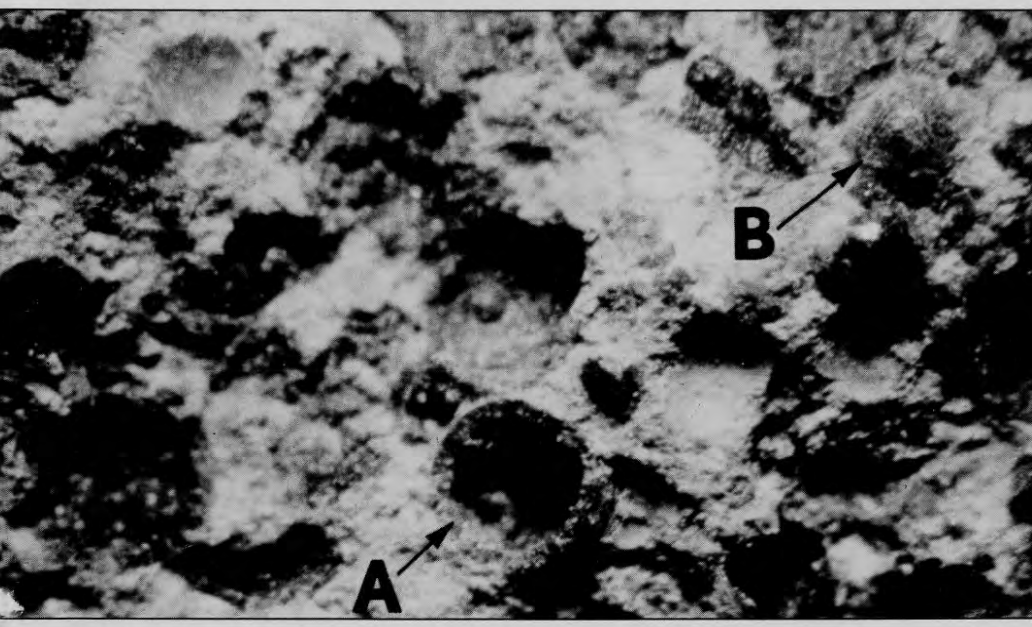
Wyoming Geo-notes

Number 39



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

Laramie, Wyoming
August, 1993

WYOMING GEO-NOTES
This quarterly digest on the State's geology and mineral resources and activities of the Geological Survey is available by subscription (four issues for $10.00) or as single copies at $3.00 each. Two-year subscriptions are accepted.

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

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

Cover: Hollow spherules in lower kaolinitic clay layer at the Cretaceous-Tertiary boundary. "A" is a one millimeter-diameter spherule that has been broken open; "B" is an unbroken spherule. See p. 54 in this issue for a discussion of these spherules.

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

Attention
Wyoming Geo-notes
Subscribers

Effective August 1, 1993, all **new** subscriptions to *Wyoming Geo-notes* will be $10.00 prepaid for four issues (1 year) or $3.00 for single copies.

still "the best bargain for news of
Wyoming's mineral industries"

Table of Contents

MINERALS UPDATE

OVERVIEW

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

Perhaps you have noticed that the "gas bubble" is seldom mentioned anymore. While we and other forecasters waited year after year for the "bubble" to burst, it is actually disappearing more like it has a slow leak. In retrospect, **Figures 1**, **2**, and **3** and **Tables 1** and **2** are perhaps the most revealing evidence that the demand for natural gas from Wyoming is gradually catching up with the supply. **Figure 1** and **Table 1** show that the production of natural gas in Wyoming began a steady climb after 1986 even though there were many shut-in gas wells. However, because the price of natural gas (**Figures 2** and **3** and **Table 2**) showed no improvement until late 1992 and early 1993, at least a remnant of the "bubble" was apparently still there, keeping the price down.

For example, the spot sale price of natural gas at Opal was under $1.20 for much of 1989 through early 1991 (**Figure 3**). It has, however, been above $1.60 for the last ten months and has averaged $1.91 per MCF for the first two quarters of 1993. The last time the spot price got this high was during the Kuwait situation in 1990 and that was for only two months.

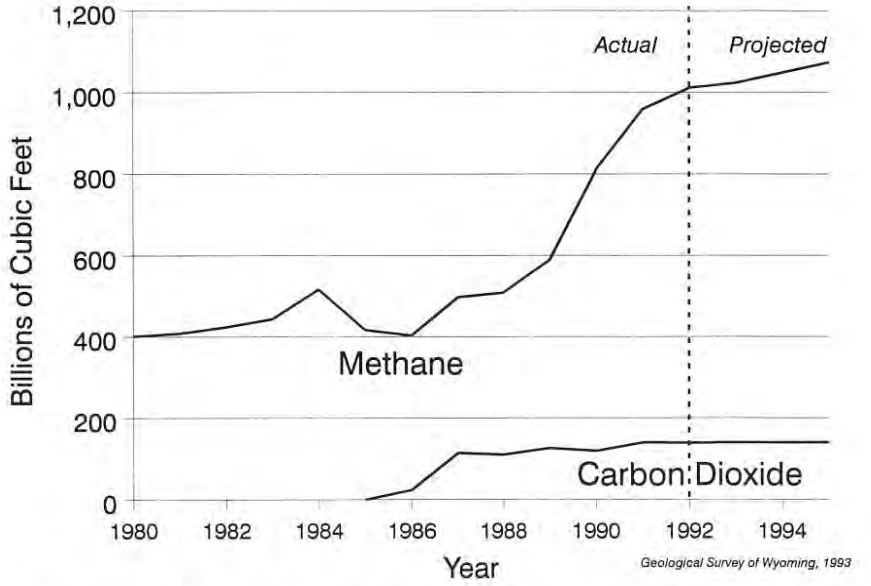


Figure 1. Annual natural gas production from Wyoming (1980 to 1992) with forecast to 1995.

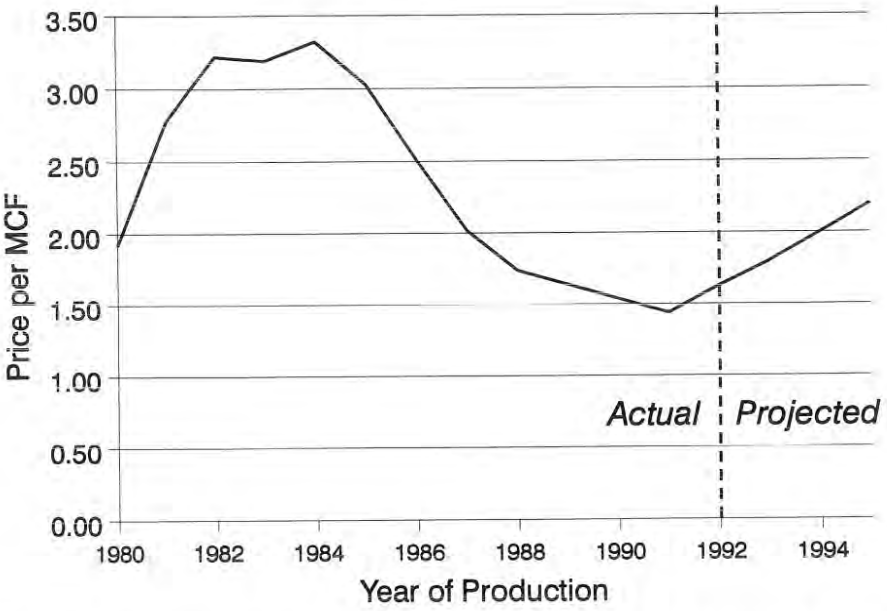


Figure 2. Average prices paid for Wyoming methane (1980 to 1992) with forecast to 1995.

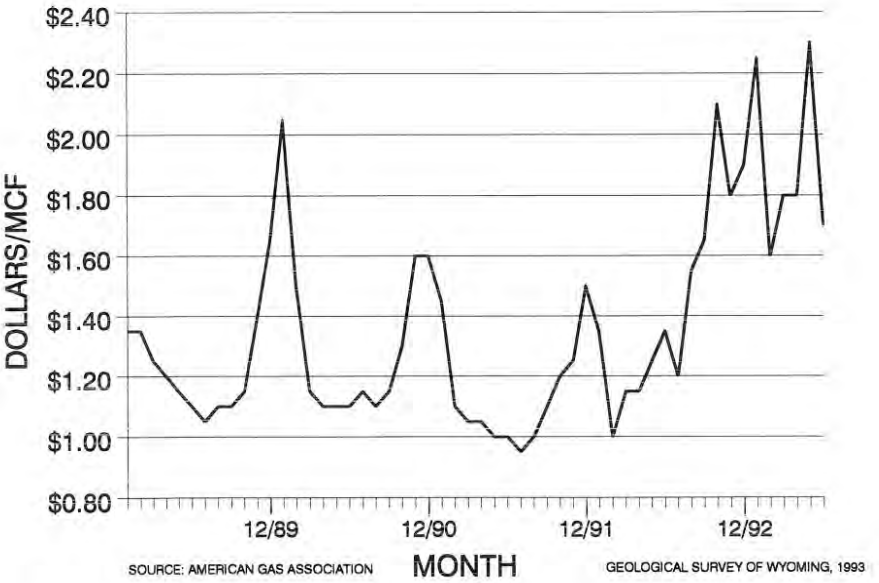


Figure 3. Spot prices for natural gas sales at Opal, Wyoming, averaged by month (1989 to present).

This has been good news for many Wyoming gas producers and that is reflected in the accelerated drilling that is occurring in the southwestern part of the State. According to the **Wyoming oil and gas exploration summary for 1992**, which is included in this issue of *Wyoming Geo-notes*, the Greater Green River Basin was the 15th leading geologic province in the U.S. in terms of new field wildcats completed in 1992. And gas well completions in the first six months of 1993 are twice the number in 1992. While a lot of these new wells are in-fill or development wells, this drilling activity has had its economic and revenue-producing spinoffs.

For Wyoming, the least positive aspect of recent natural gas activities is the probable competition from Canadian sources. For now, the Altamont pipeline is on hold. Should it become a reality, the potential effects on Wyoming producers range from positive to negative depending on who is asked. On the negative side, it is pointed out that whatever market is met by Canadian gas, reduces the market for Wyoming gas. On the positive side, Wyoming could realize some benefits from lower tranportation costs related to the pipeline.

In addition, the Metfuels coalbed methane project in the Hanna Basin of southcentral Wyoming received the U. S. Bureau of Land Management's approval to move forward with a phased-in project (see the **Coal Update**).

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

Calendar Year	Oil[2]	Natural Gas[3]	Carbon Dioxide[4]	Helium[5]	Coal[6]	Trona[6]	Mined Uranium[7, 8]	In-situ Uranium[9]	Sulfur[10]
*1981	122.1	408.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	424.7	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	444.0	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	516.7	—	—	130.7	11.0	1.6	—	0.71
*1985	131.0	416.6	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	403.3	23.8	0.15	136.3	11.9	0.2	0.04	0.76
*1987	115.9	498.0	114.2	0.86	146.5	12.4	0.2	0.06	1.19
*1988	114.3	509.1	110.0	0.83	163.6	14.9	0.3	1.16	1.06
*1989	109.1	587.4	126.1	0.94	171.1	16.2	0.1	1.07	1.17
*1990	104.0	692.5	119.9	0.90	184.0	16.2	0.2	1.1	1.04
*1991	99.8	820.0	140.3	1.05	193.9	16.1	0.4	1.1	1.18
1992	*96.8	*871.5	*139.2	*1.05	*189.5	*16.4	*0.1	*1.2	1.20
1993	93.1	884.0	140.0	1.00	194.3	16.6	—	0.8	1.20
1994	89.4	909.0	140.0	1.00	199.3	17.0	—	0.8	1.25
1995	85.8	934.0	140.0	1.00	204.3	17.2	—	0.8	1.25

*Actual values for comparison; [1]Geological Survey of Wyoming, July, 1993; [2]millions of barrels; [3]billions of cubic feet (gross production less carbon dioxide and helium); [4]billions of cubic feet; [5]billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [6]millions of tons; [7]millions of tons of uranium ore (not yellowcake); [8]although the Shirley Basin mine closed in 1992, some production of stockpiled ore may be reported in future years; [9]millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1985 because it was reported only as taxable valuation; estimates for 1993-1995 are based on company information); [10]millions of short tons.

Table 2. Average prices paid for Wyoming oil, methane, coal, trona, and uranium, forecast to 1995[1].

Calendar Year	Oil[2]	Methane[3]	Coal[4]	Trona[5]	Uranium[6]
*1985	23.61	3.03	11.35	35.18	36.82
*1986	13.10	2.51	10.71	34.80	52.45
*1987	16.50	2.02	9.54	36.56	43.55
*1988	13.41	1.74	9.09	36.88	25.77
*1989	16.64	1.64	8.63	40.76	22.09
*1990	20.10	1.54	8.31	41.86	21.16
*1991	14.41	1.44	8.05	44.18	21.00
1992	16.38 Prelim.	1.63 Prelim.	7.79	44.50	21.00
1993	15.75	1.80	7.39	46.35	21.00
1994	15.75	2.00	7.19	47.42	21.00
1995	15.75	2.20	7.03	49.00	21.00

* Actual value for comparison.

[1] Adapted from Consensus Revenue Estimating Group, Wyoming State Government Revenue Forecast FY93-FY96, January 12, 1993.

[2] First purchase price in dollars per barrel (weighted average price for sweet, sour, heavy, stripper, and tertiary oil). Prelim.= Preliminary value.

[3] Wellhead price in dollars per MCF. Prelim.= Preliminary value.

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

[5] Dollars per ton of trona, not soda ash.

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

While the outlook for natural gas is fairly optimistic, the outlook for oil has not improved much. Production has continued its decline (**Figure 4** and **Table 2**) and the price looks like it is still tracking our forecast, which shows it declining from 1992 (**Figures 5** and **6** and **Table 1**). While the average daily rig count did show improvement in the second quarter, a good percentage of the drilling is for gas, not oil. Despite this, the 1992 oil and gas summary article in this issue shows that the new field wildcats completed in the Powder River Basin ranked it as the fifth leading geologic province in the U.S.

Coal production looks like it will again exceed the previous year's production, but flooding in the mid-continent area, which is a large market area for Wyoming coal, could affect the timing of some shipments (**Figure 7**). Although the railroads have been able to route most shipments around flooded areas, some plants are using their stockpiles rather than new deliveries. The coal companies so far feel that production will increase despite the delays and deferrals caused by flooding. A look at the **Coal Update** in this issue shows that last year's shipments of Wyoming coal to Iowa, Missouri, and Illinois totalled 26.5 million tons.

As for the price of coal, there has been no improvement (**Figure 8**; **Table 3**). In fact, one three-year contract was awarded in the the second quarter for a first year price of $3.21 per ton.

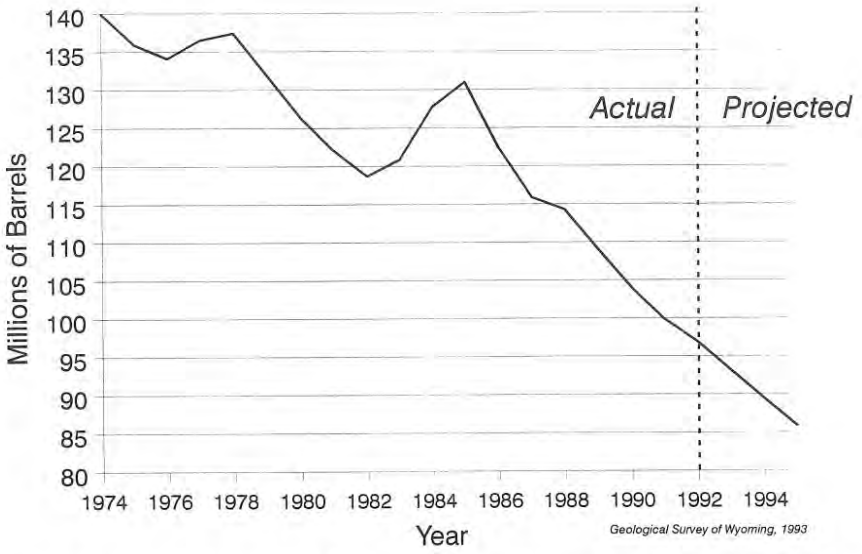


Figure 4. Annual oil production from Wyoming (1974 to 1992) with forecast to 1995.

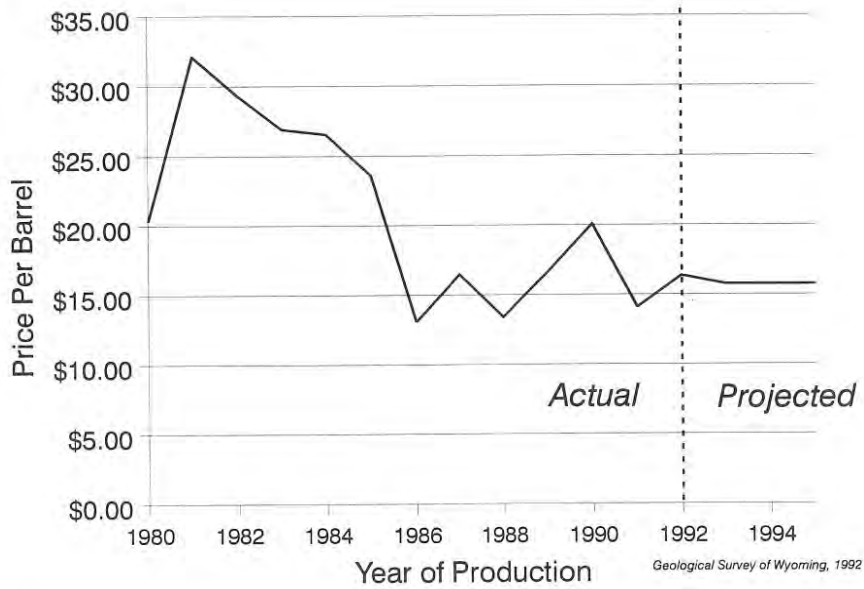


Figure 5. Average prices paid for Wyoming oil (1980 to 1992) with forecast to 1995.

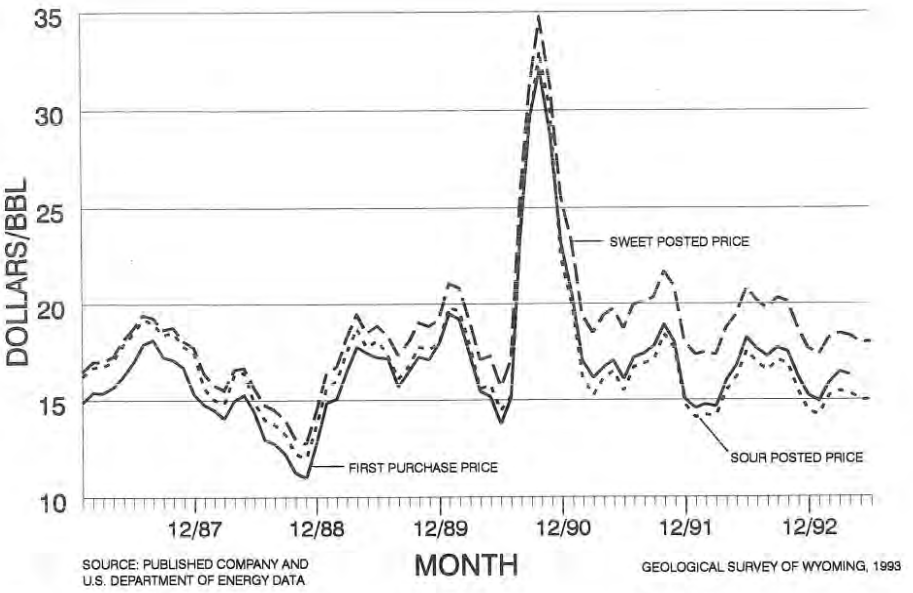


Figure 6. Wyoming posted Sweet and Sour crude prices and first purchase prices averaged by month (1987 to present).

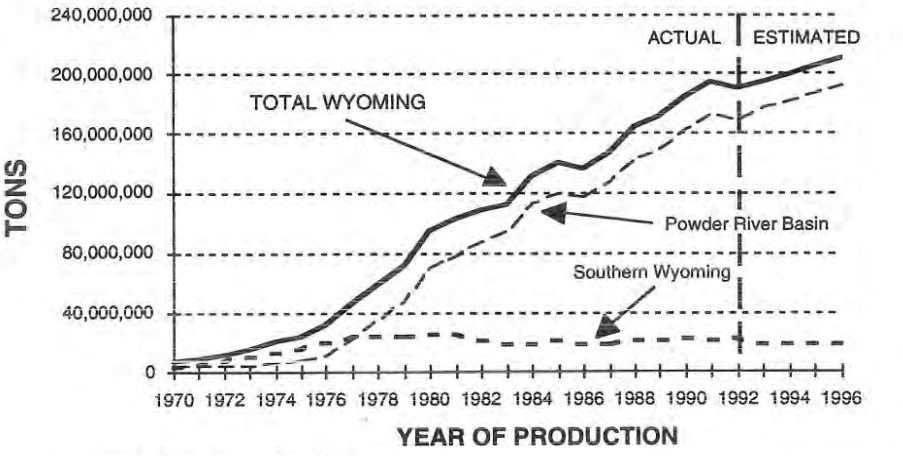


Figure 7. Annual coal production from Wyoming (1970-1992), with forecast to 1996.

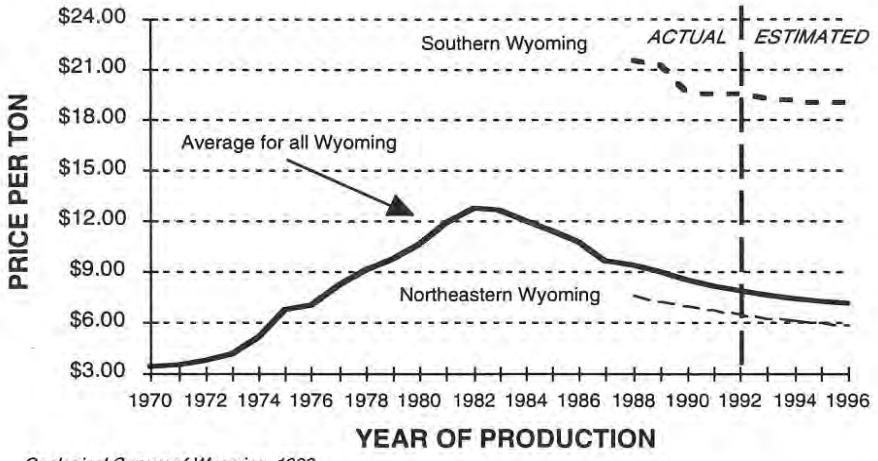


Figure 8. Average prices paid for Wyoming coal (1980-1992 with forecast to 1996 [Data from U.S. Energy Information Administration (1980-1984) and Wyoming Department of Revenue and Consensus Revenue Estimating Group (1985-1996)].

Table 3. Breakdown of average prices paid for coal from northeastern Wyoming, southern Wyoming, and Wyoming as a whole, with forecasts for 1993 through 1996.

	Northeastern	Southern	Statewide
1988	7.25	21.45	9.09
1989	7.03	20.21	8.63
1990	6.84	19.62	8.31
1991	6.68	19.50	8.05
1992	6.45	19.44	7.80
1993	6.25	19.15	7.39
1994	6.07	19.02	7.19
1995	5.93	18.99	7.03
1996	5.86	18.96	6.93

Arco and Nerco coal companies have been joined by Burlington Northern, Chicago and North Western, Union Pacific, and Southern Pacific railroads in a lawsuit over an Illinois law designed to protect that state's coal mining industry. The companies feel that law discriminates against western low-sulfur coal and may violate the commerce clause of the U.S. Constitution.

A coal mine closure in southwestern Wyoming and layoffs at two Powder River Basin mines (one in Wyoming and one in Montana) also occurred in the

second quarter as companies adjusted to market and price conditions. At the same time, however, interest in leasing additional Federal coal continued.

According to the **Industrial Minerals Update**, a strengthening market for decorative stone has prompted Sunrise Stone to investigate the possibility of building a fabricating plant in Wyoming (**Table 4**). Wold Trona Company is continuing its efforts to open a new trona mine and mill.

During the second quarter, there was still interest in diamond exploration in Wyoming. This interest was in the Laramie Mountains, the southern and central Green River Basin, and the Leucite Hills north of Rock Springs. In addition, field studies by the Geological Survey of Wyoming found indications that diamond-bearing rocks might also occur in the Seminoe Mountains (see the **Metals and Precious Stones Update**). So far, however, the only in-place diamonds found in Wyoming are those from the State Line district along the Wyoming-Colorado border.

Table 4. Production history of selected Wyoming mineral commodities[1].

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bentonite[2]	2.18	3.08	2.59	1.82	2.16	2.32	2.22[6]	2.43[6]	2.38[6]	2.21[6]
Clay[4]	36.4	59.6	35.9	23.2	1.31	61.1	23.6	---	---	---
Decorative Aggregate[2]	0.07	0.08	0.09	0.07	0.06	0.07[7]	0.06[6]	0.06[6]	0.07[6]	0.07[6]
Decorative Stone	---	---	---	---	---	---	---	---	0.24[7]	0.36[7]
Dolomite[2]	0.66	0.86	0.87	0.81	0.46	0.19[6]	0.15[6]	0.21[6]	0.23[6]	0.20[6]
Gypsum[2]	0.33	0.33	0.35	0.41	0.35	0.40[7]	0.20[6]	0.44[6]	0.42[6]	0.43[7]
Iron Ore[2]	2.48	---	---	---	---	---	minor[8]	minor[8]	---	---
Leonardite[4]	---	---	---	---	---	---	---	22.9[6]	33.3[6]	37.0[6]
Limestone[2, 5]	0.56	0.65	0.32	0.33	0.32	0.64	0.60[6]	0.48[6]	0.49[6]	0.52[6]
Construction Aggregate[2, 3]	6.72	8.31	6.40	5.01	4.12	3.15	6.46[6]	7.73[6]	8.62[6]	8.11[6]
Shale[4]	---	20.3	14.7	9.88	49.0	50.2	1.8	43.5[6]	158.2	113.3[6]
Sodium Sulfate[4]	3.19	3.25	2.71	2.03	---	2.10[6]	3.2	1.9[6]	1.5[6]	1.5[6]

Sources: [1]Wyoming Department of Revenue, unless otherwise noted; [2]millions of short tons; [3]includes ballast, scoria, and limestone used for aggregate; [4]thousands of short tons; [5]includes chemical grade limestone used for cement rock, sugar beet refining, and other uses; [6]Wyoming State Inspector of Mines; [7]estimated by Geological Survey of Wyoming; [8]less than 1,000 tons of iron ore were sold for pigment. Prepared by Geological Survey of Wyoming, July, 1993.

For dinosaur fans, there is an article in this issue that involves research that might help to explain the disappearance of these creatures. Check out the article discussing possible ejecta from a meteor crater in Iowa (p. 54).

OIL AND GAS UPDATE

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

Recovering from an all-time low in March of 1993, the rig count in Wyoming rebounded in the second quarter of 1993 to levels near those in comparable periods in recent years (**Figure 9**). The rebound is primarily related to development drilling for gas, particularly in the southwestern part of the State (see section on **Exploration and development** below).

Higher natural gas prices this year have also helped increase the rig count. The spot gas price at Opal, Wyoming, averaged $1.91 per MCF during the first six months of 1993. In contrast, the average spot gas prices at Opal during the first six months of 1991 and 1992 were only $1.21 and $1.17 per MCF, respectively (**Figure 3**).

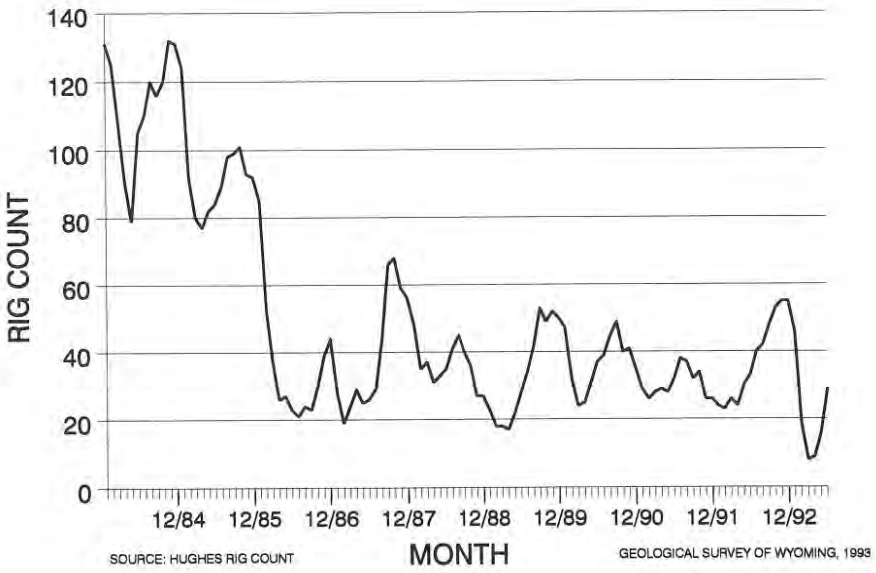


Figure 9. Wyoming daily rig count averaged by month (1984 to present).

According to Petroleum Information (1993), there were 208 well completions for the first six months of 1993. This compared to 173 well completions for the first six months of 1992. There were 111 gas well completions in the first half of 1993 compared to 55 gas well completions in the first half of 1992. The success rate for all wells in the first half of 1993 was 81.7 percent compared to a success rate of 64.7 percent for the first half of 1992. These figures point to an increased emphasis on low-risk development gas wells and less emphasis on more risky wildcat wells. A report by Arthur Anderson & Co. also confirms this trend. The report shows that domestic expenditures by the 30 leading oil and gas companies decreased 26 percent from 1991 to 1992. In that period, development expenditures dropped about 19 percent, while exploration expenditures dropped by nearly 40 percent.

The U.S. Department of Energy (DOE) awarded $923,000 to the University of Wyoming for a three-year grant to study the anisotrophy and spatial variation of relative permeability and lithologic character of Tensleep Sandstone reservoirs in Wyoming. The grant was one of seven awarded by the DOE.

The Rock Springs District Office of the U.S. Bureau of Land Management (BLM) has issued a draft version of a proposed policy to resolve conflicts in the leasing or development of oil and gas and trona in southwestern Wyoming. While the policy encourages Federal lessees to negotiate between themselves based on safety, engineering, prior existing rights, maximum economic recovery, resource conservation, development methods and timing, magnitude of capital investment, and project life, the BLM will attempt to set priorities when oil and gas operators and trona operators can't agree on mutually acceptable arrangements. When it is necessary to set priorities for the extraction of these overlapping resources, in the absence of lease stipulations to the contrary, the BLM will initially resolve the conflicts on the basis that the first lessee has operating rights superior to those issued to subsequent lessees.

The policy assumes relocation of proposed wells can mitigate most conflicts. If an acceptable well site is not available, the BLM may: 1) deny an application for a permit to drill; 2) defer drilling for a reasonable period of time; or 3) allow drilling with the condition that plugging and abandonment take place when mining approaches 850 feet from the wellbore.

The U.S. Bureau of Land Management's (BLM's) April oil and gas lease sale raised more total revenue than any sale since February, 1991 (**Table 5**). The sale's high per-acre bid of $220 was made by Hunt Oil Co. for a 120.2-acre lease that covers NW NE, NE NW, and SE NW section 13, T53N, R70W. The lease is a half mile from Minnelusa production in Deer Fly Field. Bannon Energy Inc. paid $180 per acre for a 640-acre parcel that covers section 8, T22N, R111W. The parcel is a mile from Frontier production in Emigrant Springs Field and Dodge Rim Field. Chevron USA Inc. paid $402,952 for 16 Thrust Belt leases located in T36N, R115W; T37N, R115W; T38N, R114W; and T38N, R115W. The leases are near an abandoned wildcat well that Chevron drilled in 1986 in NW NE section 33, T37N, R115W. That well, the 31-33C Cabin Creek, tested 1.5 million cubic feet

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

Month	BLM SALES Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre	STATE SALES Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1988							**1988**			
TOTAL	$27,688,861	4,119	1,591	4,412,513	1,350,897	$20.50	$6,500.00	$6,202,724	1,200	873	445,953	331,943	$18.69	$465.00
				1989							**1989**			
TOTAL	$15,832,105	4,286	1,360	4,028,750	972,403	$16.28	$3,000.00	$3,123,984	1,199	792	461,852	311,274	$10.04	$540.00
				1990							**1990**			
TOTAL	$17,997,133	2,971	1,593	2,169,138	967,293	$18.61	$340.00	$4,979,094	1,199	732	478,098	380,382	$13.09	$270.00
				1991							**1991**			
February	$4,333,861	370	200	275,600	122,225	$35.46	$16,000.00	$2,050,868	300	295	117,677	115,998	$17.68	$401.00
April	$1,880,742	470	217	332,764	132,278	$14.22	$170.00	$642,191	197	170	69,652	62,226	$10.32	$110.00
June	$2,002,440	490	176	430,576	120,992	$16.55	$275.00	$539,556	199	173	79,156	70,081	$7.70	$77.00
August	$2,005,511	557	211	472,103	120,292	$16.67	$325.00	$396,569	200	124	73,179	52,850	$7.50	$70.00
October	$1,616,314	507	175	397,011	94,899	$17.03	$340.00	$411,971	200	146	69,025	50,908	$8.09	$260.00
December	$1,095,409	421	168	283,408	85,091	$12.87	$1,600.00	$416,730	199	129	71,286	53,847	$7.74	$130.00
TOTAL	$12,934,277	2,815	1,147	2,191,462	675,777	$19.14	$16,000.00	$4,457,885	1,295	1,037	479,975	405,910	$10.98	$401.00
				1992							**1992**			
February	$940,581	342	126	213,469	67,205	$14.00	$210.00	$138,165	200	96	72,027	37,840	$3.65	$65.00
April	$331,199	355	109	229,407	58,951	$5.62	$112.00	$200,000	200	114	70,294	41,034	$4.88	103.00
June	$425,183	314	86	168,230	37,701	$11.28	$220.00	$208,166	200	93	60,687	28,605	$7.28	$230.00
August	$1,395,060	335	109	196,800	54,530	$25.58	$230.00	$200,407	199	116	74,747	43,134	$4.65	$87.00
October	$657,029	351	73	259,482	43,843	$14.99	$2,500.00							
December	$1,029,888	425	161	366,880	102,248	$10.07	$280.00							
TOTAL	$4,778,940	2,122	664	1,434,268	364,478	$13.11	$2,500.00	$745,738	799	419	277,755	150,613	$4.95	$230.00
				1993							**1993**			
February	$1,637,233	464	246	346,357	155,272	$10.54	$220.00	$601,400	200	137	74,940	54,723	$10.99	$400.00
April	$2,116,184	478	259	351,465	177,989	$11.89	$220.00	$362,840	200	141	82,388	56,770	$6.39	$90.00
June	$1,415,793	463	179	351,130	86,435	$16.38	$390.00							

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

of gas, 110 barrels of condensate, and 605 barrels of water per day from two zones in the Madison Limestone. Gas was also flared from a test in the Mesaverde. The well was drilled on the Prospect Thrust.

The State Land and Farm Loan Office's May oil and gas lease sale was the second best since November, 1991 (**Table 5**). The sale's top bids of $90 per acre were made for two Powder River Basin tracts. Brown Operating Inc. leased a 160-acre tract covering SE section 32, T48N, R70W. The lease is a half mile from Minnelusa production in Basin Northwest Field. Plains Petroleum Co. bid $90 per acre for a 240-acre tract that covers SW and N/2 SE section 21, T50N, R70W. The parcel is a half mile from Minnelusa production in Rozet Field. Brown Operating Inc. bid $80 per acre for a 320.44-acre lease that covers E/2 W/2 and SW SE section 2 and N/2 NE and NE NW section 11, T53N, R69W. The lease is about a mile from shut-in Minnelusa production in Scribner Field.

Bannon Energy Inc. made the top per-acre bid at the BLM's June lease sale. Bannon bid $390 per acre for a 1,261.28-acre parcel that covers E/2 section 14, E/2 section 23, and all of section 24, T22N, R113W. The lease is near Frontier production in Cow Hollow Field and Black Jack Field. Celsius Energy Co. bid $70 per acre for a 1,120-acre parcel that contains all of section 10, and NE and S/2 section 15, T22N, R113W. The lease is near Frontier production at Cow Hollow Field and Opal Field. The total bid for this lease was the second highest of the sale. The sale's second highest per-acre bid was made by Swift Energy Co. Swift bid $370 per acre for a 162.77-acre parcel that covers S/2 NW and N/2 SW section 8, T53N, R68W and offsets Minnelusa production in Morel Field.

Exploration and development

Company data and information compiled and published by Petroleum Information indicate the following significant exploration and development events occurred in Wyoming during the second quarter of 1993. Activities related to horizontal drilling are discussed in a separate section. The letters preceding discussions below refer to locations on **Figure 10**.

A. Union Pacific Resources began construction of its 41-mile Wahsatch Gathering System. The system will run from Cave Creek Field in Utah to Yellow Creek Field in Wyoming, and then to Amoco's Whitney Canyon gas processing plant. A number of shut-in, sour-gas wells will be reworked in Cave Creek and Yellow Creek fields. The 1 Urroz well in NW NW section 2, T14N, R121W was the first well reworked, and it tested 10 million cubic feet of gas and 185 barrels of condensate per day commingled from the Phosphoria and Weber. The gathering system is scheduled for completion later this year and will transport 55 million cubic feet of gas and 800 barrels of condensate per day to the Whitney Canyon plant.

B. Chevron USA tested a new development well in Painter Reservoir Field. The 21-18A Painter Reservoir well in SW NW section 18, T15N, R119W flowed four million cubic feet of gas and 1,100 barrels of condensate per day through perforations in the Nugget between 11,706 and 11,864 feet.

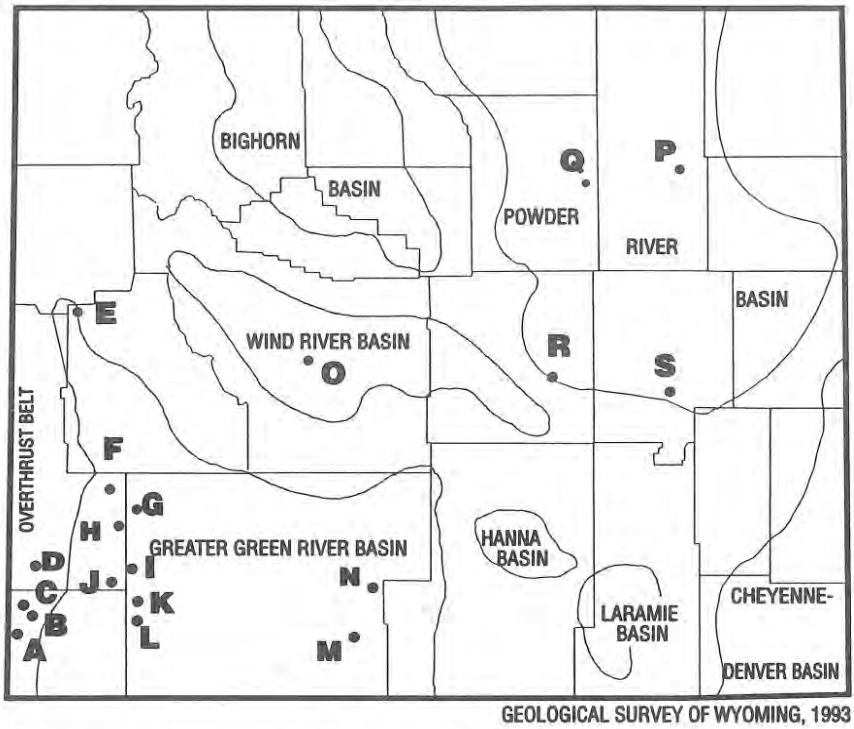


Figure 10. Oil and gas exploration and development activity in Wyoming during the second quarter of 1993 (exclusive of horizontal drilling and coalbed methane activities).

C. Amoco Production plans to build two pipelines that will connect Anschutz Ranch East Field to the Painter Complex gas plant. One 12-inch pipeline will transport nitrogen to Anschutz East Field and the other 12-inch pipeline will transport surplus gas from Anschutz East Field to the Painter Complex for processing.

D. Exxon Corp. completed a new Bighorn development well in Road Hollow Field. The 2 Bridger Fork Unit well in SE NW section 19, T20N, R119W flowed 450,000 cubic feet of gas, 170 barrels of oil, and 17 barrels of water per day from perforations between 13,162 and 13,173 feet.

E. Parker Drilling Co. was awarded a contract by Chevron Production Co. to provide a helicopter-transportable rig to drill the 1-27 Chevron-Federal well in NE NW section 27, T38N, R115W. The well is scheduled as a 7,000-foot test of the Madison and will start drilling in July or August of this year.

F. Fontenelle Field has three new Frontier development wells completed by PG & E Resources. The 12-1 Federal well in SW NW section 1, T25N, R112W

flowed 1.5 million cubic feet of gas per day from perforations between 8,428 and 8,470 feet and between 8,516 and 8,562 feet. The 31-12 Federal well in NW NE section 12, T25N, R112W flowed 1.5 million cubic feet of gas and one barrel of condensate per day from perforations between 8,558 and 8,578 feet and between 8,593 and 8,691 feet. The 13-13 Federal well in NW SW section 13, T25N, R112W flowed 693,000 cubic feet of gas per day from perforations between 8,402 and 8,582 feet.

G. Washington Energy Exploration completed 11 new Frontier development wells in the Mesa/Lincoln Road area. **Table 6** summarizes data from these wells. Washington Energy Exploration is also drilling or has staked locations for 21 other wells in this area.

H. Exxon's Shute Creek gas processing plant is back in the news. A consultant's report done for Wyoming's Natural Gas Pipeline Authority indicates that Exxon could benefit from a proposed $28 million carbon dioxide pipeline to the Powder River Basin. The carbon dioxide could be used to extract additional oil from a number of fields in the Powder River Basin. The report also stated that a low-interest loan from the State is not necessary to make the project economically viable. In early August, the Natural Gas Pipeline Authority and

Table 6. Summary of Washington Energy Exploration's new Frontier development wells in the Mesa/Lincoln Road area.

WELL NAME	WELL LOCATION	PRODUCTION RATE	PRODUCTION DEPTH
10-26 FARSON-FEDERAL	SW NW section 26, T24N, R111W	3 MMCFGPD[1] 6 BCPD[2]	10,083-10,125 feet
11-34 RATTLE-SNAKE UNIT	NW NW section 34, T24N, R111W	500 MCFGPD[3]	10,063-10,188 feet
40-23 McCULLEN BLUFF	SW SW section 23, T24N, R111W	3.2 MMCFGPD 6 BCPD	10,030-10,086 feet
10-23 McCULLEN BLUFF	N/2 NW section 23, T24N, R111W	3 MMCFGPD	9,986-10,030 feet
30-15 LINCOLN ROAD	C SE section 15, T24N, R111W	292 MCFGPD 2 BCPD	9,930-10,046 feet
20-9 LINCOLN ROAD	NE NE section 9, T24N, R111W	2.4 MMCFGPD 2 BCPD	9,546-9,662 feet
20-34 LINCOLN ROAD	SW NE section 34, T25N, R111W	7.5 MMCFGPD 10 BCPD	9,430-9,510 feet
40-34 LINCOLN ROAD	NE SW section 34, T25N, R111W	1.7 MMCFGPD 2 BCPD	9,275-9,444 feet
40-9 LINCOLN ROAD	C SW section 9, T24N, R111W	2.7 MMCFGPD 1 BCPD	9,750-9,852 feet
34-26 FARSON FEDERAL	SW SE section 26, T24N, R111W	14 MMCFGPD 95 BCPD	10,250 feet
32-35 FARSON FEDERAL	SW NE section 35, T24N, R111W	8.4 MMCFGPD 92 BCPD	10,220-10,302 feet

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

the Wyoming Oil and Gas Conservation Commission will meet with Exxon to discuss the conclusions in the consultant's report.

I. Washington Energy Exploration completed two Frontier development wells in Seven Mile Gulch Field. The 40-2 East Trumpeter-Federal well in NE SW section 2, T20N, R112W flowed three million cubic feet of gas and two barrels of condensate per day from a sand and carbon dioxide-fractured interval between 11,303 and 11,318 feet. The 10-2 East Trumpeter-Federal well in NW NW section 2, T20N, R112W flowed 766,000 cubic feet of gas and eight barrels of condensate per day from perforations between 11,270 and 11,300 feet.

J. Wexpro Co. completed a Frontier development well in Bruff Field. The 28-3 Lansdale-Federal well in NE NE section 28, T19N, R112W flowed 3.9 million cubic feet of gas per day from perforations between 11,298 and 11,346 feet.

K. American Natural Resources Production Co. (ANR) is planning to dismantle a Montana gas processing plant and reassemble it at a site seven miles southwest of Granger. The plant would process sour gas and would produce 14 million cubic feet of natural gas per day along with natural gas liquids and sulfur. The plant must be approved by the U.S. Bureau of Land Management and the Wyoming Department of Environmental Quality.

L. Celsius Energy completed a Frontier development well in Church Buttes Field. The 12-3 Thompson-Federal well in NE NE section 12, T17N, R113W flowed 905,000 cubic feet of gas per day from perforations between 12,040 and 12,080 feet.

M. Celsius Energy completed an Almond development well in Mulligan Draw Field. the 15 Unit well in SE NW section 14, T15N, R95W flowed 8.2 million cubic feet of gas per day from perforations between 13,004 and 13,024 feet.

N. Barrett Resources completed an Almond development well in Frewen Field. The 7 Frewen Field well in SW NE section 16, T19N, R94W flowed 1.1 million cubic feet of gas, 29 barrels of condensate, and eight barrels of water per day from perforations between 9,495 and 9,615 feet.

O. Wind River Gathering acquired about 110 miles of natural gas pipelines and related facilities in the Wind River Basin from Williston Basin Interstate Pipeline. Wind River Gathering is a joint venture between KN Gas Gathering and Retex Gathering.

P. Brown Operating completed a new Minnelusa discovery. The 1-27 Sparrow well in NW NE section 27, T47N, R70W pumped 86 barrels of oil per day from perforations between 9,862 and 9,868 feet.

Q. Presidio Exploration completed the second well in Demott Draw West Field. The 21-31 Heater well in NE NW section 31, T48N, R71W has produced over

23,000 barrels of oil in three months of production. The well produces from the Minnelusa at approximately 10,300 feet.

R. Bohemia Resources continues to make progress on a $400 million plant that would produce 3,000 tons of methanol and 20,000 barrels of methyl tertiary butyl ether (MTBE) per day. Both products are gasoline additives. By the end of 1993, the company hopes to purchase Texaco's abandoned oil refinery in Casper and convert it into a plant to manufacture the gasoline additives. If all goes as planned, construction on the plant could begin in 1995.

S. Doyle D. Hendrickson is deepening a 1,100-foot dry hole about four miles east of Douglas. The 34-19 Scott-Federal well in SW SE section 19, T32N, R70W will be drilled through granite to a total depth of about 11,500 feet. The well is a mile south of an east-west fault. The target for the well is confidential.

Horizontal drilling

During the second quarter of 1993, the following significant activities related to horizontal drilling occurred. The letter preceding the discussions below refer to locations on **Figure 11**. The discussions are based on company data and on information compiled and published by Petroleum Information.

A. Union Pacific Resources completed a non-commercial Niobrara discovery at the 1-H Pence Ranch 5E-17 well drilled from a surface location in NE NE section 17, T15N, R61W. The well initially produced three barrels of oil, 41,300 cubic feet of gas, and 45 barrels of water per day. True vertical depth of the well is 6,911 feet.

B. Union Pacific Resources will drill a Niobrara test to a true vertical depth of 7,643 feet. The 1-H Beartooth well will be drilled from a surface location in NE NE section 17, T15N, R63W. The well offsets an earlier discovery in Dale Field.

C. Activity continues in the Niobrara at Silo Field. Cimarron Operating staked a location for its 1-H Wilma well to be drilled from a surface location in SW SW section 26, T16N, R64W to a true vertical depth of 8,100 feet. Kachina Exploration began drilling its 13-H Wiggam well from a surface location in SW SW section 6, T15N, R63W. True vertical depth was not reported. Kachina also staked a location for its 24-1-H State well to be drilled from a surface location in NE NE section 24, T15N, R64W to a true vertical depth of 7,795 feet. Union Pacific Resources also announced plans to drill 13 horizontal wells and to redrill three wells in Silo Field this year. Ten of the wells will be drilled in partnership with Sinclair Oil Corp. Production from all horizontal wells in Silo Field is over 3,500 barrels per day and cumulative horizontal well production in the field is slightly more than one million barrels of oil.

D. Arco Oil and Gas announced that its 1-25H Morton Ranch well flowed 165 barrels of oil, 380,000 cubic feet of gas, and 135 barrels of water per day from a lateral leg drilled through the Niobrara and Frontier. True vertical depth of the well was 11,701 feet. The well was drilled from a surface location in SW SW section 25, T33N, R72W.

E. EP Operating began drilling its 1 H Federal 26-9 well from a surface location in NE SE section 26, T38N, R78W to a true vertical depth of 3,185 feet. The company expects to encounter oil in several zones in the Steele Shale and in the Niobrara Formation. The well is just south of Teapot Dome Field.

F. Conoco Inc. staked a location for a horizontal Niobrara test near Hay Field. The 1 H Patriot Unit well will be drilled from a surface location in SW NW section 30, T45N, R71W to a true vertical depth of 8,650 feet.

G. Marathon completed a Tensleep producer in Byron Field. The 3H I. Lindsay well was drilled from a surface location in SW NW section 23, T56N, R97W to a true vertical depth of 5,168 feet. The well was completed pumping 54 barrels of oil, 1,900 cubic feet of gas, and 1,343 barrels of water per day.

Reference cited

Petroleum Information, 1993, Rocky Mountain region report: Southeastern edition, v. 66, no. 127, p. 5-8.

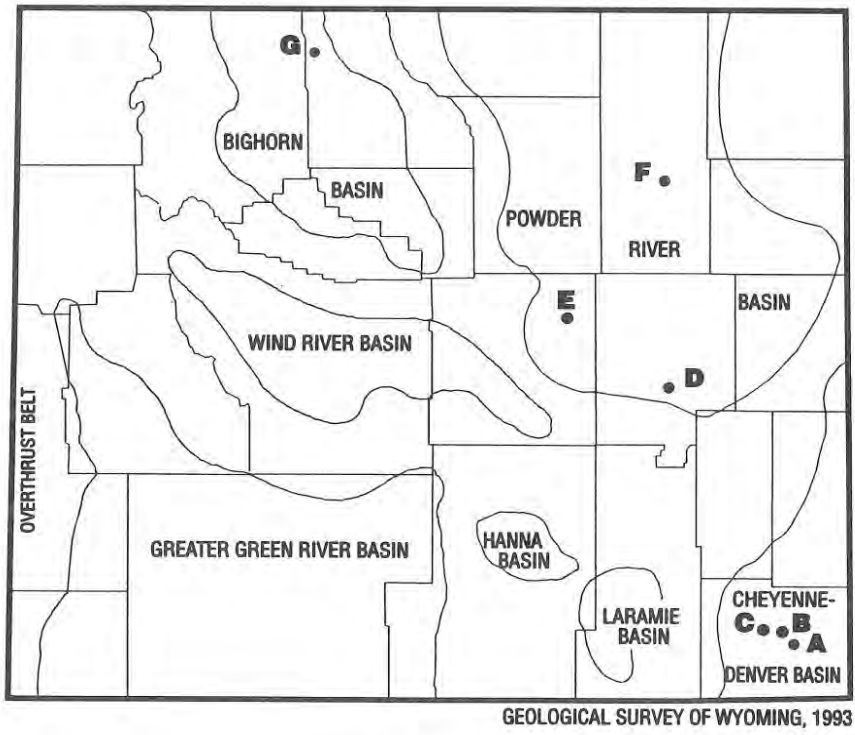


Figure 11. Horizontal drilling activity in Wyoming during the second quarter of 1993.

COAL UPDATE

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

Although 1992 saw the first decrease in coal production in Wyoming in seven years (**Table 7**), preliminary monthly production for 1993 is once again showing an increase. For the first quarter of 1993, data compiled from FERC Form 423, which is filed monthly by electric utilities, shows an increase of nearly five percent over that mined during the same period in 1992 (**Table 8**). In addition, during the month of March, over 17 million tons of coal were mined and delivered to utilities, setting a new record for Wyoming (**Table 8**; **Figure 12**). Sales of both contract and spot coal were high in March and this probably accounts for the record new monthly production (**Figure 13**).

Recently available data on the distribution and utilization of coal produced in 1992 indicates that 86 percent of Wyoming coal was used in 23 different states and 1 percent (approximately 1.3 million tons) was exported to foreign countries (**Figures 14** and **15**). In 1992, 97.3 percent of Wyoming's coal was used for electrical generation with the remainder used for industrial and residential purposes. Texas continued as the largest consumer of Wyoming coal in 1992 followed by Wyoming, Oklahoma, Iowa, Kansas, and Indiana.

In coal transportation news, Union Pacific (UP) has asked the Interstate Commerce Commission for approval to acquire the majority interest in Chicago & Northwestern Railroad (C&NW). UP said the request's main purpose is not to acquire C&NW, but to allow UP to convert its non-voting stock to voting stock. But UP said third-party transactions in C&NW may leave UP inadvertently the largest single stockholder. Other rail companies, including Burlington Northern, are opposing this acquisition.

The Wyoming Coal Refining Systems (WCRS), Inc. (formerly Char-Fuels) was turned down again in May for Federal funding from the Clean Coal Technology Demonstration Program. The Department of Energy (DOE) also rejected Amax Coal's application for funding. Amax was the only other Wyoming applicant for Clean Coal money. DOE did accept projects from each of five other states (New Jersey, Kentucky, Ohio, Pennsylvania, and Maryland). These states will receive a total of $2.16 billion.

A United Mine Workers of America strike against Arch Mineral Co., Amax Coal Co., and Ziegler Coal Co. in Indiana and Illinois is not expected to have any effect on coal production in Wyoming. All three companies have coal mines in Wyoming; Arch Mineral's miners in south-central Wyoming are covered under a separate union contract, while the Amax and Ziegler operations in Wyoming are non-union.

A planned merger of two giant U.S. minerals companies with coal mines in Wyoming will form the nation's second largest coal company. Amax Inc. of New York City and Cyprus Minerals Co. of Englewood, Colorado, will combine to form

Table 7. Coal production (1983 to 1992) with forecast to 1995 (millions of short tons).

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*	1994*	1995*
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.8	154.7	164.9	159.6	167.8	172.1	176.4
Converse County	2.7	3.3	3.6	4.8	5.1	5.7	6.1	7.9	8.2	8.5	8.7	8.9	9.2
Sheridan County	2.9	2.5	2.4	1.4	1.2	0.9	0.1	0.1	0.2	0.1	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	4.3	4.5	4.7	4.1	4.6	4.8	4.9
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	12.0	11.9	11.4	12.6	8.6	8.8	9.0
Lincoln County	4.0	4.1	4.3	4.0	3.8	4.9	4.8	4.7	4.4	4.6	4.5	4.6	4.8
Hot Springs County	M	M	M	M	M	M	M	0.1	0.1	M	M	M	M
Total Wyoming	112.1	130.7	140.7	135.6	146.4	163.5	171.1	183.9	193.9	189.5	194.3	199.3	204.3
Annual Change	4.0%	14.2%	7.1%	-3.8%	7.4%	10.5%	4.4%	7.0%	5.2%	-2.3%	2.5%	2.5%	2.4%
Low-priced coal†			6%	7%	8%	10%	17%	24%	31%	37%	42%	47%	51%

* Forecast by Geological Survey of Wyoming, February 1993. † Estimated percentage of total production that is sold on the spot market, through short-term contracts [less than one year duration], or through renegotiated, longer-term contracts all at prices under $5.00. M means minor tonnage (less than 0.1 million tons).

Table 8. Coal deliveries by month from Wyoming mines†

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

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

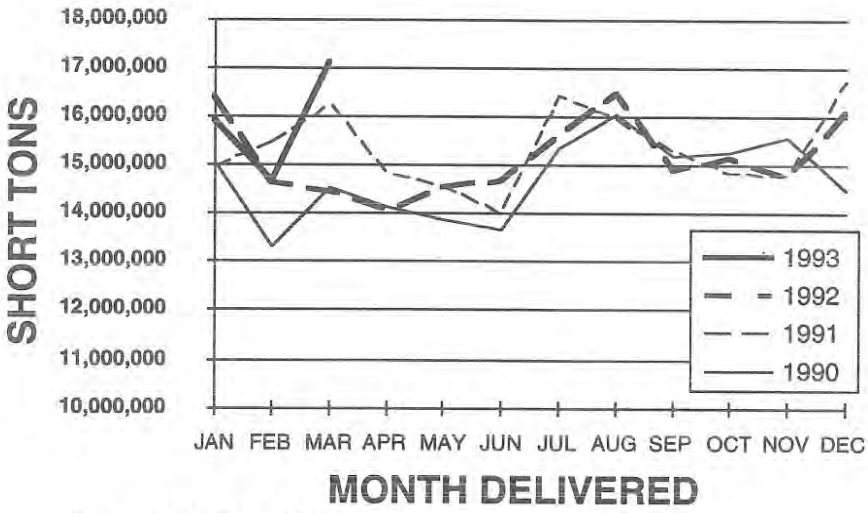


Figure 12. Reported deliveries from Wyoming coal mines. *(from COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Table 8. *continued*

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

Cyprus-Amax. The new company would be headquartered in Englewood and oversee a possible 70 million tons of coal production a year. Cyprus-Amax is also in the process of acquiring coal holdings in Australia and from USZ Mining in Pennsylvania.

Developments in western and southwestern Wyoming

All the workers at Arch Mineral's Pilot Butte underground coal mine near Rock Springs have been furloughed. Mine officials said there has been no formal decision to close the mine at Reliance, but added there is a good chance the mine will be permanently closed in the future. Arch had purchased the mothballed coal mine four years ago in hopes of marketing its high-quality coal in the West and Pacific Rim markets. The workforce was 27 in 1992.

State Abandoned Mine Lands officials are bidding contracts for reclamation of abandoned mines in three southwest Wyoming counties (Sweetwater, Lincoln, and Uinta). Much of the work will include efforts to battle underground mine fires. Specifically the projects will include excavation and backfill of subsidence holes, the closure of mine shafts and portals, minor grading, and the placing of a surface seal over underground mine fires.

Developments in the Powder River Coal Field

Campbell County plans to intervene in appeals by three coal companies over their State tax bills. An estimated $6 million is at stake, according to county

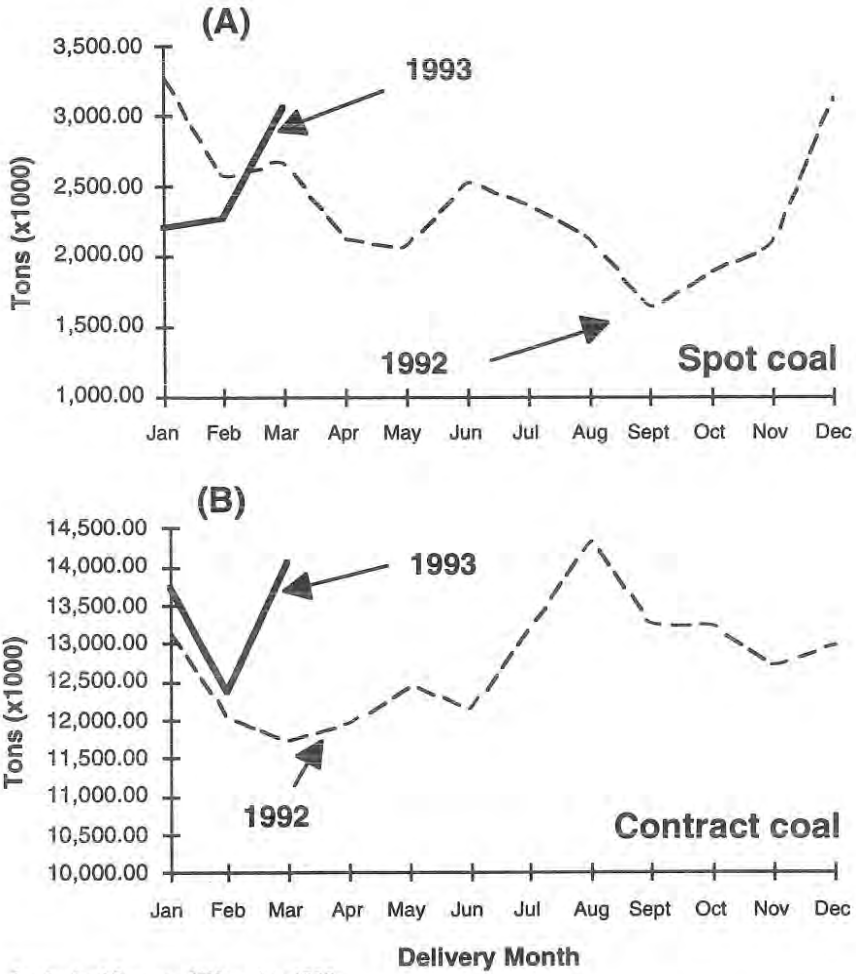


Figure 13. Monthly coal deliveries from Wyoming for 1992 and 1993. (A) Coal sold on the spot market and (B) coal sold on contract. *(from COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

officials. Kerr McGee Coal Co., Arco, and Amax have filed appeals with the Wyoming Board of Equalization over taxes the State says they owe.

Federal coal lease activities continue in the Powder River Basin. Amax Coal Company is seeking a new Federal coal lease that would extend its Eagle Butte mine into a restricted buffer zone around Gillette, but city officials say the proposal creates no real safety concerns. Amax wants to acquire a 915-acre lease containing 150 million tons of coal along U.S. Highway 14-16, just across the road

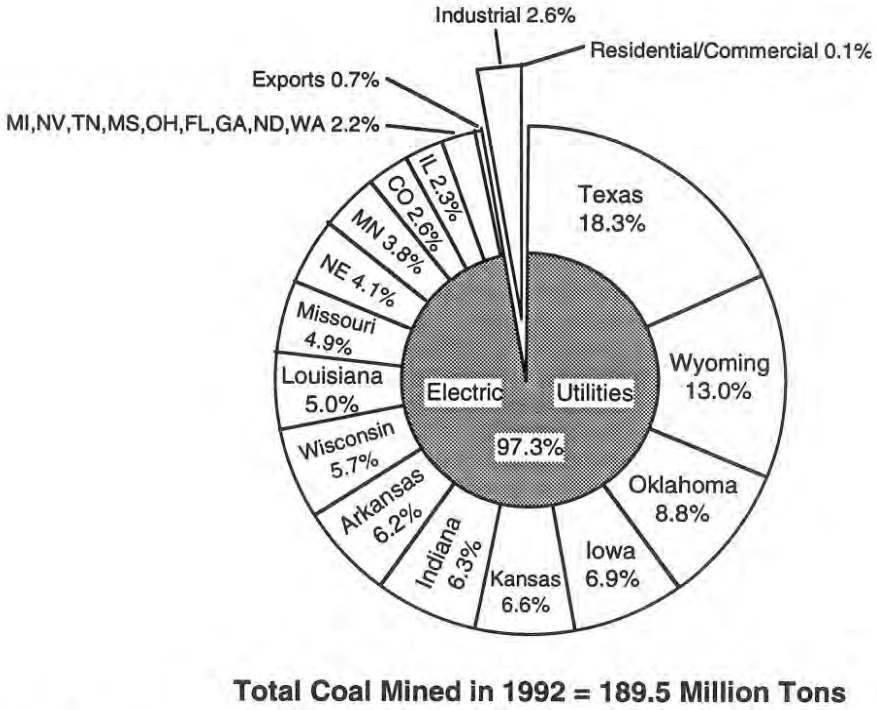


Figure 14. Utilization of Wyoming coal in 1992 in percent. *(from Energy Information Administration, 1992 and COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

from the Gillette airport. At current levels of production, this lease would extend the life of the Eagle Butte mine another ten years. Although there has been some opposition to the new lease, officials noted that the Wyodak coal mine already operates in the buffer zone.

Officials for Ziegler Coal (which recently bought the assets of Shell Coal) are asking the U.S. Bureau of Land Management (BLM) to approve the sale of a 140-million-ton lease south of Wright. The timing of the mine start would depend on the market, but it could come as early as 1996 and would create 150 permanent mining jobs. The lease value is an estimated $20 - $30 million.

The Washington office of the BLM is still in the process of deciding whether to approve a new coal lease in Campbell County. Montana-based Northwestern Resources wants to combine two existing leases near Gillette and start the new Rocky Butte mine. BLM officials have processed the Rocky Butte application, but the approval decision will be made in Washington. This transaction is apparently a very similar situation to what Ziegler Coal is proposing.

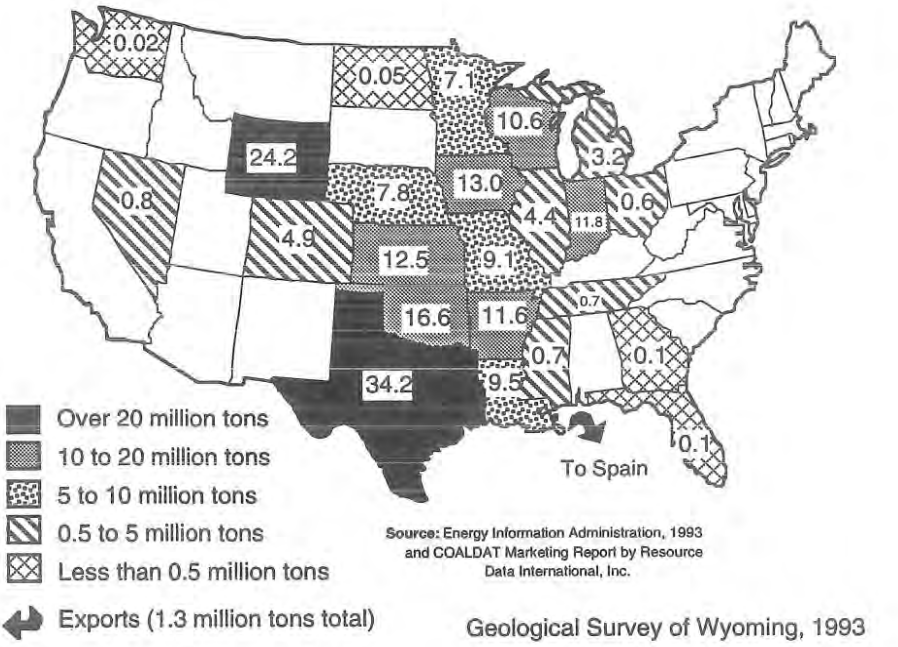


Figure 15. Distribution of Wyoming coal sales in 1992 in millions of tons. (*Energy Information Administration, 1993, and COALDAT Marketing Report by Resource Data International, Inc., compiled from FERC Form 423 filed monthly by electric utilities).*

Members of the Wyoming congressional delegation have complained to the Environmental Protection Agency (EPA) about air pollution regulations which they say could require a reduction in Powder River Basin coal production. A spokesperson for the EPA in Denver said that the agency does not perceive an air pollution problem in the Powder River Basin and will not enforce regulation in a manner that would reduce coal mining in the region. The regulations in question pertain to allowable levels of dust emissions from open-pit mines under ambient air quality standards of the Federal Clean Air Act.

The South Dakota Public Utilities Commission (SDPUC) ruled in mid-April that Rosebud Energy, a Boise company, was too late when it proposed building a petroleum-coke-fired alternative to Black Hills Corporation's (BHC's) proposed new coal-fired unit. This ruling apparently clears the way for Black Hills' plan to build an 80-megawatt, $125 million power plant near Gillette. Construction will most likely begin in July. BHC has also indicated that it will seek roughly a 10 percent rate hike in 1996 to pay for construction of the power plant.

Kennecott Corporation, which recently acquired both the Cordero mine as well as Nerco's holdings, is expected to locate its coal subsidiary's headquarters in Gillette. Kennecott will staff its Gillette office with approximately 35 administrative and sales positions, following a company policy of locating headquarters near particular operations.

Elsewhere in the Powder River Basin, layoffs of mine personnel continue. For example, although production is expected to increase by nearly 20 percent at the Black Thunder mine this year, the mine announced on July 9th that it will lay off 35 employees. The company cited declining coal prices as one of the reasons for the layoffs. Increasing automation was also a contributing factor. The mine has a new 160-cubic-yard dragline which is the third largest dragline in the world. The mine has also switched its fleet of 170-ton trucks to 240-ton trucks. Also, in the Montana portion of the Powder River Basin, Western Energy Co., the coal mining subsidiary of Montana Power Co., announced the layoff of 88 workers at their Colstrip mine in June, but they expected to rehire them by the end of the month. They noted that exceptional runoff from snow melt has provided an abundance of hydroelectric power in the Pacific Northwest. Consequently, market demand has slackened at Colstrip.

Three Powder River Basin coal companies have swapped work for forgiveness of special use permit fees in support of a U.S. Forest Service effort to consolidate public and private lands in the Thunder Basin National Grasslands. The special use permit fees are related to facilities that the companies maintain off their coal leases on the Thunder Basin National Grasslands. The three coal companies (Powder River Coal Co., SMC Mining Co., and Thunder Basin Coal Co.) entered into an agreement that in effect exchanges special use permit fees for work on cultural resource surveys on Federal land.

Contracts

New coal contracts, test burns, solicitations, and spot sales for the second quarter of 1993 are summarized in **Table 9**. Of major note is that Caballo Rojo has obtained a contract with Midwestern Power Systems for up to 1 million tons of coal. This contract has spot coal options. Also, the Lower Colorado River Authority is soliciting bids from Powder River Basin coal mines for up to 2 million tons per year. This contract would replace the current five-year contract with Cordero.

Coalbed methane

During the second quarter of 1993, the following significant activities related to coalbed methane occurred. The letters proceeding the discussion below refer to locations on **Figure 16**.

A. The U.S. Bureau of Land Management (BLM) has approved Metfuel's Hanna Basin coalbed methane project, with the condition that the drilling be done in phases, beginning with a 32-well pilot program. This approval means that Metfuel Wyoming, Inc., can now begin work on developing 123 coalbed methane wells over the next four years. The project area is about seven miles north of Hanna and the wells will be drilled on a drilling density of 160 acres.

B. Martens and Peck, a Denver-based exploration company, drilled two coalbed methane wells. The wells were located in the Gillette area and were completed in the upper Fort Union Formation.

Table 9. Recent activity involving coal producers in Wyoming during the second quarter of 1993.

Utility	Power Plant	Coal Mine or Region	Activity	Tonnage	Comments
Basin Electric Power Cooperative	Laramie River	Powder River Basin	So	350,000 - 550,000	Solicitation is for second half of 1993.
	Laramie River	Cordero	Sp	550,000	Second half coal deliveries have begun and will continue until December.
Iowa State University	N.D.	Caballo Rojo	T	N.D.	
Iowa-Illinois Gas & Electric	Louisa	Rawhide	Sp	N.D.	
Lower Colorado River Authority	N.D.	Powder River Basin	So	2 million t/y	This would replace a 5-year contract with Cordero.
Midwest Power Systems	Neal No. 4	Powder River Basin	So	850,000 - 1 million	
	Neal units	Caballo	Sp	800,000 - 1.5 million	Deliveries to begin in June.
	Council Bluff	Rawhide	Sp	300,000 - 800,000	
	Neal No. 4	Caballo Rojo	Sp/C	850,000 - 1 million	
	Council Bluff	Eagle Butte	Sp/C	200,000	
Northern Indiana Public Service Co.	Dean H. Mitchell	Cordero	Sp	33,000	
	Dean H. Mitchell	Belle Ayr	Sp	44,000	
	Schahfer, Dean H. Mitchell, or Michigan City	Powder River Basin	So	N.D.	Solicitation for as-needed spot coal.
	Bailly	Belle Ayr	Sp	30,000	
	Dean H. Mitchell	Caballo Rojo	Sp	44,000	
	Dean H. Mitchell	Cordero	Sp	22,000	
	Dean H. Mitchell	Shoshone	C	90,000	
	Michigan City	Belle Ayr	Sp	55,000	
	Michigan City	Shoshone	C	40,000	

Table 9. Recent activity involving coal producers in Wyoming during the second quarter of 1993 *(Continued)*.

Utility	Power Plant	Coal Mine or Region	Activity	Tonnage	Comments
Pacific Power	Dave Johnston	Powder River Basin	So	200,000 - 800,000	
	Centralia	Powder River Basin	So	200,000 - 1.2 million	
	Bridger	Powder River Basin	So	200,000 - 900,000	
PacifiCorp	Dave Johnston	Caballo Rojo	Sp	800,000	
	Dave Johnston	Cordero	Sp	400,000	
	Dave Johnston	North Rochelle	Sp	25,000	
	Dave Johnston	Rochelle	Sp	200,000 - 800,000	
Portland (OR) General Electric	Boardman	Western states (UT, CO, WY)	So	1 million	Previous contract relied on the Caballo mine for 500,000 tons of coal
	Boardman	Caballo Rojo	Sp	900,000	
San Antonio TX City Public Service Board	N.D.	Cordero	C	1.5 million t/y	This is a three-year contract with a fixed price bid of $3.21/t this year and $3.41/t next year.
Southwestern Electric Power Co.	Flint Creek	North Antelope	T	100,000	
Tennesse Valley Authority	Johnsonville	Black Thunder	T	N.D.	Test burn scheduled for May 15.
TU Electric	N.D.	Cordero	Sp	35,000 t/m	
West Texas Utilities	Oklaunion	Powder River Basin	So	300,000 - 600,000	Raton Basin and Colorado coal suppliers will also be solicited.
	N.D.	Powder River Basin	So	300,000 - 600,000	

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

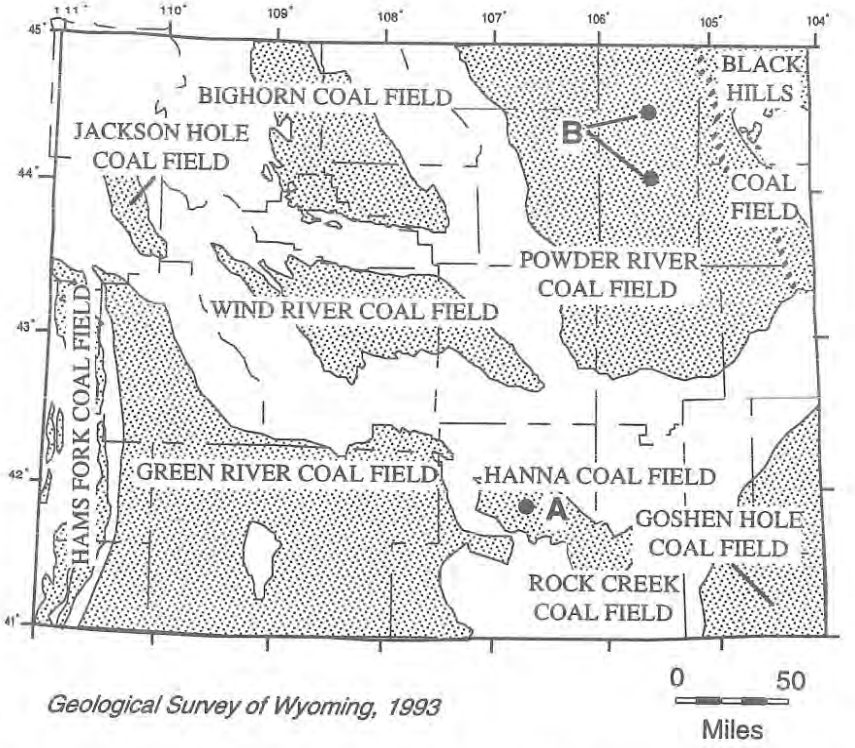


Figure 16. Coalbed methane activity in Wyoming during the second quarter of 1993.

Some new publications on Wyoming coal geology

A new feature of **Coal Update** is a listing of recent articles dealing with coal technology and geology relating to Wyoming. The journals which will be reviewed each quarter are: *International Journal of Coal Geology*, *Journal of Coal Quality*, *Fuel*, *Organic Geochemistry*, and any pertinent U.S. Geological Survey publications. While the first two publications are listed in their entirety, for the other publications only the articles relevant to coal geology in Wyoming are listed. Some back issues of the *International Journal of Coal Geology* and *Journal of Coal Quality* are cited below, but hereafter only recent issues will be cited. Most of these journals are available from the University of Wyoming libraries or through interlibrary loan from other places. Recent articles are listed with the author's address. Reprints are usually available directly from the authors.

International Journal of Coal Geology

Volume 22, No. 1, 1993

Spears, D. A., and Martinez-Tarazona, M. R., 1993, Geochemical and mineralogical characteristics of a power station feed-coal, Eggborough, England: p. 1-20.

Reprint address: *D.A. Spears, University of Sheffield, Department of Earth Sciences, Beaumont Building, Brookhill, Sheffield S37HF, UK*

Daniels, E. J., and Altaner, S. P., 1993, Inorganic nitrogen in anthracite from eastern Pennsylvania, USA: p. 21-35.

Reprint address: *E.J. Daniels, Chevron Oil Field Research Co., P.O. Box 446, La Habra, CA 90633*

Jones, T. P., Scott, A. C., and Mattey, D. P., 1993, Investigations of "fusain transition fossils" from the Lower Carboniferous: comparisons with modern partially charred wood: p. 37-59.

Reprint address: *A.C. Scott, Department of Geology, Royal Holloway, University of London, Egham, Egham Hill, Surrey, TW20 0EX, UK*

Taylor, G. H., and Teichmüller, M., 1993, Observations on fluorinite and fluorescent vitrinite with the transmission electron microscope: p. 61-82.

Reprint address: *G.H. Taylor, Australian National University, Research School of Earth Sciences, G.P.O. Box 4, Canberra, A.C.T. 2601, Australia*

Mastalerz, M., and Bustin, R. M., 1993, Variation in elemental composition of macerals; an example of the application of electron microprobe to coal studies: p. 83-99.

Reprint address: *M. Mastalerz, The University of British Columbia, Department of Geological Sciences, 6339 Stores Road, Vancouver, B.C. V6T 1Z4, Canada*

Volume 22, No. 2, 1993

Rollins, M. S., Cohen, A. D., and Durig, J. R., 1993, Effect of fires on the chemical and petrographic composition of peat in the Snuggedy Swamp, South Carolina: p. 101-117.

Reprint address: *J.R. Durig, Department of Chemistry, University of South Carolina, Columbia, SC 29208*

McFarlane, R. A., Gentzis, T., Goodarzi, F., Hanna, J. V., and Vassallo, A. M., 1993, Evolution of the chemical structure of Hat Creek resinite during oxidation: a combined FT-IR photoacoustic, NMR and optical microscope study: p. 119-147.

Reprint address: *R.A. McFarlane, Coal and Hydrocarbon Processing Department, Alberta Research Council, One Oil Patch Drive, Devon, Alberta T0C 1E0, Canada*

Mastalerz, M., Bustin, R. M., and Lamberson, M. N., 1993, Variation in chemistry of vitrinite and semifusinite as a function of associated inertinite content: p. 149-162.

Reprint address: *M. Mastalerz, Department of Geological Sciences, The University of British Columbia, 6339 Stores Road, Vancouver V6T 1Z4, Canada*

The Journal of Coal Quality

Volume 11, No. 1/2, 1992

Mastral, A. M., Izquierdo, M. T., Mayoral, M. C., and Pardos, C., 1992, Char formation through catalytic iron hydropyrolysis: p. 1-5.

Reprint address: *A.M. Mastral, Instituto de Carboquimica, CSIC, Apdo 589, 50080-Zaragoza, Spain*

Rose, C. D., 1992, A fractal model for sampling coal, ores, and other natural populations: p. 6-13.

Reprint address: *C.D. Rose, Charles Rose Consultants, P.O. Box 4344, Monroe, LA 71201*

Ryan, B., 1992, Estimation of coal washability using small samples: p. 13-19.

Reprint address: *B. Ryan, Geological Survey Branch, Ministry of Energy Mines and Petroleum Resources, Room 122, 525 Superior Str. Victoria, British Columbia V8V 1X4, Canada*

Mazumdar, M., Jacobsen, P. S., Killmeyer, R. P., and Hucko, R. E., 1992, Statistical analysis of an interlaboratory coal float-sink data set: p. 20-31.

Reprint address: *M. Mazumdar, Industrial Engineering Department, University of Pittsburgh, Pittsburgh, PA 15261*

Volume 11, No. 3/4, 1992

Rose, C. D., 1992, Applying statistical methods to coal quality issues: p. 33-38.

Reprint address: *C.D. Rose, Charles Rose Consultants, 808 North 31st Str., Suite D., Monroe, LA 71201*

Yoshida, R., Yoshida, T., Narita, H., and Maekawa, Y., 1992, Carbon distribution analysis of coals by CP/MAS ^{13}C-NMR: p. 38-43.

Reprint address: *R. Yoshida, Government Industrial Development Laboratory, Hokkaido, 2-17 Tsukisamu-Higashi, Toyokira-ku, Sapporo 062, Japan*

Godbeer, W. C., Orban, H., Riley, K. W., and Steinberg, K., 1992, Semi-micro analysis of coal for major and trace constituents: p. 43-45.

Reprint address: *W.C. Godbeer, CSIRO Division of Coal and Energy Technology, P.O. Box 136, North Ryde, Australia, 2113*

Petela, R., 1992, Analysis and correction of batch test measurements of selective agglomeration of coal: p. 46-49.

Reprint address: *R. Petela, Technology Scientific, 152 Ranch Estates Dr. N.W. Calgary, Alberta, T3G 1K4, Canada*

Selected publications since 1990

1990

Moore, T. A., and others, 1990, Maceral and palynomorph facies from two Tertiary peat-forming environments in the Powder River Basin, U.S.A.: International Journal of Coal Geology, Vol. 15, p. 293-316.

1991

Moore, T. A., 1991, The effects of clastic sedimentation on organic facies development within a Tertiary subbituminous coal bed, Powder River Basin, Montana, U.S.A.: International Journal of Coal Geology, Vol. 18, p. 187-209.

Triplehorn, D. M., and others, 1991, Volcanic ash dispersed in the Wyodak-Anderson coal bed, Powder River Basin, Wyoming: Organic Geochemistry, Vol. 17, p. 567-575.

1992

Crowley, S. S., and others, 1992, The geochemistry of the Anderson-Dietz coal bed of the Powder River Basin, Montana, in relation to detrital and volcanic-ash components: The Society for Organic Petrology, 9th Annual Meeting, The Pennsylvania State University, p. 109-111.

Glass, G. B., and Jones, R. W., 1992, Coal fields and coal beds of Wyoming: Wyoming Geological Association, 42nd Annual Field Conference Guidebook, p. 133-167; Geological Survey of Wyoming Reprint No. 47, 35 p., (1992).

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

McLellan, M., 1992. Interpretation of Paleocene coal and clastic deposition, and evolution of the northern and central Powder River Basin, Montana and Wyoming, *in* Sholes, M. A., ed., Coal geology of Montana: Montana Bureau of Mines and Geology Special Publication 102, p. 83-104.

Moore, T. A., and Shearer, J. C., 1992, [Abstract] Melding sedimentology and paleobotany in the analysis of coal and peat deposits: The Contact, Wyoming Geological Association Newsletter, Vol. 39, p. 2-4.

Sholes, M. A., and Daniel, J. A., 1992. The Knoblock coal bed, Powder River and Rosebud Counties, Montana: Correlation and petrgraphy, *in* Sholes, M. A.,

eds., Coal geology of Montana: Montana Bureau of Mines and Geology Special Publication 102, p. 105-136.

Laubach, S. E., Schultz-Ela, D. D., and Tyler, R., 1993, Analysis of compaction effects on coal fracture patterns, Upper Cretaceous Rock Springs Formation, southwestern Wyoming: The Mountain Geologist, Vol. 30, p. 95-110.

Reference cited

Energy Information Administration, 1993, Coal quarterly report, October-December 1992: U.S. Department of Energy Report DOE/EIA-012 (92/4Q), 162 p.

MODELLING COAL QUALITY PARAMETERS

A short course on low rank coals of the western U.S.

To be held at the **University of Wyoming, Laramie** from **15 - 17 October 1993**

To be taught by Dr. Jane C. Shearer
Dr. Timothy A. Moore

The course will specifically cover how to predict variations in coal thickness, chemistry (e.g. ash and sulfur content) and petrography using existing models of coal quality and also how to develop your own models of coal quality.

Course will run with a minimum of 11 and maximum of 18. So please send in your registration soon!

For more information call either Jane or Tim at the Geological Survey of Wyoming, (307) 766-2286 .

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

In the ensuing discussion, most of the mines, quarries, mills, and deposits that are mentioned are located on **Figure 17**.

Industrial Minerals Forum 1993 and 1996

In a cooperative effort with the Division of Economic and Community Development (Wyoming Department of Commerce), the head of the Industrial Minerals Section of the Geological Survey of Wyoming attended the 1993 Industrial Minerals Forum in Long Beach, California. The Wyoming booth attracted an international clientele as the State's industrial minerals were featured. In addition, Wyoming's offer to host the Forum in 1996 has been accepted. This will be the first time this international forum has been held in Wyoming.

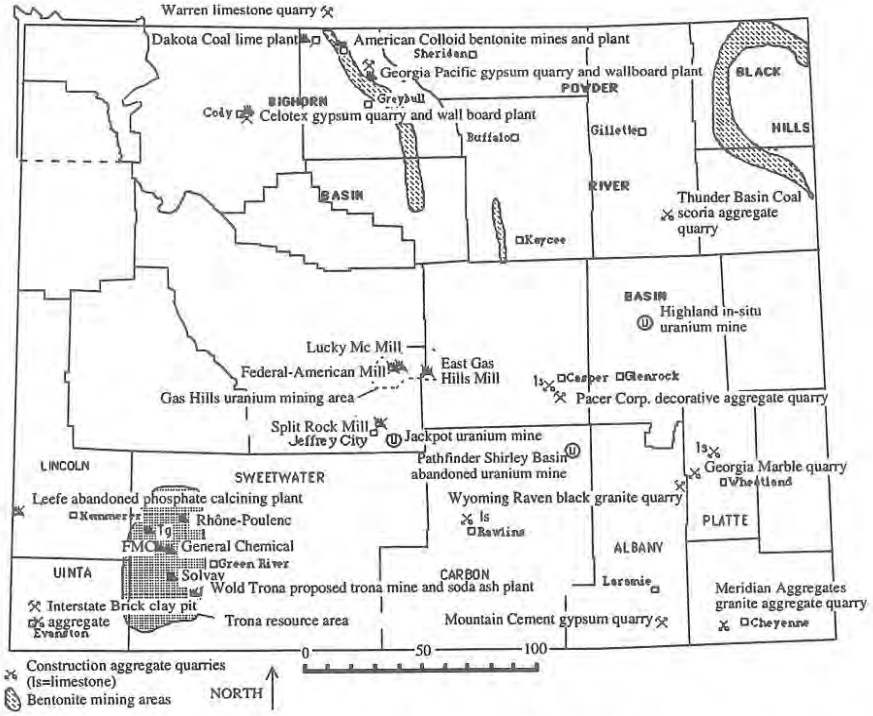


Figure 17. Industrial minerals and uranium activities in Wyoming during the second quarter of 1993.

Aggregate (Construction)

Ranked by the amount produced, the primary materials used for construction aggregate in Wyoming are crushed and sized limestone, river rock (sized natural gravel), and crushed and sized granite. Several new quarries for these construction aggregates have opened in Wyoming this year, including a limestone quarry just north of Rawlins in Carbon County, a limestone quarry eight miles west of Interstate 25 on the El Rancho Road in Platte County, and a river rock pit near Evanston in Uinta County. The use of crushed granite for construction has especially increased in southeastern Wyoming, where highway and street construction projects in Cheyenne and Laramie are using granitic aggregate from the Meridian aggregate quarry west of Cheyenne.

In the Powder River Basin, suitable crushed rock or river rock is scarce to nonexistent. However, scoria (clinker or baked and fused shale) is relatively abundant. Scoria is the bright orange-red to dark red rock that is usually found capping buttes and mesas, particularly near Gillette, Buffalo, and Sheridan. This material is suitable as a low-grade (low durability) construction aggregate that is usually mixed with asphalt to produce paving overlay. It is also used as a primary road surfacing material (for gravel roads). In April, 1993, the U. S. Forest Service issued a decision notice and finding of no significant impact for Thunder Basin Coal Company to quarry scoria for construction aggregate. Scoria occurs within the coal mining lease area, and is the closest readily available source of aggregate.

The limestone aggregate quarry on Bessemer Mountain, west of Casper, has been the subject of a dispute between nearby residents and the quarry operator for several years. The operator, Rissler & McMurry Co. has applied to the Wyoming Department of Environmental Quality for a permit to mine an additional 110 acres. This acreage includes roads and facilities, as well as the quarry itself. To date, about 10 acres have been quarried.

Bentonite

Wyoming continues to lead the nation in bentonite production. Bentonite is produced in Wyoming from several locations including the Black Hills, Kaycee, and Bighorn Basin areas. In the Bighorn Basin, bentonite produced by American Colloid Corporation at Lovell has recently found a specialized use in the "clumping" kitty litter advertised widely on television. Special properties of the bentonite in this particular deposit make it the country's sole source of "clumping" kitty litter.

The U.S. Forest Service has approved a request by American Colloid to explore for bentonite on its claims in the Thunder Basin National Grasslands. American Colloid has held these claims for years, but the bentonite on these claims is now required for expanded production. The total amount of land in the exploration area is forty acres.

Clay

Interstate Brick Co. quarries small amounts of common clay at irregular intervals from a clay pit north of Evanston in Unita County. This clay is trucked to Salt Lake City where it is stockpiled and used in the manufacture of bricks. It is more cost effective to quarry the clay at intervals and stockpile it than to continuously operate a quarry with a very small rate of production.

Decorative stone

The production of black granite at Sunrise Stone Company's Wyoming Raven quarry in Albany County continues. Toby SerVoss, owner of Sunrise Stone, recently said that his company has enough orders for the Wyoming Raven black granite and Fantastica swirled granite to sustain production for the rest of the year. There is currently a crew of four working the quarry on the Vale Ranch. The black granite is shipped in four-foot by four-foot by six-foot blocks for use as monument stone at fabricating plants in Grand Junction, Colorado, and Watertown, South Dakota. Five-foot by five-foot by ten-foot blocks are shipped to Chicago, Illinois, and Denver, Colorado, for production of slabs and tile. The Fantastica granite is shipped to Chicago for slab and tile production, also.

Sunrise Stone is investigating the possibility of constructing a decorative stone fabricating plant in Wyoming. A fabricating plant processes quarry blocks into finished products such as monuments, polished interior and exterior stone slabs, or polished stone tile. No definite plans, including a site selection, have been made.

StonExpo 1993

As a cooperative effort with the Wyoming Department of Commerce's Division of Economic and Community Development, the head of the Geological Survey of Wyoming's Industrial Minerals Section attended the StonExpo 93 in Orlando, Florida. The development potential for decorative stone resources in Wyoming was emphasized at a seminar and a booth exhibit. At least 68 stone users or mining companies visited the Wyoming booth during this international expo.

Gypsum

Nationally, the production of gypsum is about 10% less than the production for the equivalent period in 1992, according to the U. S. Bureau of Mines (Davis, 1993). This indicates a sluggish economy, since most gypsum is used in construction. The Wyoming plants at Cody and between Greybull and Lovell are producing at a rate equivalent to last year, which indicates a relatively healthier local and regional economy.

Limestone and lime

Dakota Coal's new lime plant north of Frannie, Wyoming, was completed and dedicated on July 14th. Lime produced by this plant is used for control of power plant emissions at several locations in North Dakota. The rock used in the plant is the Mississippian Madison limestone from the Warren quarry, about six miles north of Frannie in Montana. Lime (CaO) is produced from limestone ($CaCO_3$) by heating, which drives off calcium carbonate: [$CaCO_3$ » $CaO + CO_2$].

Trona

In the trona resource area west of Green River, five plants produce soda ash (sodium carbonate-bicarbonate) and other sodium compounds from mined trona. Over 90 percent of the sodium compounds produced in the U.S. come from the Wyoming trona mining area. Here, trona is found in minable beds in the Wilkins Peak Member of the Eocene Green River Formation.

Most soda ash is used in the manufacture of glass. Representatives of the domestic glass manufacturing industry, contacted at the 1993 Industrial Minerals Forum in Long Beach, California, noted that there are no plans for constructing new glass plants or even expanding any existing glass plants in the United States. Several of these industry representatives were pessimistic about the viability of the entire U.S. glass industry. Some felt that it may become more profitable to close domestic plants and construct new ones in Mexico, where labor and other production costs are lower than in the U.S. This suggests that domestic consumption of soda ash is not likely to substantially increase in the near future. According to the U.S. Bureau of Mines, the average value for U. S. soda ash in 1992 was $80.93 per short ton (Kostick, 1993).

The 1993 production of soda ash in the United States is about five percent below the corresponding period in 1992, according to figures from the U. S. Bureau of Mines. However, stockpiles are lower and consumption (including export consumption) is higher (Kostick, 1993), indicating a healthy overall market for Wyoming soda ash. Most of the increased production expected in 1993 is for export markets.

The world market for soda ash and other sodium compounds is increasing. It is noteworthy that soda ash can be produced from mined trona at a much lower cost than by the synthetic Solvay Process, where lime and salt are used to manufacture soda ash. Wyoming is one of three places in the world where minable or potentially minable trona occurs in underground beds. The other areas are in Turkey and mainland China. Other natural trona is mined from surface or near-surface deposits in recent alkaline lake beds such as Searls Lake, California, or Lake Natron and other locations in east Africa.

In late 1992, FMC, the largest Wyoming trona mining company, proposed a $120 million expansion project, designed to increase production 20 percent. In February, 1993, the Wyoming Industrial Siting Council recommended approval of

FMC's proposal. In late April, 1993, however, FMC announced that the expansion plans had been put on hold for one year.

Also in April, FMC announced that a new Idaho phosphate mine and beneficiation plant will supply the plant with phosphate for use in the production of sodium phosphorous compounds, used in soil conditioners, detergents, and related products. FMC will operate the new Dry Valley mine, near the Wyoming border. While most western phosphate is now mined in Idaho and Utah, phosphate rock was an important mineral product in Wyoming prior to 1977. The phosphate rock calcining plant at Leefe, Wyoming, in Lincoln County, closed in 1985.

In late June, Solvay Minerals announced it was closing the caustic soda plant at its soda ash refinery west of Green River. Solvay decided that the declining demand for caustic soda did not warrant the plant's continued operation. Caustic soda [sodium hydroxide (NaOH)] is used primarily for preparing metals for surface treatment, such as painting and annealing. The shutdown of the caustic soda plant will not affect employment, since Solvay will transfer the 15 employees to the soda ash plant or other operations within the Solvay complex.

Earlier this year, Wold Trona Company (WTC) anounced plans for a new trona mine and soda ash plant. According to WTC officials, the company, which has been acquiring leases in the trona region for a number of years, feels that economic conditions now favor the construction of a sixth facility in Wyoming's trona patch. The location of the proposed mine and processing plant is about 13 miles southwest of Green River. The proposed plant would produce 1.2 million short tons of dry-processed soda ash per year from mined trona. Projected mine production is 4,400 short tons of trona per day. According to WTC's proposed schedule, the plant should produce its first dry-processed soda ash in 1997.

Only this plant would produce a dry-processed product, which John Wold, owner of WTC, says he is patenting. Unlike pure soda ash, the dry-processed product is not of sufficient purity to use directly in the manufacture of glass, but it is reportedly a higher grade product than calcined trona, which Solvay produces in addition to refined soda ash. Wold said his product would be used as a chemical caustic. These products are primarily cleansing agents.

WTC is facing a situation that threatens to slow its development schedule. Its proposed mine area includes some land currently managed by the U.S. Bureau of Land Management (BLM), but which is proposed for exchange for some State of Wyoming land within the Flaming Gorge National Recreation Area (FGNRA). WTC holds leases on the State land in the FGNRA. If the exchange is approved, WTC would have a minable block of land outside the FGNRA. The FGNRA would gain by having state-controlled land exchanged out of its boundaries. The Wyoming Board of Land Commissioners has asked the BLM to speed up the exchange. However, according to BLM officials, the agency does not have the funding to study all of the aspects of the exchange.

The BLM is also proposing a policy to deal with possible conflicts between trona development and oil and gas exploration and development in the same area. The **Oil and Gas Update** in this issue provides more information about the proposed policy.

Uranium

While actual contract prices for uranium are confidential, NUEXCO, which is reportedly the world's largest uranium trading firm, provides spot market uranium prices that indicate the relative prices of yellowcake as well as price trends. NUEXCO prices are not necessarily the price at which all yellowcake is sold. NUEXCO, however, also lists some of the add-ons and other factors that alter prices. And there are other price indicators that are higher than the NUEXCO spot market price.

Since October 1992, the NUEXCO spot market price for yellowcake declined to a near-record low of $7.10 by the end of April, 1993 (**Table 10**). This is the lowest spot market price since December, 1973, when the reported price was $7.00 per pound.

Table 10. NUEXCO spot market price of yellowcake, October 1992 to April 1993, (end-of-month price in current dollars).

Month	Price
Oct. 1992	$8.00
Nov. 1992	7.90
Dec. 1992	7.85
Jan. 1993	7.65
Feb. 1993	7.60
Mar. 1993	7.45
Apr. 1993	7.10

In the last issue of *Wyoming Geo-notes*, a number of factors causing this decline in the price of uranium were reported. Some of these need clarification. Actions have been taken to prevent six former states in the Soviet Union from flooding the U.S. with inexpensive uranium like they did in 1991. The U.S. Department of Commerce (DOC) has entered into suspension agreements with these six republics. Under the terms of agreements signed in October, 1992, these republics agreed not to export uranium into the U.S. until the DOC determines that the market price of U_3O_8 [*sic*] is at least $13.00. On April 1, 1993, the DOC determined that the price was only $11.72. Consequently, these six republics cannot market any uranium in the U.S. through at least October, 1993. The writer thanks the Rio Algom Mining Group for providing this information.

Pool (1993) reported that the U.S. and the Russian Federation had initialed an agreement on August 31, 1992. That agreement provided for the purchase of highly enriched weapons-grade uranium (heu), calling for the transformation of 10 metric tons of heu per year for the first five years. This translates into 6 million pounds of yellowcake (world consumption of yellowcake is about 145 million pounds). There have been articles published in magazines and other news media stating that the conversion of weapons-grade uranium [>99% ^{235}U] to fuel-grade uranium [3% ^{235}U] has begun. However, the Rio Algom Mining Group says that negotiations for purchase of converted fuel are still underway and no weapons-grade uranium has actually been converted to nuclear fuel.

Also, in July, the U.S. Department of Energy announced that the U.S. would resume taking back high-grade uranium fuel from foreign research reactors. This had been suspended, but the State Department was concerned that it would work against nuclear nonproliferation efforts.

In *Wyoming Geo-notes No. 38*, we reported that there are those who feel that actions by the European Atomic Energy Community Supply Agency (Euratom) have protected high priced European nuclear fuel producers, particularly France, from world market conditions (Pool, 1993). We need to point out that some uranium industry representatives disagree with the above statement and believe that Euratom is acting to "ensure that market conditions remain fair". And Euratom, a governmental agency, was incorrectly reported to be a cartel.

In Wyoming, yellowcake is currently only produced at Power Resources' Highland in-situ operation in the southern Powder River Basin north of Glenrock.

The development of Kennecott Energy's Jackpot underground uranium mine continued in the second quarter of 1993. Earlier this year, Kennecott released a proposed plan of operation for consideration by the U.S. Bureau of Land Management (BLM). The proposal includes the underground mining operation; milling and yellowcake production at the Sweetwater mill, which was recently purchased by Kennecott; and transportation of ore from the mine to the mill. The BLM has begun scheduling hearings and is asking for public input regarding the proposal.

Kennecott's mine, which would have two portals, is designed to produce up to 3,000 tons of ore per day. Depending on annual production rates, the mine has reserves for up to 22 years.

In June, the U. S. House of Representatives authorized over $40,000,000 to clean up inactive uranium mill tailing sites in Wyoming and other states. The bill has yet to pass the U.S. Senate. Under this bill, the scheduled cleanup sites in Wyoming include 3,300,000 short tons of tailings at the Split Rock mill northeast of Jeffrey City, 2,800,000 short tons of tailings at the LuckyMc mill, 2,100,000 short tons of tailings at the Federal American Partners mill, and 2,100,000 short tons of tailings at the East Gas Hills mill. The latter three mill sites are all in the Gas Hills uranium mining area.

References cited:

Davis, L. L. 1993, Gypsum: U. S. Bureau of Mines Mineral Industry Surveys, February - April, 1993.

Kostick, Dennis, 1993, Soda ash and sodium sulfate: U. S. Bureau of Mines Mineral Industry Surveys, January - April, 1993.

Pool, T. C., 1993, Uranium; politics, politics, politics!: Engineering and Mining Journal, v. 194, no. 3, p. 60 - 63.

METALS AND PRECIOUS STONES UPDATE

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

Diamonds

Diamond exploration in Wyoming continued into the Summer with several exploration groups operating in the Colorado-Wyoming Kimberlite Province. In the State Line diamond district, both Canadian and American companies and independent prospectors acquired land in the district, which contains diamondiferous kimberlite and associated placers.

In May, 1993, it was reported that Royal Star of Canada had obtained the exploration rights on the Sloan 1 and 2 kimberlite diatremes in the Prairie Divide region of Colorado (Frank Yaussai, personal communication). The Sloan 1 intrusive is one of the two largest known kimberlites found in the Colorado-Wyoming Kimberlite Province. Previous testing on the Sloan property yielded 0.061 to 0.253 carat per tonne (McCallum, 1991).

Fleck Resources of Canada obtained properties south of Tie Siding in the Wyoming portion of the State Line district where the first diamonds were discovered in 1975. Several of the Schaffer group kimberlites, the Aultman diatremes, and some untested geophysical anomalies occur in this area.

North of the State Line district, diamond exploration is also reported in the Happy Jack-Pole Mountain area, Sybille Canyon region, and in the Elmers Rock greenstone belt in the Laramie Mountains to the east and northeast of Laramie. The exploration activities in the Laramie Mountains are based on a study by the Geological Survey of Wyoming, which identified numerous heavy mineral anomalies from the Wyoming-Colorado border to Wheatland Reservoir. Some additional anomalies were also detected in the Medicine Bow Mountains east of the Boden diamond discovery. However, no diamond exploration has been reported in the Medicine Bow Mountains, to date.

The report on this 12-year study by the Geological Survey of Wyoming (Hausel and others, 1988) was revised in June, 1993. The study identified dozens of localities that yielded pyrope garnet, chromian diopside, nonmagnetic ilmenite, as well as some other interesting heavy minerals including gold, ruby, and sapphire. Some stream sediment samples collected by the Survey produced more than 50 pyrope garnets!

An additional anomaly was recently identified in the Seminoe Mountains greenstone belt in central Wyoming, where a single sediment sample yielded gold, eight purple and lavendar pyrope garnets, and four chromian diopsides (Hausel, 1993). Currently, no diamond exploration is reported in the Seminoe Mountains.

Diamond exploration is reported in the Green River Basin of western Wyoming. The Green River Basin contains anthills with pyrope garnet and chromian diopside north of Cedar Mountain in the southern portion of the basin, and near Granger close to the center of the basin. The source of these minerals is unknown.

The Leucite Hills, which is one of the largest lamproite fields in the world, is also located in the Green River Basin, north of Rock Springs. This area is receiving some exploration interest.

Gold

Gold, silver, and platinum prices rose throughout the first part of the summer. This rise in price has attracted some interest in Wyoming gold deposits. A few major U.S. mining companies were reported exploring the State for precious metal deposits. Additionally, a German-based mining company continued with plans to explore for gold and high-grade base metal deposits in Wyoming.

Rattlesnake Hills

The Geological Survey of Wyoming continued mapping the Rattlesnake Hills supracrustal belt in central Wyoming, and is sampling the region for gold and other metals. The district has yielded several precious metal anomalies. Gold has been found in Archean structures and in breccias associated with Tertiary alkalic plugs and jasperoids. Plans are to expand the project southward into the Barlow Gap area and westward into the Diamond Springs area where in past years, prospectors have reportedly found diamonds.

South Pass

According to the Northern Miner (July 12, 1993, p. 16), Hol-Lac Gold Mines, the present owner of the Carissa mine, located in the South Pass greenstone belt, is negotiating for financing to sample and drill at the mine site. Earlier work by Hol-Lac, in 1989, showed that the Carissa shear zone continued to a depth of at least 150 feet below the historical mine workings. At 650 feet below the surface, Hol-Lac intersected an 80-foot-wide shear zone which yielded gold values from a trace to 2.5 ounces per ton.

Earlier sampling on the surface by the Geological Survey of Wyoming identified at least a 100-foot-wide mineralized shear zone. Hol-Lac hopes to complete the transaction within 90 days according to the Northern Miner.

References cited

Hausel, W.D., 1993, Preliminary report on the geology, geochemistry, minieralization, and mining history of the Seminoe Mountains mining district, Carbon County, Wyoming: Geological Survey of Wyoming Mineral Report MR92-6, 50 p., 2 plates.

Hausel, W.D., Sutherland, W.M., and Gregory, E.B., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 9 p., 5 plates (revised 1993).

McCallum, M.E., 1991, The Sloan 1 and 2 kimberlite complex near the southern boundary of the State Line district of the Colorado-Wyoming Kimberlite Province: Wyoming Geological Association 42nd Annual Field Conference Guidebook, p. 229-250.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1993)		
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.5	billion barrels[1]
Undiscovered	7.6	billion barrels[1]
Total	20.1	billion barrels
Remaining Reserve Base (January 1, 1993)		
Measured reserves (Proved reserves) (Includes oil, gas liquids, and condensate)	1.26	billion barrels[2]
Indicated and inferred reserves	2.80	billion barrels[1]
Total	4.06	billion barrels

NATURAL GAS

Remaining Resources (January 1, 1993)		
Discovered (Includes 20.1 trillion cubic feet (TCF) of methane[1] and 122.0 TCF of CO_2[3])	141.1	trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 31.2 TCF of CO_2[3])	3,707.2	trillion cubic feet
Total	3,848.3	trillion cubic feet
Remaining Reserve Base (January 1, 1993)		
Measured reserves (Proved reserves) (Includes 10.4 TCF of methane[2] and 60.6 TCF of CO_2[3])	70.0	trillion cubic feet

COAL

Remaining Resources (January 1, 1993)		
Identified and Hypothetical (Discovered)	1,428.2	billion tons[6]
Speculative (Undiscovered)	31.5	billion tons[6]
Total	1,459.7	billion tons
Remaining Reserve Base (January 1, 1993)		
Demonstrated strippable (Measured and indicated reserve base)	26.6	billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	42.5	billion tons[7]
Total	69.1	billion tons

TRONA

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

URANIUM

Remaining Resource (December 31, 1989)	1.99	billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1989)		
Uranium oxide recoverable at $30.00 per pound	66	million pounds[9]

OIL SHALE

Original Resources (January 1, 1981)		
Identified (Discovered)	320	billion barrels of shale oil[10]

[1] Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.
[2] Modified from Energy Information Administration, 1992, U.S. crude oil, natural gas, and natural gas liquids reserves: 1991 Annual Report, November, 129 p.
[3] De Bruin, R.H., 1991, Geological Survey of Wyoming Open File Report 91-6, 20 p.
[4] Jones, R.W., and De Bruin, R.H., 1990, Coalbed methane in Wyoming: Geological Survey of Wyoming Public Information Circular 30, 15 p.
[5] Law, B.E., and others, 1989, Estimates of gas resources in overpressured low-permeability Cretaceous and Tertiary sandstone reservoirs, Greater Green River Basin, Wyoming, Colorado, and Utah: Wyoming Geological Association, 40th Annual Field Conference Guidebook, Casper, Wyoming p. 39-61.
[6] Modified from Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:5,000,000 scale (color) and 44 p. pamphlet.
[7] Modified from Jones, R.W., and Glass, G.B., 1992, Demonstrated reserve base of coal in Wyoming as of January 1, 1991: Geological Survey of Wyoming, Open File Report 92-4, 26 p.
[8] Modified from Culbertson, W.C., 1983, Genesis and distribution of trona deposits in Wyoming (abstract) in Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19, p. 34.
[9] Energy Information Administration, 1989, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(89), 121 p.
[10] Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

WYOMING OIL AND GAS EXPLORATION SUMMARY FOR 1992

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

DRILLING ACTIVITIES AND COMPLETIONS

Based on preliminary data available from Petroleum Information (1993), there were 434 well completions in Wyoming in 1992, which is a small decrease from 1991 completions (**Figure 18**); but which continues a decline which started in 1985. It is likely that late completion reports will increase the actual 1992 completions somewhat. Of the 434 wells completed in 1992, 131 were exploration wells and 303 were development wells. The success rate for exploration wells was 23.7 percent compared to a success rate for exploration wells in 1991 of 21.6 percent. In all, 282 wells found oil or gas for a success rate of 65.0 percent compared to a success rate in 1991 of 60.0 percent.

Based on Hughes Rig Count data, the average daily rig count, which was 38 in 1992 as compared to an average of 34 in 1991, has not been above 40 since

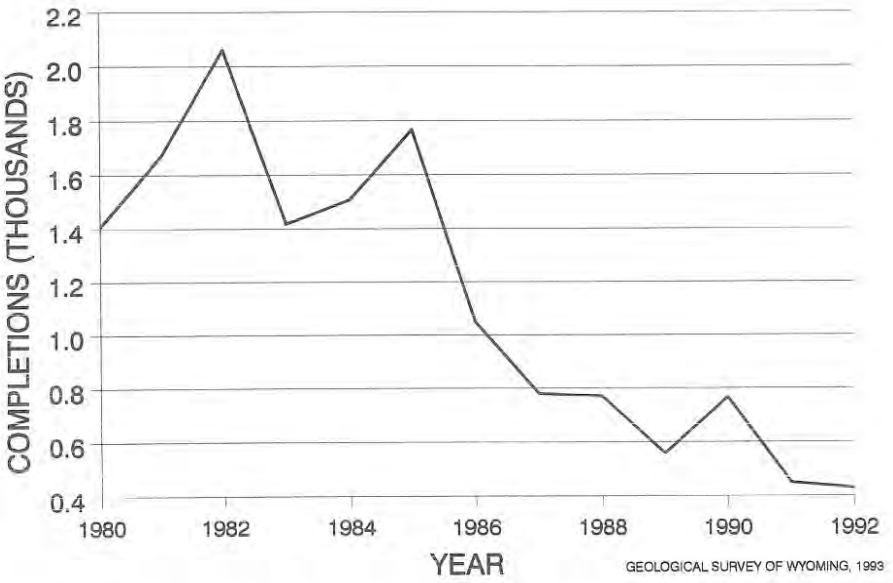


Figure 18. Annual oil and gas well completions in Wyoming [based on data from Petroleum Information (1981-1993)]

1985 (**Figure 19**). Rigs in Wyoming drilled just over 3.3 million feet in 1992, which was nearly the same as in 1991 (**Figure 20**), and which reflects a gradual decline since 1985. The average depth of a well drilled in Wyoming in 1992 was 7,687 feet, which is the highest average in the last 13 years (**Figure 21**). The average depth of an exploration well in Wyoming in 1992 was 6,720, which is the lowest average in the last 13 years.

LEASE SALES

Six lease sales held by the U.S. Bureau of Land Management (BLM) in 1992 grossed almost $4.8 million. The average price per acre was $13.11. Of the 1.43 million acres that were available for lease, only 25.5 percent were leased. For comparison, the six BLM sales in 1991 grossed nearly $13 million, and 30.9 percent of the 2.19 million acres were leased for an average of $19.14 per acre. **Figures 22** and **23** show annual revenue and average price per acre leased for recent BLM sales, respectively.

The four lease sales held by the State Land and Farm Loan Office in 1992 only grossed $747,000. The average price per acre was $4.95, but 54.3 percent of the 278,000 available acres were leased. Six sales in 1991 grossed almost $4.5 million. Of the 480,000 acres available in 1991, 84.6 percent were leased for an average price of $10.98 per acre. **Figures 22** and **23** show annual revenue and average price per acre for State sales in recent years, respectively.

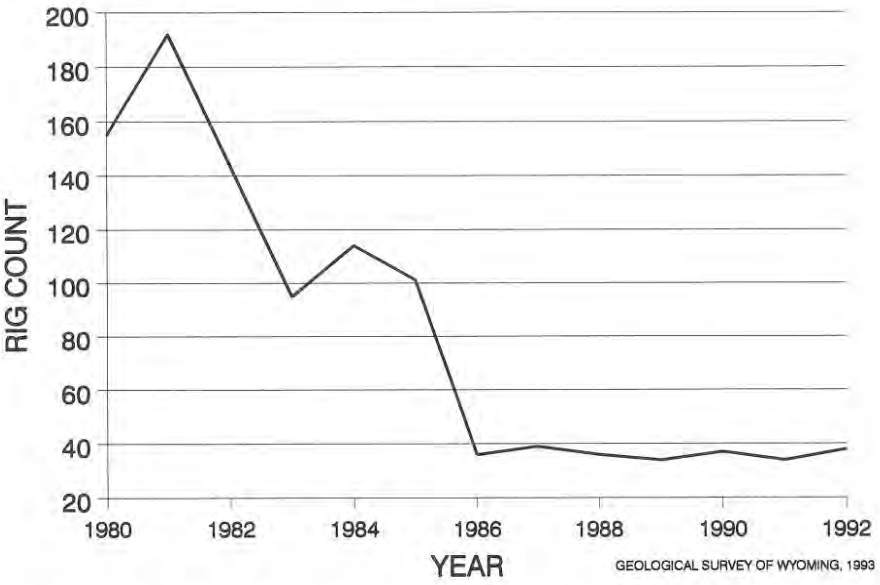


Figure 19. Wyoming daily rig count, averaged by year [based on Hughes Rig Count (1981-1993)]

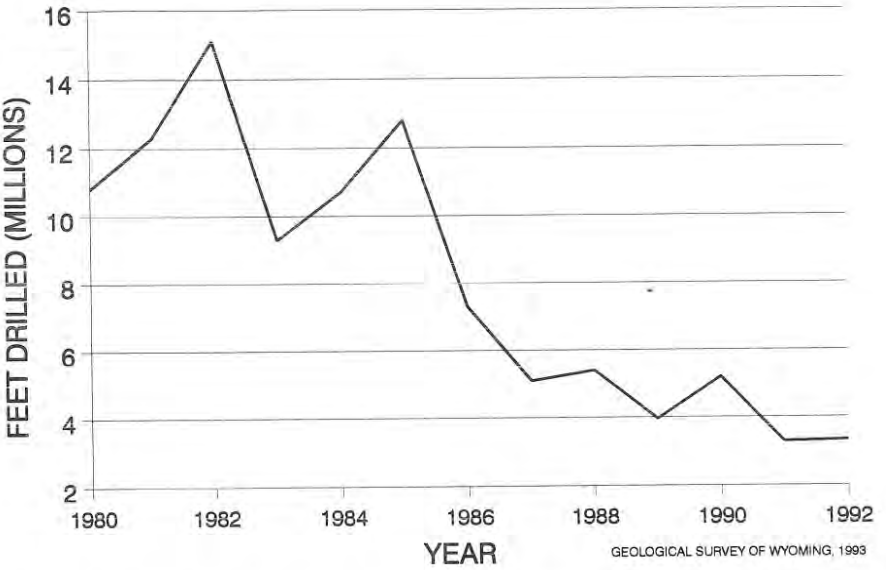


Figure 20. Total feet drilled for oil and gas in Wyoming by year [based on data from Petroleum Information (1981-1993)].

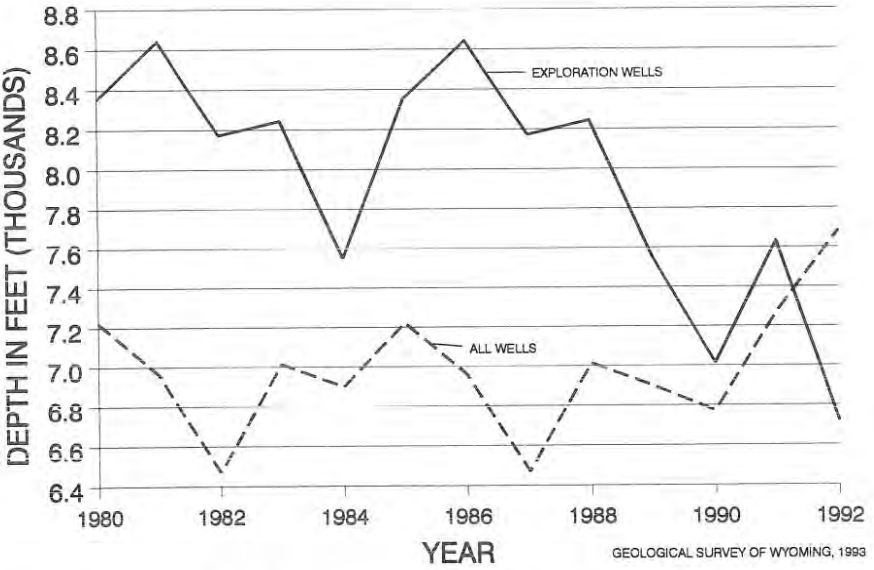


Figure 21. Average depth of oil and gas wells drilled in Wyoming by year [based on data from Petroleum Information (1981-1993)].

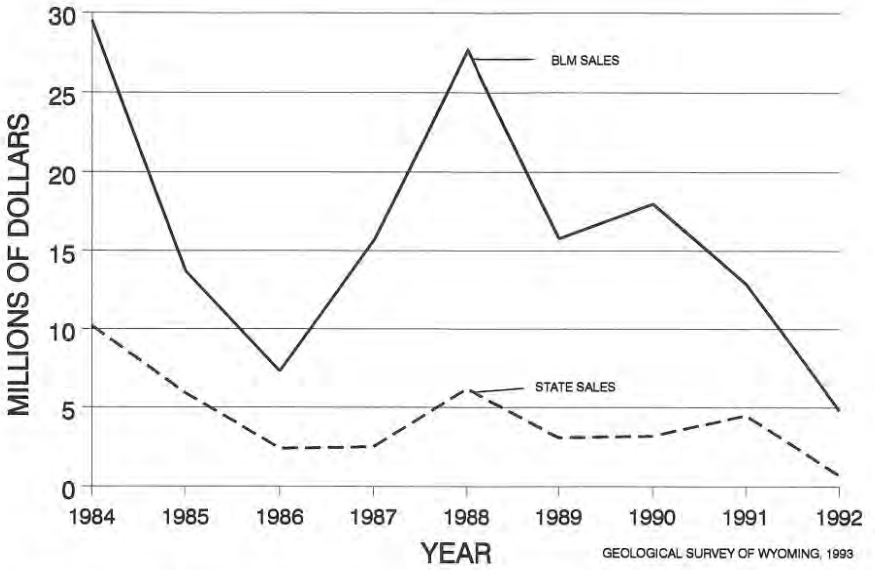


Figure 22. Annual (calandar year) revenue from Federal and from State oil and gas lease sales in Wyoming.

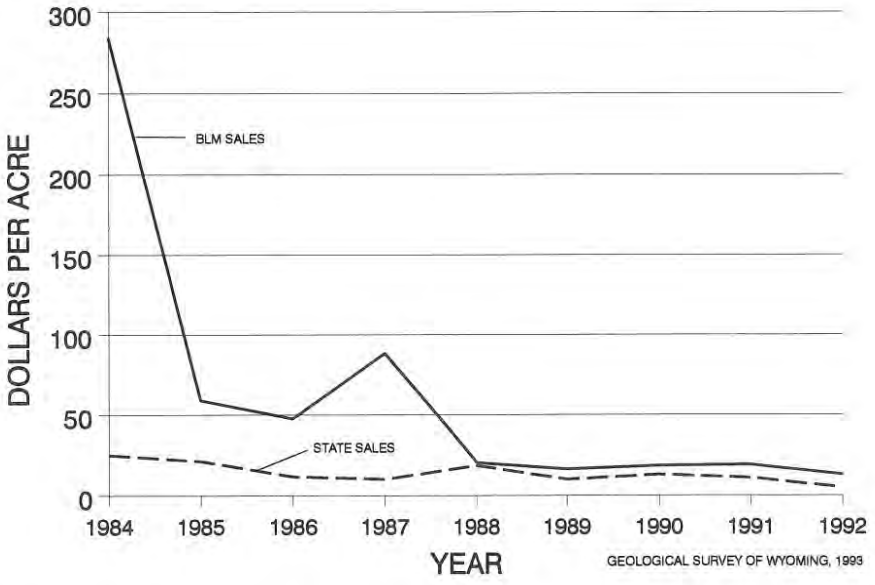


Figure 23. Average price per acre paid for Federal and State oil and gas leases in Wyoming.

POWDER RIVER BASIN

In terms of new field wildcats, the Powder River Basin was the fifth leading geologic province in the U.S. with 78 completions in 1992, including 10 new discoveries (Petroleum Information, 1993). Campbell County was the most heavily explored county in the U.S. with 42 wildcat completions. Of those 42 completions, six found oil and two found gas (Petroleum Information, 1993). In all, the Powder River Basin accounted for 73.6 percent of all new field wildcat completions in Wyoming. The majority of the completions were Minnelusa tests.

GREATER GREEN RIVER BASIN

With 24 completions, the Greater Green River Basin was the fifteenth leading geologic province in the U.S. in terms of new field wildcats completed in 1992, including seven new discoveries (Petroleum Information, 1993). Sweetwater County had 76 total well completions. Of those 76 completions, 67 found gas and one found oil (Petroleum Information, 1993). Drilling in the Greater Green River Basin focused on developing gas reserves in the Almond, Frontier, and Dakota formations. Many of the completions qualified for tight gas sand tax credits. Sweetwater, Lincoln, and Uinta counties accounted for 137 gas well completions, which were 87.3 percent of Wyoming's total gas well completions. Bruff Field led the way with 53 gas well completions.

HORIZONTAL DRILLING

There were six Niobrara oil discoveries in 1992 in and around Silo Field in the Denver-Cheyenne Basin. In addition, there was a Frontier and Niobrara oil discovery in the Powder River Basin, a Tensleep oil discovery in the Bighorn Basin, and a Phosphoria oil discovery in the Bighorn Basin.

REFERENCE CITED

Petroleum Information, 1993, 1992 annual review: Newsletter edition, v. 66, no. 25, section 3, p. 1-58.

GEOLOGIC MAPPING AND STRATIGRAPHY

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

STATEWIDE MAPPING PROJECT CONTINUES

The Geologic Mapping Section of the Geological Survey of Wyoming (GSW) resumed work on a statewide 1:100,000-scale mapping project. To date, the

Nowater Creek 30' X 60' Quadrangle has been published in color. Work has begun on the Cheyenne Quadrangle (1:100,000-scale). The current emphasis is on the completion of maps for the more populated areas in the State. The Cheyenne sheet will be followed by the Laramie and Casper Quadrangles.

Concurrent with this effort, final field checking of the Poker Butte, Hole-in-the-Wall, and The Horn Quadrangles (1:24,000-scale) is planned for the 1993 field season (**Figure 24**). When these maps are completed, the Kaycee 30' X 60' Quadrangle will be compiled and published.

The new 1:100,000-scale quadrangle maps provide a suitable scale for use by land use planners, State and Federal agencies, and the mineral industry. The ultimate goal of this project is to map the entire State (56 quadrangles) at this

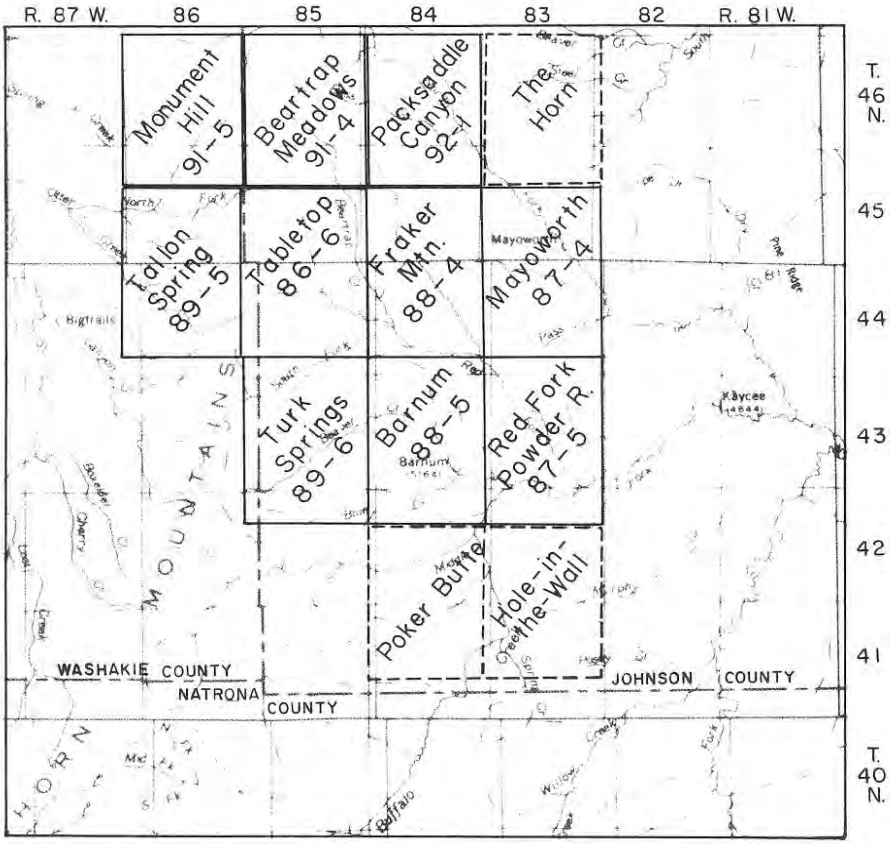


Figure 24. Index to recent geologic mapping by the Geological Survey of Wyoming in the southern Bighorn Mountains region. (Open file maps are annotated with the year and number of each map i.e., 88-5).

scale. In addition to the Nowater Creek Quadrangle (Ver Ploeg, 1992), which was published by the GSW, the U.S. Geological Survey has completed the Kemmerer (M'Gonigle and Dover, 1992) and Kinney Rim (Roehler, 1985) Quadrangles at this scale (**Figure 25**).

References cited

M'Gonigle, J.W., and Dover, J.H., 1992, Geologic map of the Kemmerer 30' X 60' Quadrangle, Lincoln, Uinta, and Sweetwater counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-2079, scale 1:100,000.

Roehler, H.W., 1985, Geologic map of the Kinney Rim 30' X 60' Quadrangle, Wyoming and Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1615, scale 1:100,000.

Ver Ploeg, A.J., 1992, Geologic map of the Nowater Creek 30' X 60' Quadrangle, north-central Wyoming: Geological Survey of Wyoming MS-39, scale 1:100,000.

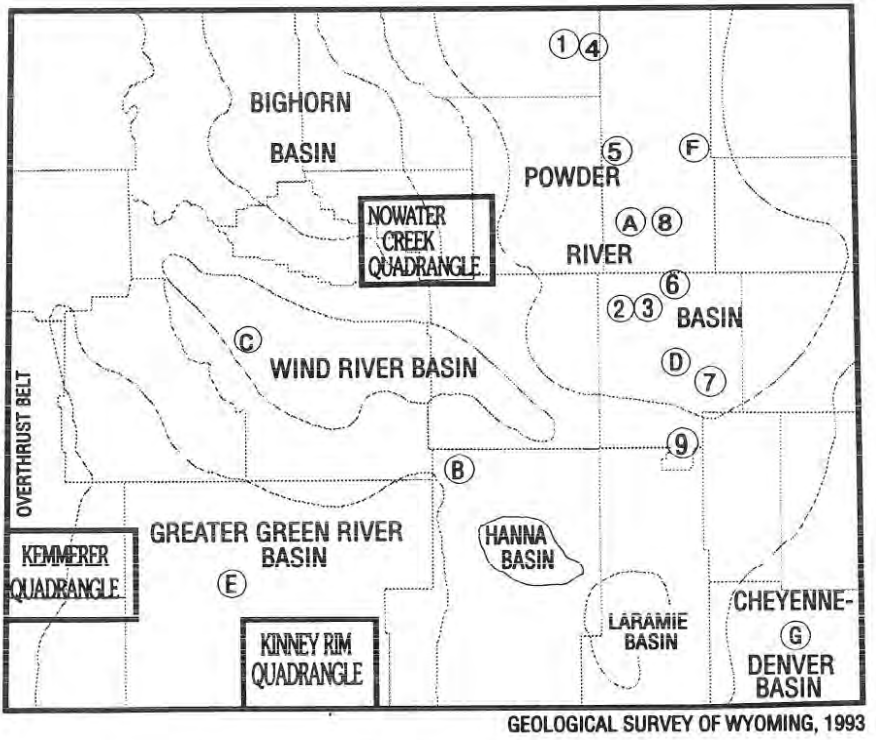


Figure 25. Index to selected geologic studies in Wyoming.

NEW ARTICLES AND REPORTS ON WYOMING GEOLOGY

Three new articles on Wyoming geology were published in the April issue of *The Mountain Geologist*. Sonnenberg and Weimer (1993) discuss the geologic structure of Silo Field in Laramie County, Wyoming, relating recent horizontal drilling successes to characteristics of the Niobrara reservoir rock and possible wrench faulting. Mitchell and Rogers (1993) detail the results of their study on the extensional tectonic influence on Cretaceous stratigraphy and resultant oil and gas reservoirs in the southern Powder River Basin. Schenk and others (1993) compare outcrops of the Permian portion of the Minnelusa Formation to the equivalent portion of the section in the subsurface in the eastern Powder River Basin.

Another two articles on Wyoming geology were recently published in the journal of *Basin Research*. Meyers and others (1992) examine intrabasinal tectonic influence on the fluvial sandstones in the Cloverly Formation in the western Wind River Basin. DeCelles and Burden (1992) summarize their study on the Morrison and Cloverly formations in central Wyoming, focusing on the sedimentology of these formations in the overfilled portion of the foreland basin.

The U.S. Geological Survey recently released two new reports on the stratigraphy of Wyoming. Roehler (1993) summarized the depositional history of continental Eocene rocks in the Greater Green River Basin in Professional Paper 1506-F. Brown (1993) examines the sedimentology and depositional history of the Tullock Member of the Fort Union Formation in the Powder River Basin. This report is a product of the U.S. Geological Survey's Evolution of Sedimentary Basins - Powder River Basin Project.

Each of these articles or reports is listed below and the study area is located geographically on the accompanying index map (**Figure 25**).

A. Brown, J.L., 1993, Sedimentology and depositional history of the lower Paleocene Tullock Member of the Fort Union Formation, Powder River Basin, Wyoming and Montana: U.S. Geological Survey Bulletin 1917-L, 42 p.

B. DeCelles, P.G., and Burden, E.T., 1992, Non-marine sedimentation in the overfilled part of the Jurassic-Cretaceous Cordilleran foreland basin: Morrison and Cloverly formations, central Wyoming, USA: Basin Research, v. 4, p. 291-313.

C. Meyers, J.H., and others, 1992, Intrabasinal tectonic control on fluvial sandstone bodies in the Cloverly Formation (Early Cretaceous), west-central Wyoming, USA: Basin Research, v. 4., p. 315-333.

D. Mitchell, G.C., and Rogers, M.H., 1993, Extensional tectonic influence on Lower and Upper Cretaceous stratigraphy and reservoirs, southern Powder River Basin, Wyoming: The Mountain Geologist, v. 30, no. 2, p. 54-68.

E. Roehler, H.W., 1993, Eocene climates, depositional environments, and geography, Greater Green River Basin, Wyoming, Utah, and Colorado: U.S. Geological Survey Professional Paper 1506-F, 74 p.

F. Schenk, C.J., Schmoker, J.W., and Fox, J.E., 1993, Sedimentology of the Permian upper part of the Minnelusa Formation, eastern Powder River Basin, Wyoming, and a comparison to the subsurface: The Mountain Geologist, v. 30, no. 2, p. 69-78.

G. Sonnenberg, S.A., and Weimer, R.J., 1993, Oil production from the Niobrara Formation, Silo Field, Wyoming: Fracturing associated with a possible wrench fault system (?): The Mountain Geologist, v. 30, no. 2, p. 39-53.

NEW MAPS AND CROSS SECTIONS ILLUSTRATE WYOMING GEOLOGY

The U.S. Geological Survey recently released several new maps and cross sections which portray some of the geology of Wyoming. Eight of the maps or charts focus on the Powder River Basin and one map illustrates the geology in the Esterbrook-Braae area of the Laramie Range. Each map or cross section is listed below and located geographically on the index map in **Figure 25**.

1. Denson, N.M., Gibson M.L., and Sims, G.L., 1993, Geologic and structure map, with contours on top of the Pierre Shale, for the north half of the Powder River Basin, southeastern Montana, and northeastern Wyoming: U.S. Geological Survey Miscellaneous Investigation Map I-2343-A, scale 1:200,000.

2. Denson, N.M., Gibson M.L., and Sims, G.L., 1993, Geologic and structure map, with contours on the top of the Pierre Shale, for the south half of the Powder River Basin, northeastern Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-2343-B, scale 1:200,000.

3. Denson, N.M., Gibson M.L., and Sims, G.L., 1993, Geologic map showing thickness of the Upper Cretaceous Pierre Shale in the south half of the Powder River Basin, northeastern Wyoming, and adjacent areas: U.S. Geological Survey Miscellaneous Investigations Map I-2380-B, scale 1:200,000.

4. Fox, J.E., 1993, Stratigraphic cross sections A-A' through F-F', showing electric logs of Upper Cretaceous and older rocks, Powder River Basin, Montana and Wyoming: U.S. Geological Survey Oil and Gas Investigations Chart OC-135, scale 1 inch = 400 feet.

5. Fox, J.E., 1993, Stratigraphic cross sections G-G' through L-L', showing electric logs of Upper Cretaceous and older rocks, Powder River Basin, Wyoming: U.S. Geological Survey Oil and Gas Investigations Chart OC-136, scale 1 inch = 400 feet.

6. Fox, J.E., 1993, Stratigraphic cross sections M-M' through R-R', showing electric logs of Upper Cretaceous and older rocks, Powder River Basin, Wyoming: U.S. Geological Survey Oil and Gas Investigations Chart OC-137, scale 1 inch = 400 feet.

7. Fox, J.E., 1993, Stratigraphic cross sections S-S' through V-V', showing electric logs of Upper Cretaceous and older rocks, Powder River Basin, Montana and Wyoming: U.S. Geological Survey Oil and Gas Investigations Chart OC-138, scale 1 inch = 400 feet.

8. Seeland, D., and others, 1993, Geophysical log signatures of lower Tertiary and Upper Cretaceous rocks in the Powder River Basin, Wyoming and Montana: U.S. Geological Survey Oil and Gas Investigations Chart OC-140.

9. Snyder, G.L., 1993, Geologic map of the Esterbrook-Braae area, Albany, Converse, and Platte counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I-2232, scale 1:24,000.

GEOLOGIC HAZARDS IN WYOMING

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

LANDSLIDE SEASON

On June 22, 1993, a landslide near the border between Johnson and Sheridan counties destroyed the eastbound lane of Interstate 90. Local newspapers reported that a 200- to 300-foot section of the Interstate broke loose and slipped down a 30-foot cliff.

Landslides are common in Wyoming, especially after periods of heavy or extended precipitation. Goshen County has the lowest landslide density in the State, while Teton County has the highest.

Over the last ten years, the Geologic Hazards Section of the Geological Survey of Wyoming (GSW) has mapped landslides on over eight hundred seventy-five 1:24,000-scale quadrangles in the State. These landslide maps are available as Preliminary Landslide Maps. The GSW recently assembled and distributed copies of the landslide maps to all counties in Wyoming. In addition, maps were distributed to all towns that have landslides within their borders.

All counties have been asked for input on additional hazards concerns. Future mapping activities will reflect those concerns. For additional information on geologic hazards mapping, contact Jim Case at 307-766-2286.

EJECTA FRAGMENTS FROM IOWA METEORITE IMPACT CRATER IN WYOMING?

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

On June 22, 1993, personnel from the Geologic Hazards Section at the Geological Survey of Wyoming met with geologists from the Geological Survey Bureau of the Iowa Department of Natural Resources to collect samples from a Cretaceous-Tertiary (K-T) boundary clay site at the Dogie Creek Ranch north of Lance Creek, Wyoming. The Iowa geologists are collecting K-T boundary rock samples from sites in the western U.S. to look for evidence that some of the materials found at the K-T boundary may have been ejected and transported from the Manson meteorite impact crater in northwest Iowa. There is some evidence that the radiometric age of the Manson crater in Iowa is about the same age as the K-T boundary (Hartung, Kunk, and Anderson, 1990). The crater, located in Pocahontas, Calhoun, Webster, and Humboldt counties in Iowa, is approximately 22 miles in diameter and is covered by Pleistocene glacial deposits.

The K-T boundary has been investigated for a number of years, primarily because of its association with mass extinctions that occurred during that time. Many dinosaurs are thought to have become extinct during the time reflected by the K-T boundary. The reasons for the mass extinctions are still conjectural, with possible causes including atmospheric changes related to meteorite impacts or volcanism.

The K-T boundary site north of Lance Creek, Wyoming, was first described by Bohor, and others (1987). The boundary clay consists of a lower kaolinitic claystone layer overlain by a thin smectitic layer. The lower kaolinitic layer is up to 3 centimeters thick and contains hollow microtektite-like spherules that are usually 1 millimeter in diameter (cover photo). The spherules are composed of goyazite, a replacement mineral. The upper smectitic layer is 2-3 millimeters thick, contains shock-metamorphosed minerals, and is enriched in iridium.

While there may be some uncertainty as to the origin of the Wyoming K-T boundary layer clays, most current research indicates an impact origin for the smectitic layer due to the presence of the shock metamorphosed minerals. Bohor, and others (1987) hypothesize that the spherules in the lower kaolinitic layer originated as air-fall deposits from a cloud of glassy material derived from the hot and depressured lower crustal rocks exposed at the crater floor soon after impact. Orth, Attrep, and Quintana (1990) hypothesize that two-layer K-T boundary clay sites represent two separate impacts, with the lower, kaolinitic, spherule-containing layer reflecting a closer impact site than the upper smectitic layer. It is also possible that the microtektite-like spherules may have an origin that is not directly related to a meteorite impact. Cisowski (1990) presents some alternative hypotheses for the origin of the spherules in boundary clays, including combustion-related and volcanic sources.

Obviously, much additional research is needed to determine both the origin of the K-T boundary layer clays in Wyoming and their relationship to the Manson meteorite impact crater in Iowa. Updates on the Iowa research will be provided as new data become available.

REFERENCES CITED

Bohor, B.F., Triplehorn, D.M., Nichols, D.J., and Millard, H.T., Jr., 1987, Dinosaurs, spherules, and the "magic" layer: A new K-T boundary clay site in Wyoming: Geology, v. 15, no. 10, pp 896-899.

Cisowski, S.M., 1990, The significance of magnetic spheroids and magnesioferrite occurring in K/T boundary sediments, in Sharpton, V.L. and Ward, P.D., editors, Global catastrophes in Earth history; An interdisciplinary conference on impacts, volcanism, and mass mortality: Geological Society of America Special Paper 247, pp. 359-365.

Hartung, J.B., Kunk, M.J., and Anderson, R.R., 1990, Geology, geophysics, and geochronology of the Manson impact structure, *in* Sharpton, V.L. and Ward, P.D., editors, Global catastrophes in Earth history; An interdisciplinary conference on impacts, volcanism, and mass mortality: Geological Society of America Special Paper 247, pp. 207-221.

Orth, C.J., Attrep, M., Jr., and Quintana, L.R., 1990, Iridium abundance patterns across bio-event horizons in the fossil record, *in* Sharpton, V.L. and Ward, P.D., editors, Global catastrophes in Earth history; An interdisciplinary conference on impacts, volcanism, and mass mortality: Geological Society of America Special Paper 247, pp. 45-59.

NEW PUBLICATIONS

* Traveler's guide to the geology of Wyoming, by D.L. Blackstone, Jr.: Bulletin 67 (Second printing), 1988.-$7.00.

  Stratigraphic chart showing Phanerozoic nomenclature for the State of Wyoming, by J.D. Love, A.C. Christiansen, and A.J. Ver Ploeg: Map Series 41, 1993.-$5.00 ($6.50 mailed rolled).

* Oil and gas fields map of southweastern Wyoming basins, by A.J. Ver Ploeg and S.D. Hostetler: Map Series 42, 1993.-$5.00 $6.50 rolled).

Occurrences of radioactive elements in Goshen County, Wyoming, by R.E. Harris: Open File Report 93-1, 1993.-$3.00.

Publications available from the Geological Survey of Wyoming, March, 1993.-free.

* Overview of the Hanna, Carbon, and Cooper Lake basins, southeastern Wyoming, by D.L. Blackstone, Jr.: Report of Investigations 48, 1993.-$10.00.

* R-54. Precious metal, base metal, and gemstone deposits of Wyoming, by W.D. Hausel: Reprint 54, 1993.-$3.00.

---

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

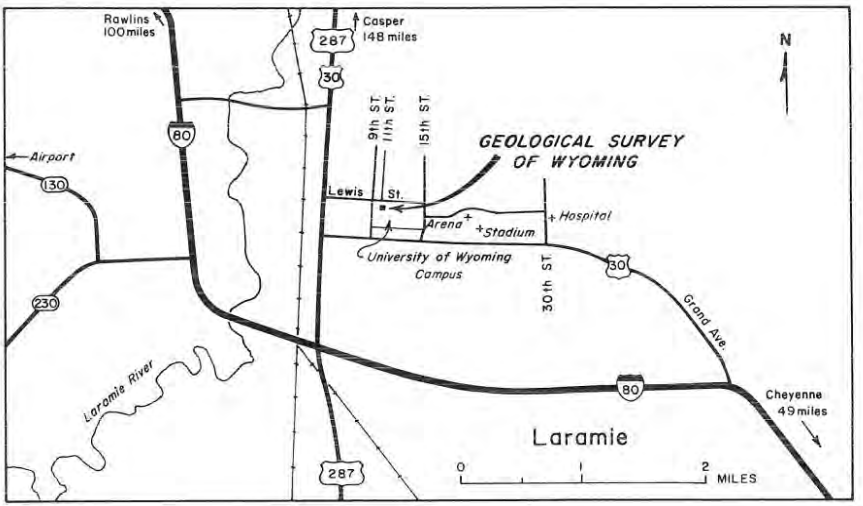
❧❧❧

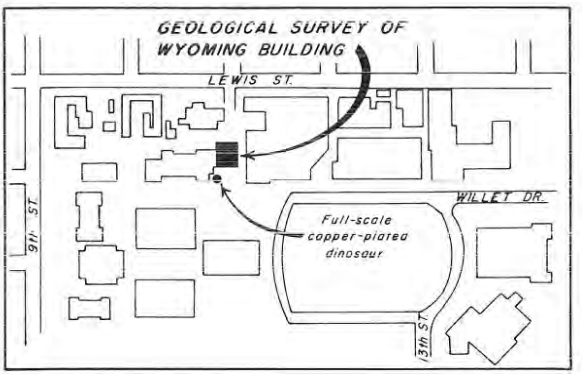
The Geological Survey of Wyoming now sells the Geologic map of Grand Teton National Park, Teton County, Wyoming by J.D. Love and others: U.S. Geological Survey Miscellaneous Investigations Series Map I-2031 (1992). The full-color map and accompanying 17-page pamphlet is available rolled or folded for $4.00. Add $1.50 for rolled maps shipped in a map tube.

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.

GEOLOGICAL SURVEY OF WYOMING
LOCATION MAPS





ORDER FORM

Send this order and make checks payable to:

The Geological Survey of Wyoming
Box 3008, University Station
Laramie, Wyoming 82071-3008

Your name, address, zip:

_____

_____

_____

_____

_____

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

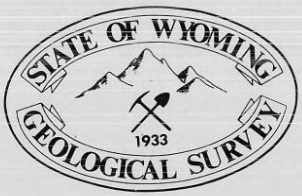
No postage charged on prepaid orders unless otherwise specified.

Prices are subject to change.

Quantity	Publication Number	Publication Title	Price	Total Price

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

(8/93)


STATE OF WYOMING
1933
GEOLOGICAL SURVEY