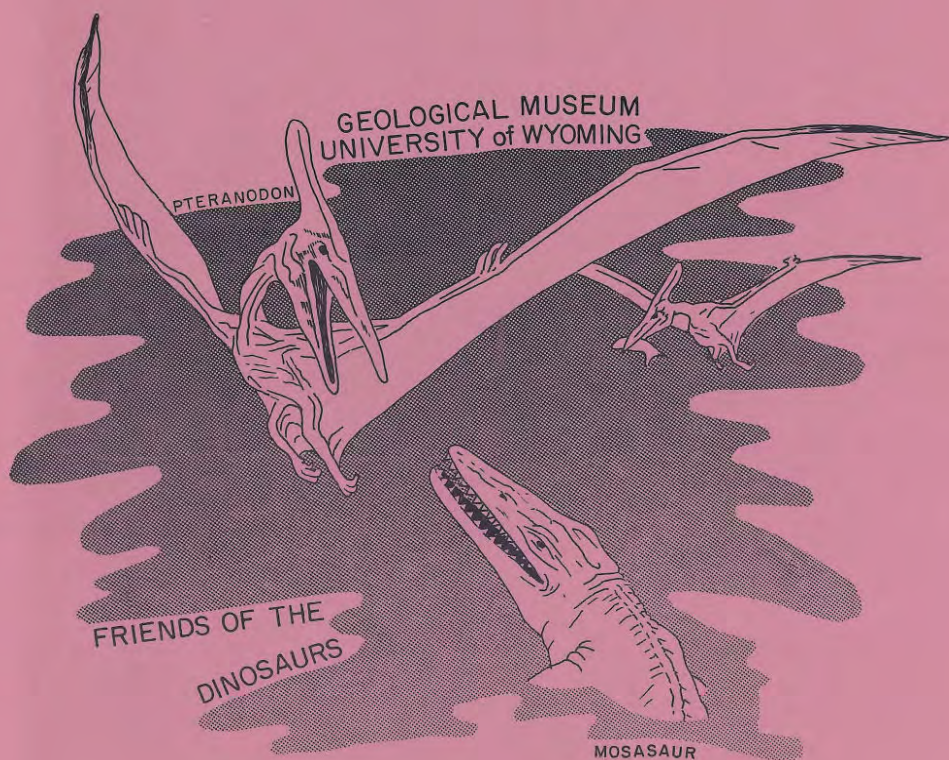


THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES

NO. 28



LARAMIE, WYOMING
November, 1990

THE GEOLOGICAL SURVEY OF WYOMING

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WYOMING GEO-NOTES

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Cover: The University of Wyoming's Geology Museum introduces "Friends of the Dinosaurs". See page 42 of this issue.

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MINERALS UPDATE

OVERVIEW

by Gary B. Glass, State Geologist

How fast things change when the Middle East is involved! The invasion of Kuwait, coupled with the United Nations' trade embargo of Iraq and the United States' "energy policy", which has allowed oil imports to exceed 50 percent of the Nation's daily requirements, have all combined to drive oil prices to their highest level since the last energy crisis. For example, oil futures were pushing \$40 a barrel in late September.

Although rapid and large swings in the price of oil are going to continue under any Middle East scenario, the bottom line is that the 4 million barrels of daily production attributable to Iraq and Kuwait are being made up by other producers. High prices for oil futures are coming from investors that are betting on an open war in which production from some of Iraq's neighbors are interrupted. We can all pray this does not happen.

Last quarter we were forecasting the posted price of oil at \$17 a barrel. Now the average posted price for Wyoming crude looks more like it will be \$22 a barrel in 1990. For the next several years, we are forecasting the average posted price at \$25 per barrel. After gravity adjustments, these posted prices translate into a first purchase price of \$20 and \$23, respectively (Table 1).

The recent higher prices for oil are not likely to stimulate oil exploration because the prices are still too volatile to attract much capital. Wyoming should; however, see some previously marginal stripper wells continue to produce and some others come back on production. There is also optimism that some tertiary and enhanced oil recovery projects that were shelved when prices were low might be dusted off and activated. Also the huff n' puff carbon dioxide process for enhanced oil recovery (*Wyoming Geo-notes No. 27*, p. 6) seems like a natural to take advantage of fluctuating changes in price.

Stripper and tertiary production are each projected to increase by about 500,000 barrels a year through 1994. With these things in mind, we have slightly increased our forecast of oil production for the next several years (Table 2). Oil production; however, is still expected to decline by about 2 percent a year.

The real excitement in the oil patch of Wyoming (other than improved prices) is still the Niobrara play in the southeastern part of the State (*Wyoming Geo-notes No. 27*, p. 41-43). Two horizontally-drilled holes in the Niobrara have come in at 2,000 and 1,462 barrels of oil per day, respectively. The newest well looks capable of sustained production over 400 barrels per day. While other horizontal wells are planned in this Niobrara play, companies are also looking at the Niobrara in other parts of the State as well as at other formations that might be equally good targets for this drilling technique.

Table 1. AVERAGE PRICE PAID FOR WYOMING OIL, NATURAL GAS, COAL, TRONA, AND URANIUM, FORECAST TO 1994¹.

Calendar Year	Oil ²	Natural Gas ³	Coal ⁴	Trona ⁵	Uranium ⁶
*1985	23.61	3.03	11.35	35.18	36.82
*1986	13.10	2.51	10.71	34.80	52.45
*1987	16.50	2.02	9.54	36.56	43.55
*1988	13.41	1.74	9.09	36.88	25.77
*1989	16.64	1.64	8.63	40.76	22.09
1990	20.00	1.64	8.29	44.00	19.00
1991	23.00	1.80	7.94	45.00	22.00
1992	23.00	1.98	7.59	46.00	25.00
1993	23.00	2.18	7.24	46.00	25.50
1994	23.00	2.40	6.99	47.00	26.00

* Actual value for comparison.

¹ Modified from Consensus Revenue Estimating Group, Wyoming State Government Revenue Forecast FY91-FY95, October, 1990, 18 p.

² First purchase price in dollars per barrel.

³ Wellhead price in dollars per MCF (includes carbon dioxide).

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

⁵ Dollars per ton of trona.

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

Table 2. WYOMING MINERAL PRODUCTION, FORECAST TO 1994¹.

Calendar Year	Oil ²	Methane ³	Carbon Dioxide ³	Helium ⁴	Coal ⁵	Trona ⁵	Mined Uranium ⁶	In-situ Uranium ⁷	Sulfur ⁸
*1981	122.1	455.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	465.1	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	539.7	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	600.1	—	—	130.7	11.0	1.6	—	0.63
*1985	131.0	597.9	—	—	140.4	10.8	0.6	—	0.60
*1986	122.4	563.2	23.8	0.15	136.3	13.3	0.3	—	0.66
*1987	115.9	619.0	114.2	0.86	146.5	13.6	0.2	0.06	1.19
*1988	114.3	701.6	110.0	0.83	163.6	14.9	0.3	1.40	0.96
*1989	109.1	739.0	126.1	0.94	171.1	16.2	0.1	1.07	1.07
1990	104.4	777.0	127.0	0.95	179.2	16.9	0.45	1.0	1.10
1991	102.3	795.0	127.0	0.95	187.6	17.5	0.45	1.5	1.10
1992	100.3	894.0	127.0	0.95	196.4	18.5	0.45	4.0	1.10
1993	98.3	1,015.0	127.0	0.95	205.0	20.0	0.45	4.0	1.10
1994	96.3	1,034.0	127.0	0.95	214.0	20.0	0.45	6.0	1.10

*Actual values for comparison; ¹Geological Survey of Wyoming, October, 1990; ²millions of barrels; ³billions of cubic feet; ⁴billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; ⁵millions of tons; ⁶millions of tons of uranium ore (not yellowcake); ⁷millions of pounds of yellowcake (U₂O₆), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1989-1994 are based on company information); ⁸millions of tons (prior to 1989, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission).

The Middle East crisis is not really affecting the natural gas and coal markets yet. Obviously, if oil prices stay up long enough, there may be some effect as energy users look for less interruptable as well as less expensive fuels. The driving forces in the growing demands for natural gas and coal; however, precede the crisis in the Middle East.

In the case of natural gas, the demand is finally catching up with the supply. The price has apparently bottomed out at about \$1.64 per MCF and should increase at about 10 percent a year at least through 1994 (Table 1). Production, which has been going up each year, will continue to increase about 2 percent a year until 1992 when a Wyoming to California pipeline should boost production at least an extra 90 million MCF and possibly more (Table 2). Although the likelihood of a pipeline being built increases each quarter, it is still unclear whether it will be built by Kern River or WyCal. Since both companies have ordered materials, there is also the possibility that two pipelines will be built.

Interest in coalbed methane has not slackened as more and more projects have been announced. There are now coalbed methane plays in nearly every basin in Wyoming. It also appears that Congress may extend the tax incentives for this kind of unconventional gas play. By the time this issue of *Wyoming Geo-notes* is published, we will have published a new report on coalbed methane in Wyoming, which summarizes the occurrences, resources, and development activities.

Coal production is expected to continue increasing at slightly less than 5 percent a year at least through 1994. By then the effect of the new Clean Air Act ought to be noticeable. Since the act contains provisions for utilities to burn low-sulfur coal, Wyoming coal producers should see some additional markets open up. However, because of the way the new standards are phased in, it is likely to be a number of years before there is significant new demand. Our forecast for coal production in Table 2 is now somewhat higher than it was last quarter.

While new coal prices are not really coming down, the average price paid for Wyoming coal is projected to decrease 3-5 percent a year (Table 1). This is because more and more spot coal, new contracts, and renegotiated contracts are in the range of \$3.50 to \$5.00 a ton. When these increasing quantities of low-priced coal are averaged with the older and higher-priced contract coal, the overall average value goes down. Low-priced coal (\$3.50-\$5.00), which only accounted for 6 percent of Wyoming's production in 1985, is estimated at 24 percent in 1990 and could be over 50 percent by 1995 (Table 8). Overcapacity is still the problem creating low coal prices. But there is an obvious bright side to overcapacity. When demand does increase substantially, Wyoming mines can supply those demands and quickly.

While it is obvious that things are continuing to improve for the oil, gas, and coal industries of the State, there is also some good news in the uranium industry. Production of uranium from both conventional open pit mining and from in-situ (solution-mining) recovery methods are both expected to increase over the next 5 years (Table 2). These increases are related to the depletion of domestic uranium stockpiles. And prices are also forecast to increase (Table 2).

In non-fuel minerals, trona has the spotlight. All five trona-mining companies have either recently expanded, are expanding, or are planning to expand their refineries and product facilities. There is a mini-boom in southwestern Wyoming with all this construction. A more detailed discussion is found on pages 31-33 of this issue of *Wyoming Geo-notes*.

In the third quarter of 1990, interest in gold, copper, aggregate, limestone, decorative stone, and silica continued. In addition there were inquiries about diatomite and vermiculite deposits in Wyoming.

Table 3. PRODUCTION HISTORY OF SELECTED WYOMING MINERAL COMMODITIES¹.

	1981	1982	1983	1984	1985	1986	1987	1988	1989
Ballast ^{2,3}	1.72	0.81	0.99	2.43	0.67	0.61	1.09	0.80 ⁸	1.28 ⁷
Bentonite ²	4.81	2.35	2.18	3.08	2.59	1.82	2.16	2.32	2.22 ⁷
Clay ⁴	23.2	15.7	36.4	59.6	35.9	23.2	1.31	61.1	NA ⁹
Decorative Stone ²	0.05	0.05	0.07	0.08	0.09	0.07	0.06	0.07 ⁸	0.06 ⁷
Dolomite ²	0.87	0.61	0.66	0.86	0.87	0.81	0.46	0.19 ⁷	0.15 ⁷
Feldspar ⁴	0.03	0.17	----	----	----	----	----	----	----
Gypsum ²	0.28	0.26	0.33	0.33	0.35	0.41	0.35	0.40 ⁸	0.20 ⁷
Iron Ore ²	4.67	3.28	2.48	----	----	----	----	----	minor ¹⁰
Limestone ^{2,5}	0.72	0.59	0.56	0.65	0.32	0.34	0.42	0.64	0.60 ⁷
Sand and Gravel ²	5.21	4.74	5.00	4.76	4.71	3.53	2.57	2.16	4.62 ⁷
Scoria ^{2,6}	0.08	0.08	0.07	0.23	0.13	0.04	----	0.20 ⁷	0.37 ⁷
Shale ⁴	----	----	----	20.3	14.7	9.88	49.0	50.2 ⁷	NA ⁹
Sodium Sulfate ⁴	3.20	3.17	3.19	3.25	2.71	2.03	----	2.10 ⁷	NA ⁹

Sources: ¹ Ad Valorem Tax Division. ² Millions of short tons. ³ Includes granite, scoria and other rock. ⁴ Thousands of short tons. ⁵ Includes limestone used for cement rock, sugar beet refining, and other uses. ⁶ Baked and fused rock, also called clinker. ⁷ Wyoming State Inspector of Mines. ⁸ Estimated by Geological Survey of Wyoming. ⁹ NA = not available. ¹⁰ Less than 1,000 tons of iron ore were sold for pigment. Prepared by Geological Survey of Wyoming, October, 1990.

OIL AND GAS UPDATE

by Rodney H. De Bruin, Oil and Gas Division Head, Geological Survey of Wyoming

In *Wyoming Geo-notes* No. 27, posted prices for Wyoming Sweet crude oil were predicted to average less than \$17 a barrel in the third quarter of 1990. Iraq's invasion of Kuwait, however, changed all that. By late September, futures' prices were hovering around \$40 a barrel, their highest level to date. Some experts predict that oil prices could go to \$65 or more per barrel if war breaks out and Iraq destroys production and transportation facilities in key producing countries such as Saudi Arabia.

Closer to home, the posted price for Wyoming Sweet was over \$30 a barrel for the last half of September and averaged \$29 a barrel for the month. The average posted price in August was \$25.55 per barrel. These prices contrast with July's pre-invasion average of \$17.05 a barrel (Figure 1). For comparison, the average price Wyoming oil producers actually receive for their oil (after gravity adjustments) is about \$2 less than the posted price (first purchase price on Figure 1).

The Wyoming rig count has not yet responded to the higher oil prices (Figure 2). Companies are apparently waiting to see if prices will remain at their present levels before they commit to more exploration and production drilling. Many companies are also not prepared to accelerate their exploration activities because the low, fluctuating prices of the past several years left them with very small professional staffs. For similar reasons, there is also a shortage of rigs and trained drilling personnel.

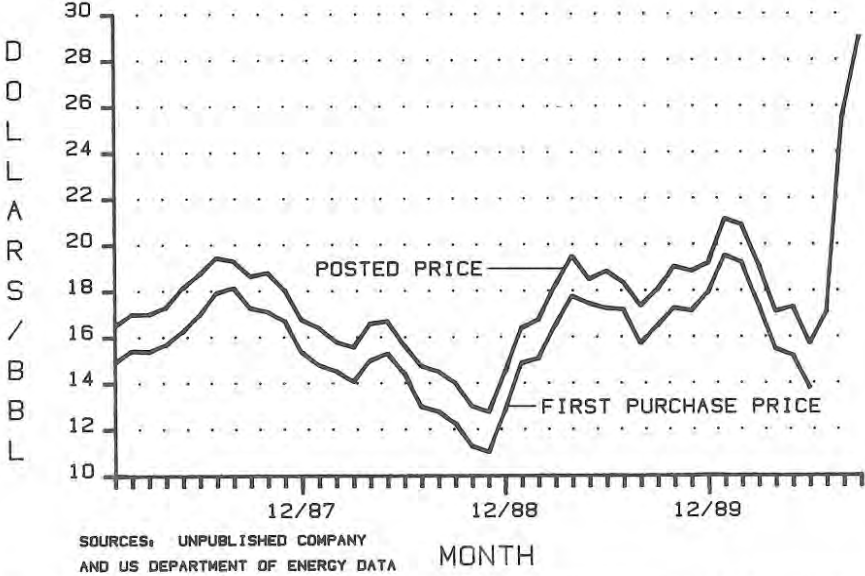


Figure 1. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987 TO PRESENT).

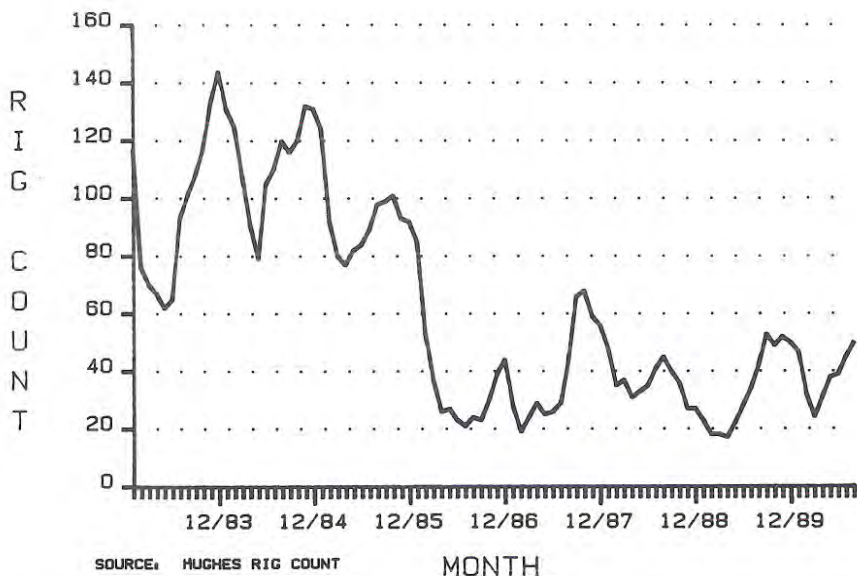


Figure 2. WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT).

In the last quarter, one thing happened that could help improve domestic oil exploration during this new energy crisis. In a recently released document, the U. S. Forest Service called for easing environmental regulations for oil and gas leases in National Forests. The proposal calls for reevaluation of environmental review procedures in 40 environmental impact statements. Five of these statements concern leases in Wyoming.

In regard to natural gas activities, Kern River Gas Transmission Co. awarded purchase orders for compressor units and valves for its natural gas pipeline from Wyoming to California. Wyoming-California Pipeline Co. (WyCal) also ordered compressor units and contracted for engines to power the compressors for their Wyoming to California pipeline. It is almost certain that one of these pipelines will be built, but it is still uncertain which will be built or if both will be built.

The Wyoming Oil and Gas Conservation Commission's final production figures for 1989 show that Wyoming produced 109.1 million barrels of oil and a record 866 billion cubic feet of gas. The top 25 oil fields in the State (Table 4) produced 53 percent of Wyoming's oil in 1989. A good share of the oil from these fields was discovered many years ago; however, 10 of the 25 largest fields were discovered after 1970. The top 25 gas fields in Wyoming (Table 5) produced 74 percent of the State's gas in 1989. In contrast to oil, most of this gas came from fields discovered after 1970, and the average year of discovery for the top five fields is 1980. All of these oil and gas fields are shown on Figure 4.

Table 4. TOP 25 OIL FIELDS IN WYOMING BASED ON 1989 PRODUCTION (WYOMING OIL AND GAS CONSERVATION COMMISSION, 1990).

Name	Year discovered	1989 Production (barrels)	Cumulative production through 1989 (barrels)
Oregon Basin	1912	7,922,408	395,687,383
Hartzog Draw	1976	5,541,132	71,671,862
Salt Creek	1889	4,494,320	631,029,665
Buck Draw North	1988	3,706,989	3,815,647
Painter Reservoir East ¹	1987	3,694,757	10,647,798
Wertz	1921	2,843,003	102,428,421
Elk Basin	1915	2,815,995	434,681,961
Garland	1906	2,659,260	165,423,174
Hamilton Dome	1918	2,581,322	232,712,535
Little Buffalo Basin	1914	2,388,915	120,831,386
Grass Creek	1914	2,292,027	187,214,863
Pitchfork	1930	2,066,198	37,135,277
Brady	1973	1,863,767	57,091,795
Lost Soldier	1916	1,742,854	211,167,326
Whitney Canyon-Carter Creek	1978	1,718,963	10,782,496
Powell	1954	1,402,424	20,560,704
Painter Reservoir ¹	1977	1,259,017	45,898,098
Luckey Ditch	1985	1,070,235	4,981,609
Sand Dunes	1981	945,284	2,726,126
Byron	1918	944,823	121,388,865
Winkleman	1917	878,903	87,342,698
Frannie	1928	877,250	113,088,509
Teapot Dome Naval Reserve	1922	817,966	20,902,077
Ryckman Creek	1976	810,663	17,918,548
Blue Forest	1983	752,377	1,527,881
		58,090,852	3,108,656,704

¹Before 1987, production for Painter Reservoir and Painter Reservoir East Fields was combined under Painter Reservoir.

Table 5. TOP 25 GAS FIELDS IN WYOMING BASED ON 1989 PRODUCTION (WYOMING OIL AND GAS CONSERVATION COMMISSION, 1990).

Name	Year discovered	1989 Production (MCF) ¹	Cumulative production through 1989 (MCF) ¹
Fogarty Creek ²	1976	130,604,759	394,473,408
Whitney Canyon-Carter Creek	1978	111,472,042	706,892,475
Lake Ridge ²	1981	41,759,754	145,731,520
Painter Reservoir ³	1977	40,031,296	395,004,149
Painter Reservoir East ³	1987	27,614,045	76,582,415
La Barge	1925	25,675,311	296,286,659
Wertz ⁴	1921	23,235,980	71,265,916
Brady	1973	22,594,107	308,979,125
Ryckman Creek	1976	21,961,971	146,023,776
Blue Forest	1983	21,017,281	39,797,884
Madden	1969	18,991,820	287,370,651
Powell	1954	16,628,154	113,921,566
Table Rock	1946	15,591,130	448,282,247
Echo Springs	1976	14,269,509	157,438,808
Standard Draw	1979	12,803,436	112,654,592
Well Draw	1973	12,513,561	87,529,297
Lincoln Road	1977	12,311,200	36,442,298
Clear Creek	1979	11,254,247	116,115,919
Tip Top	1928	11,033,834	347,313,172
Nitchie Gulch	1962	9,580,768	98,288,716
Bruff	1974	8,804,362	120,698,868
Beaver Creek	1938	8,573,404	569,889,009
Birch Creek	1957	8,110,008	174,056,063
Hogsback	1955	7,477,154	318,330,541
Green River Bend	1958	7,316,309	195,456,722
		641,225,442 ⁵	5,764,825,796 ⁶

¹ Thousand cubic feet.

² Approximately two-thirds of the production from this field is carbon dioxide.

³ Before 1987, production from Painter Reservoir and Painter Reservoir East Fields was combined under Painter Reservoir.

⁴ Nearly all gas production from Wertz is carbon dioxide derived from tertiary operations and the carbon dioxide is recycled.

⁵ Approximately 115,000,000 MCF are carbon dioxide.

⁶ Approximately 360,000,000 MCF are carbon dioxide.

Even though Wyoming's 1989 gas production increased by 53.6 billion cubic feet over 1988's production, the average price Wyoming producers received in 1989 declined about 10 cents. The spot price remained below the average sales price except during the last part of the year when a very cold winter drove up demand and spot prices (Figure 3). Although the spot price and the average sales price still show very little relationship to one another, so far this year, they are both about the same as in 1989. The higher average price of crude oil, however, should increase both the demand and the price for natural gas to some extent.

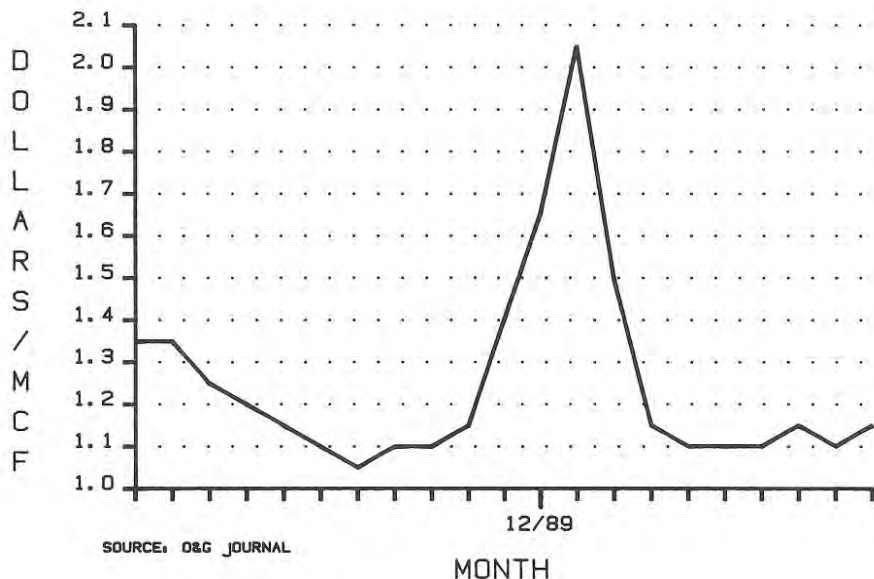


Figure 3. SPOT GAS PRICES AT OPAL, WYOMING, AVERAGED BY MONTH (1989 TO PRESENT).

Although the State Land and Farm Loan Office's July sale did not generate as much revenue as their later September sale, it was still a relatively good sale in terms of the number of tracts and acres leased (Table 6). This sale took place before the crisis in the Middle East and before oil prices shot up. Paul Sawyer made the high per-acre bid of \$60 for a 40-acre lease in NE NE section 21, T32N, R82W. The lease is in the Wind River Basin and is approximately two miles southwest of Frontier, Muddy, and Lakota oil production at Iron Creek Field. Context Energy made the second highest bid of \$58 per acre for a 640-acre parcel covering section 16, T14N, R64W. The lease is six miles north of the horizontal-drilling play in the Niobrara Formation in Silo Field (see *Wyoming Geo-notes No. 27*, p. 41-43). Several other tracts were leased in this area to test the Niobrara.

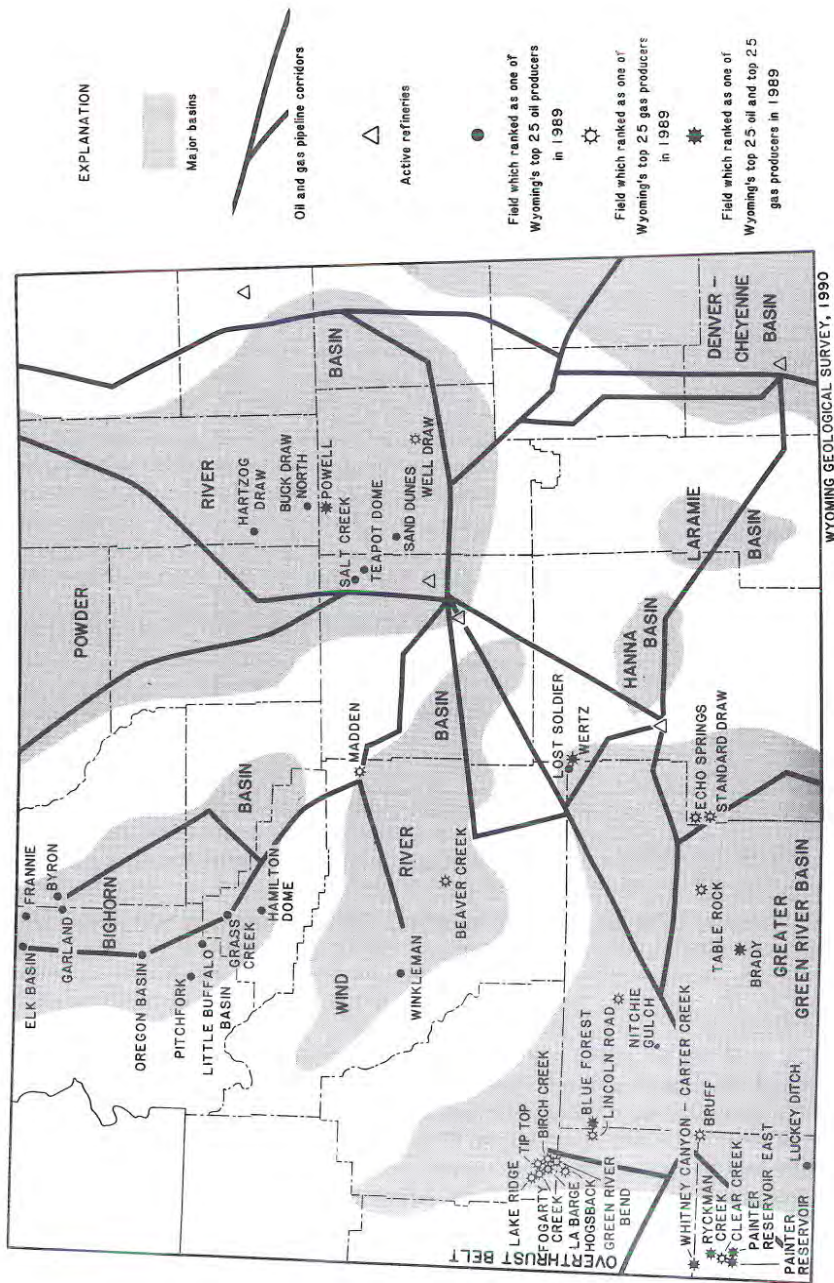


Figure 4. TOP 25 OIL AND GAS FIELDS IN WYOMING THROUGH 1989.

Table 6. FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES IN WYOMING

BLM SALES							STATE SALES								
Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
1987															
TOTAL	\$15,724,159	727	646	197,422	177,960	\$ 88.36	\$6,555.00	TOTAL	\$2,526,567	1,200	579	511,638	244,740	\$10.32	\$2,300.00
1988															
March	\$7,338,210	866	336	1,073,940	315,387	\$23.27	\$525.00	January	\$826,698	200	142	76,953	56,430	\$14.65	\$200.00
June	\$7,564,135	820	375	755,242	293,050	\$25.81	\$575.00	March	\$800,213	200	133	76,304	48,423	\$16.53	\$465.00
August	\$5,827,548	847	363	827,471	278,198	\$20.95	\$1,350.00	May	\$1,649,974	200	182	75,987	69,285	\$23.81	\$290.00
October	\$3,913,765	820	257	994,618	282,145	\$13.87	\$6,500.00	July	\$1,855,646	200	155	77,168	60,519	\$30.66	\$375.00
December	\$3,045,203	766	260	761,242	182,117	\$16.72	\$330.00	September	\$751,646	200	142	68,456	55,168	\$13.63	\$180.00
TOTAL	\$27,688,861	4,119	1,591	4,412,513	1,350,897	\$20.50	\$6,500.00	November	\$318,547	200	119	71,085	42,118	\$7.56	\$130.00
1989															
February	\$2,418,295	800	230	857,475	187,012	\$12.93	\$1,225.00	TOTAL	\$6,202,724	1,200	873	445,953	331,943	\$18.69	\$1,640.00
April	\$2,334,604	732	227	557,643	145,055	\$16.09	\$390.00	January	\$331,145	200	112	73,322	39,650	\$8.35	\$110.00
June	\$1,673,150	758	163	962,929	138,691	\$12.06	\$160.00	March	\$493,179	200	129	74,512	47,866	\$10.30	\$140.00
August	\$3,469,570	656	197	577,518	141,841	\$24.46	\$285.00	May	\$512,796	199	129	76,396	51,919	\$9.88	\$155.00
October	\$3,247,334	788	296	657,918	178,013	\$18.24	\$3,000.00	July	\$684,374	200	154	82,760	65,034	\$10.52	\$190.00
December	\$2,689,152	552	247	415,266	181,791	\$14.79	\$340.00	September	\$474,104	200	134	77,889	50,749	\$9.34	\$540.00
TOTAL	\$15,832,105	4,286	1,360	4,028,750	972,403	\$16.28	\$3,000.00	November	\$628,446	200	134	76,973	56,036	\$11.22	\$170.00
1990															
February	\$3,301,479	524	259	335,275	141,555	\$23.32	\$340.00	TOTAL	\$3,123,984	1,199	792	461,852	311,274	\$10.04	\$540.00
April	\$2,163,988	513	218	399,790	138,909	\$15.58	\$275.00	January	\$190,921	200	100	74,987	38,884	\$4.91	\$46.00
June	\$3,480,557	511	315	305,550	172,798	\$20.14	\$240.00	March	\$688,262	200	132	79,405	54,193	\$12.33	\$85.00
August	\$2,892,191	533	251	493,185	187,259	\$15.44	\$325.00	May	\$690,310	199	146	79,667	60,986	\$11.32	\$270.00
								July	\$521,824	200	154	78,507	62,999	\$8.28	\$60.00
								September	\$1,472,248	200	200	80,197	80,197	\$18.75	\$240.00

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

The State Land and Farm Loan Office's September sale sold all 200 tracts that were put up for bid. This is the first sale that sold all offered tracts since the competitive bid procedure replaced simultaneous drawings in 1983. The revenue from this sale was the highest since the July, 1988 sale (Table 6). The results of the sale are an encouraging sign that drilling activity may soon accelerate in Wyoming. The high per-acre bid at this sale was \$240 by Kenneth Berry for a 200-acre parcel that includes W/2 NE, SE NE, and W/2 SE section 12, T52N, R70W. The lease is less than a mile southeast of Minnelusa oil production at C-H Field.

Acreage in southeast Wyoming remained in demand because of the horizontal-drilling play in the Niobrara in that part of the State. Scott Airey made the second highest per-acre bid of \$61 for a 40-acre lease in SW NE section 22, T23N, R66W. The parcel is a mile south of shut-in Niobrara oil production in Chugsprings Field. Airey was the successful bidder for two other leases in T23N, R66W. He paid \$56 per acre for a 160-acre parcel covering NW section 22, and \$55 per acre for a 650-acre tract covering S/2 section 21 and N/2 section 28.

The U.S. Bureau of Land Management's (BLM) early August sale was held just after Iraq's invasion of Kuwait and before oil prices rose substantially. The sale was still relatively good in terms of acres leased and total revenue (Table 6). The high bid of \$325 per acre was made by Andover Partners for a 370.64-acre tract, which covers various lots in sections 27 and 28, T53N, R69W, near Minnelusa oil production in Candy Draw Field. Marathon Oil paid \$170 per acre for an 800-acre parcel which covers parts of sections 8, 9, and 24, T23N, R112W. The lease is in the area of Frontier gas production at Storm Shelter and Emigrant Springs Fields.

A sale of leases owned by Warren Livestock Co. was also held in August and drew \$621,000. A total of 21 tracts covering 35,780 acres in Wyoming's Laramie County and Colorado's Larimer and Weld Counties were sold. William Colson made the high per-acre bid of \$40 for a 1,916.48-acre parcel that covers all of sections 1, 11, and 12, T15N, R66W in Laramie County. The tract is approximately five miles west of Cowan Oil's successful horizontal test of the Niobrara in Silo Field (*Wyoming Geo-notes No. 27*, p. 14). All the tracts leased are related to the Niobrara play in Wyoming and Colorado.

Based on company data and on information compiled and published by Petroleum Information, the following significant exploration and development events occurred in Wyoming during the third quarter of 1990. The letters preceding the discussions below refer to locations on Figure 5.

A. In western Wyoming, DEKALB Energy scheduled the first methane test of coal beds in the Upper Cretaceous Adaville Formation. The location is in SE NW section 36, T22N, R117W.

B. WEXPRO Co. completed three new gas producers in Church Buttes Field. The 78 Church Buttes Unit well in SE NW section 26, T17N, R112W, flowed 3.6 million cubic feet of gas, three barrels of condensate, and eight barrels of water per day from the Frontier and Mowry comingled. The 82 Church Buttes Unit well in C NW

section 28, T17N, R112W, was completed flowing 1.7 million cubic feet of gas per day from the Dakota. The 79 Church Buttes Unit well flowed 557,000 cubic feet of gas per day during a test in the Dakota. The company is ready to complete three more tests and is drilling another well in Church Buttes Field.

C. Texaco has plans to drill a horizontal test of the Dakota in Bruff Field. Plans are to drill a vertical hole in C SE section 26, T19N, R112W, run geophysical logs, and then drill the Dakota horizontally if results from the vertical hole are unsatisfactory.

D. Two more extension wells in Sugarloaf Butte Field were completed. Presidio Exploration completed the 33-35 UPRR well in SE NE section 35, T22N, R111W. The well is producing 290,000 cubic feet of gas and 200 barrels of oil per day from the Dakota based on the latest production figures. General Atlantic Resources completed the 25-1 Sugarloaf-UPRR well in NE SE section 25, T22N, R111W, flowing 1.3 million cubic feet of gas and 446 barrels of oil per day from the Dakota. A drillstem test of the Frontier recovered 1,176 feet of oil.

E. Amoco Production completed the 1 State of Wyoming-AI well in SW NE section 16, T22N, R111W, flowing 1.6 million cubic feet of gas, 72 barrels of condensate, and 36 barrels of water per day from the Frontier. The well is about a mile west of the Legacy Field discovery, which produces oil and gas from the Dakota.

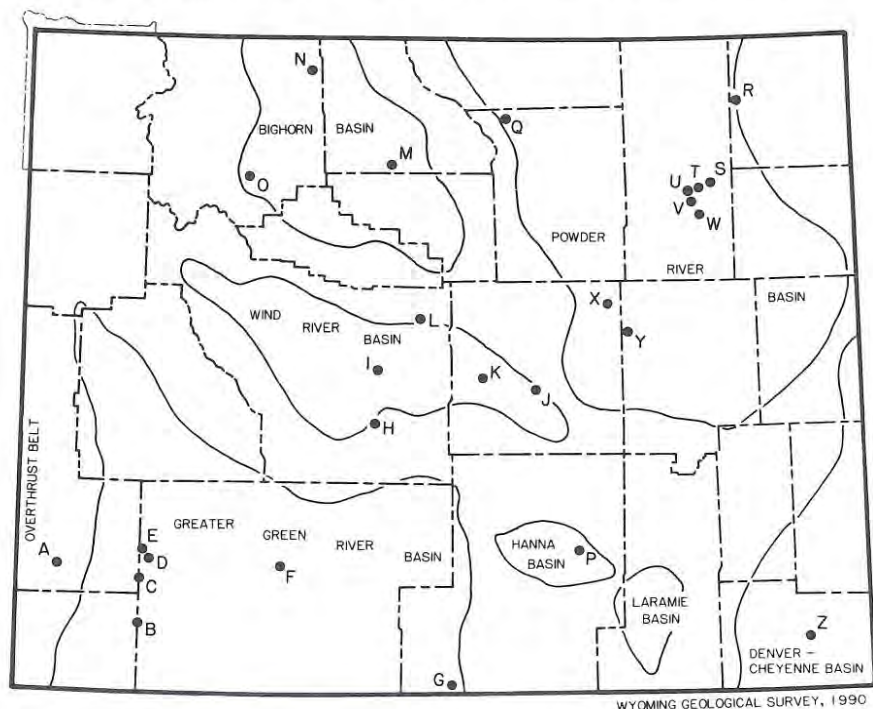


Figure 5. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING.

F. Triton Oil and Gas Corp. plans to drill 94 wells to develop gas from coal beds in the Rock Springs Formation in T22N and T23N, R101W-R103W. Triton's plans to drill up to 48 wells during the last part of 1990 may be changed or postponed because the BLM decided to require an environmental impact statement. Fifty-seven of the 94 wells are planned on land administered by the BLM. Triton estimates that each well will produce 1,200-1,600 barrels of water initially, but that the water production will quickly drop to 200 barrels per day. If all 94 wells are drilled, up to 23 evaporation ponds could be required.

G. Fuel Resources Development Co. (Fuelco) has staked 18 more new locations in sections 1, 2, 3, 4, 10, 11, and 12, T12N, R90W, and in sections 34 and 35, T13N, R90W, to test coal beds in the Almond Formation. Fuelco may drill up to 30 wells in this area. Four coalbed-methane wells drilled by Fuelco in sections 2 and 11, T12N, R90W are currently being evaluated.

H. John S. Wold completed the 4 Government-Hearney well in SW NE section 5, T31N, R94W, flowing one million cubic feet of gas per day from the Lakota. The well is in Longs Creek Field, which produces from the Phosphoria. A well earlier this year also established production from the Frontier in this field.

I. TCF Inc. completed another Fort Union well in Fuller Reservoir Field. The Conoco Federal 1-25 in NE NW section 25, T36N, R94W, was completed in 13 sandstone zones between 4,750 and 7,550 feet. The well flowed 4.1 million cubic feet of gas per day.

J. Unocal plans to expand their tertiary steam injection project at South Casper Creek Field. Projected incremental oil recovery for the expansion is 9.75 million barrels of oil. An additional 1.4 million barrels will be produced from existing steam injection activity. Total projected recovery for this project is 11.15 million barrels of oil.

K. Medallion Petroleum is producing gas and condensate from the Muddy Sandstone at an extension to Wallace Creek Field. The 1 Wallace Creek well in SE SE section 21, T34N, R87W, produced an average of 855,000 cubic feet of gas per day during June, the last month for which production figures are available.

L. Louisiana Land and Exploration (LL&E) will drill the third Madison well on the Madden Deep Unit. The well is a proposed 24,500-foot test on the eastern end of the Madden anticline in SW NE section 12, T38N, R90W, and is eight to 10 miles east of two other wells, the 1-5 Bighorn in SW NW section 5, T38N, R90W, and the 2-3 Bighorn in NW SE section 3, T38N, R90W, which were completed in the Madison, flowing 20 million and 38 million cubic feet of gas per day, respectively. The company also announced plans to build a \$50 million, 50 million cubic feet per day gas processing plant. The Madison gas is sour and the company estimates that 4.7 tons of sulfur will be recovered for each million cubic feet of gas the plant processes. If the plant runs at capacity, LL&E estimates it will produce 235 marketable tons of sulfur per day.

M. Two wells drilled by Unocal have been completed in the Muddy Sandstone on the southeastern flank of Five Mile Field. The 55A-J34 Worland Unit well produced an average of 27 barrels of oil and 753,000 cubic feet of gas per day during June. The well is in SW NE section 34, T49N, R93W. The 60-M34 Worland Unit well produced an average of 4 barrels of oil and 266,000 cubic feet of gas daily during June. The well is in SW SW section 34, T49N, R93W.

N. Texaco Inc. completed a workover of an abandoned Tensleep Sandstone well in Whistle Creek Field. The 36-16 Whistle Creek Unit well in NE SW section 16, T56N, R98W, pumped 327 barrels of oil and 58 barrels of water per day from the Morrison Formation. Texaco plans to work over three other abandoned Tensleep producers in the field for completion in the Morrison.

O. Phillips Petroleum recovered 447 barrels of oil and five barrels of water during a one-day swab test of the Dinwoody-Phosphoria at their 39-2 Rose Creek-State Well in SW SW section 34, T49N, R103W in Rose Creek Field. Phillips has locations staked for two more wells in the area.

P. Exploration for coalbed methane continues in the Hanna Basin. Metfuel Inc. took over as operator of Anderman-Smith's wells and has cased one well and finished drilling another. The 11-1 UPRR-Palm Livestock well in the NE NW section 11, T23N, R81W, was cased and the 3-1 UPRR-Palm Livestock well in NE SE section 3, T23N, R81W was drilled as a 6,000-foot test of coals in the Ferris Formation. Three other locations have been staked in the area.

Q. Texaco staked a location for a 1,500-foot test of coal beds in the Wasatch Formation on the western side of the Powder River Basin. The 1 Texaco-Lott-Fee well will be drilled in SE SE section 13, T52N, R83W.

R. McAdams, Roux, and Associates completed two new Minnelusa producers in Cambridge Field. The 32-28 Cambridge-Plains-Federal well in SW NE section 28, T53N, R68W, pumped 474 barrels of oil per day. The 21-28 Plains-Federal in NE NW section 28, T53N, R68W, pumped 111 barrels of oil per day.

S. Caza Exploration discovered Railroad Bend Field when their 1-Burnor-State well in SE SW section 16, T48N, R70W, pumped 403 barrels of oil per day from the Minnelusa Formation. Caza is also testing their 1 Ripcord-State well in SW NW section 16, T47N, R70W, after recovery of 2,300 feet of gas-cut oil on a drillstem test of the Minnelusa.

T. DCD Inc. recently completed two shallow Fort Union coalbed methane producers south of Gillette. The 6-9 Linny well in SE NW section 9, T47N, R71W, flowed 108,000 cubic feet of gas daily from an interval between 169 and 242 feet. The 13-16 State well in SW SW section 16, T47N, R71W, flowed 30,000 cubic feet of gas per day from an interval between 275 and 340 feet. No water production was reported at either well.

U. Ampolex Inc. completed a Minnelusa discovery on the southwestern edge of the Minnelusa trend. Their 24-21 Wagensen Heirs well in SE SW section 21, T46N, R72W, pumped 271 barrels of oil and 75,000 cubic feet of gas daily. During the well's first month of production, it produced 5,177 barrels of oil.

V. LASMO Energy completed a new Minnelusa discovery. Their 1-30 Appaloosa well in SW SW section 30, T45N, R72W, pumped 23 barrels of oil and 60 barrels of water per day through perforations between 12,309 and 12,321 feet. This well is one of the most southwesterly producers in the Minnelusa trend.

W. Harvey E. Yates proposed a horizontal test of Niobrara in the Powder River Basin. The well would have a surface location near the center of section 19, T44N, R71W. The Niobrara is around 9,000 feet deep in this area. A vertical Niobrara producer, completed in 1985 by First Energy Corp, in NE SE section 24, T44N, R72W, has produced over 32,000 barrels of oil from the Niobrara.

X. GLG Energy proposed the Si Tanka Federal Exploratory Unit which would cover 85 square miles in T38N-T41N, R77W and R78W on the eastern flank of Salt Creek and Teapot Dome Fields. The company proposes the evaluation of the Niobrara Formation with horizontal drilling. A secondary objective is the Carlile Shale. According to the company, over four million barrels of oil were produced from the Niobrara and Carlile at Salt Creek Field between 1911 and 1957. There is currently production from the Niobrara at Teapot Dome Field. GLG plans to drill four obligation wells scattered throughout the unit.

Y. Kerr-McGee Corp. completed their 43-26 Derrick Draw-Federal well in NE SE section 26, T36N, R76W, to confirm their Derrick Draw Field discovery. The new well is currently shut in, but it produced a total of 12,416 barrels of oil and 10 million cubic feet of gas from the Muddy during 21 total days of production in April and May.

Z. Cowan Oil scheduled four more horizontal Niobrara tests in Silo Field. The company's first horizontal well, which was completed earlier this year in NW NE section 11, T15N, R65W, initially flowed 2,000 barrels of oil and 500,000 cubic feet of gas from the Niobrara. This well is reportedly capable of several hundred barrels of oil per day on sustained production. The new tests will have surface locations in sections 20, 21, 22, and 29, T16N, R64W. Cowan is also drilling a horizontal well with a surface location in E/2 SE section 22, T16N, R64W. Union Pacific Resources has also staked two additional locations for horizontal Niobrara tests in the Silo Field area. The new locations are in NE NW section 5, T15N, R64W and section 12, T15N, R65W. In October, Union Pacific's earlier well, the 1H Antelope 9-11 in NW SE section 11, T15N, R64W came in at 1,462 barrels on a 21-hour test. At last report, this new well looked like it would be capable of producing at about 400 barrels of oil per day.

COAL UPDATE

by Richard W. Jones, Coal Division Head, Geological Survey of Wyoming

Wyoming's coal production for 1990 appears to be headed for another record. Coal deliveries for the first half of this year were about 5 million tons (or 6 percent) ahead of those recorded for the first half of last year (see Table 7 and Figure 6). Accordingly, our previous forecast has been revised upward to 179.2 million tons for 1990. This represents a total increase of slightly less than 5 percent over 1989's production. Coal production in the Powder River Coal Field (Campbell, Converse, and Sheridan counties) is expected to increase about 5 percent each year from 1990 through 1995 (see Table 8 and Figure 7). Southern Wyoming counties will show slight increases from 1990 through 1992 and then level off or decrease slightly from 1993 to 1995. By 1993, the State's coal production will exceed 200 million tons per year.

Much of the forecasted production increases are directly related to increases in the amount of low-priced coal (under \$5.00 per ton) sold on the spot market, through short-term contracts, or through renegotiated long-term contracts. For example, during the first half of 1989, about 6.1 million tons of spot coal alone was delivered to utilities. This amount of spot coal accounted for about 8 percent of all coal deliveries. During the first half of 1990, about 11.0 million tons of spot coal accounted for about 13 percent of all coal deliveries. The percentage of low-priced coal (including spot, short-term and renegotiated contract coal) will continue to increase at least through 1995 (see Table 8). The prevailing spot coal prices (\$3.50 - \$4.50) appear to be controlling, to a large degree, the short-term contract prices as well as the long-term contract prices that are being renegotiated under price reopener clauses in the contracts.

As more and more Wyoming coal is sold for under \$5.00 per ton, the average price paid for the State's coal production will continue to decline. If the trend continues, the overall price of Wyoming coal could drop from the \$8.63 a ton observed in 1989 to \$6.99 a ton in 1994 (Table 1).

National coal production for 1990, recently estimated by the National Coal Association (NCA), is expected to exceed 1 billion tons for the first time ever. This is an increase of 22 million tons or about 2.3 percent more than that produced in 1989 and will mark the fourth consecutive year that national production has set a new record. The NCA predicted that the increase in electrical generation from 1989 to 1990 would be only 1.6 percent, as compared to the 2.7 percent increase recorded from 1988 to 1989, and that coal consumption for electrical generation would increase by 7 million tons in 1990. About 77 percent of the Nation's coal production is used to generate electricity. The NCA also reported that western coal production for the first third of 1990 was 11.7 percent greater than for the same period in 1989 and that by year's end, it could be about 397 million tons.

Additional data on Wyoming's 1989 coal production became available in the third quarter of 1990 (see Table 9 and Figure 8). According to the 1989 Annual

Table 7. COAL DELIVERIES BY MONTH FROM WYOMING MINES¹

	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE	1990 MONTHLY	1990 CUMULATIVE
JANUARY	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020	15,059,530	15,059,530
FEBRUARY	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160	13,328,290	28,387,820
MARCH	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,885,490	14,535,270	42,923,090
APRIL	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940	14,155,470	57,078,560
MAY	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110	13,882,590	70,961,150
JUNE	10,469,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970	12,948,350	79,482,460	13,649,070	84,610,220
JULY	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640	14,043,350	93,525,810	15,368,280	99,978,500
AUGUST	11,773,510	87,195,190	13,460,470	92,150,870	15,041,090	101,533,730	15,428,210	108,954,020		
SEPTEMBER	11,474,820	98,670,010	12,651,550	104,802,420	13,433,610	114,967,340	13,795,760	122,749,780		
OCTOBER	10,954,670	109,524,680	12,248,080	117,050,500	13,696,190	128,653,530	14,523,480	137,273,260		
NOVEMBER	11,971,990	121,496,670	12,340,720	129,391,220	13,889,890	142,553,420	14,507,130	151,780,390		
DECEMBER	13,025,490	134,522,160	13,008,300	142,399,520	14,540,510	157,093,930	13,527,880	165,308,270		

TOTAL TONNAGE 134,522,160

142,399,520

157,093,930

165,308,270

TOTAL TONNAGE 1,782,896

4,089,128

6,494,270

5,831,734

TOTAL TONNAGE 136,305,056

146,488,648

163,588,200

171,140,004

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

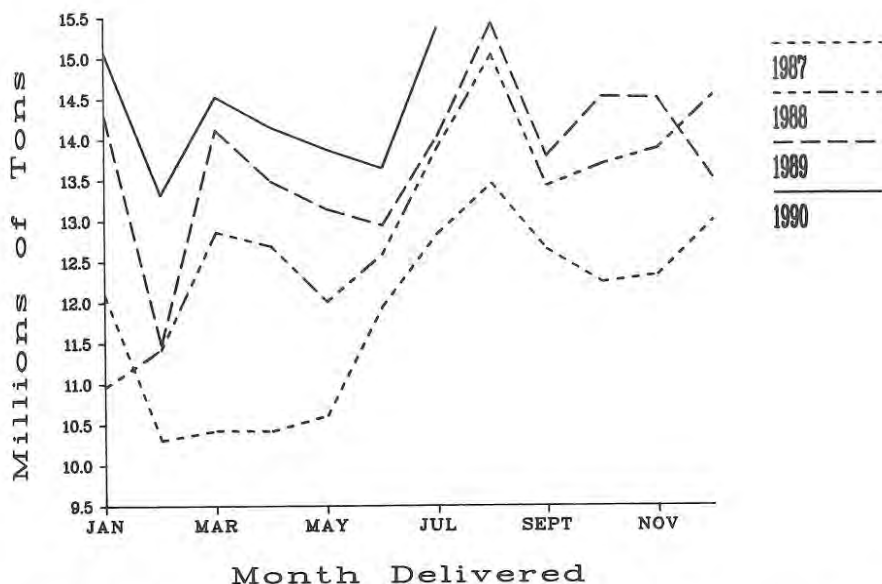


Figure 6. REPORTED DELIVERIES FROM WYOMING COAL MINES. (FROM COALDAT MARKETING REPORT BY RESOURCE DATA INTERNATIONAL, INC., COMPILED FROM FERC FORM 423 FILED MONTHLY BY ELECTRIC UTILITIES).

Report of the State Land and Farm Loan Office, coal produced from State of Wyoming leases was at its lowest level in twelve years; the 1.7 million tons produced in 1989 was about half of that produced in 1988. In spite of the decline in production, the value of the coal produced on State leases increased from \$36.5 million in 1988 to \$39.6 million in 1989 and the royalties generated from the coal increased from \$4.6 million to \$5.1 million. The increases in royalties and value of State coal in 1989 were caused by a dramatic decline in coal production on State leases in Campbell County and an increase in production in Sweetwater County (see Table 9). The State coal in Campbell County had an average value of \$4.92 a ton in 1989 while the State coal in Sweetwater County had an average value of \$24.26 a ton. This caused the average value of coal from State leases to increase from \$10.36 per ton in 1988 to \$22.68 per ton in 1989.

According to one Government report, Federal coal produced in Wyoming in 1989 accounted for about 85 percent of the State's total production (Minerals Management Service, 1990). Private coal produced in the State accounted for 14 percent of the total and State-owned coal accounted for only one percent of the total. Federal coal produced in Wyoming in 1989 was slightly more than that reported in 1988 (see Table 9), but it still accounted for almost 70 percent of the total 209.3 million tons of Federal coal reportedly produced in the United States. Production of Federal coal in 1989 accounted for 21 percent of the total coal production in the U.S. The Federal coal produced in Wyoming during the 1989 calendar year had a total market value of about \$1.6 billion, an average value of \$10.85 (an increase of 6

Table 8. COAL PRODUCTION AND FORECAST TO 1995 (MILLIONS OF TONS).

	1983 ¹	1984 ¹	1985 ¹	1986 ¹	1987 ¹	1988 ¹	1989 ¹	1990	1991	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	150.0	157.4	164.8	172.4	181.1	190.1
Converse County	2.7	3.3	3.6	4.8	5.1	5.7	6.1	7.5	8.0	9.0	10.0	10.5	11.0
Sheridan County	2.9	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.1	M ²	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	4.3	4.6	4.5	4.3	4.1	3.8	3.5
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	12.0	12.0	12.5	13.0	13.0	13.0	13.0
Lincoln County	4.0	4.1	4.3	4.0	3.8	4.9	4.8	5.0	5.1	5.3	5.5	5.6	5.8
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming ³	112.2	130.7	140.7	135.7	146.5	163.6	171.1	179.2	187.6	196.4	205.0	214.0	223.4
Annual change	4%	16.5%	7.7%	-3.6%	8.0%	11.7%	4.6%	5%	5%	5%	4%	4%	4%
Low-priced coal ⁴			6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%

¹ These are actual values for comparison. ² M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, September, 1990. ³ Totals may not equal sum of components because of independent rounding. ⁴ Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under \$5.00.

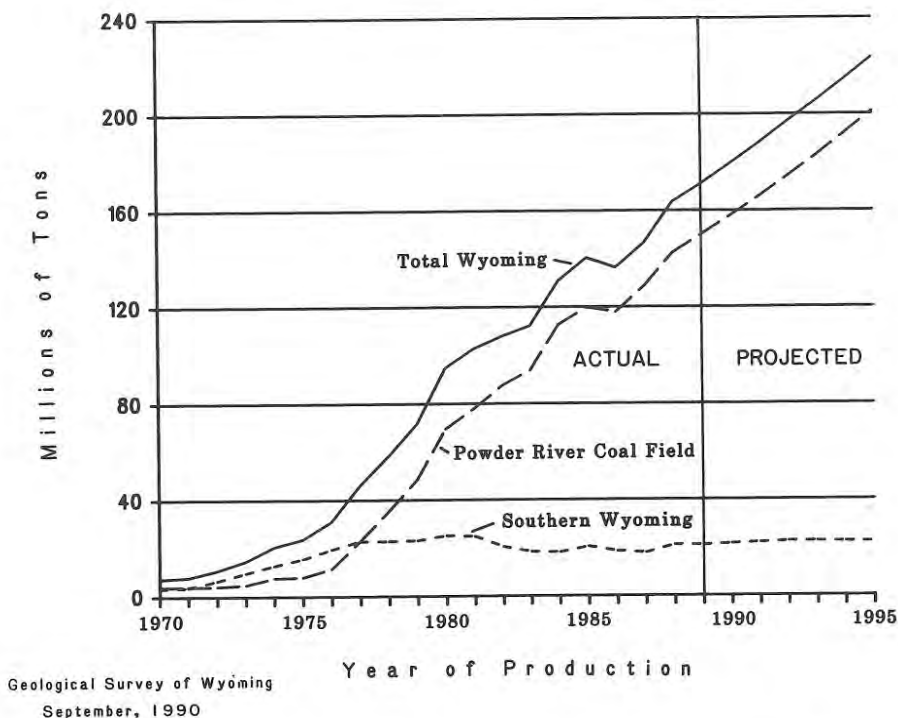


Figure 7. WYOMING COAL PRODUCTION AND FORECAST TO 1995.

percent over 1988), and generated royalties of over \$100 million. The State of Wyoming receives half the Federal royalties collected on the coal.

Another somewhat different report on Federal coal production released during the third quarter of 1990 also summarized Federal coal activities during the 1989 Fiscal Year (October 1, 1988, to September 30, 1989). According to this report, 151.7 million tons of Federal coal were produced in Wyoming. This accounted for about 72 percent of the 211.4 million tons produced nationally (U.S. Department of the Interior, 1990). Montana, Utah, and Colorado accounted for 14 percent, 10 percent, and 7 percent, respectively, of the Federal coal produced. The Federal coal produced in Wyoming during Fiscal Year 1989 had a total value of nearly \$1.3 billion and an average value of about \$8.50 per ton.

We note that the average value of a ton of coal on a calendar year basis (as reported by the Minerals Management Service) was \$10.85 as compared to the

Table 9. COAL PRODUCTION STATISTICS FOR WYOMING ARRANGED BY COAL OWNERSHIP.

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

COAL PRODUCTION ON STATE LEASES BY COUNTY²

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

Data sources:

¹ Minerals Management Service Annual Reports, 1981-1989.² State Land and Farm Loan Office's Annual Reports, 1979-1990.³ Derived by subtraction of State and Federal production from total.⁴ Annual Reports, Wyoming State Mine Inspector and Wyoming Ad Valorem Tax Division.

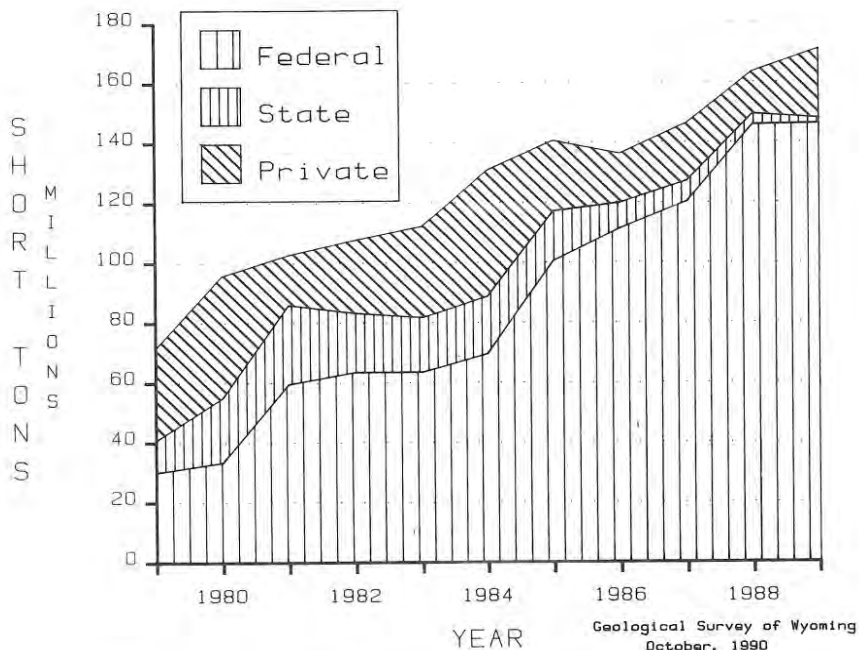


Figure 8. WYOMING COAL PRODUCTION BY OWNERSHIP CATEGORY (DERIVED FROM TABLE 9).

\$8.50 per ton reported on a fiscal year basis. The differences in production and prices between various Federal publications are not only complicated by the differing reporting period, but also by the fact that they may include some collections from previous reporting periods, i.e. funds held by litigation, and perhaps reflect corrections as well. Consequently, the statistics in these reports are often contradictory and confusing.

In other developments concerning Federal coal, leasing activities in Wyoming as well as in other states appears to be increasing. When the four Regional Coal Teams (RCT's) in the western U.S. were decertified in 1988 and 1989, leasing of Federal coal went to a lease-by-application system. Since the new system was implemented, the Powder River Federal Coal Production Region alone has had 4 coal companies apply for a total of 7,557 acres of Federal coal in 5 tracts adjacent to active mines on existing Federal leases in Wyoming.

Developments in western and southwestern Wyoming

In September, the U.S. Bureau of Land Management held a lease sale for an 81-acre tract of Federal coal located adjacent to Lion Coal Company's Swanson underground mine east of Rock Springs. The tract was sold in response to a lease-

by-application submitted by Lion Coal Company. The apparent high bidder at the lease sale was Lion Coal Company, which submitted a bid of \$353.37 per acre and a total bid of \$28,976.34. Published data for the tract listed recoverable coal reserves of 289,762 tons. The tract contains coal having a heating value of 11,300 Btu per pound, 1.2 percent sulfur, 6.1 percent ash, and 11.7 percent moisture, all on an as-received basis.

The proposed Thousand Springs coal-fired project in northeastern Nevada (see *Wyoming Geo-notes No. 26*, April, 1990, pages 19-20 and *Wyoming Geo-notes No. 27*, July, 1990, page 24) has apparently been cancelled by its developer, Sierra Pacific Resources. Four of the project's 8 participants withdrew from the project, citing market uncertainties (lowered demand for electric power plus lack of firm purchase contracts), increased cash demands for licensing, and environmental problems. The project was slated to use coal from both western Wyoming (Pittsburg and Midway Coal Mining Company's Kemmerer mine) and Utah. Much of the opposition to the project came from groups in Idaho and Utah concerned with the potential air quality impacts downwind from the plant. The Environmental Impact Statement for the project was due to be completed in January, 1991. Each of the eight 250-megawatt units in the project would have used about 0.9 million tons of coal annually.

Developments in the Hanna Coal Field

Coal from the Hanna Coal Field was tested during the third quarter of 1990 by several utility companies. Iowa Electric Light and Power (IEL&P) tested coal from Rosebud Coal Sales Company's Rosebud mine north of Hanna. Evidently, the test burns were so successful at IEL&P's Sutherland, Iowa, power plant that the utility expects to use 140,000 tons of the 10,600 Btu-per-pound coal by the end of the year.

Niagara Mohawk Power Corporation has also tested coal from the Hanna Coal Field at two of the utility's power plants in New York. Although no specific tonnages or coal sources were made public, the utility company is evidently planning to blend western coal with eastern coal in the event that clean air legislation mandates a reduction in plant emissions. The utility might blend from 10 to 50 percent western coal. Powder River Basin coals have also been tested by Niagara Mohawk.

Cyprus-Shoshone Coal Company has recently installed a large longwall shearing machine in the Shoshone No. 1 underground mine. The machine, which is capable of cutting a 16.5-foot-high coal bed, will only cut 14.5 feet of the coal bed in the Shoshone mine because the roof support shields are limited to that height. The shearer is 49 feet long with an 8-foot diameter cutting drum and a 1,400 horsepower electric motor. It was reported that Cyprus-Shoshone expects the shearer to help increase production at this mine to 2.0 million tons per year (Taliaferro, 1990). Currently the mine produces 1.5 million tons per year.

Developments in the Powder River Coal Field

In late September, Amax Coal Company announced that 50 employees at the Eagle Butte mine and 10 employees at the Belle Ayr mine would be laid off. In

explaining the reasons for the cuts, the company cited more efficient mining plans and operational changes, brought about by depressed spot market pricing related to excess production capacity. These layoffs are the first since 1987. According to the State Inspector of Mines, the Belle Ayr and Eagle Butte mines averaged 273 and 253 employees, respectively, in 1989.

Amax Coal Company also announced in the third quarter of 1990 that they were considering building up to five more coal drying units adjacent to their Campbell County coal mines. The dried coal product produced from the company's first coal dryer at the Belle Ayr mine has been sold to some electric utility companies (see Coal Contracts - Powder River Coal Field below for details). The dried coal, which has a heating value of from 10,500 to 10,800 Btu per pound and a moisture content of about 10 percent, can be blended with coals having a higher sulfur content to reduce sulfur emissions. The dried coal can also be blended with run-of-mine coal in various amounts to bring up the overall heating value of the coal. A single coal drying plant costs about \$14 million to construct and is capable of producing about 1.2 million tons of dried coal each year. If all five additional coal drying plants are constructed, Amax would construct three at the Eagle Butte mine and two more at the Belle Ayr mine.

Each year more companies in the Powder River Coal Field are introducing large draglines for removing the overburden that lies on top of their coal beds. In past years, surface coal mines in the Powder River Coal Field have been dominated by truck and shovel operations. With increased production at many of the eastern Powder River Basin coal mines, the shallowest coal on many mine properties has already been extracted and more overburden must be removed and handled to continue production. The large draglines make it easier and more efficient to handle the large volumes and increased thicknesses of overburden.

In September, Nerco Coal Corporation dedicated a large dragline equipped with a 78-cubic yard bucket on a 295-foot-long boom at the Antelope mine in northern Converse County. This year at the Antelope mine, Nerco is expecting to nearly double their 1989 production of 3.5 million tons. Cordero Mining Company has also announced that they will be purchasing a dragline before 1992 for their Cordero mine south of Gillette. The North Antelope mine in southern Campbell County has used a dragline since the mine was opened in 1983 and Thunder Basin Coal Company has been operating a dragline at its Black Thunder mine for several years. A dragline has also been used at Thunder Basin Coal Company's Coal Creek mine. Glenrock Coal Company's Dave Johnston mine in Converse County has also used draglines extensively in their stripping operation since the mine opened in 1958.

The new Dry Fork coal mine northeast of Gillette began mining operations in August as it became Campbell County's fifteenth active coal mine. The mine is operated by Dry Fork Coal Company, a limited partnership between Phillips Coal Company and Western Fuels-Wyoming, a subsidiary of Western Fuels Association. Initial production of 2.7 million tons per year will be shipped to the Laramie River Power Station north of Wheatland, Wyoming. The mine has an estimated 270 million tons of recoverable coal reserves and is permitted to produce up to 15 million tons of coal per year.

Coal Contracts - Powder River Coal Field

Purchasing activities in this coal field continued during the third quarter with much of the coal being sold on the spot market for test burns, for blending with other coals, and for supplementing existing longer-term contracts.

New coal contracts/sales are summarized below:

1) Nerco Coal Company's Antelope mine will supply 49,590 tons (45,000 metric tons) of coal to the Puentes power plant, which is operated by Endesa, Spain's national utility company. This is the third coal sale that Nerco has made to Spain and follows previous sales made in May and July (see *Wyoming Geo-notes No. 26*, April, 1990, p. 20 for details). The coal was shipped on the Union Pacific Railroad (UP) to the Mississippi River, barged to New Orleans, and then loaded on a ship to Spain. Evidently the coal from previous shipments performed well and blended easily with local Spanish lignites. The sale was arranged through Carbotex, an international coal trading company.

2) Amax Coal Company sold 40,000 tons of spot coal from the Belle Ayr mine to Northern Indiana Public Service Company's (NIPSCO) Mitchell power plant in Indiana. The coal was used during September and October under NIPSCO's "as-needed, as-available" spot coal purchase program.

3) Mobil Coal Producing, Inc.'s Caballo Rojo mine also supplied NIPSCO's Mitchell plant with 10,000 tons of spot coal for October.

4) Venture Fuels, a coal brokerage company, has arranged deliveries of 350,000 tons of coal per year for five years to Consumers Power Company's B.C. Cobb generating plant at Muskegon, Michigan. Venture Fuels is a partnership between Nerco Coal Company and Midwest Energy Resources Company. The coal will be mined at the Antelope mine in Converse County and at the Spring Creek mine in Montana; tonnages from each mine were not announced. Burlington Northern Railroad (BN) will transport the coal to Superior, Wisconsin, where it will be loaded on barges and transported on Lake Superior and Lake Michigan to the Cobb receiving dock at Muskegon.

5) Cordero Mining Company's Cordero mine will supply up to 400,000 tons of spot coal to Iowa-Illinois Gas and Electric's Louisa power plant in Iowa through the end of 1990. Cordero also supplies long-term contract coal to the same plant. The spot coal will be delivered under previously-existing rail contracts.

6) Sun Coal Company's subsidiary, Cordero Mining Company, will also supply coal from its Cordero mine to Iowa Public Service Company's Neal No. 4 unit south of Sioux City, Iowa. The 750,000 tons of coal will be delivered during the fourth quarter of this year via Western Railroad Properties, Inc., Union Pacific, and Chicago and North Western Transportation Company.

7) Amax Coal Company has signed a new contract with Portland General Electric (PGE) to supply the recently-activated Boardman power plant in Oregon.

The new contract was part of a June, 1990, settlement over a lawsuit and a counter-suit filed by Amax and PGE in 1988 (see *Wyoming Geo-notes No. 20*, 1988, p. 20). At issue was a 1974 take-or-pay contract for 1.2 million tons per year; PGE idled the plant in 1984 and continued to pay Amax for the full amount of the contracted coal (of which only a small amount of coal was ever shipped), but at a coal price that neither party could agree on. Amax Coal Company received \$29 million in the settlement and PGE bought out the remainder of the 24-year contract. The new contract has no guaranteed tonnage because PGE has the option of supplementing or substituting other coal for the Amax coal if PGE can obtain it at delivered prices less than Amax's. As a result of the new contract terms, PGE was soliciting for up to 1.3 million tons of spot coal for the Boardman plant for the last quarter of 1990 and the first half of 1991.

Coal purchased for test burns is summarized below:

1) Cordero Mining Company (a subsidiary of Sun Coal Company) began, in mid-September, to furnish up to 200,000 tons of spot coal from the Cordero mine for test burns at Northern States Power Company's Sherco Units 1 and 2 in Minnesota. The coal will be blended with Montana and other Wyoming coals.

2) Amax Coal Company's Belle Ayr mine will supply an undisclosed amount of blended coal (15 percent dried coal product and 85 percent run-of-mine) to Omaha Public Power District's North Omaha power plant in Nebraska. The coal will be tested for a two-month period after being delivered via the Burlington Northern Railroad. The blended coal was reported to have a moisture content of 26 percent and a heating value of 8,900 Btu per pound.

3) Amax Coal Company's Belle Ayr mine will also supply from 150,000 to 200,000 tons of run-of-mine coal and 500,000 tons of blended coal to Houston Lighting and Power Company's (HL&P) Parish power plant in Texas. Utility Fuels, Inc., the fuel purchaser for HL&P, arranged the sale. Deliveries began in September and will continue for several months. The blended coal is 15 percent dried coal product and 85 percent run-of-mine coal; the moisture content and heating value of the blended coal is the same as that reported for the coal supplied to Omaha Public Power District (see above).

4) Through December, 1990, Thunder Basin Coal Company's Black Thunder mine will supply up to 20,000 tons of coal a month to two of Consumers Power Company's power plants in Michigan. Part of the coal is being tested at the Karn No. 2 plant as part of a 5 percent western, 95 percent eastern coal test burn. Part of the coal will also be burned at the Weadock plant, which burns 35 percent western coal.

5) Mobil Coal Producing, Inc.'s Caballo Rojo mine supplied 33,000 tons of test coal to Iowa Electric Light and Power's (IEL&P) Sutherland plant in Iowa and 66,000 tons of coal to IEL&P's Prairie Creek station, which is also in Iowa. The coal going to Prairie Creek will be blended with varying amounts of Illinois Basin coal as well as burned alone.

6) During the third quarter of 1990, Thunder Basin Coal Company's Black Thunder mine supplied an undisclosed amount of coal to Wisconsin Public Service Corporation's Pulliam and Weston power plants in Wisconsin. The coal was blended with 20 percent and 25 percent eastern coals, respectively.

7) The Caballo Rojo mine (Mobil Coal Producing, Inc.) sold an additional 100,000 tons of spot coal to Tennessee Valley Authority (TVA) for continued test burns at the Paradise power plant in Kentucky (see related coal sale in *Wyoming Geo-notes No. 27*, 1990, page 25). The sale was arranged through Mobil's coal broker in the eastern U.S., Coal Network, Inc. The coal will be used in experiments to reduce the emissions at the plant, which lacks scrubbing equipment.

8) Triton Coal Company's Buckskin mine furnished 10,000 tons of test coal to Iowa Southern Utilities Company's Burlington, Iowa plant. The coal was blended with Illinois coal in amounts up to 50 percent and the test burns were reportedly successful.

9) Niagara Mohawk Power Corporation has burned an unspecified amount of coal from mines in the Powder River Coal Field for testing at its power plants. The coal is being tested as a possible blend with eastern coal to reduce sulfur emissions. The coal was burned at the Dunkirk and Huntley power plants, both in New York.

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INDUSTRIAL MINERALS AND URANIUM UPDATE

by Ray E. Harris, Industrial Minerals and Uranium Division Head, Geological Survey of Wyoming

Aggregate (Construction)

There is significant interest in locating crushed aggregate deposits in southeastern Wyoming. This interest is due to the construction of the new Denver airport, which will require large amounts of aggregate. This use for Wyoming aggregate, however, is influenced by a number of geologic, economic, and political factors. Suitable construction aggregate deposits near Denver are becoming scarce due to their proximity to residences, and transportation costs from Wyoming sources to the airport site are not much different than from the nearest Colorado sources. Colorado has more costly permitting regulations than Wyoming. However, Colorado may require that a certain amount, up to 100%, of the material used in the construction of the airport come from Colorado. So the development of a materials source in Wyoming is not certain at present.

Railroad ballast is a specific type of construction aggregate. Meridian Minerals produces railroad ballast from a quarry and processing plant at Granite Cañon west of Cheyenne. This property is for sale along with the rest of Meridian's industrial minerals properties in the United States. Other locations in Wyoming, particularly near Wheatland and in the Hartville uplift in east-central Wyoming, continue to be examined for additional ballast sources.

Bentonite

The primary use of bentonite is for drilling mud, and the major user of drilling mud is the oil and gas industry. Despite the crisis in the Middle East, the amount of oil and gas well drilling in North America is not expected to increase dramatically this year. Consequently, the production of bentonite in Wyoming is not expected to increase significantly. If the crisis is prolonged and oil prices stabilize at high enough levels to promote accelerated drilling activity, the bentonite industry would see a proportionate increase in production.

Bentonite production in Wyoming has been stable since about 1985, after production fell from record levels in the early 1980's. Although none of the bentonite producers has announced any plans for expansion, Baroid, which was trying to sell its mothballed property east of Lovell, is no longer interested in selling the plant and may resume production there in the future. Baroid is also restructuring its operations according to a recent article in the *Wall Street Journal*. It will separate its petroleum-related service operations from its mining operations, including the bentonite mining operations in Wyoming. The company will then be known as Baroid Corporation.

Diatomite

Diatomite is a siliceous rock composed of the skeletal remains of one-celled organisms called diatoms. Diatomite is used in filters. Most domestic diatomite is

produced in California, Nevada, and other west coast states. This summer there have been some inquiries about occurrences of diatomite in Wyoming. Known occurrences are summarized by Harris and King (1986). A diatomite source in Wyoming would benefit by lower transportation costs to the industrial midwest and east coast areas, which use much of the diatomite produced in the United States.

Gypsum

In Wyoming, gypsum is produced at two plants in the Bighorn Basin (near Cody and at Himes, between Lovell and Greybull). Production at these plants is continuing at levels near capacity. Mountain Cement also mines gypsum near Laramie for use in producing cement.

Nationally, 1990 gypsum production is about 20% higher than in 1989 according to reports released by the U. S. Bureau of Mines. Gypsum producers in Wyoming, however, have not announced any plans for expansion and there has been no indication of new companies coming in.

Limestone

Divide Construction quarried limestone from the Bass Quarry north of Hartville for use in controlling emissions at the Laramie River power plant. Limestone was also quarried in several areas of the State either for construction aggregate or for the manufacture of cement. Pete Lien and Sons, Inc. filed for a permit to open a limestone quarry two miles east of Laramie, Wyoming. According to Laramie and county officials, the limestone from the quarry will be trucked to Fort Collins for processing. The limestone in Lien's proposed quarry is a high-calcium zone in the Permian-Pennsylvanian Casper Formation. It is suitable for industrial uses including the manufacture of lime (CaO).

There has been an increase in exploration for limestone deposits in Wyoming. Missouri Basin Power, which operates the coal-fired Laramie River power plant near Wheatland, and several other power plants in other states, particularly North Dakota, are looking for limestone as a source of lime for control of plant emissions. Some North Dakota companies also want limestone to test some methods of increasing the combustion rates of low-Btu coals and North Dakota lignites. Several limestone occurrences in eastern Wyoming were tested this summer, including a deposit near Manville (Harris, 1987) and a deposit just east of Guernsey, Wyoming.

Because limestone is also cut and polished for decorative stone, some limestone locations in Wyoming have also been sampled to evaluate them for this use.

Silica

A California company that had been studying the feasibility of constructing a glass plant in Wyoming dropped its plans and lease on the Cassa silica property (Harris, 1988b) in September. The company had been in financial problems due to the drought in California and could not invest in a glass plant at this time. However,

other companies are taking a look at this and other silica sources in Wyoming. Deposits near Laramie (Harris, 1988a) and Lovell are also attracting interest. The Geological Survey of Wyoming is preparing a technical report on the Lovell deposit.

Wyoming silica may be suitable for the production of several kinds of glass, for high purity silica (SiO_2) and glass pellets, for foundry sand, and for hydraulic-fracturing sand. Because soda ash (refined trona) is a major ingredient in the manufacture of glass and because 90 percent of the soda ash produced in the U. S. comes from the trona patch near Green River, Wyoming, the cost of transporting raw materials to glass plants can be saved if glass is manufactured near the raw materials in Wyoming.

Stone (decorative and dimension)

As part of an ongoing project, the Industrial Minerals and Uranium Division of the Geological Survey of Wyoming has now prepared over eighty cut and polished samples of decorative rock from Wyoming, some suitable for dimension stone. These samples are available for inspection in the Geological Survey building in Laramie. Interested persons should call Ray E. Harris at (307) 766-2286. These decorative rocks are suitable for use as facing materials, in floors, in walls, as tile, and as shaped and polished decorative stone.

Sunrise Stone, (see *Wyoming Geo-Notes No. 27*), is proceeding with its plans to produce decorative stone quarried in Wyoming.

Trona and its products

The demand for products produced from trona continues to increase at a rapid rate and most of the producing Wyoming companies have announced expansion plans, including the construction of new product plants (Table 10). Trona is primarily used to make soda ash, caustic soda, sodium cyanide, and other sodium compounds. All of these products are produced in Wyoming by five companies located west of Green River. These five companies produce 90 percent of the sodium compounds manufactured in the U. S., and they have enough underground reserves of trona to last hundreds of years. Exports account for around 20% of Wyoming's production. Since exports are not increasing as rapidly as domestic purchases of sodium products, this proportion is decreasing. The following is a company-by-company report on activities for the third quarter of 1990:

FMC Wyoming

FMC, a part of FMC Corporation, operates the world's largest trona-complex (Table 10). This underground mining operation is also Wyoming's oldest trona producer. FMC has recently modernized its underground mining operation through the installation of a longwall mining machine. Past mining methods were primarily room-and-pillar operations involving a variety of mining machines. The length of the underground workings in this mine exceeds 2,500 miles. FMC is also producing trona by an in-situ, solution-mining process, and it is recovering trona from brines in its evaporation ponds.

Table 10. OWNER, TYPE, AND CAPACITIES OF EXISTING AND PLANNED FACILITIES ASSOCIATED WITH THE TRONA MINES IN SWEETWATER COUNTY.

Company name	Plant type	Existing plant capacity ¹	Planned increases in capacity ¹	Trona production in 1989 ^{1,2}
FMC Wyoming	Soda Ash	2,850,000	-	4,726,487
	Caustic Soda	65,000	-	
	Sodium Cyanide	30,000	-	
	Sodium Tripolyphosphate and Tetrasodium pyrophosphate	400,000	-	
	Sodium Bicarbonate	30,000	-	
General Chemical Company	Soda Ash	2,200,000	300,000	4,101,110
Rhone-Poulenc of Wyoming Company	Soda Ash	1,960,000	330,000	3,290,053
Tenneco Minerals Company	Soda Ash	1,250,000	2,750,000	1,938,869
	Caustic Soda		75,000	
Tg Soda Ash, Inc.	Soda Ash	1,300,000	-	2,131,213
	Caustic Soda	-	100,000	
	Total Soda Ash	9,560,000	3,380,000	
	Total Caustic Soda	65,000	175,000	
Total Trona				16,187,732

¹Short tons per year

²Source: State Inspector of Mines

FMC's on-site plants produce 2.85 million tons of soda ash by two methods (the *sesqui-* and the *mono-*methods). They also produce sodium phosphate, sodium tripolyphosphate and tetrasodium pyrophosphate, sodium bicarbonate, and sodium cyanide (Table 10). FMC recently expanded and modernized its soda ash facilities; its sodium cyanide and sodium phosphate plants were dedicated this year.

General Chemical Company

General currently produces 2.2 million tons of soda ash and plans to expand this production by 0.3 million tons per year (Table 10). In the third quarter of 1990, members of the United Steelworkers of America rejected an offer by the company for a new three-year contract and threatened a strike. However, by the middle of September, tentative agreements between the union and company management had been made, and the possibility of a strike seemed to have been averted.

Rhone-Poulenc of Wyoming Company

Rhone-Poulenc is a joint venture between Rhone-Poulenc Basic Chemicals Co., and Union Pacific Resources Co. Construction has begun on the company's

announced plant expansion. This expansion will result in about a 17% increase in output of soda ash (about 0.33 million tons per year), and will not require any expansion of their underground mine as the existing mine is sufficient to supply the expanded plant. Currently the plant produces 1.96 million tons of soda ash each year (Table 10).

Tenneco Minerals Company

Tenneco, which recently joined with Asahi Glass Company, Japan's largest glass producer, announced a two-stage plant expansion. A first stage expansion, approved by the Wyoming Industrial Siting Administration (ISA), will increase soda ash production capacity to 2 million tons per year, a 0.75 million ton per year increase. A second stage expansion, not yet approved by the ISA, will increase production by another 2 million tons of soda ash per year, making this operation the second largest, after FMC. Tenneco has also announced plans to construct a 75,000-ton caustic soda plant (Table 10).

Tg Soda Ash, Inc.

Due to the demand for caustic soda (NaOH), Tg has announced tentative plans to build a new \$40 million caustic soda plant at its soda ash complex northwest of Green River. Tg will recover the feedstock for this new plant from waste water removed from the mine.

This expansion project, which is slated for completion by 1992, is a joint venture between Tg and Atochem North American, Inc., both of which are subsidiaries of Elf Aquitaine, Inc. of Paris, France. Tg currently produces about 1.3 million tons of soda ash per year, and is expected to produce about 0.1 million tons of caustic soda per year from its projected plant (Table 10).

All of this activity has fueled a near-boom demand for construction workers necessary to build the new plants. Permanent employment is also expected to increase as new plants are brought on line. At the present time, the trona patch is certainly the brightest spot in Wyoming's nonfuel mining industry.

Uranium

Quoted uranium prices increased again this quarter, from just over \$11.00 per pound of U_3O_8 to almost \$12.00 per pound. Purchasers of uranium are finding that stockpiles of mined uranium from the early 1980s are depleted. As a result, the price of uranium is increasing and, according to one industry official, may reach \$20.00 to \$24.00 in a year or two.

While depleted stockpiles and price increases bode some optimism for the future of Wyoming's uranium industry, the only uranium production in Wyoming in the third quarter of 1990 was at Power Resources (London Central Energy) in-situ (solution-mining) operation at the Highland mine property in Converse County. Power Resources is also constructing an in-situ well field on the North Morton Ranch ore body, formerly owned by Tennessee Valley Authority.

The in-situ or solution-mining process for uranium involves the injection of solutions into the ore body. These solutions, which are introduced through bore holes, dissolve the uranium minerals. The resultant uranium-rich solutions are pumped to the surface where processing precipitates the uranium as uranium oxide (yellowcake). After treatment, the solutions are reusable.

Electricité de France (EdF) purchased Malapai Resources' Irigary and Christiansen Ranch in-situ properties in late September. Malapai's holding company, Pinnacle West Capital Corp., had shut down the Irigary facility in January. Total Minerals Corp., a wholly-owned subsidiary of EdF, will be the new operator for both of these Johnson County facilities. Total Minerals plans to have the two facilities operational in 1992.

Rio Algom is drilling an in-situ well field northwest of the Bill Smith shaft, which was recently purchased from Kerr-McGee. Rio Algom is a wholly-owned subsidiary of RTZ, a British mining company.

Uranerz, USA, Inc., a German company, recently announced that it had applied to the State for an in-situ mining permit. Uranerz's well field and recovery plant would be located south of the Pumpkin Buttes in Campbell County.

COGEMA's Pathfinder Mines is continuing to strip overburden at the Shirley Basin open pit mine in Carbon County. Production of yellowcake from the Shirley Basin mill is expected to resume late this year.

President Bush signed the bill that provides compensation to uranium miners who became ill due to the effects of radon gas in underground uranium mines. Radon gas is a product of the natural atomic decay of uranium and thorium. It is now known to concentrate in unventilated areas and, since it is a heavy gas, it concentrates more in low areas. Radon is suspected to be a cause of certain kinds of cancer. Originally, uranium miners in Wyoming had been excluded from the bill. The bill also compensates persons exposed to radiation from surface atomic weapons tests conducted between 1951 and 1958 and in 1962.

Vermiculite

Vermiculite is a mineral of the clay family that expands when heated. This produces a lightweight product called expanded vermiculite or "vermiculite". Expanded vermiculite is used in insulation, as a soil conditioner, in concrete, and in other uses such as potted plant soil.

With the announced closure of the largest producing vermiculite mine in the U.S., the Rainy Creek mine near Libby, Montana, interest in vermiculite deposits has increased. There are several known vermiculite occurrences in Wyoming, some of which produced vermiculite in the 1950's (Harris, 1990). The Industrial Minerals and Uranium Division has received numerous inquiries regarding these vermiculite deposits, and several deposits have been examined in the field. While rumors had indicated that one company had already begun mining, no mining permits have been filed with the Wyoming Department of Environmental Quality.

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METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel, Deputy Director, Geological Survey of Wyoming

During the last two quarters, several companies conducted reconnaissance studies of various mineral deposits in Wyoming (principally for gold and copper). A few companies announced intentions to continue to explore and invest exploration dollars in the Cowboy State.

During the summer and fall field season, the Head of the Metals and Precious Stones Division of the Survey led five field trips to mining districts in Wyoming, but additional company requests were too numerous to handle.

Diamond

Exploration for diamond deposits resumed this summer with staff of the Geological Survey of Wyoming searching the central Laramie Range for indications of diamondiferous kimberlite and lamproite. The project was also expanded into the Medicine Bow Mountains in the vicinity of Mullison Park where two diamonds were discovered in 1977. Samples collected during the summer are currently being processed and examined.

Seminole Mountains

The Geological Survey's Metals and Precious Stones Division continued field studies in the Seminole Mountains greenstone belt throughout the summer. Many samples were collected for laboratory work and detailed mapping of lithologies and structures continued.

Analyses of many samples collected last field season were reported in *Wyoming Geo-notes No. 25* and *27*. Samples collected during this field season are currently being analyzed for metals and for whole rock chemistry.

The Seminole Mountains is a relatively young greenstone belt (2.7 to 2.9 billion years old), with a lower mafic to ultramafic metavolcanic unit having an apparent thickness of nearly 10,000 feet. The lower unit is overlain by an ultramafic unit with nearly 1,000 feet of serpentinites and spinifex-textured basaltic and peridotitic komatiites. This unit is overlain by several hundred feet of banded iron formation, clastic metasediments, felsic metavolcanics, and metagabbro. Gold in the greenstone belt occurs in veins associated with pervasive chloritic alteration, sulfides, quartz, and calcite.

South Pass

Goldstake Explorations Inc., of Toronto, announced in the *Mining Record* (v.101, no.31, Aug.1, 1990, p.1) that they are selling 40% of their gold reserves in their mine in South Dakota. "Part of the proceeds of the sale will be used to develop Goldstake's major projects, particularly the Stowell (in the Black Hills) and the South Pass (in Wyoming)". The *Northern Miner* (July 2, 1990, p.13), went on to say that Goldstake was "...undertaking a 100-hole drilling program this summer".

A paper on some gold deposits in the South Pass region was recently published by the Society for Mining, Metallurgy, and Exploration (Hausel, 1990).

Powder River Basin

The Geological Survey of Wyoming has published a map which shows occurrences of metallic and radioactive minerals and lapidary materials in the Powder River Basin and the Black Hills of Wyoming (Hausel and others, 1990). The occurrences include gold anomalies in the northern portion of the basin north of Gillette, gold and silver anomalies in the Cambria coal mines north of Lusk, gold and tin anomalies in oil wells west of Newcastle, gold deposits north of Sundance, titanium-iron-rare earth deposits southwest of Midwest, and chromium and manganese deposits south of Casper.

References

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- Hausel, W.D., Harris, R.E., King, J.K., and Sutherland, W.M., 1990, Metallic and radioactive minerals and lapidary materials of the Powder River Basin and adjacent uplifts, Wyoming: Geological Survey of Wyoming Map Series 32, scale 1:500,000.

Table 11. MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING.

PETROLEUM	
Remaining Resources (January 1, 1990)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.8 billion barrels ¹
Undiscovered	7.6 billion barrels ¹
Total	20.4 billion barrels
Remaining Reserve Base (January 1, 1990)	
Measured reserves (Proved reserves) (Includes 0.815 billion barrels of oil and 0.805 billion barrels of gas liquids)	1.51 billion barrels ²
Indicated and inferred reserves	2.8 billion barrels ¹
Total	4.31 billion barrels
NATURAL GAS	
Remaining Resources (January 1, 1990)	
Discovered (Includes 23 trillion cubic feet (TCF) of methane ¹ and 12 TCF of CO ₂ and He ³)	34.1 trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane ¹ ; 7 TCF of coalbed methane ⁴ ; 3,611 TCF of methane in tight gas sands in the Green River Basin ⁵ ; and 103 TCF of CO ₂ and He ³)	3,779.0 trillion cubic feet
Total	3,813.1 trillion cubic feet
Remaining Reserve Base (January 1, 1990)	
Measured reserves (Proved reserves) (Includes 10.9 TCF of methane ² and 11.8 TCF of CO ₂ and He ³)	21.6 trillion cubic feet
COAL	
Remaining Resources (January 1, 1990)	
Identified and Hypothetical (Discovered)	1,431.2 billion tons ⁶
Speculative (Undiscovered)	31.5 billion tons ⁶
Total	1,462.7 billion tons
Remaining Reserve Base (January 1, 1990)	
Demonstrated strippable (Measured and indicated reserve base)	26.6 billion tons ⁷
Demonstrated underground-minable (Measured and indicated reserve base)	38.3 billion tons ⁷
Total	64.9 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, 1985)	1.99 billion pounds U ₃ O ₈ ⁹
Remaining Reserve Base (December 31, 1985)	
Uranium oxide recoverable at \$30.00 per pound	83 million pounds ⁹
OIL SHALE	
Original Resources (January 1, 1983)	
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, 1989, U.S. crude oil, natural gas, and natural gas liquids reserves: 1988 Annual Report, October.

³ Derived from Exxon information.

⁴ DeBruin, R.H., and Jones, R.W., 1989, Coalbed methane in Wyoming: Wyoming Geological Association 40th Annual Field Conference Guidebook, Casper, Wyoming, p. 97-103.

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

⁷ Geological Survey of Wyoming, October, 1990, (Modified from Berryhill, H.L., Jr. and others, 1950), Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.

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

⁹ Energy Information Administration, 1985, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(85) 142 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.

GEOLOGICAL HAZARDS IN WYOMING

by James C. Case, Geologic Hazards Division Head, Geological Survey of Wyoming

Earthquakes

Wyoming has experienced a number of magnitude 3.0 and greater events in the period from September 1, 1989, to September 1, 1990. The National Earthquake Information Center in Golden, Colorado, reported the following seismic events for this time period:

Date	Magnitude	Latitude	Longitude	Description
9-30-89	3.5	44.779	111.125	Hebgen Lake area. A swarm of events with a maximum magnitude of 3.5. No damage reported.
11-2-89	3.0	42.08	106.69	Seminole Reservoir area. Felt at Saratoga. No damage reported.
2-26-90	3.2	44.636	111.062	Hebgen Lake area. 15 events with magnitudes of 2.4 or greater in a 20-hour period. No damage reported.
3-5-90	4.1	43.401	110.717	Jackson area. Felt at Wilson (Intensity IV), Moran, and Jackson. No damage reported.
4-9-90	3.5	43.145	110.627	Northern part of the Thrust Belt in western Wyoming. No damage reported.

In addition, the University of Utah's seismograph stations in Salt Lake City, Utah, recorded a number of events in the Yellowstone National Park area. A moderate swarm occurred in the park on October 14, 1989, including two magnitude 3.5 events. Numerous events of smaller magnitude occurred throughout the year. No significant damage was reported.

Active Fault Research

Dr. Bob Smith and his students at the University of Utah's Department of Geology and Geophysics continued their research on the Teton fault. In the past year, the following observations were made:

- 1) A 25-mile-long (40 kilometers), north-south trending area on the hanging-wall side (valley floor) of the Teton fault has subsided up to 85 feet (26 meters). It

would take an estimated ten earthquakes at magnitude 7.0 to five earthquakes at magnitude 7.5 in the past 15,000 years to account for this deformation.

2) Between 1988 and 1989, it appears that the footwall side of the Teton Fault (Teton Range) has subsided 0.2 inches (5 mm) relative to the valley floor (hanging wall). Anomalous horizontal compression is needed to explain this kind of movement on a normal fault. These observations will be tested by follow-up measurements in 1991 (see discussion of cooperative project in item 3 below).

3) The southern end of the Teton fault experienced a magnitude 7.1 to 7.5 earthquake with a 13-foot (4-meter) displacement 7,200 years ago. While no large ground-breaking events have occurred in this area since that event, a return period of 800 to 3,600 years has been suggested for the Teton fault. As a result, the Teton fault may be near or beyond the expected recurrence interval for a large earthquake.

The National Park Service has provided \$4,885 to the Geological Survey of Wyoming to partially fund a joint project between the Geological Survey and Dr. Bob Smith of the University of Utah. The project will be used to continue the University of Utah's ongoing investigations of the Teton Fault. This one-year project is designed to (1) refine the timing of movements on the fault through age dating, (2) substantiate the relative vertical movement as well as the amount of recent or ongoing movement on the fault, and (3) summarize the seismic risk to the Jackson Hole area. The Geological Survey of Wyoming is providing \$4,795 to pay for the Carbon 14 age dating.

Dr. Jim McCalpin and his students at Utah State University completed a trench across the Star Valley fault system in western Wyoming. The trench, located in the town of Afton, indicated three episodes of late Quaternary-Holocene activity, with each episode resulting in 10 to 13 feet (3 to 4 meters) of movement. Dates of movement are not yet available. A maximum credible earthquake of magnitude 7.5 has been estimated for the fault trace.

Earthquake Education

On September 26, 1990, the Wyoming Emergency Management Agency (WEMA) conducted a statewide warning and communications exercise which included a test of the Emergency Broadcast System. All the schools in the State were asked to participate in the exercise, which included a message from WEMA stressing hazards awareness. As a follow-up to the exercise, school systems in the State were supplied with a variety of hazards education materials. The Geological Survey of Wyoming supplied copies of "Earthquakes: A Teachers Package for K-6", "Guidebook for Developing a School Earthquake Safety Program," as well as numerous other earthquake-related brochures, tapes, games, and buttons from the Federal Emergency Management Agency. The Wyoming Emergency Management Agency distributed the materials to schools throughout the State. The teachers in the schools were asked to utilize the materials in classroom exercises as well as for long-range planning.

In order to assist the State's earthquake education efforts in western Wyoming, the Federal Emergency Management Agency sent some county representatives from that part of the State, an industry representative, and a civil engineering professor at the University of Wyoming to a training session for utility managers and engineers. The course, titled "Earthquake Hazard Mitigation-Utility Lifeline Systems," was held at the Federal Training Center in Emmitsburg, Maryland, July 9-12, 1990. Participants from western Wyoming counties were specifically chosen because this is the portion of Wyoming with the highest earthquake risk. An in-state training session, which will include the participants that attended the course, is planned for 1991.

The Wyoming State Engineer's Office hosted the 1990 Western Regional Association of Dam Safety Officials, which met in Jackson, Wyoming, on May 14-16, 1990. Three of the speakers discussed earthquake-related topics. Vernon Person of the California Division of Safety of Dams, spoke on the response to the 1989 Loma Prieta earthquake and damage to dams in that part of California. Jim McCalpin of Utah State University spoke on earthquakes in the Intermountain Seismic Belt, and a representative of the U.S. Bureau of Reclamation spoke on the rehabilitation of Jackson Lake Dam. As a result of that meeting, the national office of the Association of Dam Safety Officials sponsored a workshop on "Seismic Evaluation of Small and Medium Dams" on September 26-27, 1990.

Landslides

In a seven-year effort, the Geologic Hazards Division at the Geological Survey of Wyoming has mapped landslides on over 800 7.5-minute quadrangles. These landslide maps, some of which are still in preparation, are at scales of 1:24,000, 1:250,000, and 1:1,000,000. A text on slope movements in Wyoming is also in preparation.

The highest landslide densities in Wyoming are in the western portions of the State, where the seismic risk is also the greatest. If a major earthquake occurred along the Teton or Star Valley faults in western Wyoming, numerous transportation routes would likely be closed due to landslide activity.

GEOLOGIC MAPPING AND STRATIGRAPHY

by Alan J. Ver Ploeg, Stratigraphy Division Head, Geological Survey of Wyoming

FIELDWORK COMPLETED ON BEARTRAP MEADOWS QUADRANGLE

The Stratigraphy Division completed its field examination of the Beartrap Meadows Quadrangle in September. As mentioned in *Wyoming Geo-notes No. 27*, this quadrangle was of particular interest in that the Big Trails fault runs diagonally southwest to northeast across the quadrangle. Field examination of the fault showed a graben of Tensleep Sandstone, bordered on the west and east by Madison Limestone. While the Big Trails fault had little apparent vertical offset on it, the graben was down dropped into the fault a minimum of 300 feet.

Approximately 1.5 miles south of this graben, a horst of Cambrian Gallatin Limestone was seen wedged between Ordovician Bighorn Dolomite. Again, while there was very little vertical offset on the Big Trails fault, the horst of Gallatin Limestone had been forced upward at least 200 feet.

Both of these features lend support to the theory that movement on the Big Trails fault was primarily horizontal or strike-slip. The graben could have been caused by a minor releasing bend in the fault and the horst by a minor restraining bend. These sorts of features are common to strike-slip faults, and there are other examples of them farther to the south on this fault.

The Beartrap Meadows Quadrangle and the Monument Hill Quadrangle, immediately to the west, may be available as open file maps later this fall.

STATUS OF THE WESTERN INTERIOR CRETACEOUS PROJECT

The initial phase of the Western Interior Cretaceous (WIK) Project was completed and exhibited in poster sessions at the Rocky Mountain Section Meeting of the American Association of Petroleum Geologists in Denver, September 16-19, 1990. As mentioned in *Wyoming Geo-notes No. 25*, the first phase of the project was a standardized compilation of surface and subsurface reference sections of Cretaceous-age sedimentary rocks for the Laramide basins of the U.S. Western Interior. These reference sections were annotated with available sedimentologic, paleontologic, geochemical, petrophysical, and geophysical data. A total of 41 sections were compiled by various groups. For the names of the project leaders for the different basins in Wyoming see *Wyoming Geo-notes No. 25*, p. 39.

For the second phase of the project, regional stratigraphic cross sections, time-stratigraphic cross sections, paleogeographic maps, and basin-wide interpretations

will be prepared. The final published product of the project will be a stratigraphic atlas of the entire study area.

FRIENDS OF THE DINOSAURS

Friends of the Dinosaurs is a new organization open to anyone with an interest in geology, paleontology (particularly dinosaurs), and natural history. Designed to invite participation in and support for the Department of Geology and Geophysics' Geology Museum at Laramie, members receive a membership card entitling them to special privileges at the Geology Museum as well as a subscription to the Museum's newsletter "Bronto". There are various membership levels each with differing benefits. Some of the basic benefits include: monthly "Friends Night" programs, advance notice and discounts on field trips and other public programs, discounts on Museum t-shirts, and special activities for "Friends only". For more information, application forms, and a detailed description of membership levels and benefits, contact the Friends' founder (and Museum Curator), Brent Breithaupt, at the Geology Museum or write to him at the following address:

Friends of the Dinosaurs
Geology Museum
P. O. Box 3006
University of Wyoming
Laramie, WY 82071-3006

NEW PUBLICATIONS BY THE GEOLOGICAL SURVEY OF WYOMING

- *Metallic and radioactive minerals and lapidary materials of the Powder River Basin and adjacent uplifts, by W.D. Hausel, R.E. Harris, J.K. King, and W.M. Sutherland: Map Series 32, 1990, scale 1:500,000 (color) - \$4.00.
- *Coal map of the Powder River Basin and adjacent areas, Wyoming, by R.W. Jones: Map Series 33, 1990, scale 1:500,000 (color) - \$4.00.
- Illustrated geologic history of the Medicine Bow Mountains and adjacent areas, Wyoming by S.H. Knight: Memoir 4, 1990, 48 p. - \$7.00.
- Bibliography of graduate theses and dissertations on the geology of Wyoming (exclusive of the University of Wyoming), 1899 through 1987, by P.L. Greer and A.J. VerPloeg: Open File Report 90-6, 1990, 104 p. - \$10.00.
- Strategic mineral resources in Wyoming -titanium by W.D. Hausel: Open File Report 90-7, 1990, 18 p. - \$2.50.
- *Geology of the Cheyenne belt, by E.L. Duebendorfer: Open File Report 90-8, 1990, Plate 1 (scale 1:24,000), Plate 2 (scale 1:50,000) - \$8.00.
- Geologic tours of western Wyoming and parts of adjacent Idaho, Montana, and Utah, edited by Sheila Roberts: Public Information Circular No. 29, 1990, 191 p. - \$12.00.
- *Coalbed methane in Wyoming, by R.W. Jones and R.H. DeBruin: Public Information Circular 30, 1990 - \$4.00.
- *Results of coal drilling projects in the Bighorn Basin, Wyoming, by P.J. Taucher, R.W. Gregory, and G.B. Glass: Report of Investigations 43, 1990 - \$12.00.

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

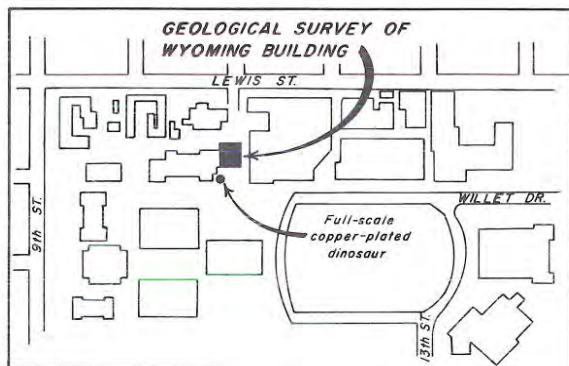
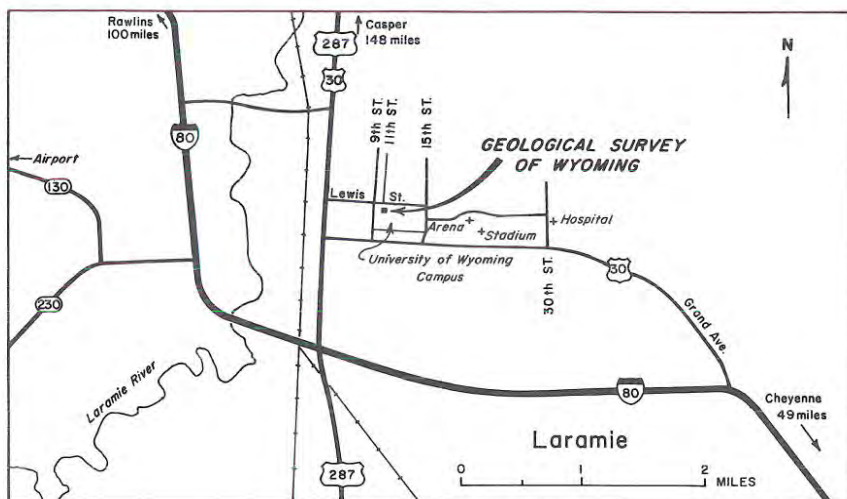
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

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

— NEW SERVICE AVAILABLE —

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

GEOLOGICAL SURVEY OF WYOMING LOCATION MAPS



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