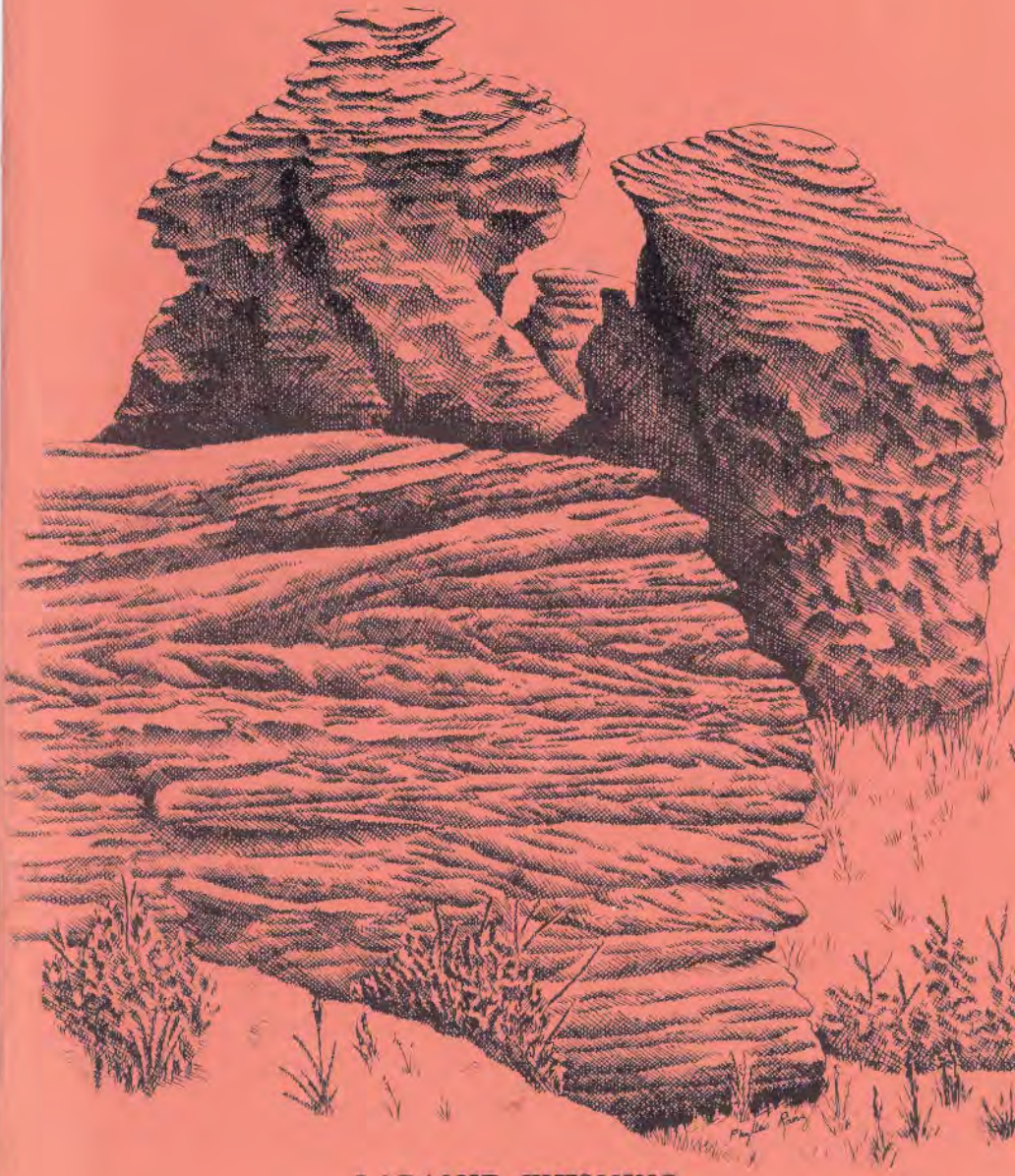
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES NO. 12



LARAMIE, WYOMING
October, 1986

WYOMING GEO-NOTES

This quarterly newsletter on the geology, mineral resources, and activities of the Geological Survey is available by subscription (four issues for $5.00) or as single copies at $1.50 each.

Front cover: Outcrop of cross-bedded sandstone in the Casper Formation in the Sand Creek area, located approximately 30 miles southwest of Laramie at the extreme southern end of the Laramie Basin. Read pages 49 through 51 of this volume for a description of this unique area.

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Minerals Update

OVERVIEW

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

The bright spots in Wyoming's mineral industry are a slight increase in oil prices over the second quarter; completion of Chevron's fertilizer plant, which uses sulfur from Wyoming; the completion of Exxon's Shute Creek gas processing plant; continued exploration for platinum and gold; probable increased production of gypsum; and another year of relatively stable production of trona from southwestern Wyoming.

Natural gas and coal production, however, have not met earlier expectations and have been revised downward (see table on page 3). Coal production, in particular, is expected to decrease by four percent and will for the first time since 1966 not increase over the previous year. Bentonite production will undoubtedly also decrease. The prices paid for almost all of Wyoming's produced minerals have also declined. Sulfur is a notable exception with its value expected to increase in 1986.

Precipitous abandonment of stripper oil wells has not yet materialized although an estimated 1,000 of the 5,000 or so stripper wells in Wyoming have been at least temporarily shut-in. If oil prices do not at least stabilize, more stripper wells will meet this same fate in the future along with some other oil wells with high production costs. The good news is that there are some indications that oil prices may at least stabilize in the middle teens for awhile at least. $14-$16 per barrel oil, however, will do little to stimulate a renewal of exploration drilling activities, and the chances of oil approaching $20 per barrel seem slim. There is little likelihood that the Federal

government will establish an import quota to boost prices during the present Administration although most of the oil-producing states, including Wyoming, have asked for this action.

The domestic oil industry now finds itself in the same position as the uranium and other metals industries. The oil industry, particularly the independent producers, are fighting for survival in the face of foreign competition and many are losing. Federal policies did not protect these other mineral commodities, and there does not appear to be any trends that would lead one to believe that the demise of the oil industry will be turned around in the near term. A second Arab oil embargo is highly improbable; as mentioned earlier, a Federal import quota is also unlikely; and the chances of a new Federal energy policy promoting the domestic oil industry seems remote. Short of a Middle East war cutting off OPEC supplies, which would have other grave consequences, the best chance for help is a relatively stable price even it is below the often cited goal of $20 per barrel.

Wyoming mineral production forecast to 1991[1].

Calendar Year	Oil Production[2]	Natural Gas Production[3]	Carbon Dioxide Production[3]	Coal Production[4]	Trona Production[4]	Uranium Production[4]
*1981	122.1	455.4	--	102.8	11.8	4.6
*1982	118.7	465.1	--	107.9	10.1	2.1
*1983	120.9	539.7	--	112.2	10.5	3.0
*1984	127.8	600.1	--	130.7	11.0	1.6
*1985	131.0	597.9	--	140.7	10.8	0.6
1986	123.0	585.0	25.0	135.0	11.5	0.3
1987	115.5	623.0	75.0	140.0	11.7	0.3
1988	107.5	659.0	100.0	143.0	12.1	0.4
1989	100.0	696.0	100.0	146.0	12.1	0.5
1990	93.0	732.0	100.0	150.0	12.2	0.5
1991	86.5	780.0	100.0	152.0	12.5	0.6

*Actual values for comparison, [1] Geological Survey of Wyoming, September, 1986, [2] in millions of barrels, [3] in billions of cubic feet, [4] in millions of tons.

Production history of selected other mineral commodities[1].

	1980	1981	1982	1983	1984	1985
Ballast[2,3]	1.65	1.72	0.81	0.99	2.43	0.67
Bentonite[2]	3.58	4.81	2.35	2.18	3.08	2.59
Clay[2]	0.04	0.02	0.02	0.04	0.05	0.04
Decorative Stone[2]	0.05	0.05	0.05	0.07	0.08	0.09
Dolomite[2]	1.67	0.87	0.61	0.66	0.86	0.87
Feldspar[4]	200	25	----	----	----	----
Gypsum[2]	0.30	0.28	0.26	0.33	0.33	0.35
Iron Ore[2]	4.88	4.67	3.28	2.48	----	----
Limestone[2,5]	0.50	0.72	0.59	0.56	0.65	0.32
Sand and Gravel[2]	5.06	5.21	4.74	5.00	4.76	4.71
Scoria[2,6]	0.03	0.08	0.08	0.07	0.23	0.13
Shale[2]	----	----	----	----	0.02	0.01
Sodium Sulfate[4]	----	3,201	3,174	3,194	3,250	2,705
Sulfur[2,7]	0.05	0.05	0.08	0.55	0.69	0.77

[1]Source: Ad Valorem Tax Division. [2]Millions of short tons. [3]Includes granite, scoria and other rock. [4]Short tons. [5]Includes limestone used for cement rock, sugar beet refiing and other uses. [6]Baked and fused rock, also called clinker. [7]Data from U.S. Bureau of Mines.

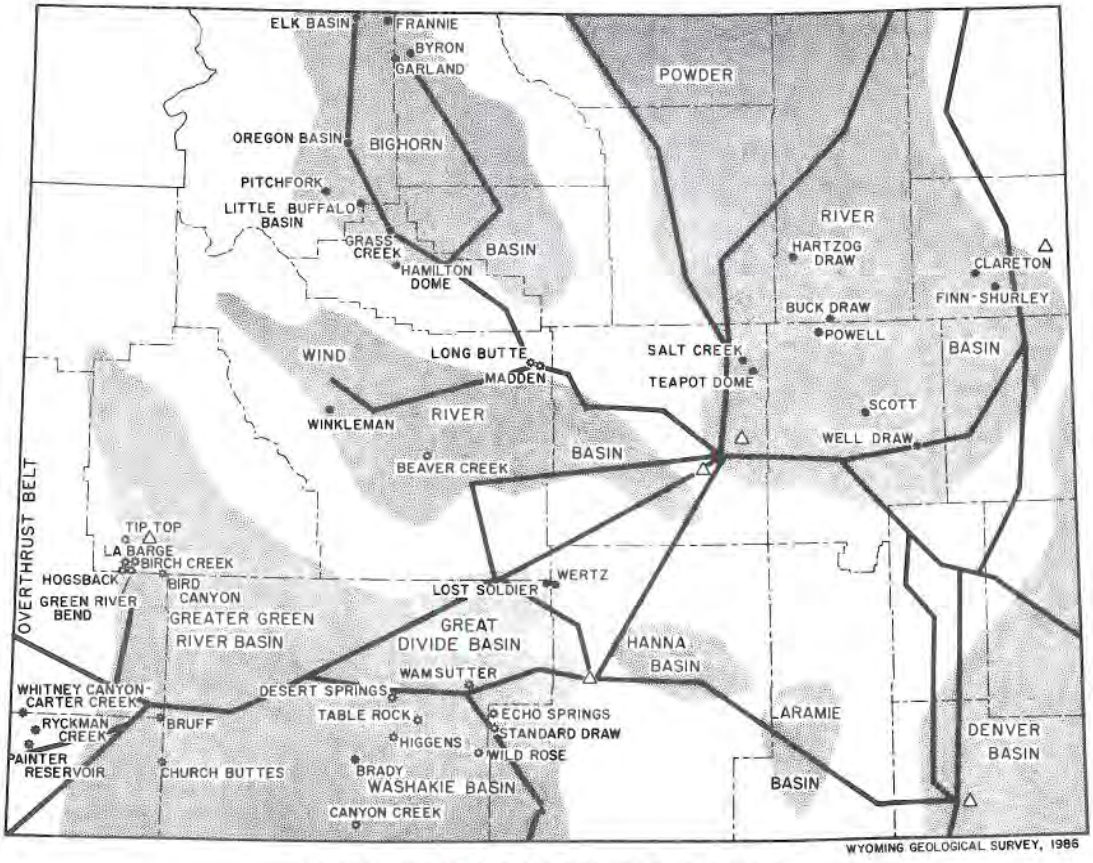
OIL AND GAS UPDATE

by Rodney H. DeBruin, Petroleum Geologist, Geological Survey of Wyoming.

OPEC's decision to institute a trial production agreement for September and October has raised the posted price for Wyoming crude oil to the $14 a barrel range. Just several months ago, some Wyoming producers were receiving less than $10 a barrel for their oil. There is still a great surplus of oil on the world market due to significant production increases by OPEC through August of this year. It may be several months before the surplus dries up and prices start to rise, assuming that the countries belonging to OPEC honor their production quotas. If they do not, a return to $10 or less for a barrel of oil is possible. Such a significant decline in oil prices, however, does not appear likely.

Low oil prices, which have characterized most of this year, are having their effect in several interrelated areas. The number of active rigs has been below 30 since the first week in April, dropped as low as 18 in July and has averaged 37 for the first eight months of 1986. Compare this to the average rig count of 93 for all of 1985 and 190 for all of 1981 (see graphs on page 8).

It has been estimated by the Wyoming Oil and Gas Conservation Commission that about 1,000 of the State's more than 5,000 stripper wells have been shut down since Federal and State regulators notified well operators in April that they could temporarily stop production from the wells without losing their leases. Production from the shut-in wells would probably be in the neighborhood of 1,000,000 barrels a year since they were probably averaging under three barrels a day.



GENERALIZED OIL AND GAS INDEX MAP OF WYOMING

Well completion statistics for the first eight months are summarized and compared with figures for 1985, 1984, 1983, 1982 and 1981 in the table below:

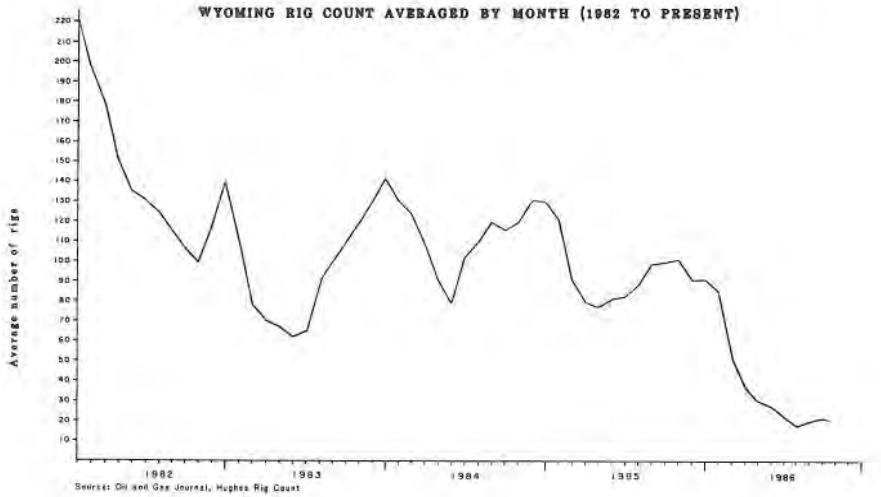
	New field wildcats				All wells			
	Oil	Gas	Dry	Total	Oil	Gas	Dry	Total
1986*	18	2	157	177	266	16	246	488
1985	64	8	469	541	820	109	809	1,738
1984	57	9	440	506	801	142	750	1,693
1983	23	13	305	341	698	152	550	1,400
1982	68	28	404	500	1,029	272	827	2,128
1981	76	43	471	590	756	222	746	1,724

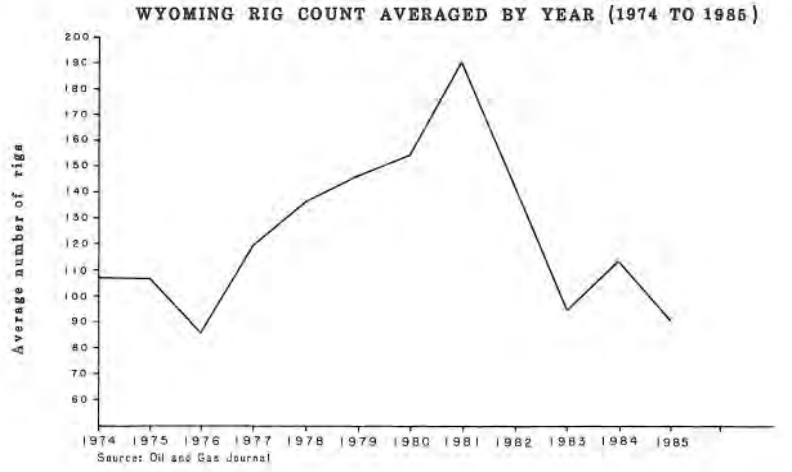
* 8 months

From: Petroleum Information Corporation, Rocky Mountain Region Report, September 17, 1986, p. 7.

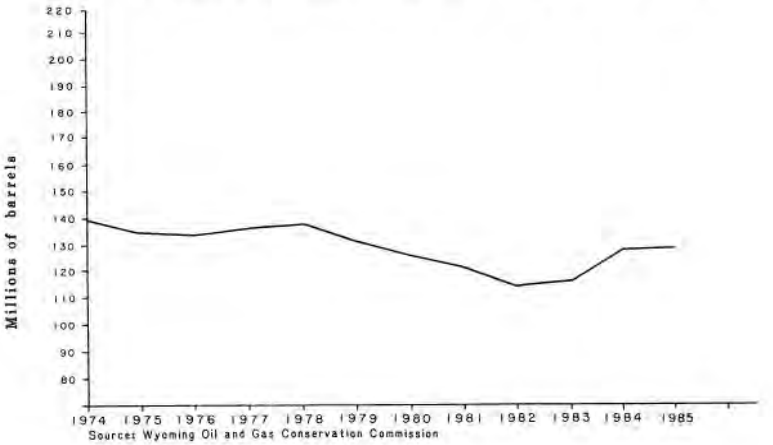
If the completion figures for the first eight months of 1986 are projected to the end of the year, new field wildcats will probably total less than 300 and all wells will probably be under 800. There may be some increased year-end drilling which could push these totals somewhat higher, however, it appears that 1986 will be the State's worst year since 1971 when 345 new field wildcats and 893 total wells were completed. That was prior to the OPEC oil embargo when oil was selling for around $3 a barrel.

The completion rate along with rig count and oil price, illustrate the depressed state of the Wyoming oil and and gas industry. The completion figures also show a lack of interest in finding new gas reserves. Gas prices are currently averaging around $2.40 per MCF. Even if new gas is discovered at the present time, it is almost impossible to find a market due to surplus gas. It does appear, however, that the current gas bubble may disappear in 1987 or early 1988.


WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT)
Average number of rigs
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1982
1983
1984
1985
1986
Source: Oil and Gas Journal, Hughes Rig Count

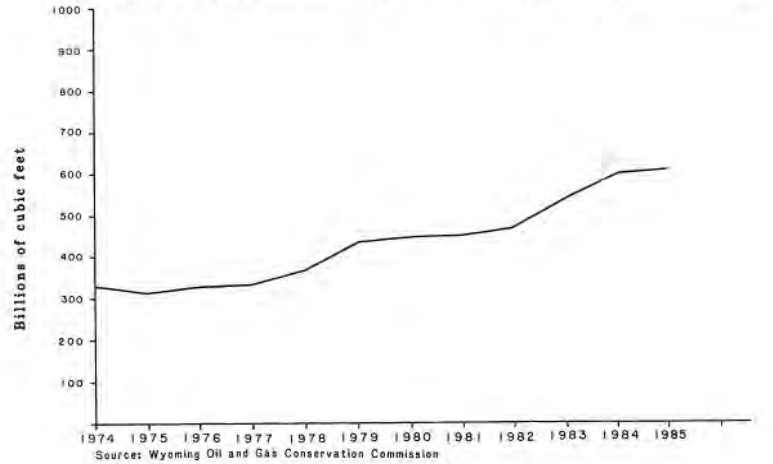

WYOMING RIG COUNT AVERAGED BY YEAR (1974 TO 1985)
Average number of rigs
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985
Source: Oil and Gas Journal

WYOMING OIL PRODUCTION BY YEAR (1974 TO 1985)



Source: Wyoming Oil and Gas Conservation Commission

WYOMING NATURAL GAS PRODUCTION BY YEAR (1974 TO 1985)



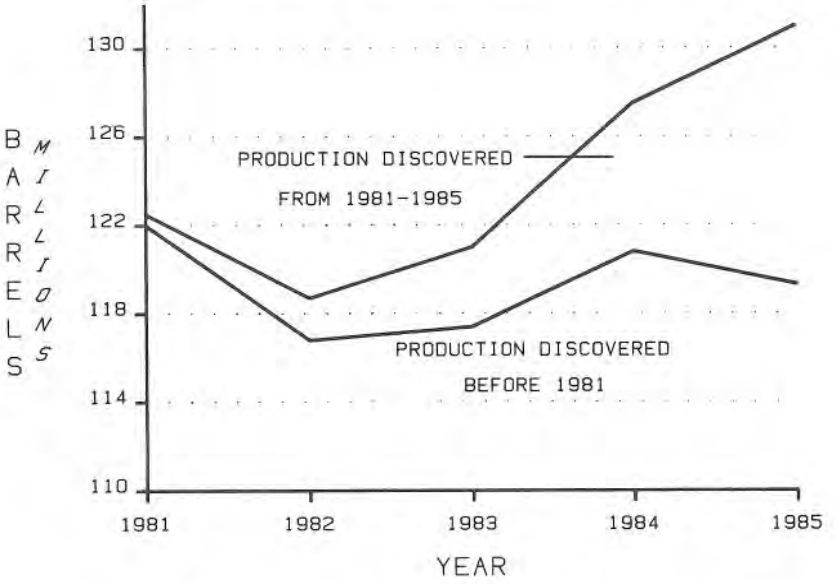
Source: Wyoming Oil and Gas Conservation Commission

Two graphs, shown on page 11, may give a clearer picture of what is happening to oil and gas production during the 1981-1985 period. The upper graph shows that oil production from fields discovered before 1981 may have peaked in 1984. The increase in production from these older fields between 1982 and 1984, was probably caused for the most part by production from large discoveries of the middle 1970's in the Overthrust Belt and the Powder River Basin. Although these fields are still producing, it is not enough to offset the decline in many of the other older fields in the State. The graph also shows that production from fields discovered from 1981-1985 is still increasing due to the drilling boom of that period. Now that many fewer wells are being drilled, it is certain that there will not be enough new discoveries to offset the decline in the older fields and the projected future decline in the 1981-1985 fields.

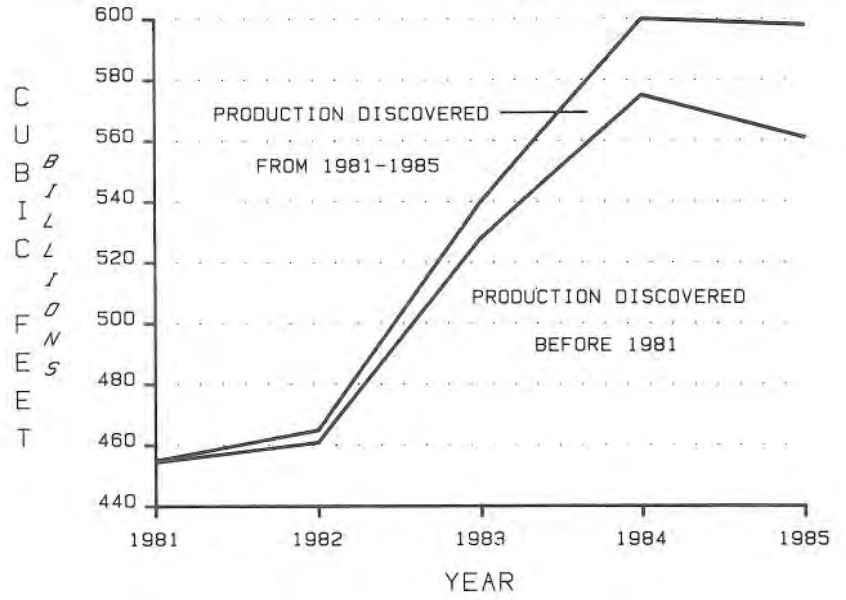
The bottom graph on page 11 shows a very sharp production gain in gas from 1982 to 1984; almost entirely caused by tremendous production from Whitney Canyon-Carter Creek and Painter Reservoir Fields in the Overthrust Belt. The small decline in production from 1984 to 1985 was due to the surplus of gas on the market. Production should again increase when the surplus dries up, since a large percentage of the State's gas wells are presently shut-in and several large gas discoveries are awaiting full-scale development.

In a related item, the new Exxon gas processing plant has started up and is presently running performance tests in preparation for full-scale production later this year. Exxon has contracts to sell up to 200 million cubic feet per day of carbon dioxide (CO_2) to Chevron for an enhanced oil field recovery project in northern Colorado and 50 million cubic feet of CO_2 per day to Amoco for a similar operation in Wertz Field near Bairoil. About 110 million cubic feet of methane per day has been sold to three natural gas pipeline companies. The plant will also produce several hundred

WYOMING OIL PRODUCTION 1981-1985



WYOMING NATURAL GAS PRODUCTION 1981-1985



tons of sulfur per day (from hydrogen sulfide gas) and small amounts of helium and nitrogen. These by-products will also be sold.

Exxon Pipeline Company has announced the completion of a 112-mile, 20-inch pipeline to carry CO_2 from Rock Springs to a receiving facility near Bairoil. Exxon completed a 49-mile, 24-inch pipeline in 1985 from its gas plant to Rock Springs.

Wyoming's Attorney General has released an opinion on severance tax rates for carbon dioxide, hydrogen sulfide, helium and other non-hydrocarbon gases contained in natural gas. The opinion stated that these non-hydrocarbon gases can be taxed at a six percent rate rather than the two percent rate that Amoco and Chevron had claimed. The opinion relied on a number of definitions of the term "natural gas" to support its argument that non-hydrocarbon gases are natural gases.

The Interior Department announced that starting in August it will modify the way it determines the value of natural gas produced from Federal and Indian lands. In the past, companies have been required to pay gas royalties based on the regulated price in excess of $3 per MCF when they were only able to sell the gas for much less. The new changes should accommodate either falling or rising gas prices more equitably.

Anschutz Corporation began work on their Mosquito Creek well earlier this month. It is to be a 5,000-foot test and should take only a month to drill. Work had been delayed due to an appeal by a Wilson resident to the Interior Board of Land Appeals.

Phillips Petroleum has scheduled a 6,500-foot Amsden test in Shoshone National Forest about 14 miles west of Cody in an undrilled township. The closest Pennsylvanian production is 15 miles to the east at Shoshone Field.

Amoco Production reported the completion of a CO_2 gas discovery in southwestern Wyoming in T.24N., R.112W. The well flowed 13.1 million cubic feet of gas per day from the Madison between 16,466 and 16,496 feet.

Since the last issue of *Geo-notes* the Wyoming Board of Land Commissioners has held two lease sales. The July 15 lease sale drew $418,280 in high bids. Only 63 of the 200 tracts received bids, and the average bid was $16.43 per acre. The high $234 per-acre bid was made by Texaco, Inc. for a 640-acre lease on the Moxa Arch. The lease is located in Lincoln Road Field which produces gas from the Frontier Formation.

The September 16th sale received high bids totaling $171,975 for 80 of the 200 parcels offered. The average bid was only $5.10 per acre. The high per-acre bid of $360 was made by American Oil and Gas Corporation for a 75.5-acre tract adjoining Minnelusa oil production in Camp Creek Field in the Powder River Basin.

The U.S. Bureau of Land Management's August lease sale drew high bids of $529,184. Of the 104 tracts offered, 88 received bids with an average per-acre bid of $23.29. The high bid was $227.63 per acre by Hunt Oil for an 80-acre lease in the northern Powder River Basin. The lease is located on the southeast side of Rocky Point Field which produces oil from the Muddy Sandstone and the Minnelusa Formation.

The last State and last Federal sale produced much less revenue and much lower average per-acre bids than almost all of the sales shown on the table on page 14. This is probably due in part to the depressed condition of the industry, but may have been due to a shortage of high-quality tracts.

WYOMING FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES

BLM SALES 1984

Month	Total Revenue	Number of parcels offered	Number of parcels sold	Total acres	Acres sold	Average price per acre sold	High price per acre
February	$ 7,262,056	21	21	2,304	2,304	$3,151.31	$21,239.34
March	615,088	28	28	4,015	4,015	153.20	500.00
April	330,798	29	29	3,977	3,977	83.17	412.51
May	1,571,896	77	75	14,565	14,470	108.63	1,300.00
August	12,465,683	162	162	30,110	30,110	414.00	13,333.33
October	2,521,434	115	115	19,852	19,852	127.01	3,852.00
December	4,761,794	123	123	29,202	29,202	163.07	5,751.50
TOTAL	$29,528,749	555	553	104,025	103,930	$ 284.12	$21,239.34

1985

February	$ 3,547,273	117	115	34,948	34,028	$ 104.24	$ 1,700.00
April	2,025,793	133	128	25,497	24,056	84.21	2,609.53
June	1,963,897	140	137	40,304	38,904	50.48	2,577.15
August	2,854,821	190	146	75,094	56,906	50.17	1,732.14
October	1,876,105	208	105	81,611	32,052	58.53	1,108.77
December	1,467,265	211	144	73,723	46,908	31.28	1,167.23
TOTAL	$13,735,154	999	772	331,177	232,854	$ 58.99	$ 2,609.53

1986

February	$ 1,992,326	211	154	58,507	38,809	$ 51.34	$ 680.00
April	1,795,890	189	116	54,136	29,938	59.99	1,881.88
June	1,332,216	86	75	27,137	24,512	54.35	437.50
August	529,184	104	88	25,686	22,725	23.29	227.63

STATE SALES 1984

Month	Total Revenue	Number of parcels offered	Number of parcels sold	Total acres	Acres sold	Average price per acre sold	High price per acre
January	$ 2,316,714	200	165	118,285	92,785	$ 23.97	$ 502.04
March	2,173,851	200	166	85,993	66,781	31.49	524.00
May	1,527,903	200	162	87,469	67,579	32.49	390.00
July	2,028,880	200	181	86,387	73,849	26.46	2,100.00
September	1,379,138	200	141	87,095	53,066	24.99	1,020.00
November	739,766	200	135	82,363	51,640	13.33	280.00
TOTAL	$10,166,252	1,200	950	547,592	405,700	$ 25.05	$2,100.00

1985

January	$ 757,214	200	86	80,019	27,520	$ 26.51	$1,700.00
March	2,077,478	300	172	137,321	69,781	29.77	1,600.00
May	936,374	199	117	73,625	35,273	26.55	350.00
July	636,350	200	113	83,491	43,630	14.59	280.00
September	989,069	200	126	95,052	60,356	16.39	325.00
November	494,739	200	109	70,144	41,399	11.95	320.00
TOTAL	$ 5,891,224	1,299	723	539,652	277,959	$ 21.19	$1,700.00

1986

January	$ 630,069	200	123	83,064	49,783	$ 12.66	$ 320.00
March	773,492	199	112	77,237	44,504	17.38	370.00
May	354,941	200	70	74,128	27,543	12.89	140.00
July	418,280	200	63	86,495	25,461	16.43	234.00
September	171,975	200	80	87,017	33,738	5.10	360.00

Sources: Wyoming Department of Public Lands, Petroleum Information Corporation - Rocky Mountain Region Report and U.S. Bureau of Land Management.

COAL UPDATE

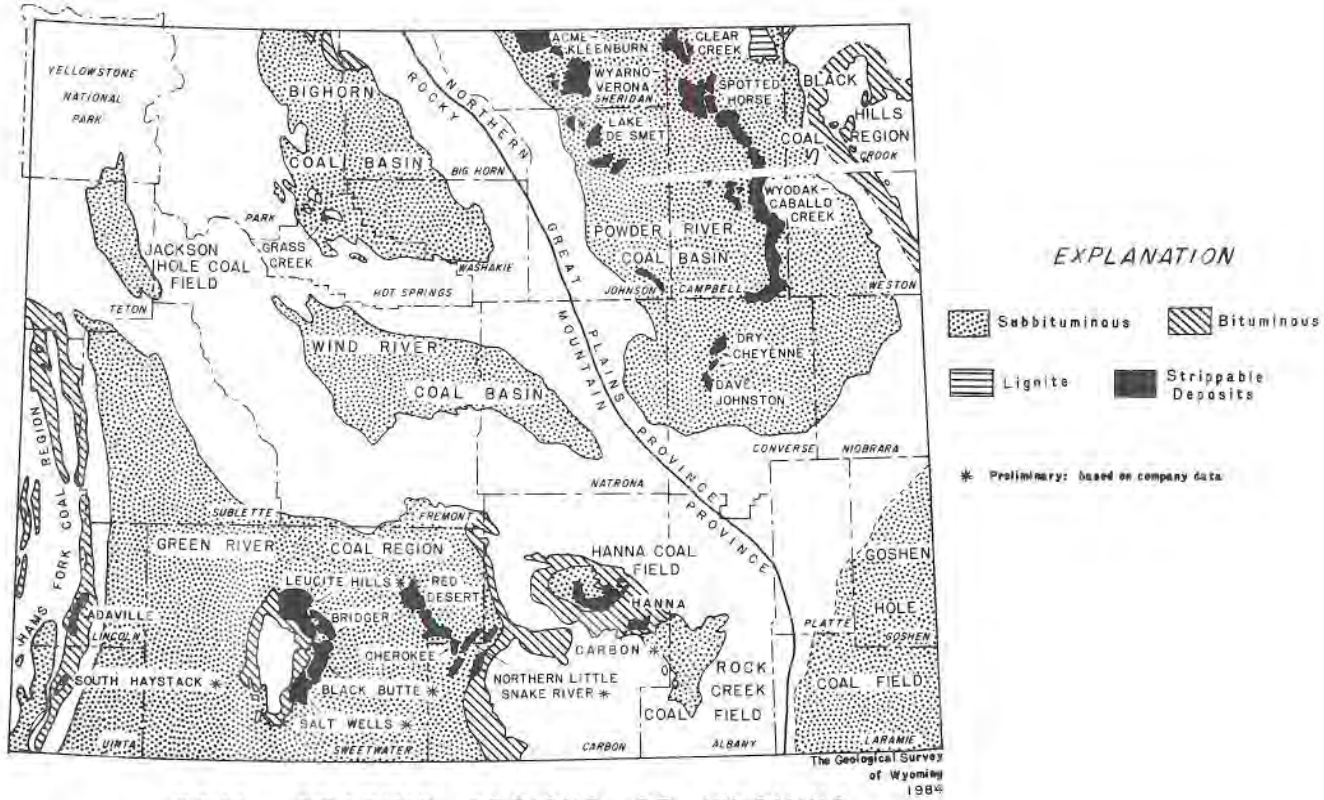
by Richard W. Jones, Coal Geologist, Geological Survey of Wyoming.

Wyoming coal production for 1986 appears to be heading downward for the first time in almost 20 years. Coal delivery reports for the first six months of the year indicate that coal deliveries are almost five million tons less than they were a year ago (see table on page 17). After second quarter 1986, deliveries were substantially less than those for the same period a year ago. If monthly deliveries for the remainder of 1986 were to continue at 1985's rate, final production figures for 1986 could still be five million tons less. If deliveries in the second half of 1986 continue at the same rate as the first half, total coal production could be as much as nine million tons less than in 1985 (see figure on page 18).

Some coal producers in the Powder River Basin have predicted that their 1986 production will be ten percent less than 1985 production. If this is the case for all Powder River Basin mines, 1986 coal production could even be below 1984's production of 130.7 million tons. Preliminary data, however, indicates that Powder River Basin production for the first half of 1986 is only five percent less than production for the first half of 1985.

It is most likely that production in the second half of 1986 will continue at or about 1984's rate, and that the unreported tonnage will be between the 1984 and 1985 totals. This means that 1986 coal production in the State will be about 135 million tons, a decrease of four percent over last year's production.

Coal deliveries to the states of Indiana, Iowa, Louisiana, Oklahoma and Texas in the first half of 1986 were down the most from 1985 deliveries. In the case of Indiana, this probably reflects the cessation of



COAL- BEARING REGIONS OF WYOMING

REPORTED COAL DELIVERIES IN TONS[1]

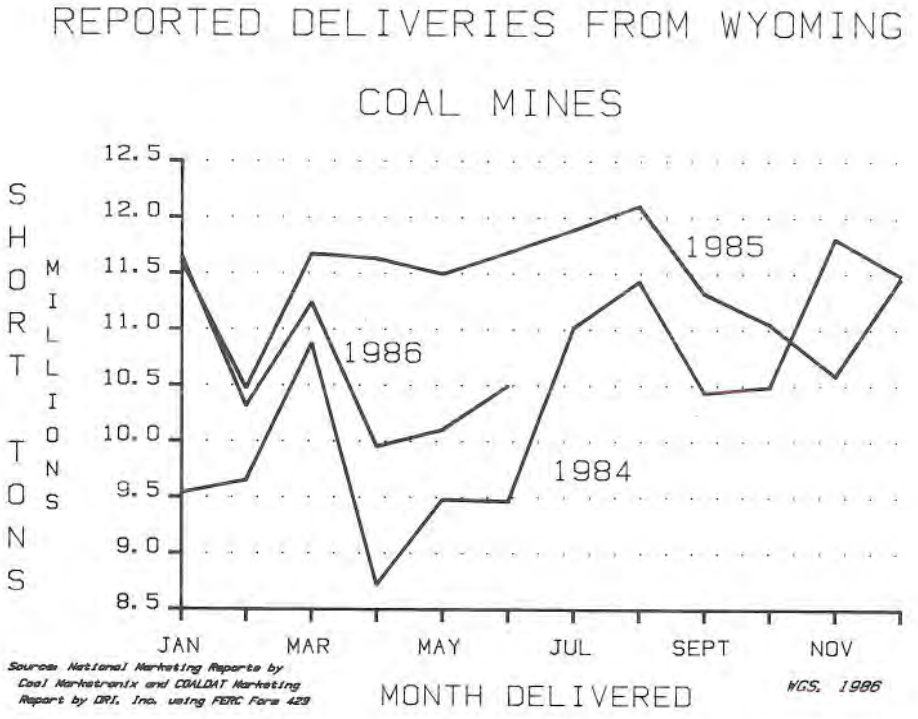
	1984 MONTHLY	1984 CUMULATIVE	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE
JANUARY	9,540,200	9,540,200	11,601,200	11,601,200	11,646,300	11,646,300
FEBRUARY	9,654,600	19,194,800	10,473,900	22,075,100	10,317,700	21,964,000
MARCH	10,875,000	30,069,800	11,674,900	33,750,000	11,238,520	33,202,520
APRIL	8,721,400	38,791,200	11,632,800	45,382,800	9,954,170	43,156,690
MAY	9,481,500	48,272,700	11,497,900	56,880,700	10,105,320	53,262,010
JUNE	9,464,500	57,737,200	11,692,200	68,572,900	10,499,280	63,761,290
JULY	11,019,600	68,756,800	11,893,500	80,466,400		
AUGUST	11,433,000	80,189,800	12,107,100	92,573,500		
SEPTEMBER	10,440,000	90,629,800	11,325,000	103,898,500		
OCTOBER	10,492,500	101,122,300	11,048,500	114,947,000		
NOVEMBER	11,814,200	112,936,500	10,589,700	125,536,700		
DECEMBER	11,486,800	124,423,300	11,459,300	136,996,000		
TOTAL REPORTED DELIVERED TONNAGE	124,423,300		136,996,000			
TOTAL TONNAGE NOT REPORTED	6,322,479		3,428,446			
TOTAL TONNAGE PRODUCED[2]	130,745,779		140,424,446			

[1] Source: National Marketing Reports by Coal Marketronix and Coaldat Marketing Reports by DRI, Inc., compiled from FERC Form 423 filed monthly by electric utilites.

[2] Source: Wyoming State Mine Inspector's Annual Report.

deliveries from Carbon County Coal Company in early 1986. For the other states above, this could reflect the displacement of coal by lower priced oil and gas in those utilities capable of fuel switching and/or the availability of lower priced electricity generated elsewhere from low cost oil- or gas-fired generating plants.

In a recent article discussing the major threats to the U.S. coal industry (Schleede, 1986), it was pointed out that coal as a utility fuel has lost much of its delivered cost advantage over oil and gas, especially near waterways, on the coast or near refineries [or gas fields] where oil [and gas] is available in large quan-



tities. According to the article, coal is displaced by oil and gas in several situations. First, regional power pools generally use the lowest cost power plants or generating units first when adding generating capacity to the system. At present, the lowest cost units available in the power pool are oil- or gas-fired. Second, when coal had a price advantage over oil and gas, it was more economical for utilities to shut down or decrease the use of oil- and gas-fired units and purchase electricity "by wire" from coal-fired units elsewhere. Today it is more economical for utilities to utilize any available oil- and gas-fired units rather than purchase electricity from coal-fired units. Third, utilities that operate both older oil- or gas-

fired units and newer coal-fired units find it cheaper to back down the capacity of the coal-fired units (and take the minimum amount of coal allowed by contract) and utilize oil- or gas-fired plants as much as possible. Finally, there is a danger that continued low prices for oil and gas in the utility fuel market could result in reconverting oil- and gas-fired units that had been converted to coal in the early 1970s back to oil or gas. The article concludes that the displacement of coal is inevitable with OPEC's low prices, that although the delivered price of coal has decreased, the F.O.B. mine price has decreased much more (on a national average) than the price of transportation and that coal producers have been forced to absorb most of the price reductions.

Although all of the factors described above may not apply directly to any given utility company using Wyoming coal, all these factors are influencing both the production and the price of Wyoming coal to some degree. The presence of low priced oil and gas available to utilities appears to be having a direct effect on the State's spot coal sales. In March of this year, coal delivered on the spot market accounted for about 7.4 percent of the total deliveries. The amount of spot coal sales has decreased each month since then; in June, 1986, spot sales accounted for only 2.5 percent of the total deliveries.

It would appear that the disadvantages of spot sales are outweighing the advantages. Most small producers cannot compete with large producers for the extremely low priced spot coal sales (and still stay in business), and the large producers are affected by the erosion of contract prices at the time of renegotiation (under reopener clauses in their contracts) due to the presence of low priced spot coal that is also available to the utility. The low priced spot coal also causes a decrease in overall coal prices, which translates to less valuation and a decreased tax base, less revenue from taxes and royalties, decreased state and local

services and decreased public and community projects. On the plus side, spot sales have kept some companies in business and reduced layoffs, but break-even or loss sales cannot continue indefinitely.

Our latest estimate of future coal production for Wyoming by county (see table, page 21) reflects decreased production in 1986; production is not expected to exceed 1985's record year until 1988. We project a gradual increase in production until 1991, at which point actual production is estimated to be the same as contract production. The major markets for Wyoming coal, based on known or existing contracts, have also been summarized (see map, page 23). In 1991, nearly all the State's coal production will still be used by electric utility companies, as is the case today. A summary of the factors that will influence future production and utilization of Wyoming coal appears in *Wyoming Geo-notes No. 8* (September, 1985).

Average coal prices will probably continue to fall in the next few years in response to overall market conditions as well as the result of a greater percentage of the State's coal being produced at Powder River Basin mines. The value of the State's coal produced in 1984 was approximately $1.2 billion dollars or about $9.77 per ton. About 85 percent of the production that year came from low-cost producers in the Powder River Basin; the average value of this coal was about $7.18 per ton. The higher-cost coal produced in the remainder of the State had an average value of about $23.13 per ton. Coal produced in 1985 had approximately the same value of $1.2 billion, but the average value per ton was $9.30. Low-cost producers in the Powder River Basin accounted for 83 percent of the State's total production; the average value of the coal was about $6.73 per ton. The higher-cost coal had an average value of $22.02 per ton. Although 1985 saw both the high production cost and low production cost coal drop in price, the increased production forecast for low-cost coal coupled with a decreased price will

Coal production and forecast to 1991 (millions of tons).

	1981[1]	1982[1]	1983[1]	1984[1]	1985	1986	1987	1988	1989	1990	1991
Campbell County	71.6	81.2	88.2	106.8	113.9	110.3	114.1	116.4	119.7	122.9	125.4
Converse County	3.6	3.4	2.7	3.3	3.6	4.1	6.2	6.8	7.5	8.7	8.7
Sheridan County	2.8	3.0	2.9	2.5	2.4	2.8	2.0	1.5	-	-	-
Carbon County	8.5	5.0	4.8	5.1	3.3	2.0	1.9	1.5	1.3	0.8	0.3
Sweetwater County	11.2	11.0	9.5	8.9	13.2	12.6	12.0	12.3	12.5	12.5	12.5
Lincoln County	5.0	4.3	4.0	4.1	4.3	3.2	3.8	4.5	5.0	5.1	5.1
Hot Springs County	M[2]	M	M	M	M	M	M	M	M	M	M
Total Wyoming	102.8	107.9	112.2	130.7	140.7	135.0	140.0	143.0	146.0	150.0	152.0
Annual change	9%	5%	4%	16.5%	11%	-4%	+4%	2%	2%	3%	1%
Estimated contracted production	110.0	119.0	122.6	137.7	145.2	149.2	149.4	151.5	148.6	150.6	152.0
Below contract	7%	9%	8%	5%	3%	10%	6%	6%	2%	-	-

[1] These are actual values for comparison. [2]M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, September, 1986.

result in future decreases in overall coal value (price) even if the value of high-cost coal increases.

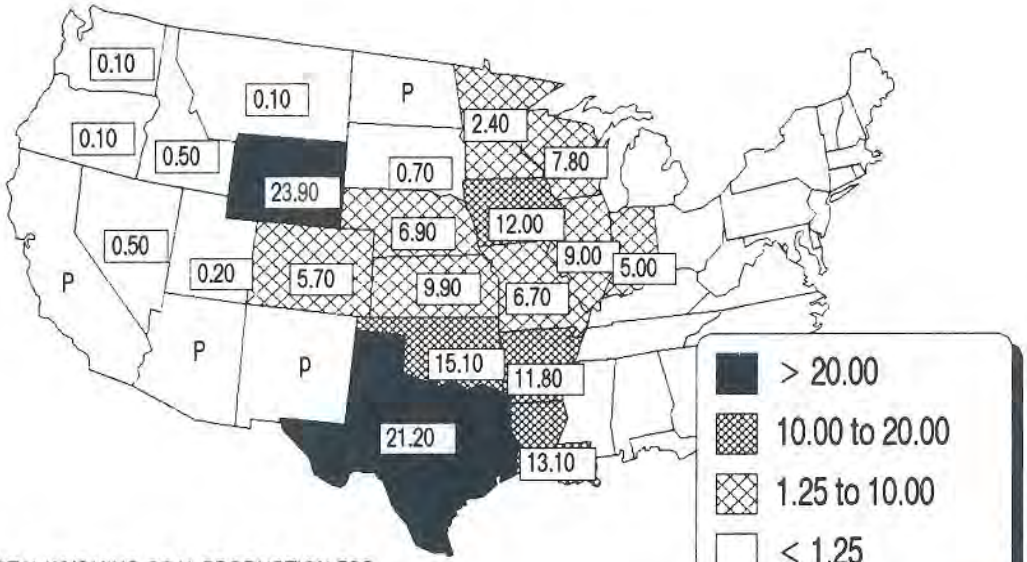
Revenues from coal taxes in the next few years will fall along with the value of the coal. The revenues generated by coal production and sales will decrease even more after 1986 because the State's severance tax rate on coal (currently 10.5 percent on strip-mined coal) is expected to drop to 8.5 percent. This decrease in tax rate results from the expiration of the special two percent Coal Impact Tax that was imposed ten years ago. The tax is due to expire automatically on the first of January following the year total collections from the tax reach $160 million. It is now estimated that the total collections will exceed the $160 million limit sometime in late 1986 or early 1987. Last year the Wyoming State Legislature did not pass a bill that would have continued the Coal Impact Tax.

Electric utility companies and their customers continue to benefit by the bargain-basement coal prices available in the current buyer's market. In July, Iowa Public Service (IPS) completed price reopener negotiations with Arch Mineral Corporation on a 360,000-ton per year coal contract. The utility was able to cut coal costs by $4.19 million or $3.88 per ton for their Neal No. 1 and 2 units at Salix, Iowa. Coal mined at the Seminoe No. 2 mine in the Hanna Basin was previously delivered to Iowa for $38.80 per ton. With transportation costs on the Union Pacific Railroad (UP) of $10.06 per ton, the coal had an F.O.B. mine price of $28.74 per ton. Under the renegotiated contract, the coal now sells for $24.86 per ton F.O.B. at the mine.

Iowa Public Service (IPS) is also saving their customers $12.2 million on a three-year contract renegotiated with Carter Mining Company (*Wyoming Geo-notes No. 11*, June, 1986, page 37). It was also reported that IPS was evaluating bids on a spot contract for the same unit, the George Neal No. 4, for the last half of 1986. This spot purchase was canceled after a July 28

1991 MARKETS FOR WYOMING COAL

IN MILLIONS OF SHORT TONS



TOTAL WYOMING COAL PRODUCTION FOR
1991 IS ESTIMATED AT 152.0 MILLION TONS

Geological Survey of Wyoming, 1986

P = POSSIBLE MARKET

tornado damaged the unit and forced a six- to 12-month shut-down. It may cost the utility (and its customers) $25 to $50 million to repair the unit. IPS also declared *force majeure* on the contract it had renegotiated with Carter earlier, even though much of the coal had already been delivered.

In August, Indiana and Michigan Electric (a utility owned by American Electric Power) completed renegotiating both coal and transportation contracts that could result in saving the utility $70 million per year. The new contracts will result in a January, 1987, delivered price of $23.67 per ton, a savings of $17.90 per ton from the January, 1986, price of $41.57 and in five years (1991) will be subject to renegotiation. The four-million-ton per year contract (with a 3.6-million-ton minimum) is with Carter Mining Company, operator of the Rawhide and Caballo mines in the Gillette area. Burlington Northern (BN) will deliver the coal to the utility's Rockport, Indiana, generating plant. Although the reduction in mine price will not go into effect until January, 1987, the railroad rates have already gone into effect. Delivered price of the coal dropped from $42.41 per ton in March, 1986, to $38.17 per ton in April, 1986.

San Antonio City Public Service (CPS) announced this summer that they have decided on a fuel choice for a new 500-megawatt generating unit they were planning to build in the early 1990s (see *Wyoming Geo-notes No. 9*, December, 1985, page 30). The utility had been studying several different ways to supply additional electricity needed in the early 1990s, including a mine mouth lignite plant, a cogeneration unit or a conventional western subbituminous coal-fired plant. The utility has decided that it can save about $1.2 billion in construction and operating costs over a 25-year period if it builds a western coal unit. A major factor in CPS's decision was their recently acquired 20-year transportation contract with the Chicago and North Western Transportation Company (C&NW)/Union Pacific

(UP) joint venture railroad. This contract saves the utility $8.00 per ton in freight costs for coal delivered from Cordero Mining Company's mine south of Gillette to an existing CPS unit.

Two new coal supply contracts were signed this summer with Wyoming coal mines. Black Butte Coal Company, a joint venture of Rocky Mountain Energy and Peter Kiewit Sons, won a 4.6-million-ton contract to supply coal to Valmy Units 1 and 2 in north-central Nevada. Black Butte, operator of a 5.5-million-ton per year surface mine east of Rock Springs, began shipments to the units via the Union Pacific Railroad on July 1, 1986. This is the first utility coal contract to Nevada from a Wyoming mine. The plant is owned jointly by Idaho Power and Sierra Pacific Power, and the plant also uses coal from an underground mine in Utah. The contract calls for 0.2-1.2 million tons per year and depending on annual deliveries, the contract could last 21 years.

The second new contract is for coal from the Rochelle mine in southern Campbell County to fuel power plants in Minnesota. The plants are operated by Northern States Power (NPS). The Rochelle mine is operated by Rochelle Coal Company (a wholly-owned subsidiary of Peabody Holding Company) and is Wyoming's newest coal mine. Rochelle and two other Montana mines (operated by Westmoreland Resources, Incorporated, and Western Energy Company) will supply NPS with a total of 5.5 to 13.5 million tons of coal per year through 1990 with the possibility of extending the contract an additional five years. Another Wyoming mine, Nerco's Antelope mine in northern Converse County, has also signed a tentative contract with NPS. Burlington Northern will transport the coal. The utility expects to save some $19 million in fuel costs in 1987 and about twice that amount each year for the next 15 years.

Despite the new contracts, several Wyoming mines have been forced to lay off workers. In July, 100 workers were permanently laid off at Glenrock Coal Com-

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1986)

Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	13.4 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	21.0 billion barrels

Remaining Reserve Base (January 1, 1986)

Measured reserves (Proved reserves)	0.82 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[3]
Total	3.62 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1986)

Discovered	19.2 trillion cubic feet[1]
Undiscovered (there is at least another 115 trillion cubic feet of noncombustible CO_2 gas)[9]	58.0 trillion cubic feet[1]
Total	77.2 trillion cubic feet[1]

Remaining Reserve Base (January 1, 1986)

Measured reserves (Proved reserves)	9.88 trillion cubic feet[2]

COAL

Remaining Resources (January 1, 1986)

Identified (Discovered)	136.2 billion tons[4]
Undiscovered	800.0 billion tons[5]
Total	936.2 billion tons

Remaining Reserve Base (January 1, 1986)

Demonstrated strippable (Measured and indicated reserve base)	27.3 billion tons[4]
Demonstrated underground-minable (Measured and indicated reserve base)	38.4 billion tons[4]
Total	65.7 billion tons

TRONA

Original Resources (1983 estimate)

Trona	81.7 billion tons[6]
Mixed trona and halite	52.7 billion tons[6]
Total	134.4 billion tons

URANIUM

Remaining Resource (January 1, 1983) ..... 995,000 tons[7]

Remaining Reserve Base (January 1, 1983)	ORE	U_3O_8
Ore recoverable at $30 or less/ton	29.4 million tons	39,700 tons[7]
Ore recoverable at $30.01-$50.00/ton	225.1 million tons	151,500 tons[7]
Ore recoverable at $50 or less/ton	254.5 million tons	191,200 tons

OIL SHALE

Original Resources (January 1, 1983)

Identified (Discovered) ..... 320 billion barrels of shale oil[8]

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

[2] Energy Information Administration, 1985, *U.S. crude oil, natural gas, and natural gas liquids reserves: 1984 Annual Report, October.* (1984 and 1985 production has been subtracted).

[3] Modified from Barlow and Doelger (1983), footnote 1.

[4] Wyoming Geological Survey, March, 1985. (Modified from Berryhill, H.L., Jr. and others, 1950, *Coal resources of Wyoming:* U.S. Geological Survey Circular 81, 78 p.

[5] Averitt, Paul, 1975, *Coal resources of the United States:* U.S. Geological Survey Bulletin 1412, p. 15.

[6] 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.

[7] U.S. Department of Energy, 1983, *Statistical data of the uranium industry:* Open-file Report GJO-100-(83), 77 p.

[8] 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.

[9] Derived from Exxon information.

pany's Dave Johnston mine in Converse County, following the announcement that Pacific Power and Light Company (PP&L) would be curtailing electricity generation at the Dave Johnston plant at Glenrock and that less coal would be needed from the mine. This mine produced 3.5 million tons of coal in 1985 and is one of the State's older surface mines, having begun production in 1958. PP&L also announced that power generation would be cut at the Wyodak plant east of Gillette. No layoffs at the Wyodak coal mine, which supplies coal to the nearby power plant, have been announced.

Also in the Powder River Basin, Cordero Mining Company laid off six employees this summer. The layoffs apparently involved administrative personnel and left the mine's workforce at 250.

In the Hanna Basin, Arch Mineral Corporation temporarily shut down its Seminoe No. 2 mine on August 25, laying off 87 miners. Arch closed the mine after failing to reach a new labor agreement with its miners. Negotiations were expected to continue in October, 1986, but in the meantime, Arch has purchased stockpiled coal from the recently closed (April, 1986) Carbon County Coal Company underground mine. The coal purchased by Arch is being used to fill contracts with Kansas City Power and Light and Iowa Public Service.

In western Wyoming, FMC Corporation laid off 13 employees at its Skull Point mine south of Kemmerer in early September. FMC cited the competitive pressures of the coal industry as the reason for the layoffs. The mine produced 0.9 million tons of coal in 1985 and had a workforce of 107 before the layoffs. This mine supplies industrial coal to several of its own operations (including a nearby formcoke plant and trona plant to the east) as well as to other industrial users in nearby states.

The second quarter of 1986 saw renewed activity in *in situ* gasification and synfuels. These activities

have been relatively quiet in the last few years in Wyoming so this activity is encouraging for the renewed development of alternate fuel sources. In July, Energy International, Incorporated received a three-year $12 million grant from the U.S. Department of Energy's Federal Clean Fuels From Coal Program for development of an *in situ* coal gasification project west of Rawlins. The project is in steeply-dipping coal seams in the same area that Gulf Research and Development Company conducted their North Knobs *in situ* project. Energy International will contribute another $12 million to what has been termed a "proof of concept" project. If the initial phase of the project has succeeded at the end of three years, a decision will be made in 1989 whether or not to expand the project into a commercial operation.

In August it was announced that the U.S. Department of Energy was providing $4.5 million for a $9.8 million underground coal gasification project near Hanna. The remaining $5.3 million will be provided by an industry consortium consisting of Amoco Production Company, the Gas Research Institute, the Electric Power Research Institute and Rocky Mountain Energy Company. The project will test a process called Controlled Retracting Injection Point (CRIP) in a 30-foot thick, flat-lying subbituminous coal seam. Stearns Catalytic Corporation of Denver, Colorado, will be the project operator of the experiment with Energy International, Incorporated of Pittsburgh, Pennsylvania, as a subcontractor. The project is near the Hanna underground coal gasification experiments that were conducted by the U.S. Department of Energy in the late 1970s and early 1980s.

In a development related to synfuels, a Denver Company, Carbon Fuels Corporation, also announced in August that they were planning a $10 to $12 million experimental plant to convert coal to "charfuel". The plant would be located in either the Powder River Basin or the Hanna Basin. This "charfuel", which is chemically similar to diesel fuel, is prepared by a patented

process that refines raw coal by removing most of the organic sulfur, nitrogen and hazardous chemicals (such as benzene, toluene and xylene), leaving relatively pure carbon ("char") and a hydrogen-rich liquid. The company is currently searching for funding sources for the project.

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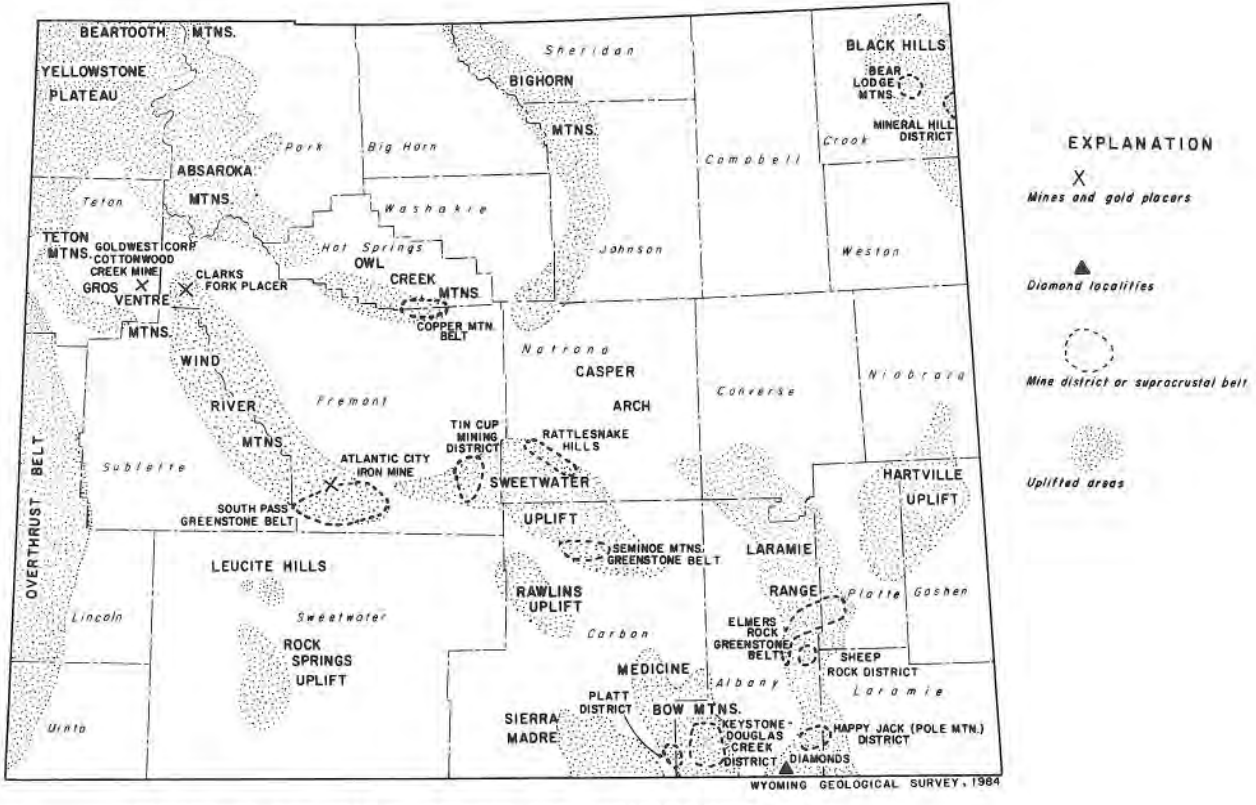
METALS AND PRECIOUS MINERALS UPDATE

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

In the 1985 Annual Report of Silver Lake Resources, Inc. (presently known as International Platinum Corporation, a Canadian company based in Toronto), it was reported that the company had acquired 4,800 acres of land surrounding the historic New Rambler mine (Albany County) for platinum exploration. The company reported that between 1900 and 1918, some high grade copper ore and concentrate shipped from the New Rambler mine, averaged 2.41 ounces per ton palladium and 0.12 ounce per ton platinum. Possible total platinoid production from the mine was 16,870 ounces of palladium and 910 ounces of platinum. Exploration of this area was reportedly initiated on the basis of information reported in several Geological Survey of Wyoming publications (see Currey, 1965; McCallum, 1968; McCallum and Orback, 1968; and Hausel and Harris, 1983).

Interest in platinum mineralization has recently increased in Wyoming, not only because of the worldwide



REGIONS OF EXPLORATION ACTIVITY FOR STRATEGIC MINERALS

increases in platinum prices (recently as high as $650 per ounce), but also because Wyoming has at least two favorable exploration targets. The worldwide increase in the value of platinum was fueled by social unrest in South Africa (one of the principal producers of the precious metal), and by European regulations requiring new vehicles to have catalytic converters, which use platinum.

The two favorable areas for possible platinum mineralization are located in the Medicine Bow Mountains of southeastern Wyoming. These areas are the Lake Owens and Mullen Creek mafic complexes (Houston and others, 1968). The Lake Owens and Mullen Creek layered mafic complexes are similar to the Stillwater Complex in Montana where platinum deposits are presently being developed. Anomalous platinum has been detected at several localities in the Medicine Bow Mountains, particularly along the northern and eastern margin of the Mullen Creek mafic complex. McCallum and others (1976) suggest that the platinoids could have been leached from several small mafic bodies and transported into nearby shear zones, or the platinoids could have been remobilized from the Mullen Creek mafic complex. In addition to the Canadian company, two major mining firms have interests in the area.

The famous Ferris-Haggarty copper mine in the Sierra Madre of southern Wyoming (see Harris and others, 1985, for location) has recently become a topic of interest. The Ferris-Haggarty was Wyoming's principal copper producer and operated from about 1900 to 1908.

According to the Laramie Boomerang (9-2-86), a Denver-based company known as Andover Resources Corporation, plans to put the historic mine back into production. Actual production from the Ferris-Haggarty is not known, but mined high-grade ore ran from 30 to 40 percent copper with some silver and 0.1 to 0.37 ounce per ton gold (Beeler, 1905). The ore at the Ferris-

Haggarty is hosted by Magnolia Formation quartzite of Proterozoic age.

As a final note, some exploration for massive sulfides has been occurring in the Hartville uplift, and a significant amount of exploration for gold has taken place in the South Pass region during the past quarter.

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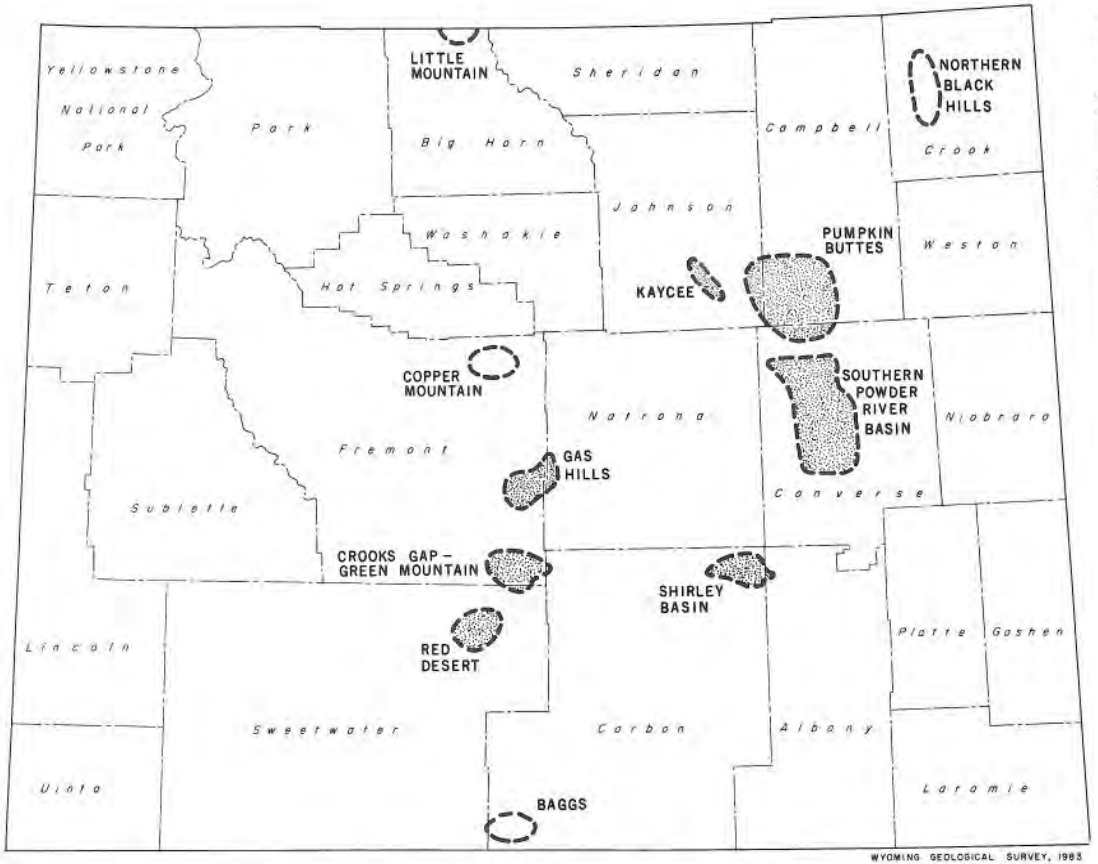
URANIUM AND INDUSTRIAL MINERALS UPDATE

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

Uranium

In the third quarter of 1986, there was still only one uranium mine operating (Pathfinder - COGEMA's Shirley Basin mine) in Wyoming. Pathfinder - COGEMA also continued work upgrading its Gas Hills mill. Everest Minerals continued to operate an *in situ* uranium recovery project at the Highland mine in Converse County in the Southern Powder River Basin District. Two pilot-sized *in situ* projects began in 1986 (AGIP Mining in the Poison Basin District and Malapai Resources in the Pumpkin Buttes District). U.S. Energy is working on plans for development of their Green Mountain deposit southeast of Jeffrey City. Present plans call for an underground mine in the deposit, which averages about 0.3 percent U_3O_8, higher than most Wyoming uranium deposits. Meanwhile, uranium mine reclamation issues and national legislation on uranium import restrictions were in the news. Based on these activities, a slight increase in uranium production is anticipated in future years.



MAJOR ACTIVE AND INACTIVE URANIUM DISTRICTS

Malapai Resources plans to start testing uranium recovery methods on their Christiansen Ranch property. This project is located immediately south of the Irigary Ranch property from which Westinghouse Electric Corporation produced small amounts of uranium by an *in situ* process around 1980. Malapai has identified 30 million pounds of U_3O_8 reserves on their property. Their test program, set to begin in three to six months, plans to produce about 25 gallons per minute of pregnant solution (uranium-bearing) from the test field using portable equipment. Malapai is also conducting baseline studies for a commercial permit. Commercial scale production is expected to begin in one to 1-1/2 years. If feasible, Malapai may produce from the Irigary property as well.

Pathfinder Mines, Incorporated, 80 percent of which is owned by the French uranium mining and enrichment company COGEMA, proposed changes to the reclamation guidelines in Wyoming's Environmental Quality Act. The proposed changes primarily addressed the timing of reclamation, so that property acquired from another company would not have to be reclaimed if it was to be mined later. Pathfinder's petition, however, was tabled by the Wyoming Environmental Quality Council in September.

The Environmental Protection Agency (EPA) has proposed Federal regulations that apply to mine wastes from hardrock mines, phosphate, oil shale and asbestos mines as well as uranium mines. The mining industry was critical of the proposed regulations since uranium mine wastes are already regulated by other agencies, both state and Federal.

A bill to restrict uranium imports and establish a fund for cleaning up uranium mill tailings was introduced in the U.S. Senate by Wyoming Senator Alan Simpson and New Mexico Senator Pete Domenici. If adopted, this bill would aid the domestic uranium mining industry by requiring utilities to purchase uranium for

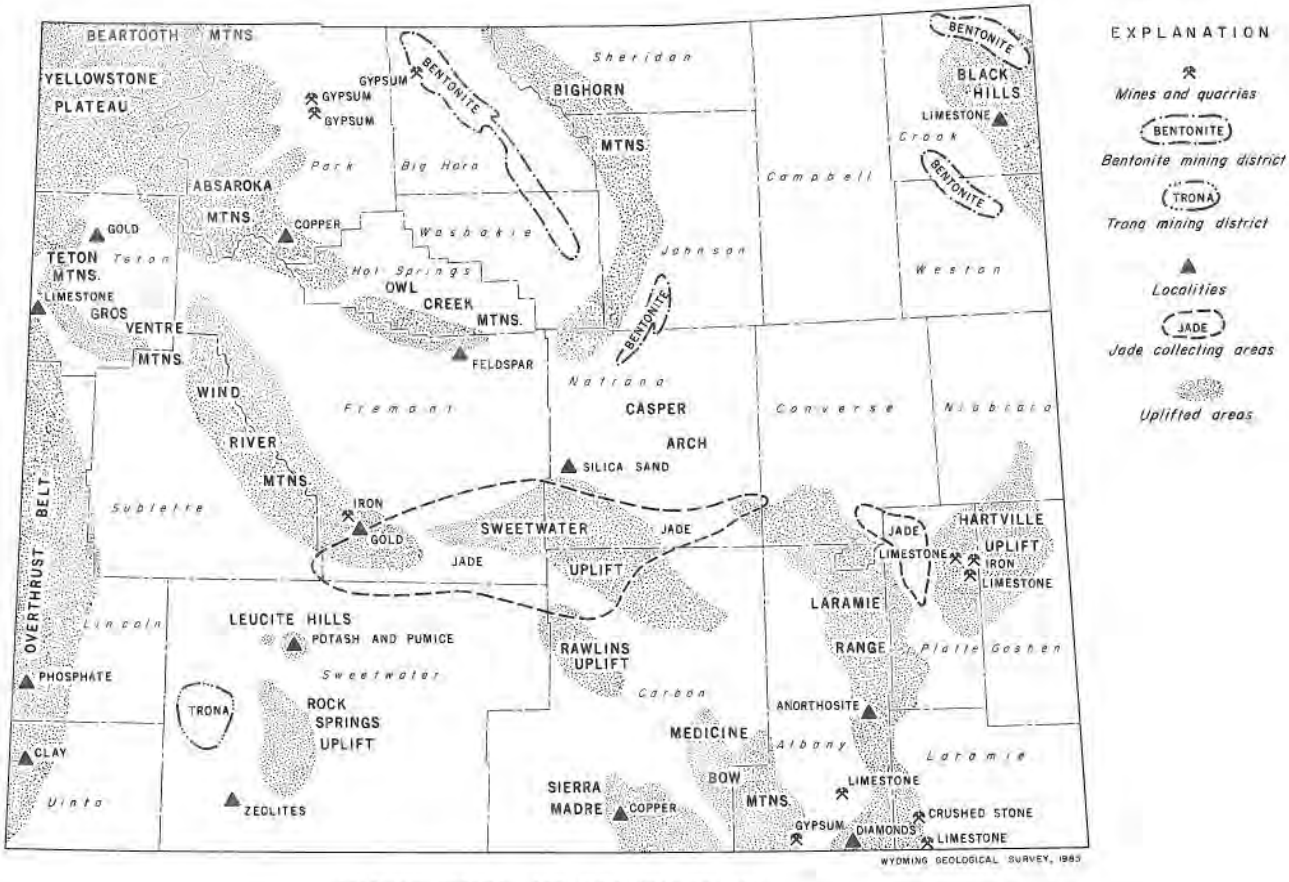
power plants from U.S. producers. Meanwhile, a Federal Court ordered the U.S. Department of Energy to reduce by 75 percent the amount of foreign uranium that it enriches to power plant grade U-235 and to limit its future enrichment activities to domestically-produced uranium.

As in the previous four years, there was little uranium exploration in Wyoming this summer. Only the Rocky Mountain Energy - Taiwan Power (Taipower) joint venture announced Wyoming exploration plans (see *Wyoming Geo-notes No. 10*, p. 21). Some land acquisition and(or) exploration may also have occurred in the Powder River Basin. The only significant uranium exploration activity in the United States in 1986 was in the Colorado Plateau area of northern Arizona.

Trona

The U.S. Bureau of Mines reports that trona production in 1986 continued at a rate slightly higher than 1985. According to the Wyoming Department of Revenue, 1985 production was less than one percent below 1984 production. Trona is Wyoming's largest (in terms of revenue generated) non-fuel mineral. Soda ash (refined trona) exports are increasing. New export contracts have been let to Mainland China, Korea, Australia and Scandanavia, according to the cooperative marketing organization, the American Natural Soda Ash Corporation.

Wyoming's five soda ash producers, FMC, General Chemical Company (formerly Allied Chemical), Stauffer Chemical, Tenneco and TG are still operating at an average 70 percent capacity. Producers expect to increase production from one to five percent over the next five years. It is not likely that there will be either major growth or a major decline in Wyoming's trona production during that time. Soda ash prices are expected to increase slightly.



SELECTED MINERAL AND ROCK OCCURRENCES

General Chemical Company laid off about 90 employees in early August, following reorganization of the former Allied Chemical Company. The company said the layoffs were necessary to cut costs. The workforce at General is now about half of what it was in 1979.

Phosphate

Chevron Chemical Company dedicated its new phosphate processing plant near Rock Springs in early September. Construction on the plant, which employs about 200 people, began in 1983. This plant processes phosphate mined north of Vernal, Utah. The phosphate is transported to the plant via a slurry pipeline. Sulfur from Chevron's Carter Creek gas processing plant in Lincoln County is combined at the plant with the phosphate to produce fertilizer.

According to the U.S. Bureau of Mines, the domestic consumption of phosphate for fertilizer has been declining for the past five years. The plant most affected by the opening of Chevron's Rock Springs plant is owned by J.T. Simplot Company in Pocatello, Idaho. Simplot announced the need to lower wages to remain competitive with the Chevron plant and to keep their plant open.

Sulfur

Nationally, sulfur production was down about one percent for the first half of 1986 from the corresponding period in 1985. Imports however, declined 35 percent in the same time period due to the depletion of Canadian supplies. Prices increased $5.00 per ton in the first six months of 1986 according to the U.S. Bureau of Mines. In Wyoming, sulfur from Chevron's Carter Creek gas plant is now being used at the new phosphate plant at Rock Springs, and sulfur from Exxon's new Shute Creek gas plant has been committed to

contract. There have been no new developments regarding the mining of natural sulfur deposits in Wyoming in this last quarter.

Cement

Mountain States Cement Company in Laramie continued plant modernization and exploration for new supplies of limestone and gypsum. The Albany County Commissioners agreed to lower taxes paid by Mountain States by reducing the plant's assessed value, thereby providing an incentive for continued operation. Currently, the plant employs about 30 persons. Nationally, cement production is running about ten percent more than last year according to the U.S. Bureau of Mines.

Limestone

Both the Torrington sugar refinery and the Laramie River power plant are seeking new lime sources. The Torrington refinery, which imports limestone from South Dakota for use in the refining of sugar beets, is looking for a closer source. The Laramie River power plant uses limestone in stack scrubbers. They are currently using limestone from stockpiles at the Holly Sugar Lost Day quarry north of Fort Laramie, but they are looking for a source of limestone to replace that supply when it is depleted. The Hartville uplift area is probably the nearest source area for these limestone requirements.

Crushed limestone is the principal aggregate used on Wyoming's highways. Construction projects throughout Wyoming used large quantities of limestone aggregate this summer.

Gypsum

Gypsum production in Wyoming remained at high levels in 1986. Nationally, gypsum production also remained high, but production is below the record levels of December, 1985, and January, 1986. These two national production increases were not reflected in Wyoming, however, as regional construction did not peak at the same time here. Mountain States Cement Company in Laramie was searching for new gypsum supplies in the third quarter of 1986 and conducted exploration drilling on some areas in Albany County.

Stone

Basins, Incorporated, which produces white marble at Wheatland, was purchased by Georgia Marble Company. There was no immediate change in production, however. A proposal to mine "pumice" (actually a potash-rich igneous rock) at a location near Superior in Sweetwater County, was denied by the Wyoming Environmental Quality Council for environmental reasons. There has been no announcement of plans to mine the rock in a less environmentally - sensitive area.

The Geological Survey of Wyoming published an Open File Report (86-20) regarding sinter (including travertine) deposits in Wyoming (see page 53). Sinter deposits have been used as a source for ornamental stone in the past.

Other Industrial Minerals

Bentonite production continues to decrease as domestic oil well drilling decreases.

The Geological Survey of Wyoming published Open File Reports on pumice and pumicite (86-17), diatomite (86-16) and ballast (86-22) (see page 53). Pumice and

pumicite are used as aggregates and abrasives; diatomite is primarily used in filters and filter aids. Pumicite has been locally produced in Wyoming in the past. The occurrence of diatomite had not previously been summarized for Wyoming.

Ballast is crushed aggregate used specifically for weighting and holding railroad ties in place. The three railroads operating in Wyoming produce ballast from Wyoming.

STRATIGRAPHY UPDATE

by Alan J. VerPloeg, Stratigrapher, Geological Survey of Wyoming.

In regard to geologic mapping, the Stratigraphy Section of the Geological Survey of Wyoming is currently working on a field mapping project funded by the U.S. Geological Survey under its COGEOMAP Program. The area being mapped is west of Kaycee, Wyoming, on the southeastern flank of the Bighorn Mountains. The majority of this area was last mapped by Darton in 1906 at a scale of 1:250,000. Field work for Fraker Mountain and Barnum 7½-minute Quadrangles was completed during the summer of 1985. Mayoworth and Red Fork Powder River Quadrangles were completed during the summer field season of 1986. These four quadrangles will be released as open file maps at a 1:24,000 scale during the winter of 1987. Tabletop and Turk Springs Quadrangles will be mapped next field season. As planned, the project will involve the geologic mapping of twenty quadrangles. The Geological Survey of Wyoming will eventually publish a colored version of each map as part of its Map Series. Also, upon completion of the mapping project, the Survey will compile all twenty maps into a single map at a 1:100,000 scale with cross sections and a discussion of the regional geology and stratigraphy.

In addition, the Metallic Minerals Section of the Survey is preparing geologic maps at a scale of 1:24,000 for the South Pass - Atlantic City area along the southern end of the Wind River Mountains in Fremont County. During 1985, preliminary geologic maps of Radium Springs and Lewiston Lakes Quadrangles were completed. In 1986, Anderson Ridge and NE Parting of the Ways Quadrangles were mapped; South Pass City, Atlantic City and Miners Delight Quadrangles are scheduled for revision in 1987. Upon completion of these 1:24,000 scale maps, a 1:100,000 scale map of the region will be produced and published by the Survey.

The Wyoming Geological Association's Nomenclature Committee is currently in the process of compiling a new stratigraphic nomenclature chart for the State of Wyoming. The current chart was last updated in 1969. This new expanded chart will include additional columns for most of the basins, to better illustrate stratigraphic nomenclature changes across the basins.

Six columns are planned for the Powder River Basin; the Bighorn Basin, the Wind River Basin and the Greater Green River Basin will consist of four each; the Thrust Belt will have three; the Denver Basin will have two; and the Laramie, Shirley and Hanna Basins as well as Jackson Hole will have one. The columns will have a vertical scale in millions of years and formations will be color coded as to lithology. Notes will document the age of the various formations as determined by fossil evidence. Anyone wishing to volunteer their assistance on any of the basins or individual columns may call Hal Boyd at (307)265-7086. It is hoped that these new columns will clear up any confusion over existing informal stratigraphic nomenclature. A first draft for comment is expected in 1987.

The Stratigraphy Section of the Survey is assisting in a biostratigraphic study of the Frontier Formation at Cumberland Gap south of Kemmerer, Wyoming. The Section is cooperating in this project with Dr. William E.

Frerichs of the University of Wyoming's Department of Geology and Geophysics, and one of his students, Chris McRoberts. The study will emphasize microfossil identification, rock description and geochemistry derived from samples collected from outcrops of the Frontier Formation. The results will be tied into the detailed described section of Cobbin and Reeside (1952). In addition, some shale samples may be analyzed for total organic carbon to get a better picture of the Frontier as a hydrocarbon source rock.

If you want to know who is doing what in geology in Wyoming or who has done what, there are a number of publications from the Geological Survey of Wyoming to help you. The newest publication is titled, *Ongoing studies on the geology of Wyoming*, which was released as Open File Report 86-21. This report lists 135 ongoing geologic projects in the State and was based primarily on the replies from more than 500 questionnaires mailed to various universities and Government agencies earlier this year (see page 53). A list and map that show geology field camps, run by various universities but located in Wyoming, were included in *Wyoming Geo-notes* No. 9, (December, 1985).

Another new publication is Open File Report 86-19, which is an index map to graduate theses maps of the University of Wyoming's Department of Geology and Geophysics (1980-1985) (see page 53). This map supplements four new index maps published in the Map Series (MS). These four maps depict the location of graduate theses maps completed between 1928-1949 (MS-9N), 1950-1959 (MS-9O), 1960-1969 (MS-9P) and 1970-1979 (MS-9Q). There are 13 other MS-9 series maps which show other areas of the State for which there are geologic maps.

Late last year the Survey published the *Bibliography and index of graduate theses and dissertations of the Department of Geology and Geophysics, University of Wyoming*, and the year before, it published a similar publication on theses and dissertations exclusive of

the University of Wyoming (Public Information Circular 24).

In addition, the Survey has published conventional bibliographies on Wyoming geology for the years 1823 through 1969.

A complete listing of all these publication is in the Survey's free list of publications.

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GEOLOGIC HAZARDS UPDATE

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

Earthquake activity in Wyoming for the period of January through August has been relatively minor. Most of the earthquakes that occurred were barely felt. As usual, most of the activity has been in the Yellowstone National Park - Hegben Lake area. A summary of the activity is presented on page 46.

To answer numerous questions on earthquakes and earthquake activity in the State, the Geological Survey of Wyoming published a report titled, *Earthquakes and related geologic hazards in Wyoming* (see page 53). The report is Public Information Circular 26 and is available from the Geological Survey of Wyoming in Laramie as well as from the Wyoming Oil and Gas Conservation Commission office in Casper, Wyoming.

Date	Location	Magnitude/Intensity
January 15	Yellowstone National Park	ML 2.8/Felt Intensity II at West Yellowstone
February 11	Yellowstone National Park	ML 4.1
January 16	Hegben Lake Area	ML 3.4/Felt Intensity III at Madison Junction
March 2	Hegben Lake Area	ML 3.2
April 4	Hegben Lake Area	ML 3.0
April 18	Hegben Lake Area	ML 3.2/Felt Intensity II at Old Faithful
April 29	South of Point of Rocks near the State Line	ML 2.5
June 12	Northern Laramie Mountains southwest of Douglas	ML 3.0
June 21	Eastern Idaho	ML 3.5/Felt Intensity IV at Auburn, Wyoming

Landslides continued to be a problem in the State, resulting in the partial or complete closing of numerous roads. In addition to the road damage, an irrigation canal was closed due to landslide activity near Arlington. Although landslide damage estimates are not generally calculated for the State, and none have been generated for 1986, the Wyoming Highway Department estimated that maintenance charges alone for landslide damage to highways in FY 1985 came to $365,000.

The Geologic Hazards Section of the Geological Survey of Wyoming is completing a four-year study on landslides in Wyoming. A map showing locations of existing landslides, and a report describing landslide processes is in preparation. Studies have shown that there are numerous landslides in the State that have not been recognized or previously described. Many of the landslides are located in remote areas away from

human habitation and as such have caused little monetary damage to date.

A summary of known damaging landslides that have occurred to date this year is presented below:

Arlington Area: In June, an earthslide-earthflow occurred southeast of Arlington. This landslide disrupted and closed an irrigation canal. Adjacent to the existing slide, another slide was developing at the time a field inspection was conducted. The landslide is visible from Interstate 80. A report on this landslide is available upon request.

Bondurant Area: In April, U.S. Highway 187 was moved and partially covered by a landslide approximately five miles southeast of Bondurant. Active landslides had been identified in the vicinity prior to the present occurrence.

Hoback Junction Area: Numerous landslides have been mapped in the Hoback Junction area, many of which are active. One area that has destabilized in the past and moved again this year is one mile south of the junction on the northwest side of Highway 89. Another is just north of the junction on the east side of the highway. All the landslides in the area have been recently mapped by the Geological Survey of Wyoming's Geologic Hazards Section.

Jack Creek: In April-May a slump-earthflow that has been recurrently active, destabilized and destroyed a county road along Jack Creek northeast of Bondurant. Jack Creek was partially diverted and nearby cabins were threatened. By the end of May, the landslide had stabilized.

Atlantic City Area: A slope movement in 1985 that occurred during the reconstruction of Wyoming Highway 28 reactivated in 1986 near Beaver Creek north of Atlantic City. The movement occurred before drains were installed in early summer.

Miller Mountain Area: Miller Mountain is located south of Rock Springs on the east side of the Flaming Gorge Reservoir. Landslides have occurred for many years where U.S. Highway 191 traverses the southern portion of Miller Mountain and the eastern flank of Little Mountain to the south. The highway has been frequently closed or disrupted at those two locations in the past. This year, landslide activity near the road is apparent, but no landslides have greatly disrupted it. The Geological Hazards Section of the Survey conducted a slope stability study in the area in 1983-1984. Results of that study and a geologic and landslide map of the area are available for viewing in Laramie.

Salt River Pass: This area is located south of Afton in Lincoln County. In early spring, material used as fill for U.S. Highway 89 destabilized below the level of the road, requiring some reconstruction.

Sheridan - Beckton Area: A small slump-earthflow disrupted Wyoming Highway 331 between Sheridan and Beckton.

Tensleep Canyon Area: A landslide covered part of U.S. Highway 16 between Ten Sleep and Buffalo earlier this year. The landslide was located near the first switchback out of Ten Sleep towards Buffalo. A drain was put in to stabilize the slide.

Thayne Area: In May, U.S. Highway 89 was closed south of Thayne (Star Valley) near the Narrows. Attempts were made to remove the slide material covering the highway before the slide had completely stabilized. This resulted in renewed activity and considerable road destruction. A detour around the slide used local roads.

Togwotee Pass Area: Numerous landslides have occurred in the Togwotee Pass area in the past. This year U.S. Highway 287 was being realigned and moved to the north. As the slope was being cut, it destabilized and threatened the highway. It is suspected that a portion of the cut was in older landslide debris.

The highway will now be moved to the south over road bed fill material that destabilized last year. Attempts are being made to stabilize the fill area before reconstruction. This area has been recently mapped for landslides by the Geological Hazards Section of the Survey.

Radon has been in the news lately. Very little work has been done concerning radon sources and radon migration in Wyoming. In order to guide future radon studies, the Geologic Hazards Section of the Survey, in collaboration with the Uranium and Industrial Minerals Section, generated a *Planning guide map for radon studies in Wyoming*. The map identifies areas of higher than normal background gamma radiation, which can be an indication of radon. Not all gamma radiation, however, is associated with radon. The map, which is available as Open File Report 86-18, is only for use as a guide to planning future studies (see page 53). Much field work is needed before areas actually generating radon can be delineated.

Vegetation, water, soil and rocks in the vicinity of Savery, Wyoming, are being examined to determine their selenium content. This project is a cooperative

effort of the U.S. Geological Survey, the University of Wyoming and the Geological Survey of Wyoming and is funded by the Wyoming Water Development Commission. This area includes the site of the proposed Sandstone reservoir near Savery and is part of a geotechnical study for the dam site.

In regard to selenium-bearing areas, late last year the Geologic Hazards Section of the Geological Survey of Wyoming prepared a preliminary map of potentially seleniferous areas in Wyoming as a planning guide to future studies of the occurrences of this element. This Open File Report 85-14 is available from the Geological Survey (see page 53).

SAND CREEK AREA, WYOMING

The Sand Creek area has spectacular scenery and great scientific interest, with large cross-bedded sandstone pillars and monuments, beautifully eroded sandstone cliffs, an unusual erosional feature known as Camel Rock (or Chimney Rock), an interesting fossil deposit, sand dunes and blowouts.

The drive southwest from Laramie to Sand Creek covers 30 miles of rather monotonous prairie. It never fails to amaze visitors to the Sand Creek area when the beautiful erosional features, reminiscent of the arid southwest, suddenly come into view. To the east are pillars and monuments of bare rock consisting of finely cross-laminated white Casper Formation and red Fountain Formation arkose. These features occur as isolated conical hills or clusters, and they are usually surrounded by small sand dunes that result from the current dry climate and persistent winds. To the west is a sheer cliff of red and white sandstone that in places rises 300 feet above the road. The cliff has been carved into a number of fascinating features by wind and water. On the edge of the cliff at the top, the large festoon cross-bedded sandstones of the Casper

Formation are eroded into individual conical hills. Near the south end of the area, on the Colorado-Wyoming border is a feature known as Camel Rock or Chimney Rock. It is a large erosional feature 200 feet high that was isolated from the main cliff to the west by erosion. From the north or south it resembles a large chimney. In side view, however, it resembles a camel.

During the Pennsylvanian Period, about 280 million years ago, granite was eroded from the ancestral Rocky Mountains and deposited as alluvial fans. This coarse arkosic sediment is known as the Fountain Formation, and it is found in the Sand Creek area resting on the Precambrian Sherman Granite (greater than 1.7 billion years old). This classic unconformity (the surface of erosion between the Fountain Formation and the Sherman Granite) represents a hiatus of more than a billion years.

The younger white festoon cross-bedded sands of the Casper Formation were deposited at the edge of a Pennsylvanian sea in shallow nearshore waters (Knight, 1929) or in coastal sand dunes (Steidtmann, 1974; McKee, 1979).

A late Pleistocene fossil deposit in an animal trap discovered in the area indicates a much colder environment in the Sand Creek area about 11,000 years ago. Fossils from the deposit include a large extinct Pleistocene mountain lion, an extinct eagle-like vulture, an extinct marten and many animals not presently found in the area (Hager, 1973). In addition, the deposit provided evidence that very ancient Indians inhabited the area.

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RECENT AND NEW PUBLICATIONS BY THE GEOLOGICAL SURVEY OF WYOMING

**Geologic highway map of Wyoming*, compiled by R.D. Christiansen, 1986, scale 1:1,000,000 (color), ($6.00).

**Fifty-third annual report of the Geological Survey of Wyoming, for fiscal year 1986, July 1, 1985 to June 30, 1986*, G.B. Glass, 1986, (free).

**History of the Geological Survey of Wyoming*, W. Bryans, Bulletin 65, 1986, ($6.00).

**Minerals and rocks of Wyoming*, W.D. Hausel, Bulletin 66, 1986 ($5.00).

**Index of geologic maps of Wyoming included in 1928-1949 graduate theses from the University of Wyoming*, compiled by R.H. DeBruin, MS-9N, 1986, ($2.50).

**Index of geologic maps of Wyoming included in 1950-1959 graduate theses from the University of Wyoming*, compiled by R.H. DeBruin, MS-9O, 1986, ($2.50).

**Index of geologic maps of Wyoming included in 1960-1969 graduate theses from the University of Wyoming*, compiled by R.H. DeBruin, MS-9P, 1986 ($2.50).

**Index of geologic maps of Wyoming included in 1970-1979 graduate theses from the University of Wyoming*, compiled by R.H. DeBruin, MS-9Q, 1986 ($2.50).

Geologic map of Sheep Canyon Quadrangle, Wyoming, R.E. Ladd, Map Series MS-20, 1:24,000 scale, color, 1986, ($3.00).

Construction materials map of Wyoming, R.E. Harris and J.E. Meyer, Map Series MS-21, 1:500,000 scale, color, 1986, ($10.00).

Preliminary report and map on potentially seleniferous areas in Wyoming, J.C. Case and C.S. Boyd, Open File Report 85-14, 1985 ($3.50).

**Diatomite (diatomaceous earth) in Wyoming*, R.E. Harris and J.K. King, Open File Report 86-16, 1986, ($2.00).

**Pumice, scoria and pumicite in Wyoming*, R.E. Harris and J.K. King, Open File Report 86-17, 1986, ($3.00).

**Planning-guide map for radon studies in Wyoming*, compiled by J.C. Cannia and J.C. Case, Open File Report 86-18, scale 1:500,000, 1986, ($4.00).

**Geologic maps of Wyoming included in 1980-1985 graduate theses from the University of Wyoming*, compiled by A.J. VerPloeg and P.L. Greer, Open File Report 86-19, 1986, ($3.00 ordered separately or free with each purchase of the four Geological Survey of Wyoming Map Series indexes MS-9N, MS-9O, MS-9P and MS-9Q).

**Sinter (including travertine) resources of Wyoming*, R.E. Harris and J.K. King, Open File Report 86-20, 1986, ($2.50).

**Ongoing studies on the geology of Wyoming*, compiled by P.L. Greer and A.J. VerPloeg, Open File Report 86-21, 1986, ($2.00).

**Ballast in Wyoming*, R.E. Harris, Open File Report 86-22, 1986, ($3.00).

Metallic and nonmetallic deposits of Wyoming and adjacent areas, 1983 Conference Proceedings, edited by Sheila Roberts, Public Information Circular 25, 1986, ($8.00).

**Earthquakes and related geologic hazards in Wyoming*, J.C. Case, Public Information Circular 26, 1986, ($5.00).

Foreland compressional tectonics: southern Bighorn Basin, and adjacent areas, Wyoming, D.L. Blackstone, Jr., Report of Investigations 34, 1986, ($8.00).

**Coal resources of the Tongue River Member, Fort Union Formation (Paleocene), Powder River Basin, Wyoming and Montana*, W.B. Ayers, Jr., Report of Investigations 35, 1986, ($3.00).

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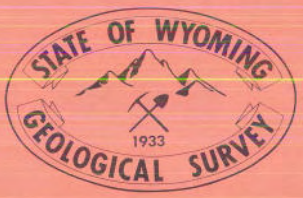
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