Sweet and Sour crude prices and first purchase prices averaged by month (1987 to present).



Wyoming State Geological Survey, 1994

Figure 8. Average prices paid for Wyoming oil (1980 to 1993) with forecasts to 1997.

of the year. If those prices do hold, the average first purchase price for Wyoming crude could exceed $15.00/barrel for the last six months of the year, which would bring the yearly average closer to $14.00 than $12.00. In the case of oil prices, we increased the average price for 1993 by 5 cents, to $14.55/barrel.

The **Oil and Gas Update** notes that lease sales remained strong in the second quarter. If interest holds up for the last half of the year, 1994 could be the best year since 1988.

During this quarter, the U.S. Bureau of Mines released a special report on the availability of Federally owned minerals in Wyoming (Anderson and others, 1993). In regard to locatable minerals (uranium, iron, base and precious metals, and nonmetallic industrial minerals to include bentonite, gypsum, and limestone), they found that 58% of the Federally owned minerals in Wyoming were available without special legal or management restrictions to exploration or development (Anderson and others, 1993). Of the 42% of the Federal mineral lands that did have restrictions related to these mineral resources, 27% were unavailable or severely restricted. The other 15% were slightly to moderately restricted.

In regard to leasable minerals (coal, oil, natural gas, trona, phosphate, oil shale, and others), they found that 62% of the Federal minerals were available to exploration and development without special restrictions. Twenty-one

percent of the Federal mineral lands were unavailable or severely restricted, with another 17% slightly to moderately restricted.

The report contains definitions, a discussion of methodology, as well as summary tables. There are also four colored maps depicting the restricted and unrestricted acreages for the various mineral resources. Although published in 1993, the maps and discussions refer to the land status in 1990. This is easily the most comprehensive study of this subject ever published. Copies have been given to the Geology Library at the University of Wyoming, the State Library in Cheyenne, and the Natrona County Library in Casper.

The **Industrial Minerals Update** in this issue provides an historical summary of phosphate production in Wyoming. Also, **Table 4** provides historical production for some selected mineral commodities.

The **Metals and Precious Stones Update** features information on diamond, gold, platinum, and(or) copper exploration, including the recovery of a 14.2-carat diamond from the State Line district.

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]	2.53[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]	0.08[6]
Decorative Stone[10]	---	---	---	---	---	---	---	---	0.24[7]	1.00[7]	168.0[6]
Dolomite[2]	0.66	0.86	0.87	0.81	0.46	0.19[6]	0.15[6]	0.21[6]	0.23[6]	0.20[6]	
Gypsum[2]	0.33	0.33	0.35	0.41	0.35	0.36[6]	0.42[6]	0.44[6]	0.42[6]	0.43[7]	0.43[7]
Iron Ore	2.48[2]	---	---	---	---	---	40[8]	40[8]	---	---	250[7,9]
Leonardite[4]	---	---	---	---	---	minor[6]	38.9[6]	41.7[6]	22.9[6]	37.0[6]	39.0[6]
Limestone[2,5]	0.56	0.65	0.32	0.33	0.32	0.64	0.60[6]	0.48[6]	0.49[6]	0.52[6]	0.63[6]
Construction Aggregate[2,3]	6.72	8.31	6.40	5.01	4.12	3.15	6.46[6]	7.73[6]	8.62[6]	8.11[6]	10.6[6]
Shale[4]	---	20.3	14.7	9.88	103.2	52.1[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]	1.5[6]

Sources: [1]Wyoming Department of Revenue, unless otherwise noted; [2]millions of short tons; [3]includes ballast, scoria, and limestone used for aggregate; [4]thousands of short tons; [5]includes chemical grade limestone used for cement rock, sugar beet refining, and other uses; [6]Wyoming State Inspector of Mines; [7]estimated by Wyoming State Geological Survey; [8]short tons of iron ore used for pigment; [9]short tons of iron ore used as weighting additive in cement; [10] short tons. Prepared by Wyoming State Geological Survey, July, 1994.

Reference cited

Anderson, N.B., and others, 1993, Availability of Federally owned minerals for exploration and development in western states: Wyoming, 1990: U.S. Bureau of Mines Special Publication, 54 p.

OIL AND GAS UPDATE

by Rodney H. De Bruin
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The rig count in Wyoming began a seasonal increase in the second quarter of 1994, which follows a trend set in recent years (**Figure 9**). The count should improve further in the third quarter, especially in view of the large infill-drilling projects in southwestern Wyoming.

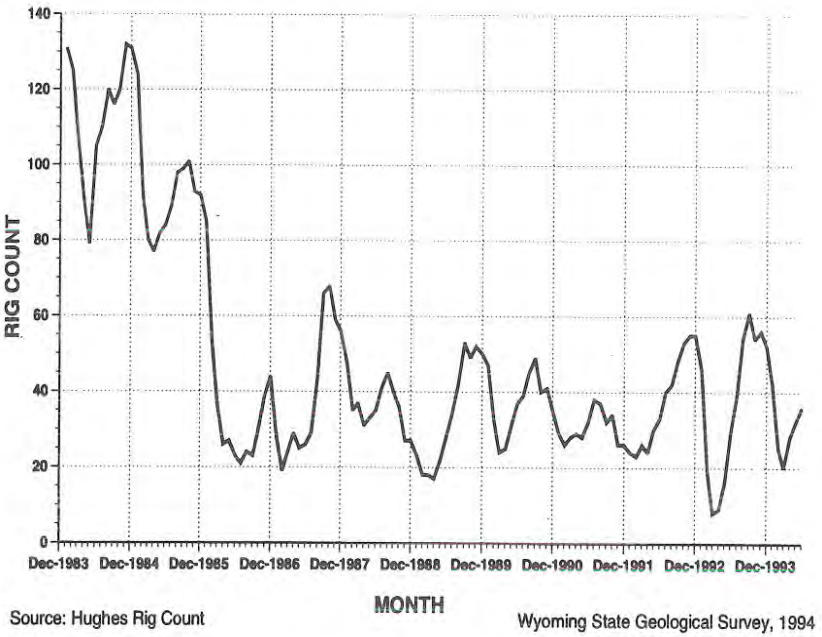


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

The sixth annual *Rocky Mountain Natural Gas Strategy and Marketing Conference*, sponsored by the Colorado Oil and Gas Association and the Rocky Mountain Natural Gas Association, was held in Denver, Colorado, on July 12-14. The conference focused on the North American energy corridor, which encompasses an area that begins in western Canada and extends south through the main U.S. Rocky Mountain gas-producing basins and into Mexico. The emphasis was on the supply potential from the corridor, expanding demands, new market opportunities, technologies that will increase production, and the evolution of marketing centers.

A number of experts who spoke at the conference agreed on the following items: (1) The Rocky Mountain region has an adequate supply of natural gas to increase its production; (2) Demand from the Rocky Mountain region will increase further as dwindling Gulf Coast resources fail to meet the demand from traditional Gulf Coast markets; (3) New market opportunities include the use of natural gas for transportation fuel, for fuel cells, and for the generation of electricity, especially co-generation with renewable resources such as wind and solar; (4) Exploration for natural gas can be enhanced through the use of 3-D seismic techniques; (5) New fracture techniques and horizontal drilling can increase production; and (6) Most natural gas will be marketed through electronic marketing centers at hubs such as Opal, Wyoming, where many pipelines interconnect. Presently there are over 30 marketing centers proposed for the U.S. Three of these centers are proposed for the Opal area (see below and Item F on p. 14 in *Wyoming Geo-notes No. 42*). It is likely that not all of these centers will survive due to the competition among them.

Northwest Pipeline and Williams Energy Ventures have announced plans to open a market center this fall. The project is billed as the first live, computerized network for cash-market natural gas transactions in North America. The companies will develop the center in three phases. Phase one will implement a computerized system (accessible by personal computer) to streamline cash-market natural gas transactions at their gas processing plant at Opal, Wyoming. The system will have an initial capacity of approximately 750 million cubic feet of gas per day. Phase two and three will expand the geographic area to include interconnects with other pipelines and will increase the capacity of the system to over one billion cubic feet of gas per day. This project looks like the newest of at least three groups planning market centers in southwestern Wyoming.

More oil companies are cutting jobs in Wyoming. In the latest round of cuts, Conoco will eliminate over 100 jobs when it shuts its Casper office in September. After Amoco announced cuts of 100 employees in five operational areas in Wyoming, it also announced it would cut another 4,500 jobs worldwide. Marathon plans to lay off about 35 Wyoming workers this year. And Texaco announced that it will lay off 2,500 workers worldwide, which will probably affect some of its 170 workers in Wyoming.

The U.S. Forest Service, in cooperation with the U.S. Bureau of Land Management (BLM), issued a record of decision for oil and gas leasing in the Thunder Basin National Grasslands. The grasslands cover approximately 1.8 million acres in Campbell, Weston, Niobrara, and Converse counties. The record of decision, however, covers only the 520,000 acres of that total where both the surface and mineral estates are Federal. Under the terms of the decision, all that acreage will be available for leasing. While controlled-surface-use restrictions will be applied to three areas, no-surface-occupancy restrictions will be applied to another two areas.

The Wyoming State Office of the BLM issued new guidelines for nominations for the BLM's bimonthly lease sales. Effective immediately, the BLM will only accept nominations for unleased land that has been on a sale list for two years, land in low interest areas, and land in leases that have been relinquished, terminated, or expired for at least 15 months.

Because land acquisition is an important indicator of future drilling activity, recent lease sales indicate that Wyoming should experience a higher level of drilling activity in the next few years. In the first six months of 1994, lease sales by both the BLM and the State Land and Farm Loan Office were the best in the last six years.

The first five oil and gas lease sales in 1994 generated over $13.6 million in total revenue, leased over 800,000 acres, and averaged $17.04 per acre leased (**Table 5**). If these trends continue through the remaining sales in 1994, the combined revenue from this year's 10 Federal and State sales will be the best since the 12 sales held in 1988.

The heaviest leasing activiities were in southwestern Wyoming where gas exploration and production predominate and in the oil-prone Powder River Basin. Parcels near gas production in the Wind River Basin were also in fairly high demand (**Figures 10** and **11**). While leasing in the Powder River Basin picked up during the last two sales, leasing fell off somewhat in southwestern Wyoming.

The BLM's April sale had a high per-acre bid of $275. The bid was made by Donald B. Anderson for a 1,560-acre parcel that covers parts of sections 13, 26, and 35 and all of section 25, T30N, R113W in Sublette County. The parcel is in an area of oil and gas production from the Almy, the Fort Union, the "transition zone", and the Mesaverde. The second highest per-acre bid was made by Joe Currie for a 2,560-acre parcel that includes sections 10, 11, 12, and 13, T26N, R107W in Sweetwater County. Currie also bought two additional parcels that totaled 4,146.11 acres in T26N, R107W. There is presently no production in this township. This sale had 25 tracts that sold for $50 or more per acre.

The State Land and Farm Loan Office's sale in May had a high per-acre bid of $205. The bid was made by Wilshire Oil Co. for a 160-acre parcel that covers

Table 5. Federal and State competitive oil and gas lease sales in Wyoming.

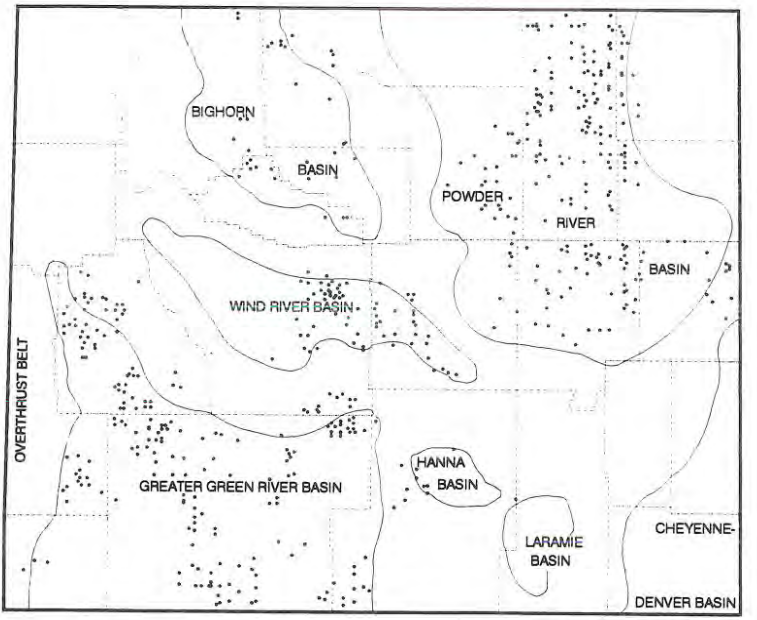
BLM SALES

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

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							
TOTAL	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
1992							
January	$138,165	200	96	72,027	37,840	$3.65	$65.00
March	$200,000	200	114	70,294	41,034	$4.88	103.00
May	$208,166	200	93	60,687	28,605	$7.28	$230.00
November	$200,407	199	116	74,747	43,134	$4.65	$87.00
TOTAL	$745,738	799	419	277,755	150,613	$4.95	$230.00
1993							
March	$601,400	200	137	74,940	54,723	$10.99	$400.00
May	$362,840	200	141	82,388	56,770	$6.39	$90.00
September	$505,587	200	141	80,428	56,845	$8.89	$225.00
November	$510,290	200	143	73,517	53,801	$9.48	$155.00
TOTAL	$1,980,017	800	562	311,273	222,139	$8.91	$400.00
1994							
March	$917,380	200	169	84,571	73,061	$12.56	$170.00
May	$802,688	200	141	75,523	54,199	$14.81	$205.00

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

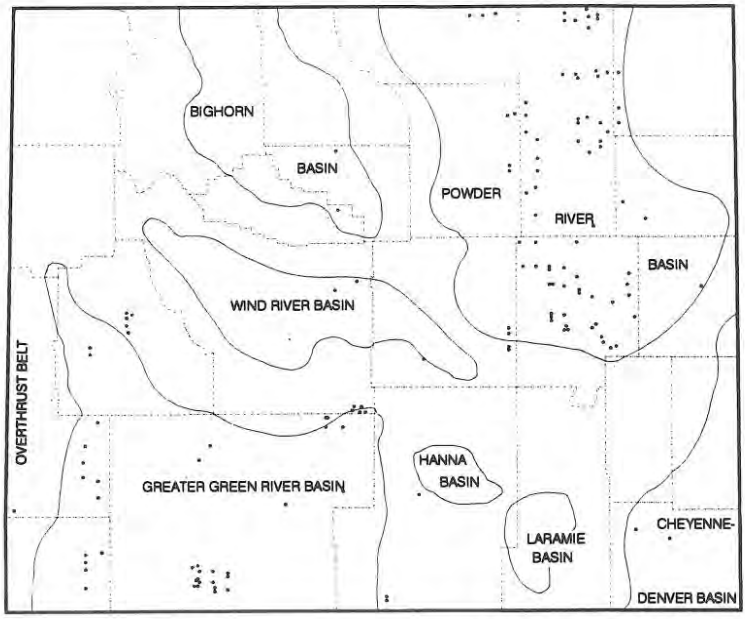


WYOMING STATE GEOLOGICAL SURVEY, 1994

Figure 10. Locations of Federal oil and gas leases sold during the second quarter of 1994.

S/2 S/2 section 32, T16N, R65W in Laramie County. The tract is a mile west of horizontally-drilled Niobrara oil production from Silo Field. Wilshire has drilled several horizontal wells in the Silo Field area. The second highest per-acre bid of $175 was made by Carol Salisbury for a 715.68-acre tract that includes lots 1-14, NW, and N/2 SW section 36, T23N, R113W in Lincoln County. The parcel is one half mile west of Frontier gas and condensate production from Shute Creek Field. Marathon Oil Co. paid $150 per acre for a 640-acre lease that covers section 36, T15N, R103W. The lease is less than two miles north of Frontier, Dakota, and Lakota production from Salt Wells Field in Sweetwater County. Tyrex Oil Co. paid $120 per acre for a 640-acre lease that covers section 16, T37N, R93W in Fremont County. Three years ago a well on this lease was completed in the Fort Union for an initial flowing potential of 410,000 cubic feet of gas.

The BLM's June sale had a high per-acre bid of $325. The bid was made by Hanson & Strahn Energy Land Services for a 1,278.95-acre parcel that covers SW SW section 1; lot 2, S/2 NE, and SE section 2; S/2 N/2 and S/2 section 3; and S/2 N/2 and S/2 section 4, T30N, R113 W in Sublette County. The tract is about one mile from Almy and Mesaverde production at Star Corral Field. The second highest per-acre bid of $275 was made by Yates Petroleum for a 40-acre lease that covers SE SW section 34, T47N, R75W. The lease is near Sussex



WYOMING STATE GEOLOGICAL SURVEY, 1994

Figure 11. Locations of State oil and gas leases sold during the second quarter of 1994.

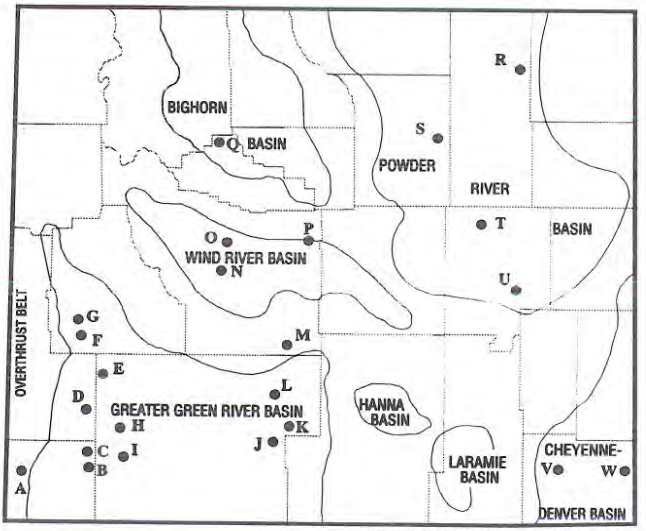
oil and gas production from House Creek Field in Campbell County. At this sale, Yates leased 52 tracts, totaling over 51,000 acres. Marathon Oil Co. bid $160 per acre for a 160-acre lease that covers NW section 8, T16N, R99W in Sweetwater County and is about three miles from Cretaceous gas production at Bitter Creek Field. This sale had 18 tracts that sold for $50 or more per acre.

Exploration and development

Company data, news releases, and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the second quarter of 1994. The letters preceding discussions below refer to locations on **Figure 12**.

A. Amoco Production and its partners, Chevron USA and Union Pacific Resources, dedicated new facilities at the Painter Reservoir Complex. These facilities enable the partners to produce liquefied natural gas (LNG). Although LNG production capacity is currently 40,000 gallons per day, it could more than double. The Union Pacific Railroad is conducting a three-year test of LNG in several of its locomotives.

B. Wexpro Co. completed a new Dakota producer in SE SW section 17, T18N, R112W. The 33 Bruff Unit well flowed 6.5 million cubic feet of gas per day from perforations between 12,202 and 12,215 feet.



WYOMING STATE GEOLOGICAL SURVEY, 1994

Figure 12. Oil and gas exploration and development activity in Wyoming during the second quarter of 1994 (exclusive of coalbed methane activities).

C. Coastal Gas Gathering and Processing Co. is planning a new gas processing plant. Phase I of the project is a processing plant with a capacity of 84 million cubic feet of gas per day. Phase II of the project would increase the capacity to 126 million cubic feet of gas per day.

D. Bannon Energy announced plans to drill up to 124 wells on the Moxa arch this year. Most of the wells will develop the Frontier Formation. The drilling area is in T18N-T28N and R110W-R114W.

E. Presidio Exploration completed two new Frontier wells in Mesa Field. The 40-34 Brass well in SE SE section 34, T24N, R111W produced an average of 2.1 million cubic feet of gas and 60 barrels of condensate per day during its first month of production from an undisclosed Frontier interval. The 32-26 McCullen Bluff well in SW SE section 26, T24N, R111W produced an average of 2.8 million cubic feet of gas and seven barrels of condensate per day during its first month of production from an undisclosed Frontier interval.

F. Enron Oil & Gas completed a new Mesaverde producer. The 88-22 Mills Unit well in SE SE section 22, T28N, R113W pumped 240 barrels of oil per day from an undisclosed Mesaverde interval above 3,150 feet.

G. Enron's proposed enhanced oil and gas recovery project at Burly Field has been approved by the U.S. Bureau of Land Management. The project will

produce about 8.2 million barrels of oil and 8.2 billion cubic feet of natural gas through the use of enhanced recovery techniques. The company received approval to drill up to 32 oil and gas wells in the Mesaverde.

H. Questar Pipeline plans to build a new 40-mile-long, $5.1 million pipeline to gather natural gas from fields on the Moxa arch in southwestern Wyoming. The pipeline will extend from the company's present pipeline about 38 miles northwest of Green River to Dry Piney Creek.

I. A new methanol plant is planned for an area about 13 miles west of Green River. American Methanol Ltd. may begin construction of the $30 million plant by this fall. Natural gas is used as feedstock for methanol production. Methanol is used in the production of antifreeze, gasoline additives, and general solvents. It is also used to prevent water produced with some natural gases from freezing in pipelines. The planned output of the plant is 90,000 gallons of methanol per day.

J. Union Pacific Resources will directionally drill a 10,040-foot well to test the Almond. The site for the 1-29 Tiffen well is NW SE section 29, T20N, R94W. To minimize surface disturbance, Union Pacific plans to drill up to four wells from one drill pad at this location.

K. Amoco Production will test the Almond and Ericson with its 1-H Amoco-Federal-Brookie well. This horizontal hole will be drilled from a surface location in NE NW section 24, T20N, R93W to a true vertical depth of 10,604 feet in the Ericson.

L. Presidio Exploration completed a new Lewis well. The 30-16 Strike Unit well in C SW section 16, T22N, R95W produced an average of 1.6 million cubic feet of gas and 220 barrels of condensate per day during its first month of production from an undisclosed Lewis interval.

M. Wold Oil Properties established the first Muddy gas production from Happy Springs Field. The 17 Unit well in SW SE section 4, T28N, R93W flowed 1.2 million cubic feet of gas per day from perforations between 4,180 and 4,186 feet.

N. Tom Brown finalized an agreement for exploration on 400,000 acres on the Wind River Reservation. The company agreed to acquire 40 square miles of 3-D seismic data and to drill at least four wells in the next five years.

O. Muddy Ridge Field has a new Fort Union producer. Tom Brown Inc. completed its 19-11 Tribal well in NW NW section 19, T4N, R3E. The well flowed 2.7 million cubic feet of gas per day through perforations between 7,089 and 7,269 feet.

P. Louisiana Land and Exploration Co. began construction of its $80 million gas processing plant near Lost Cabin. Although the plant will initially only

process about 50 million cubic feet of gas per day, it will have the capability to process twice that amount. The company will process sour gas from two wells in the Madison Limestone. The Madison is over 24,000 feet deep in both of these wells. The initial plant will also produce about 214 tons of sulfur per day.

Q. MW Petroleum plans to test the Phosphoria Formation with its horizontally-drilled 375H Little Buffalo Basin well. The well will have a surface location in NW NW section 18, T47N, R99W and a true vertical depth of 4,830 feet.

R. Ampolex Inc. completed a new Minnelusa producer. The 22-26 Pickrel-Federal well in SE NW section 26, T54N, R69W pumped 78 barrels of oil per day from an undisclosed interval in the Minnelusa.

S. Presidio completed three new Shannon wells in the Culp Draw/Heldt Draw Field area. The H-121 Culp Draw Unit well in NE NW section 25, T46N, R77W pumped 285 barrels of oil and 20,000 cubic feet of gas per day between 9,292 and 9,302 feet. The C-122 Culp Draw Unit well in SE SW section 14, T46N, R77W pumped 161 barrels of oil and 30,000 cubic feet of gas per day from between 9,268 and 9,280 feet. The C-116 Culp Draw Unit well in SE NW section 23, T46N, R77W pumped 107 barrels of oil and 13,000 cubic feet of gas per day from between 9,308 and 9,318 feet.

T. Meridian Oil completed two new Sussex wells in Spearhead Ranch Field. The 23-15 Waring well in NE SW section 15, T39N, R74W produced an average of 428 barrels of oil and 30,000 cubic feet of gas per day from an undisclosed interval during its first month of production . The 11-16 State well in NW NW section 16, T39N, R74W produced an average of 126 barrels of oil and 27,000 cubic feet of gas per day from an unreported interval during its first month of production.

U. Vastar Resources staked a location for a Niobrara/Frontier test. Its 1-27H Idarado well will be drilled from a surface location in SW SE section 27, T33N, R71W. Vastar will drill the well at a 45 degree angle into the Niobrara, will case off the Niobrara, and will then drill horizontally into the Frontier. The company expects to encounter the top of the Frontier at a true measured depth of 11,532 feet.

V. Wilshire Oil Co. completed another horizontally-drilled Niobrara producer in Silo Field. Its 1-26H McWilliams well was drilled from a surface location in NE NE section 26, T16N, R64W to a true vertical depth of 7,716 feet. The well was completed pumping 367 barrels of oil, 98,000 cubic feet of gas, and five barrels of water per day. Union Pacific Resources completed the northwesternmost Niobrara producer in Silo Field. Its 1H Bedrock 14-15 well was drilled from a surface location in SW SW section 15, T16N, R65W to a true vertical depth of 8,302 feet, averaged 192 barrels of oil, 56,000 cubic feet of gas, and 84 barrels of water per day during the first month of production.

W. Headington Oil has a new J sand producer in Lindberg East Field. The 22-35 Jesson well in SE NW section 35, T16N, R60W pumped 51 barrels of oil, 51,000 cubic feet of gas, and 15 barrels of water per day from between 7,459 and 7,471 feet.

COAL UPDATE

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

Following a trend of the last three years, monthly delivered coal tonnages dropped 13.56% in February. This drop followed a record setting 19.73 million tons in January (**Table 6** and **Figure 13**). Total delivered tonnages, however, rebounded dramatically in March, due to increases in both contract and spot deliveries, (**Figures 13** and **14**).

Twelve additional power plants started using Wyoming coal in 1993 for a total of 6.4 million tons of coal. Of the new power plants to burn Wyoming coal: 7 were in the Midwest (4.0 million tons), 4 were in the North (0.5 million tons), one was in the Southeast (0.7 million tons), and one was in the Southwest (1.2 million tons). Illinois, which has dominantly used local coal for many years, had four power plants which burned an initial 2.5 million tons of Wyoming coal last year. It is assumed that these plants have switched to Wyoming coal either to comply with Phase I regulations of the 1990 Amendments to the Clean Air Act and(or) to take advantage of lower fuel prices.

A report from the Illinois Coal Development Board indicates that 47% of the utilities in the Illinois coal market affected by Phase I regulations of the 1990 Amendments to the Clean Air Act will employ fuel switching and(or) blending of feedstocks (Philo and Coovert, 1994). The report also notes that of the utilities currently using Illinois coal, but planning to switch and(or) blend fuels, 33% will purchase low-sulfur western coals.

Wyoming coal mines are currently producing at 52% of "permitted capacity". "Permitted capacity" is the highest future tonnage that is allowable under permits with the Wyoming Department of Environmental Quality's Air Quality Division. Currently "permitted capacity" is approximately 420 million tons per year, compared with production of 209.9 million tons per year (**Tables 7, 8,** and **9**). The largest production increases in 1993 were at the Black Thunder (+16.5%) and Rochelle (+19.5%) mines (**Table 9**). These two mines are the largest producers in the nation with a combined annual production greater than 55 million tons per year.

Table 6. Coal deliveries by month from Wyoming mines.

	1990 Monthly	1990 Cumulative	1991 Monthly	1991 Cumulative	1992 Monthly
JAN	15,059,530	15,059,530	14,960,450	14,960,450	16,407,150
FEB	13,328,290	28,387,820	15,480,110	30,440,560	14,604,480
MAR	14,535,270	42,923,090	16,278,870	46,719,430	14,429,650
APR	14,155,470	57,078,560	14,820,240	61,539,670	14,063,060
MAY	13,882,590	70,961,150	14,589,790	76,129,460	14,518,590
JUN	13,649,070	84,610,220	14,007,600	90,137,060	14,655,600
JUL	15,368,280	99,978,500	16,451,090	106,588,150	15,592,050
AUG	16,046,910	116,025,410	15,940,620	122,528,770	16,467,100
SEP	15,166,020	131,191,430	15,314,490	137,843,260	14,878,150
OCT	15,244,760	146,436,190	14,810,510	152,653,770	15,122,820
NOV	15,569,280	162,005,470	14,783,000	167,436,770	14,757,230
DEC	14,479,970	176,485,440	16,716,630	184,153,400	16,096,150
Total Tonnage Reported[1]		**176,485,440**		**184,153,400**	
Total Tonnage Not Reported		**7,521,261**		**9,710,406**	
Total Tonnage Produced[2]		**184,006,701**		**193,863,806**	

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

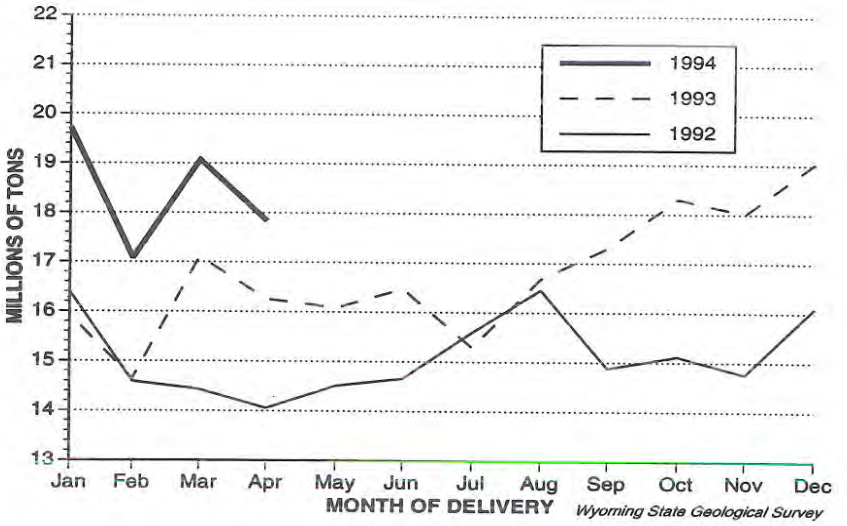


Figure 13. Reported deliveries from Wyoming coal mines (1992 through April, 1994). *(From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Table 6. *continued*

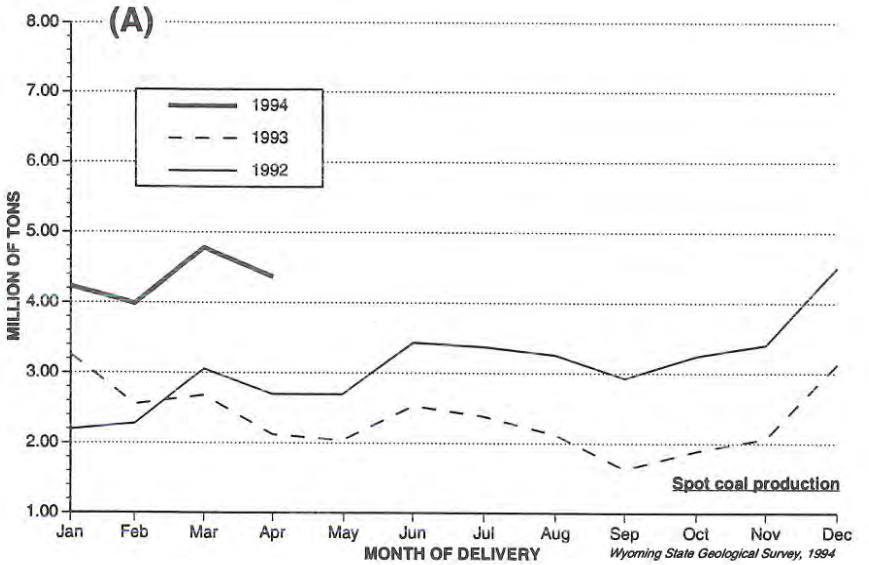
1992 Cumulative	1993 Monthly	1993 Cumulative	1994 Monthly	1994 Cumulative
16,407,150	15,931,150	15,931,150	19,326,770	19,326,770
31,011,630	14,646,090	30,577,240	17,171,910	36,498,680
45,441,280	17,112,970	47,690,210	19,178,990	55,677,670
59,504,340	16,259,770	63,949,980		
74,022,930	16,085,470	80,035,450		
88,678,530	16,473,920	96,509,370		
104,270,580	15,296,480	111,805,850		
120,737,680	16,682,090	128,487,940		
135,615,830	17,310,330	145,798,270		
150,738,650	18,300,070	164,098,340		
165,495,880	18,007,907	182,106,310		
181,592,030	19,034,530	201,140,840		
181,592,030		**201,140,840**		**55,677,670**
7,878,226		**8,784,986**		
189,470,256		**209,925,826**		

The Alliance for Clean Coal, which recently won its suit against the state of Illinois' "scrubber law", has now filed suit against the state of Indiana. Indiana's "scrubber law" allows utilities to charge rate payers for the installation of scrubbers, and it requires that a utility consider the economic impacts of lost employment to the Indiana coal industry if the utility would rather switch fuels than scrub the coal. The Alliance for Clean Coal includes Arco and Kennecott coal companies, as well as the Union Pacific, Burlington Northern, and Chicago and Northwestern railroads.

The Black Lung Benefits Restoration Act of 1994 passed the U.S. House of Representatives in May and is still pending in the U.S. Senate. This legislation will make it easier for miners who suffer from "black lung" to get benefits. Currently surface mines pay $0.55 per ton and underground mines pay $1.10 per ton into an account to fund black lung benefits.

Developments in western and southwestern Wyoming

After laying off 200 workers last year, Black Butte Coal Company has hired 20 temporary workers and plans to hire an additional 16. These hirings follow the signing a new 400,000-ton contract with Portland General Electric Company (Item 11, **Table 10** and **Figure 15**).



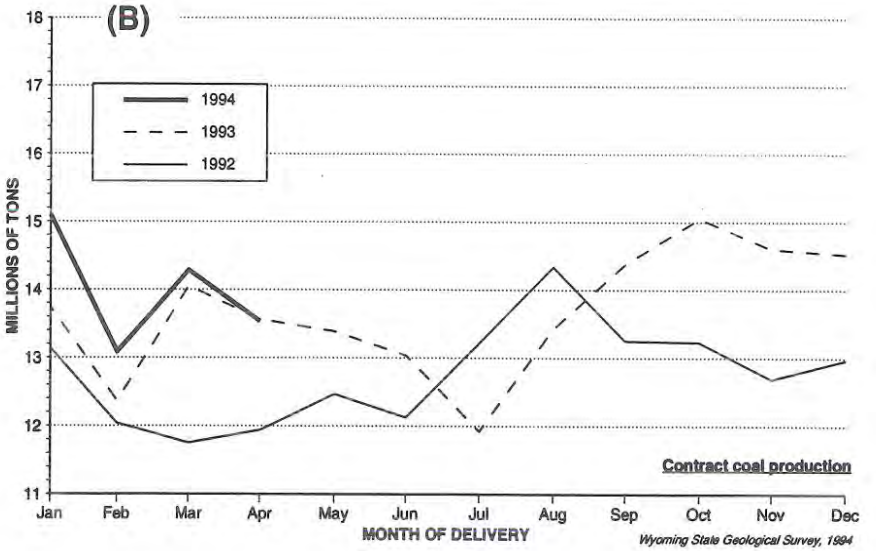


Figure 14. Monthly coal deliveries from Wyoming (1992 through April, 1994). (A) Coal sold on the spot market and (B) coal sold on contract. *(From COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Table 7. Permitted capacities of coal mines in Wyoming.

Parent Company	Mining Operator	Mine Name	Production[1]	Permitted Capacity[2]
Kennecott Energy Co.	Antelope Coal Co.	Antelope	7,286,610	12.00[3]
Cyprus-AMAX	Cyprus-AMAX Coal West	Belle Ayr	15,588,000	25.00
Kiewit Mining Group	Big Horn Coal Co.	Big Horn	120,000	4.60
Kiewit Mining Group	Black Butte Coal Co.	Black Butte	2,569,713	9.50[4]
ARCO	Thunder Basin Coal Co.	Black Thunder	34,320,470	36.00
Zeigler	Triton Coal Co. (SMC Mining Co.)	Buckskin	11,180,379	24.00
Exxon	Carter Mining Co.	Caballo	15,418,125	24.00
Drummond, Inc.	Caballo Rojo, Inc.	Caballo Rojo	8,023,000	20.00
ARCO	Thunder Basin Coal Co.	Coal Creek	110,488	18.00
Kerr-McGee Corp.	Kerr-McGee Coal Corp.	Clovis Point	0	4.00[5]
Kennecott Energy Co.	Cordero Mining Co.	Cordero	12,988,628	24.00
Nerco Coal Corp.	Glenrock Coal Co.	Dave Johnston	2,902,306	4.00
Phillips/Western Fuels Assoc.	Dry Fork Coal Co. (Phillips Coal Co.)	Dry Fork	3,277,794	15.00
Cyprus-AMAX	Cyprus-AMAX Coal West	Eagle Butte	16,700,000	29.60[6]
Fort Union Ltd. Partnerhip	Fort Union Coal Co.	Fort Union	58,131	9.30
Entech Inc. (Montana Power)	Northwestern Resources (Western Energy Co.)	Grass Creek	41,566	0.35
Kerr-McGee Corp.	Kerr-McGee Coal Corp.	Jacobs Ranch	18,387,422	25.00
PacifiCorp/Idaho Power	Bridger Coal Co.	Jim Bridger	6,417,662	7.90
Chevron Corp.	Pittsburg & Midway Coal Mining	Kemmerer	3,261,818	4.20
Arch Minerals	Arch of Wyoming, Inc.	Medicine Bow	2,614,424	4.00
Peabody Holding Co.	North Antelope Coal Co. (Powder River Coal Co.)	North Antelope	11,761,704	20.00[7]
Zeigler	Triton Coal Co. (SMC Mining Co.)	North Rochelle	21,775	8.00[8]
Arch Minerals	Arch of Wyoming, Inc.	Pilot Butte	205,279	2.00[9]
Public Service Co. of Oklahoma	Ash Creek Mining Co.	PSO #1	1	0.50
Exxon	Carter Mining Co. (Exxon Coal USA, Inc.)	Rawhide	9,864,353	24.00
Peabody Holding Co.	Rochelle Coal Co. (Powder River Coal Co.)	Rochelle	21,184,217	30.00[10]
Entech Inc. (Montana Power)	Northwestern Resources (Western Energy Co.)	Rocky Butte	0	16.00[11]
Kiewit Mining Group	Rosebud Coal Sales Co.	Rosebud	0	1.75
Arch Minerals	Arch of Wyoming, Inc.	Seminoe II	0	2.10
Cyprus-AMAX, Inc.	Cyprus Shoshone Coal Co. (Cyprus-AMAX Coal West)	Shoshone #1	1,590,696	3.50
FMC Corporation	FMC Wyoming Corp.	Skull Point	803,449	1.50
Lion Coal Co.	Lion Coal Co.	Swanson	200,460	0.25
Black Hills Corp.	Wyodak Resources	Wyodak	3,027,356	10.00[12]
		Total	209,925,826	420.05[13]

[1]Tonnage from State Mine Inspector's Annual Report for 1993.
[2]Tonnage in millions of tons/year (MMTPY) from Department of Environmental Quality, Division of Air Quality.
[3]Permitted for 8.5 MMTPY through 2003; 12.0 MMTPY for 2004 and beyond.
[4]Tonnage and capacity figures include Black Butte and Leucite Hills mines.
[5]Constructed but mine is closed temporarily.
[6]Permitted for 17.2 to 29.6 MMTPY in various years of the mine's life.
[7]Current Expansion Application (as of 3/14/94) - 16 MMTPY 1994, 18 MMTPY 1995 & 1996, 20 MMTPY 1997 on.
[8]Permitted but not yet constructed.
[9]Closed 7/10/93.
[10]Current Expansion Application (as of 3/14/94) - 26 MMTPY 1994, 28 MMTPY 1995 , 30 MMTPY 1996 on.
[11]Not constructed yet, permitted for 8 MMTPY for first two years of operation; 16 MMTPY each following year
[12]On a build up schedule to 10 MMTPY a year.
[13]This tonnage is based on using the highest possible capacity figures as shown in the footnotes. Compiled by Wyoming State Geological Survey, May 1994.

Table 8. Coal production from Wyoming in millions of tons, 1984 to 1993.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Campbell County	106.8	113.9	111.0	122.3	135.7	143.8	154.7	164.9	159.6	181.9
Converse County	3.3	3.6	4.8	5.1	5.7	6.1	7.9	8.2	8.5	10.2
Sheridan County	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.2	0.1	0.1
Carbon County	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.7	4.1	4.4
Sweetwater County	8.9	13.2	12.9	11.8	12.2	12.0	11.9	11.4	12.6	9.2
Lincoln County	4.1	4.3	4.0	3.8	4.9	4.8	4.7	4.4	4.6	4.1
Hot Springs County	M	M	M	M	M	M	0.1	0.1	M	M
Total Wyoming	130.7	140.7	135.6	146.4	163.5	171.1	183.9	193.9	189.5	209.9
Annual Change	14.2%	7.1%	-3.8%	7.4%	10.5%	4.4%	7.0%	5.2%	-2.3%	9.7%
Low-priced coal[1]		6%	7%	8%	10%	17%	24%	31%	37%	42%

[1]Estimated percentage of total production that was sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under $5.00. M means less than 0.1 million tons.

Public comment was taken on Carbon County UCG Inc.'s proposed underground coal gasification project in the Separation Flats area northwest of Rawlins. Williams Energy Ventures, Inc. of Tulsa, Oklahoma, has joined with Energy International (EI) of Pittsburgh to take over the project begun at this site by EI in 1987. Carbon County UCG plans a test up to 2 years in duration, compared to the 60-day tests back in 1987. This test is designed to prove the commercial feasibility of the site. The coal gasification plant will cost an estimated $5 million and will create 10 jobs. If the site begins commercial production, it will create 200 construction jobs and 100 permanent positions. The Rawlins District Office of the U.S. Bureau of Land Management is preparing an Environmental Assessment for this project.

Developments in the Powder River Basin

In the Montana portion of the basin, the proposed Tongue River Railroad has still not been approved. Proponents and opponents are waiting for a final decision by the Interstate Commerce Commission.

The Lower Colorado River Authority (LCRA) in a move to secure future Powder River Basin coal needs has signed an interruptable coal supply contract with Cyprus/Amax, Kennecott, Drummond, and Exxon. Under this agreement, contracts are awarded to the lowest cost bid when LCRA is in need of Powder River Basin coal. Current bids are:

1) $5.25/ton FOB, max. of 200,000 tons at 8,775 Btu/lb from the Antelope mine (Kennecott).

2) $5.15/ton FOB, max. of 500,000 tons at 8,500 Btu/lb from the Caballo mine (Exxon).

3) $4.50/ton FOB, max. of 500,000 tons at 8,515 Btu/lb from the Belle Ayr mine (Cyprus/Amax), or a guaranteed 200,000 tons at $5.00 FOB.

4) $4.25/ton FOB, max. of 500,000 tons at 8,450 Btu/lb from the Caballo Rojo mine(Drummond).

5) $4.25/ton FOB, max. of 300,000 tons at 8,515 Btu/lb from the Cordero mine (Kennecott).

In 1994, Thunder Basin Coal Co. anticipates increasing production at its Coal Creek mine to greater than 1.8 million tons. The mine only produced 110,488 tons in 1993 (**Table 9**). Short term market demand and improved prices are cited as reasons for the increase in production.

The Rochelle mine (Powder River Coal Co.) produced its 100 millionth ton of coal in April. The mine produced 21,184, 217 tons last year, and is expected to sell 23 millions tons of coal in 1994. It is currently the second largest coal mine

Table 9. Comparison of 1992 and 1993 coal industry employment and production from Wyoming by coal field and mine.

Company	Mine Name		1992 Employees	1992 Production(tons)	1993 Employees	1993 Production(tons)	Production Difference 1993-1992	Percentage Increase/ Decrease
	POWDER RIVER COAL FIELD							
Amax Coal Co.	Belle Ayr	(surface)	234	12,965,204	238	15,588,000	2,622,796	16.83
	Eagle Butte	(surface)	214	13,669,205	226	16,700,000	3,030,795	18.15
Antelope Coal Co.	Antelope	(surface)	94	5,734,603	103	7,286,610	1,552,007	21.30
Ash Creek Mining Co.	PSO Mine #1	(surface)	1	0	1	1	1	100.00
Big Horn Coal Co.	Big Horn	(surface)	12	105,391	13	120,000	14,609	12.17
Caballo Rojo, Inc.	Caballo Rojo	(surface)	135	7,598,978	225	8,023,000	424,022	5.29
Carter Mining Co.	Caballo	(surface)	246	15,378,609	290	15,418,125	39,516	0.26
	Rawhide	(surface)	194	8,629,613	181	9,864,353	1,234,740	12.52
Cordero Mining Co.	Cordero	(surface)	229	13,308,010	187	12,988,628	-319,382	-2.40
Dry Fork Coal Co.	Dry Fork	(surface)	50	3,440,668	49	3,277,794	-162,874	-4.73
Fort Union Coal Co.	Fort Union	(surface)	4	24,930	5	58,131	33,201	57.11
Glenrock Coal Co.	Dave Johnston	(surface)	175	2,783,077	176	2,902,306	119,229	4.11
Kerr-McGee Coal Corp.	Jacobs Ranch	(surface)	349	16,444,206	357	18,387,422	1,943,216	10.57
North Antelope Coal Co.	North Antelope	(surface)	137	10,149,243	148	11,761,704	1,612,461	13.71
Rochelle Coal Co.	Rochelle	(surface)	178	17,050,965	215	21,184,217	4,133,252	19.51
SMC Mining Co.	North Rochelle	(surface)	2	24,085	2	21,775	-2,310	-9.59
Thunder Basin Coal Co.	Black Thunder	(surface)	513	28,644,138	493	34,320,470	5,676,332	16.54
	Coal Creek	(surface)	27	152,760	7	110,488	-42,272	-27.67
Triton Coal Co.	Buckskin	(surface)	133	9,121,349	138	11,180,379	2,059,030	18.42
Wyodak Resources	Wyodak	(surface)	58	2,957,999	55	3,027,356	69,357	2.29
TOTAL			2,985	168,183,033	3,109	192,220,759	24,037,726	12.51
	HANNA COAL FIELD							
Arch of Wyoming	Medicine Bow	(surface)	93	2,402,009	97	2,614,424	212,415	8.12
Arch of Wyoming	Seminoe No.2	(surface)	5	0	6	0	0	0.00
Cyprus Shoshone Coal Co.	Shoshone #1	(deep)	179	1,651,966	178	1,590,696	-61,270	-3.71
Rosebud Coal Sales Co.	Rosebud	(surface)	17	2,000	17	0	-2,000	-100.00
TOTAL			294	4,055,975	298	4,205,120	149,145	3.55

Table 9. Comparison of 1992 and 1993 coal industry employment and production from Wyoming by coal field and mine *(continued)*.

Company	Mine Name		1992 Employees	1992 Production(tons)	1993 Employees	1993 Production(tons)	Production Difference 1993-1992	Percentage Increase/ Decrease
	BIGHORN COAL FIELD							
Northwest Resources Co.	Grass Creek	(surface)	14	57,208	1	41,566	-15,642	-27.34
TOTAL			14	57,208	1	41,566	-15,642	-27.34
	HAMS FORK COAL FIELD							
FMC Wyoming Corp.	Skull Point	(surface)	96	810,020	93	803,449	-6,571	-0.81
Pittsburg & Midway	Kemmerer	(surface)	326	3,784,041	315	3,261,818	-522,223	-13.80
Wyoming & WV Inc.	Wy & W.V.	(surface)	6	0	0	0	0	0.00
TOTAL			428	4,594,061	408	4,065,267	-528,794	-11.51
	GREEN RIVER COAL FIELD							
Arch of Wyoming	Pilot Butte	(deep)	49	453,566	48	205,579	-247,987	-54.67
Black Butte Coal Co.	Black Butte	(surface)	421	5,889,973	222	2,569,713	-3,320,260	-56.37
Bridger Coal Co.	Jim Bridger	(surface)	395	6,073,832	396	6,417,662	343,830	5.36
Lion Coal Co.	Swanson	(deep)	62	162,608	71	200,460	37,852	18.88
TOTAL			927	12,579,979	737	9,393,414	-3,186,565	-25.33%
TOTAL UNDERGROUND			290	2,268,140	297	1,996,735	-271,405	-11.96%
TOTAL SURFACE			4,358	187,202,116	4,256	207,929,391	20,727,275	9.97%
GRAND TOTAL			4,648	189,470,256	4,553	209,926,126	20,455,870	9.74%

Source: Annual reports of the Wyoming State Inspector of Mines, 1992 and 1993

Table 10. Activities involving coal producers in Wyoming during the second quarter of 1994. [Figure 15 shows locations of the listed power plants][1].

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
1.	Central Illinois Public Service Co.	Newton No. 2	Powder River Basin coal	So	150,000 t	
2.	Central & South West Services	various plants	Powder River Basin coal	So	up to 1.0 million t	
3.	Commonwealth Edison (CE)	various plants	Jacob's Ranch	Sp	1.5 million t	
			Caballo Rojo	Sp	500,000 t	
4.	Georgia Power[2]	Scherer	Powder River Basin coal	So	5.4-10.8 million t	
5.	Indiana Michigan Power Co.	Rockport	Western subbituminous coal	So	ND	Must be less than 1.2 lbs SO_2/ million Btu.
6	Lower Colorado River Authority (LCRA)	Fayette Power Project Unit No.'s 1 & 2	Powder River Basin coal	So	200,000 t	
			Jacob's Ranch	Sp	200,000-400,000 t	
			Caballo Rojo	C	500,000 t	Part of interruptable coal contract.[3]
			Cordero	C	300,000 t	Part of interruptable coal contract.[3]
			Belle Ayr	C	200,000 t	Part of interruptable coal contract.[3]
			Antelope	C	200,000 t	Part of interruptable coal contract.[3]
			Caballo	C	500,000 t	Part of interruptable coal contract.[3]
7	Midwest Power Systems	Council Bluffs	Powder River Basin coal	So	25.0 million t	Contract term is at least until 2005.
8	Montana Power	Corette	Powder River Basin coal	So	100,000 t	
9.	Nebraska Public Power District	Gentleman	Jacob's Ranch	T	24,000 t	
			Antelope	T	24,000 t	
			Belle Ayr	T	24,000 t	
			Caballo Rojo	T	24,000 t	
			Rawhide	T	24,000 t	

Table 10. Activities involving coal producers in Wyoming during the second quarter of 1994 *(continued)*.

	Utility	Power Plant	Coal Mine/Region	Activity	Tonnage	Comments
10.	Northern Indiana Public Service Co. (NIPSCO)	various plants	Powder River Basin coal	So	ND	
		Bailly	Black Thunder	Sp	11,000 t	May
		Michigan City	Shoshone	C	77,000 t	May
				C	84,000 t	July
			Belle Ayr	Sp	66,000 t	May
				C	48,000 t	July
		Dean H. Mitchell	Antelope	Sp	57,000 t	May
			Cordero	C	60,000 t	July
		R.M. Schahfer	Shoshone	C	77,000 t	May
				C	30,000 t	July
			Black Thunder	Sp	36,000 t	May
				C	168,000 t	July
11.	Portland General Electric (PGE)	Boardman	Black Thunder	C	1.5 million t	
			Black Butte	C	400,000 t	
12.	VA Medical Center, Sheridan, WY	VA plant	Powder River Basin coal	So	6,750 t	Double-screened coal by truck delivery.
13.	Wisconsin Electric Power Co. (WEPCO)	Presque Isle	Antelope	T	50,000 t	

[1]Data obtained from : Coal Week, trade journals, periodicals, FERC database, and personal contacts.
[2]This power plant is jointly owned by Georgia Power and six other utilities.
N.D. =no data available; C =contract coal; T =Test burn; Sp =Spot coal; So =solicitation; t =short ton; t/y =short tons per year.

Figure 15. Coal marketing activities related to Wyoming in the second quarter of 1994. [Numbers correspond to those in **Table 10**; circled numbers denote more than one plant in an area].

in the United States, second only to the Black Thunder mine, which is about 8 miles north of it.

The Powder River Basin Resource Council (PRBRC), a Sheridan-based group, had appealed the recent West Rocky Butte Lease By Application (LBA) sale on the grounds that the U.S. Bureau of Land Management (BLM) hadn't allowed public input on the market value of the LBA when it was sold. The Interior Board of Land Appeals (IBLA) rejected that appeal in March of 1993, but the PRBRC asked the IBLA to reconsider its decision. In May, the IBLA refused to reconsider the matter. Northwestern Resources, a subsidiary of Montana Power, which has the adjacent Rocky Butte lease and the West Rocky Butte lease, hopes to have the combined leases permitted by 1996. Northwestern Resources believes construction of the new mine could begin as early as 1998.

There are three Lease By Applications (LBAs) in progress in the Powder River Basin of Wyoming. There will be an Environmental Impact Statement prepared for the North Roundup LBA , nominated by SMC Mining. This LBA contains approximately 140 million tons of coal. A public scoping meeting is scheduled for the fall of 1994 with a decision expected by the summer of 1995. The Antelope LBA contains 60 million tons of coal. An Environmental Assessment (EA) is in preparation. A decision should be forthcoming in the fall. A final EA has been released on the Eagle Butte LBA, which contains 150 million tons of coal.

The Encoal project at the Buckskin mine is underway. The goal is to reduce the high moisture content of the coal mined at that site. Officials of this industry-funded project believe commercial quantities of the product could be available by the end of the decade.

The Antelope mine has submitted an exploration plan to the U.S. Forest Service. Antelope mine officials hope to drill 40 holes for the purpose of obtaining coal quality/quantity information. These coreholes will be drilled mainly in T41N, R 71W, an area between Teckla and Wyoming Highway 59.

Coalbed methane

Martens and Peck Operating Co., a Denver based firm, is drilling two coalbed methane wells (including a stratigraphic test) approximately 17 miles south of Gillette. They plan to drill to a depth of 630 feet with mud and then make open-hole completions with air into the Wyodak seam. No stimulations of the payzones are planned.

Metfuels, Inc. continues to develop its project in the Hanna Coal Field.

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Philo, G.R., and Coovert, D.E., 1994, Outlook for the Illinois coal industry; Report of the Illinois Coal Development Board, Illinois Department of Natural Resources, Springfield, Illinois, p. 26-27.

INDUSTRIAL MINERALS UPDATE

by Ray E. Harris
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Ranked by value, Wyoming's share of domestic nonfuel mineral production dropped from 10th to 11th place among states in 1993 (Peterson, 1994). Wyoming fell behind Missouri, probably because Missouri increased its output of lead. Wyoming continued to lead the nation in trona and bentonite production, and was second in recovered sulfur production (Peterson, 1994). Other important industrial minerals produced in Wyoming and ranked by value, are: construction aggregate (both river rock and crushed rock), chemical-grade limestone, gypsum, and decorative stone. Additional industrial minerals produced in small amounts in Wyoming include (in alphabetical order): iron (as a cement additive and mineral pigment), leonardite, shale (as a cement additive), sodium sulfate, and steatite.

The production histories (1920 to the present) of industrial mineral commodities produced in Wyoming, are available in spreadsheet and graph form from the Industrial Minerals and Uranium Section of the Wyoming State Geological Survey. Also available are recent price histories for selected commodities, in current dollars. Spreadsheets and graphs were prepared from the best available production data, including the former Wyoming State Board of Equalization, the Ad Valorem Tax Division of the Wyoming Department of Revenue, the Wyoming State Inspector of Mines, the U.S. Bureau of Mines, the U.S. Atomic Energy Commission (now the U.S. Department of Energy), as well as individual company data. The production history of phosphate is included in this issue of *Wyoming Geo-notes*. The production and price histories of bentonite, gypsum, sodium sulfate, and trona have already been presented in previous issues of *Wyoming Geo-notes*. Others will be included in future issues.

Bentonite

Bentonite production in Wyoming continues to increase. Production in 1993 was over 2.5 million tons, an increase of 320,000 tons over the previous year (**Table 4**). Wyoming-type (high-sodium) bentonite is used in foundry castings, in taconite pellets, for environmental containment, and in oil well drilling mud. Wyoming ranks first in the nation in bentonite production. Other states with bentonite production include Montana, South Dakota, and Mississippi. Mississippi's production, which consists of high-calcium, low-sodium bentonite is used primarily as a mineral filler.

Construction aggregate

The production of construction aggregate in Wyoming increased in 1993 over the previous year (**Table 4**). Most of the construction aggregate is used for highway construction or repair. Meridian Aggregates, located west of Cheyenne, remains the largest producer of construction aggregate in the state (**Figure 16**).

In May, a Teton County task force identified the alluvial gravel deposits of the Snake River as the primary future source of construction aggregate for the projected growth in that area (**Figure 16**). Although Teton County is rich in construction aggregate deposits of all types, much of the land in the county is Federally owned, and under mining restrictions. The task force noted, however, that adequate resources of gravel exist in the Snake River alluvium and that sites are available for extraction. These sites, however, must be approved by the U.S. Army Corps of Engineers.

Decorative stone

In June Sunrise Stone opened its granite fabricating plant. The plant, located near the junction of Wyoming Highway 34 and Tunnel Road in Platte County, has been under construction since late 1993 (**Figure 16**). The plant produces standard and custom-sized cut black granite called Wyoming Raven

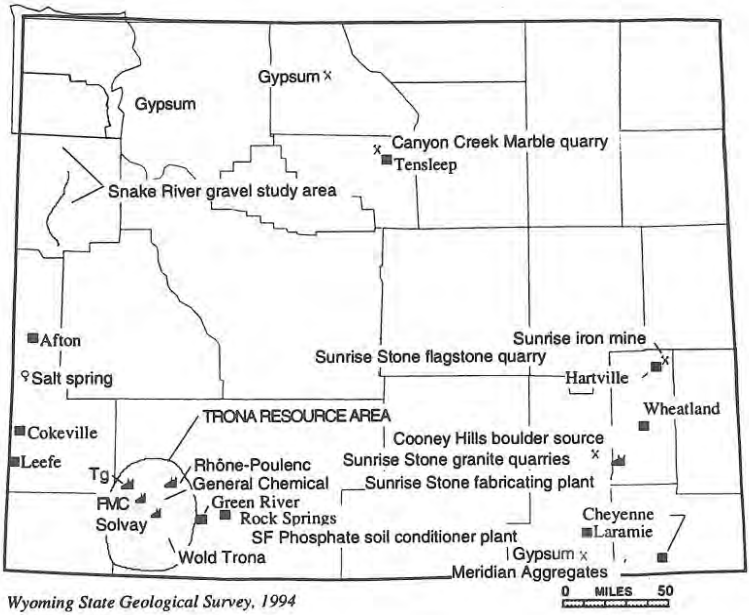

Figure 16. Industrial minerals activities in Wyoming during the second quarter of 1994.

and a pink swirled gneiss call Fantastico, both for use in buildings and monuments. Other granites may be processed at the plant in the future. Wyoming Raven and Fantastico are both quarried by Sunrise on the Vale Ranch in Albany County, 20 miles west of the plant.

Sunrise Stone also continued production of tan flagstone from a quarry south of Douglas in Converse County (**Figure 16**). This flagstone has been shipped to Denver for sale in Colorado, and to Orlando, Florida, for use at Disney World.

A source of pink and gray boulders for use in landscaping at Aspen, Colorado, has been located in the Cooney Hills in southwestern Platte County (**Figure 16**). When all arrangements and permits have been completed, nearly 100 semi-truckloads of boulders will be shipped. The source was located by the Wyoming State Geological Survey in response to a request from the architectural firm responsible for the landscaping design in Aspen.

Canyon Creek Marble (formerly Mesa Marble) began small-scale production of marble flagstone and moss rock from a quarry near Tensleep (**Figure 16**). According to officials at Canyon Creek Marble, the quarry will increase its production later this summer.

Gypsum

According to 1993 figures, the production of gypsum in Wyoming remained about the same as 1992 (**Table 4**). This production came from three mines. Two plants in the Bighorn Basin produce wallboard from nearby gypsum deposits, and gypsum is also mined near Laramie for use in cement (**Figure 16**). All of these plants are operating near their design capacities.

Iron minerals (industrial)

Shipments of iron-rich tailings continue from the former Sunrise iron mine near Hartville in northeastern Platte County (**Figure 16**). These tailings are shipped to the Colorado Lien cement plant in Fort Collins, Colorado, for use as an additive in cement.

Phosphate

Phosphate, which is a mineral product containing the phosphate anion PO_4, is produced from mined phosphate rock. It is used primarily in fertilizers to provide the phosphate required for plant growth. It is also used in animal feeds, detergents, and chemical products. Phosphate rock is defined as: *A rock material that contains phosphate minerals which are sufficient for commercial usage* (Bartels and Gurr, 1994). Phosphorite refers to non-commercial, high-phosphate rock.

In western Wyoming, the Permian Phosphoria Formation consists of beds of phosphorite and potential phosphate rock. Some of these beds have been mined in the past and constitute a resource that may be mined in the future.

In the 1920's, Cokeville Phosphate Company mined rock near Cokeville in Lincoln County (**Figure 16**). Beginning in 1947, phosphate rock was mined and calcined at a plant near Leefe in Lincoln County (**Figure 16**). The latter deposit was first developed by the San Francisco Chemical Company, which became the Stauffer Chemical Company in 1968. Production reached a maximum of 226,123 tons of phosphate rock in 1973 (**Figure 17**). The mines in Wyoming closed in 1977, but the calcining plant continued to operate using phosphate rock mined in Utah until the plant closed in 1985. The plant has been razed, and the property is currently being reclaimed. There has been no subsequent mining of phosphate rock in Wyoming. One-half mile west of the Wyoming border, in Idaho, FMC operates a phosphate mine, and there are four active phosphate calcining operations in that state. In 1992, the production of phosphate rock from Idaho was second only to that in Florida (Morse, 1993). Phosphate rock is also mined in Utah, Montana, North Carolina, and Tennessee (Morse, 1993).

The price of phosphate rock, which varied between $5 to $7 until 1974, increased to over $25 per ton by 1975. Prices have fluctuated between $17 to $26 per ton since then, and were at about $23 per ton in 1992. Currently, there

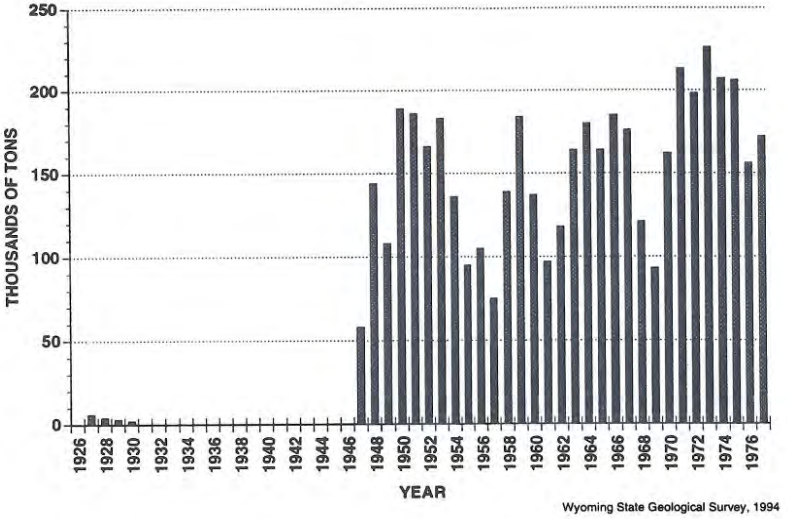

Figure 17. Historical phosphate production from Wyoming (1927-1977).

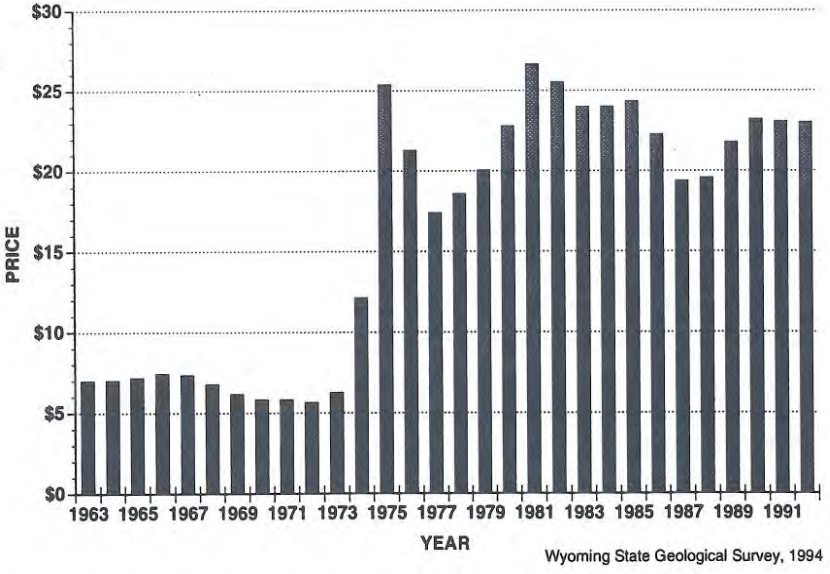

Figure 18. Average price per ton for phosphate produced in the U.S. (1963-1992). [Source: U.S. Bureau of Mines]

is a domestic oversupply of phosphate, due primarily to a lessening in the demand by the manufacturers of phosphate-based detergents. While domestic production has declined, prices have only dropped slightly (**Figure 18**) (Morse, 1993).

Phosphate rock is also mined from the Phosphoria Formation on the south slope of the Uinta Mountains north of Vernal, Utah. This phosphate rock is crushed and shipped by slurry pipeline to SF Phosphate's plant southeast of Rock Springs, where it is combined with Wyoming sulfur to make a soil conditioner.

Salt

A salt deposit, located south of Afton in Lincoln County, is under consideration for future development. Natural halite (NaCl) occurs in the subsurface in this area, and a salt spring is located at the surface (**Figure 16**). The developer plans to divert the water from the spring to evaporation ponds and sell the salt that is left behind.

Salt from this area was used by travelers on the Oregon Trail, and the Salt River takes its name from this locality. The salt deposits in the area have been leased for over thirty years.

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 the refinery complexes associated with the mines (**Figure 16**). See *Wyoming Geo-notes No. 41* for a historical summary of trona production and prices. In 1993, trona production was down about 400,000 tons from 1992 (**Table 1**). This decrease reflected a decline in production by General Chemical. While FMC increased production slightly, the remaining three producers, Rhone-Poulenc, Solvay, and Tg remained at 1992 production levels. A strike at General Chemical in late 1993 may have been a factor in lowering their production.

As for the future, Taiwan has agreed to lower its tariff on imports of soda ash. This move should help increase the imports of soda ash to that country, most of which should come from Wyoming producers.

Wold Trona is continuing with its plans to develop a sixth underground trona mine and to construct a soda ash refining plant at the surface (**Figure 16**). According to an environmental assessment released in mid-April, the plant will produce 97 to 98 percent pure soda ash by a dry process. Wold plans to truck the product to a Union Pacific Railroad (UP) railhead in Green River until a rail spur can be built to the plant. The new rail spur would connect to the spur leading to the Solvay plant, which connects to the UP main line at Bryan. Wold officials are also working to develop a plan to haul their product to the rail siding without going through Green River.

Rhone-Poulenc has begun a project to move its surface tailings into mined-out areas of its underground mine. The $15 million project involves construction of both surface and underground facilities to handle movement of the tailings. About 100 people will be employed during the construction phase, and the facilities should be complete by early 1995, according to company officials.

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URANIUM UPDATE

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

In Wyoming, uranium is produced at Power Resources' Highland and North Morton Ranch in-situ facility north of Glenrock in Converse County, and at COMIN's Christiansen Ranch and Irigary Ranch in-situ sites west of the Pumpkin Buttes in Johnson County.

In May, American Nuclear, of Riverton, announced that it was closing its operations. American Nuclear operated mines in the Gas Hills and other areas of Wyoming in past years. Following this announcement, the Nuclear Regulatory Commission said that American Nuclear would have to revise the reclamation plans for its former properties.

A trade agreement between the U.S. and Russia, which allows U.S. utilities to import Russian uranium at prices far lower than previously allowed by trade laws, was protested by domestic uranium producers and other uranium producing countries. According to these producers, domestic production of uranium, already reduced far below its peak years of 1978 and 1979, will suffer as a result of this agreement.

METALS AND PRECIOUS STONES UPDATE

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

During the second quarter, exploration for diamond, gold, platinum, and(or) copper was reported at several locations in the State.

The exploration activity included BHP. This company was exploring paleoplacers for gold at an undisclosed location in southern Wyoming. This is the third year BHP has been exploring this region for gold.

Annabel Mines of Canada continued its exploration for widespread gold mineralization at the Carissa mine and associated placers at South Pass. This project is in an area where earlier studies by the Wyoming State Geological Survey indicated the presence of a large-tonnage gold deposit (Hausel, 1991). A Wyoming and a Washington company were also exploring the South Pass area for a major gold deposit.

Compass Minerals of Australia was exploring the Copper King, Kurtz-Chatterton, and Mineral Hill copper-gold deposits following recommendations by the Wyoming State Geological Survey. All of these deposits were studied by the State Survey and appear to have potential for substantial reserves of copper and gold (Hausel, 1989).

Royal Gold of Denver began exploration for gold in southern Wyoming with emphasis on the Aspen Mountain prospect south of Rock Springs. Earlier studies in this area by the Wyoming State Geological Survey identified numerous gold anomalies where none had previously been reported (Hausel and others, 1992; 1993).

Four different companies were continuing their exploration for gold in the Rattlesnake Hills in Natrona County. This region appears to have good potential for widespread, low-grade gold deposits (Hausel, 1994).

A & E Resources of Jackson, Fleck Resources of Canada, Bald Mountain Mining of South Dakota, and Verdstone Gold of California were all exploring the Laramie Mountains for diamonds. Detailed studies of this area have been published by the Wyoming State Geological Survey (Hausel and others, 1988). Additionally, Union Pacific Resources, Bald Mountain Mining, and others were continuing their diamond exploration in the Leucite Hills near Rock Springs, based on studies by the State Survey (Hausel and others, 1992).

According to the July 4, 1994, issue of the *Northern Miner*, Colorado Diamond Company has recovered one of the largest gem quality diamonds ever found in North America. The 14.2-carat octahedron was extracted from a 9,100-

tonne bulk sample from the Kelsey Lake kimberlites along the Colorado-Wyoming border south of Laramie.

Zinn-Wolfram of Germany reported plans to explore for platinum and other strategic metals in the Lake Owen area of the Medicine Bow Mountains later this year. The Lake Owen area is in a layered mafic-ultramafic complex with zones of anomalous platinum, palladium, chromium, and vanadium (Hausel, 1991).

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MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1994)

Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.4	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.0	billion barrels

Remaining Reserve Base (January 1, 1994)

Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.28	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.08	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1994)

Discovered (Includes 20.1 trillion cubic feet (TCF) of methane[1] and 122.0 TCF of CO_2[3])	140.0	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,847.2	trillion cubic feet

Remaining Reserve Base (January 1, 1994)

Measured reserves (Proved reserves) (Includes 10.4 TCF of methane[2] and 60.4 TCF of CO_2[3])	70.8	trillion cubic feet

COAL

Remaining Resources (January 1, 1994)

Identified and Hypothetical (Discovered)	1,428.0	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,459.5	billion tons

Remaining Reserve Base (January 1, 1994)

Demonstrated strippable (Measured and indicated reserve base)	26.4	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	68.9	billion tons

TRONA

Original Resources (1990 estimate)

Trona	81.0	billion tons[8]
Mixed trona and halite	52.7	billion tons[8]
Total	133.7	billion tons

URANIUM

Remaining Resource (December 31, 1989) ..... 1.99 billion pounds U_3O_8[9]

Remaining Reserve Base (December 31, 1989)

Uranium oxide recoverable at $30.00 per pound ..... 66 million pounds[9]

OIL SHALE

Original Resources (January 1, 1981)

Identified (Discovered) ..... 320 billion barrels of shale oil[10]

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

[2] Modified from Energy Information Administration, 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
Staff Geologist-Geologic Mapping, Wyoming State Geological Survey

WYOMING STATE GEOLOGICAL SURVEY PROVIDES EXHIBIT AT NATIONAL CONVENTION IN DENVER

Over 6,600 registrants (as compared to 6,444 in New Orleans in 1993) contributed to a successful annual meeting of the American Association of Petroleum Geologists (AAPG) in Denver. The 1994 annual convention ran from June 12-15, and focused on global exploration and development. Three days of oral presentations and poster sessions highlighted new developments in geology and geophysics related to the domestic and international petroleum industry.

There were 305 exhibitors who displayed the latest in technology and available geologic information and data. The International Pavillion, a new addition to this year's exhibition, included over 40 foreign countries promoting petroleum exploration opportunities in their countries. The Wyoming State Geological Survey promoted Wyoming through their recent oil and gas publications and the answering of questions related to Wyoming geology, petroleum, and other mineral activity in the State. The booth was manned by Survey staff geologists Alan Ver Ploeg and Rod De Bruin. Among the numerous conventioners that stopped by the State Survey's booth, interest was especially high with respect to gas exploration in Wyoming.

SYMPOSIUM ON DINOSAURS HELD IN CASPER

Between June 16th and 20th, the Wyoming Geological Association and the Friends of the Tate Museum sponsored a symposium on dinosaurs. Over 300 dinosaur enthusiasts attended the five-day gathering in Casper. The symposium included 22 papers presented on various dinosaur related topics, varying from descriptions of recent dinosaur discoveries to paleontologic resource management on Federal lands. The symposium was preceded by field trips to the Como Bluff area and the Alcova area where the participants could look at these famous historical sources for Jurassic Morrison Formation dinosaurs in Wyoming (**Figure 19**). Some of the participants also went on a post-conference field trip to the dinosaur finds in the Cretaceous Lance Formation in eastern Wyoming and to Sussex, Wyoming, for an examination of the Cretaceous-Tertiary boundary claystone layer (**Figure 19**). On various evenings, paleontologists Bob Bakker, Kraig Derstler, and Jack Horner each presented general

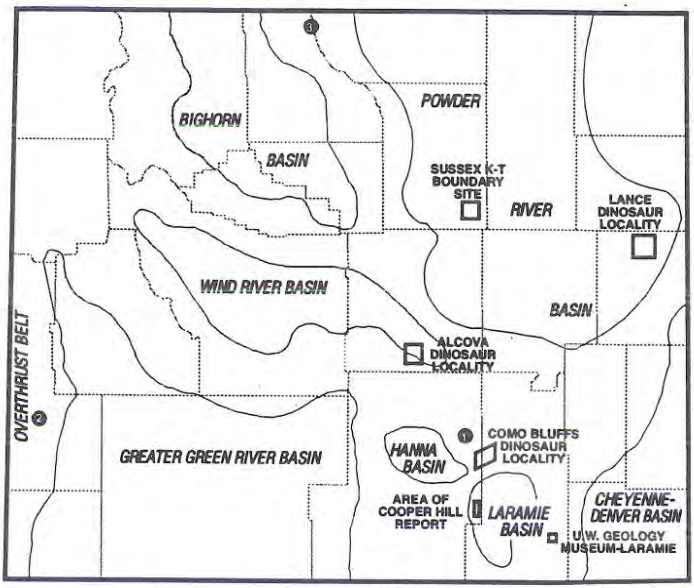


Figure 19. Index to selected geologic activities and recently released maps and reports on Wyoming geology.

interest talks relating to Wyoming dinosaur finds. A special teacher workshop on Wyoming dinosaurs was presented by Bob Bakker and Kent Sundell.

In addition, at this meeting, First Lady Jane Sullivan announced that *Triceratops* was the new Wyoming State Dinosaur. School children in about 650 classrooms across the State elected *Triceratops* the state dinosaur from a group of dinosaurs which included *Apatosaurus*, *Meglosaurus*, and *Diplodocus*. *Triceratops* was elected with 70% of the vote in an election mandated by legislation passed by the Wyoming State Legislature last winter. According to Brent Breithaupt, curator of the University of Wyoming Geology Museum, *Triceratops* was the first dinosaur discovered in Wyoming. Drs. Meek and Bannister of the Hayden Survey discovered the remains of *Agathaumas sylvestris*, a form of *Triceratops*, near Black Butte Station in western Wyoming in 1872 (**Figure 19**). Part of these remains are on display at the University of Wyoming's Geology Museum in Laramie (**Figure 19**). These three-horned plant-eaters were about 25 feet long and may have weighed as much as 5 tons, making them one of the largest of the horned dinosaurs. They are found in the Upper Cretaceous Lance Formation, which was deposited 66-68 million years ago.

PUBLIC COMMENT PERIOD EXTENDED ON LANCE CREEK ACEC

In early March, a public hearing in Lusk drew over 250 area residents. Ninety percent of the comments at the meeting were critical of the U.S. Bureau of Land Management's (BLM's) proposal to establish a new Area of Critical Environmental Concern (ACEC) near Lance Creek to help protect paleontologic values in the area (see p. 57, *Wyoming Geo-notes No. 42*) (**Figure 19**). As a result, the BLM decided to extend the comment period into early May and delay the release of the final Resource Management Plan. Many commentors were concerned that the proposed ACEC designation would draw even more attention to the area, increasing the potential for trespass on private lands, or that it would lead to more restrictions on oil and gas exploration and development.

REPORT ON COOPER HILL MINING DISTRICT PUBLISHED

The Wyoming State Geological Survey recently published a new geologic report authored by W. Dan Hausel and titled, *Geology and mineralization of the Cooper Hill mining district, Medicine Bow Mountains, southeastern Wyoming.* This publication, released as Report of Investigations 49, discusses the general geology and mining history of the Cooper Hill area (**Figure 19**), and includes whole-rock and trace element analyses of selected rock samples from the Cooper Hill district. A geologic map of the Cooper Hill district and maps of the various historic mines in the area are included in the report.

NEW JOURNAL ARTICLES ON WYOMING GEOLOGY

Three new journal articles were recently published on Wyoming geology. Blackstone (1994) discussed the structural geology of the Oil Springs and Flat Top anticlines in Carbon County, Wyoming, in the April issue of the *Mountain Geologist*. The article includes a geologic map, structure contour map, and cross sections. The structure of these two features is discussed relative to the adjacent Freezeout Hills and Hanna Basin. The influence of inherited taper on structural variability and conglomerate distribution in the thrust belt was outlined by Lawton and others (1994) in the April issue of *Geology*. The authors noted that changes in thickness of the pre-thrust stratigraphy of the North American Cordillera within the U.S. affected the development of the late Mesozoic fold and thrust belt. In the April issue of the *AAPG Bulletin*, Willis (1994) presents a potential new treatment of data gathered on the Laramide deformation of the basement in the Five Springs area on the western flank of the Bighorn Moun-

tains. The author expresses concern with previous interpretations of data used to determine regional stress orientations.

These articles are listed below and the study areas are indicated by number on **Figure 19**.

1. Blackstone, D.L., Jr., 1994, Oil Springs and Flat Top anticlines, Carbon County, Wyoming: An unusual fold pair: The Mountain Geologist, v. 31, no. 2, p. 53-60.

2. Lawton, F.L., Boyer, S.E., and Schmitt, J.G., 1994, Influence of inherited taper on structural variability and conglomerate distribution, Cordilleran fold and thrust belt, western United States: Geology, v. 22, p. 339-342.

3. Willis, J.J., 1994, Laramide basement deformation in an evolving stress field, Bighorn Mountain front, Five Springs area, Wyoming: Discussion: American Association of Petroleum Geologists Bulletin, v. 78, no. 4, p. 644-651.

GEOLOGIC HAZARDS IN WYOMING

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

MAPPING OF SURFICIAL GEOLOGY IN WYOMING

Most homes, roads, buildings, or other facilities in Wyoming are constructed on surficial materials derived from the weathering and transport of bedrock, rather than on the bedrock itself. Consequently, the designs for these construction projects must take these surficial materials into account. Surficial materials can also have an effect on processes other than construction. The supply and quality of shallow ground water, for example, can be affected by surficial materials. Also, because many aquifers in Wyoming are composed entirely of surficial materials, such as alluvium, these surficial materials can affect the recharge rates and water quality of these aquifers. Surficial materials are usually the first to be affected when toxic materials are spilled. The type, lateral extent, and thickness of the surficial materials often controls both the route and the rate of migration of the toxic materials.

Only a few selected areas in Wyoming have had their surficial geology extensively mapped. There are six 1:100,000-scale surficial geology maps published: the Evanston, Gillette, Kemmerer, Recluse, Reno Junction, and Sheridan 30'x60' quadrangles. A 1:125,000-scale surficial geology map has

also been published for Yellowstone National Park. In addition, soils maps have been published for select areas or counties in the State, but soils maps are usually not the same as surficial geology maps. Surficial geologic maps differ from both soils maps and bedrock geologic maps in that they delineate surficial landforms and the materials or deposits associated with the landforms.

The Geologic Hazards Section at the Wyoming State Geological Survey is in the process of generating preliminary surficial geologic maps for the entire State of Wyoming. The landforms and deposits on the maps include alluvium, bench and terrace deposits, colluvium, eolian features and deposits, glacial features and deposits, landslides, mesas, residuum, slopewash, clinker, hot spring deposits, and gruss. In addition, bedrock and truncated upturned bedrock are mapped in areas where they are not covered with surficial materials. Combinations of the above parameters are also shown on the maps.

The first draft of a statewide map at a scale of 1:500,000 is nearing completion. The Section is also preparing maps at a scale of 1:100,000 to provide more detail. In addition to being a project of the Geologic Hazards Section, the mapping is in support of a cooperative project between the U.S. Environmental Protection Agency (EPA) and the State of Wyoming. In that project, investigators will be examining the vulnerability of aquifers to agricultural contamination. The Wyoming Water Resources Center, Wyoming Department of Environmental Quality-Water Quality Division, Wyoming State Geological Survey, Wyoming State Engineer, and University of Wyoming, including the Department of Geography, Department of Geology and Geophysics, and Department of Plant, Soil, and Insect Sciences, are all responsible for varying aspects of data generation and compilation on the aquifer vulnerability project.

The Wyoming Water Resources Center will digitize and incorporate the surficial geologic maps into a Geographic Information System when the maps are completed. The Wyoming State Geological Survey will also make the maps available. Planners, developers, soil scientists, engineers, geologists, and others should find these maps valuable. For additional information on the surficial geology maps, contact Jim Case or Laura Larsen at the Wyoming State Geological Survey.

ROCKHOUND'S CORNER

The U.S. Forest Service has rescinded its proposed new regulations that would have severely limited, if not eliminated, recreational fossil and mineral collecting on all Forest Service lands. Public comments on the proposed changes to 36 CFR Parts 261 and 262 were overwhelmingly opposed to the new wording. Rockhounds, recreational prospectors, geologists, educators, and

virtually anyone who entered Forest Service lands would have been adversely affected.

The Forest Service's Enforcement Division is redoing the proposed rules to clarify what they intended to say. Presumably, hobby collection of invertebrate fossils, rocks, and minerals will be permitted after the rules are rewritten. It is not clear if the new rules will be made public before they are again published in the Federal Register. A word to the wise, keep your ears and eyes alert to the forthcoming revisions.

Persons interested in tracking the progress of these rule changes may find Jack Gregory at (912) 267-2471 or Kathryn Toffenetti at (202) 720-2651 helpful. These were the contact persons on the first version of the rule changes.

Rockhound's Corner is a new addition to *Wyoming Geo-notes*. If you have any rockhounding or fossil collecting questions, send them to Rockhound's Corner, Wyoming State Geological Survey, P.O. Box 3008, University Station, Laramie, WY 82071, and we will try to answer them.

NEW PUBLICATIONS OF THE WYOMING STATE GEOLOGICAL SURVEY

Geology of Wyoming, edited by A.W. Snoke, J.R. Steidtmann, and S.M. Roberts: Memoir 5, 1993.- $75.00 plus postage and handling. Wyoming addresses include 6% sales tax before adding postage. Add first class postage of $5.00 (Wyoming), $10.00 (other states), and $20.00 (International, including Canada).

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

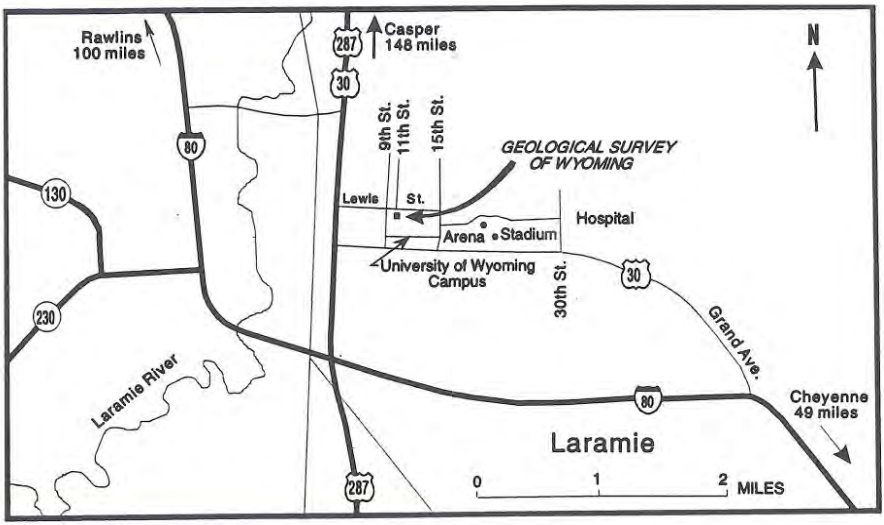
*Geology and mineralization of the Cooper Hill mining district, Medicine Bow Mountains, southeastern Wyoming, by W.D. Hausel: Report of Investigations 49, 1994. - $7.00

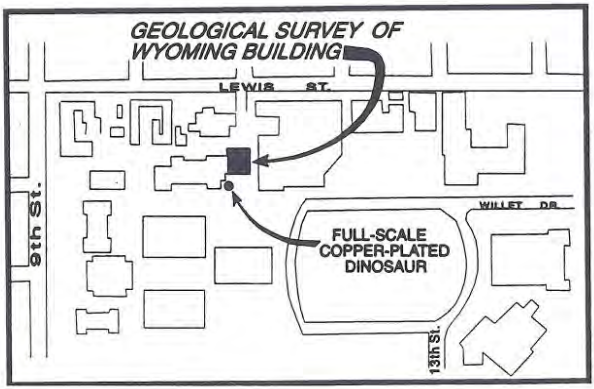
*New releases since the last issue of *Wyoming Geo-notes*.

The Wyoming State Geological Survey sells the *Atlas of major Rocky Mountain gas reservoirs*, a publication prepared by the state geological surveys of New Mexico, Colorado, Utah, and Wyoming.- $99.75. Available over-the-counter or PREPAID, by mail from the Wyoming State Geological Survey in Laramie. Checks must be made out to: New Mexico Bureau of Mines and Mineral Resources. (Price includes postage and handling).

"Order these and other publications from: Wyoming State Geological Survey, P.O. 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."

WYOMING STATE GEOLOGICAL SURVEY
LOCATION MAPS





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