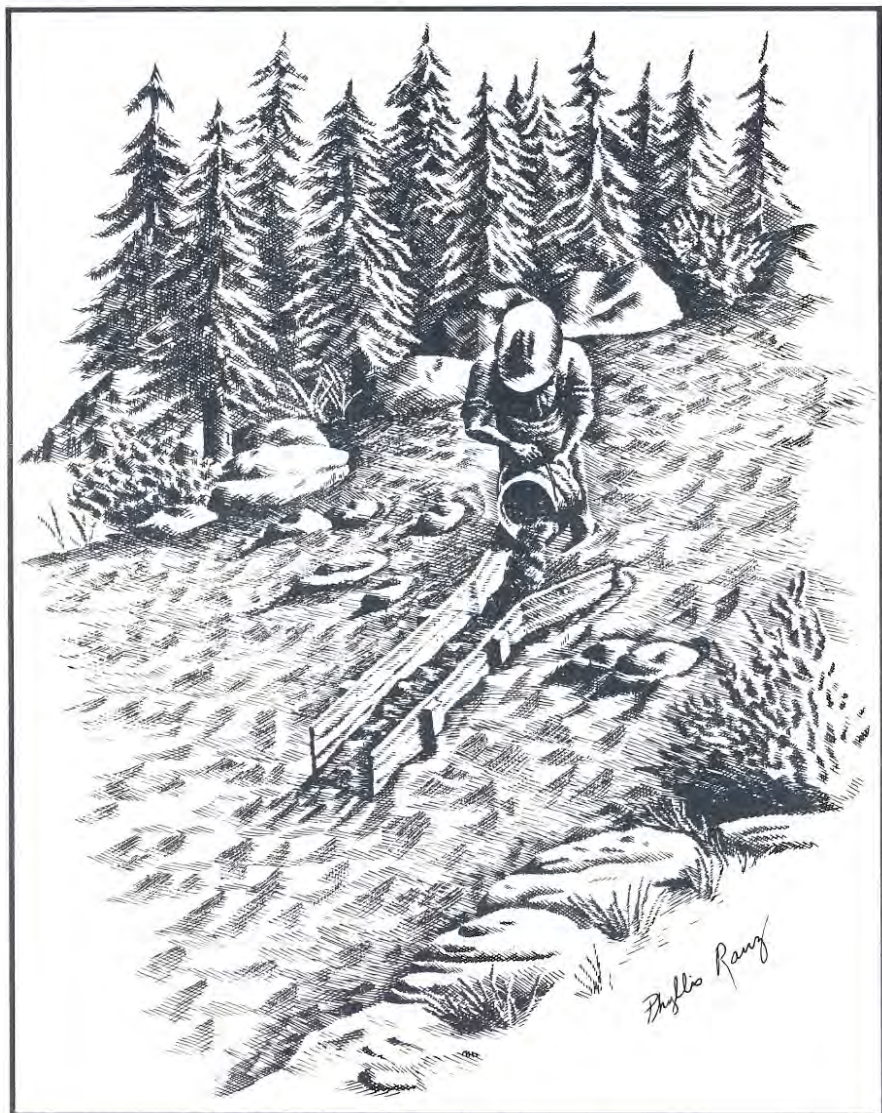


Gary B. Glass, State Geologist
THE GEOLOGICAL SURVEY OF WYOMING

WYOMING GEO-NOTES NO. 22



LARAMIE, WYOMING
April, 1989

THE GEOLOGICAL SURVEY OF WYOMING

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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 \$5.00) or as single copies at \$1.50 each.

Front cover: Historic one-man gold placer mining operation (drawing by Phyllis A. Ranz). The illustration is from *The geology of Wyoming's precious metal lode and placer deposits* by W. D. Hausel, [Geological Survey of Wyoming Bulletin 68 (1989)]. This new bulletin summarizes 10 years of research into Wyoming's precious metal districts, mines, prospects, occurrences, and anomalies. There are 248 pages of descriptions, maps, and assay data to back up the author's contention that Wyoming has tremendous potential for commercial precious metal deposits.

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- Please note -

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Several lines are accessed by this
single number, so you should
experience fewer busy signals.

*We hope this change will be more
convenient for everyone.*



MINERALS UPDATE

OVERVIEW

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

The pleasant surprises mentioned at the end of last year continued into the first quarter of 1989 and have made the writing of this update rather upbeat for a change. Oil prices, which strengthened at the end of 1988 following OPEC's agreement on new reduced production quotas, have gradually risen through the new year to where Wyoming Sweet crude was quoted at more than \$19.00 a barrel in early April. At least on the short term, these higher oil prices look like they will continue. This is welcome news to the domestic oil industry and to states like Wyoming that are heavily dependent on the production and value of oil for their revenue. Incidentally, the Oil and Gas Update in this issue includes a new table depicting historical oil prices, and there is a new report on oil and gas activities in Wyoming in the 1980s at the printers.

While a new Wyoming to California gas pipeline is still not a reality, its likelihood of being built remains strong. Recently several California utilities that formerly opposed a new pipeline have changed their stand on the matter. Also there are now some potential markets for the gas besides enhanced oil recovery operations.

Without a doubt, coal production provided as great a surprise as the sustained increases in oil prices. Our estimates for 1988 coal production increased each quarter and looked like about 155 million tons at the end of the year. Preliminary production for 1988 as reported by the Wyoming State Inspector of Mines, however, showed a record setting 163.6 million tons! While this increase probably did not make Wyoming production the highest in the Nation, it certainly cinched second place once again with only Kentucky producing more coal. Considering this kind of production, Dick Jones, the Head of the Coal Division, has considerably revised his forecast for future production. Those revisions are shown in the tables on pages 2 and 15.

In regard to some other minerals, trona production has remained high through the first quarter; plans for a new uranium mine at Green Mountain and a new bentonite mine near Casper are continuing; and there was some encouraging activity in regard to gold properties in the State.

At this time there is no reason to suspect that the optimism of this first-quarter report will deteriorate in the second quarter of 1989.

Wyoming mineral production forecast to 1992¹.

Calendar Year	Oil Production ²	Methane Production ³	Carbon Dioxide Production ³	Helium Production ⁴	Coal Production ⁵	Trona Production ⁵	Mined Uranium Production ⁶	In situ Uranium Production ⁷	Sulfur Production ⁸
*1981	122.1	455.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	465.1	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	539.7	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	600.1	—	—	130.7	11.0	1.6	—	0.63
*1985	131.0	597.9	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	563.2	23.8	0.15	136.3	13.3	0.3	—	0.66
*1987	115.9	622.7	110.5	0.84	146.5	13.6	0.2 ⁸	0.06	1.20
1988	114.0	683.0	110.5	0.84	163.6	15.1	0.02	3.0	1.20
1989	116.0	708.4	110.5	0.84	165.0	15.3	0.02	3.0	1.20
1990	110.0	728.0	110.5	0.84	165.0	15.5	0.02	3.0	1.20
1991	103.0	748.1	110.5	0.84	167.0	15.5	0.02	3.0	1.20
1992	96.5	768.9	110.5	0.84	168.0	16.5	0.02	4.0	1.20

*Actual values for comparison; ¹Geological Survey of Wyoming, April 1989; ²millions of barrels; ³billions of cubic feet; ⁴billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; ⁵millions of tons; ⁶millions of tons of uranium ore (not yellowcake); ⁷millions of pounds of yellowcake (U₃O₈), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1988-1992 are based on company information); ⁸millions of tons, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission; ⁹includes previously stockpiled ore processed by the Lucky Mc mill in 1987.

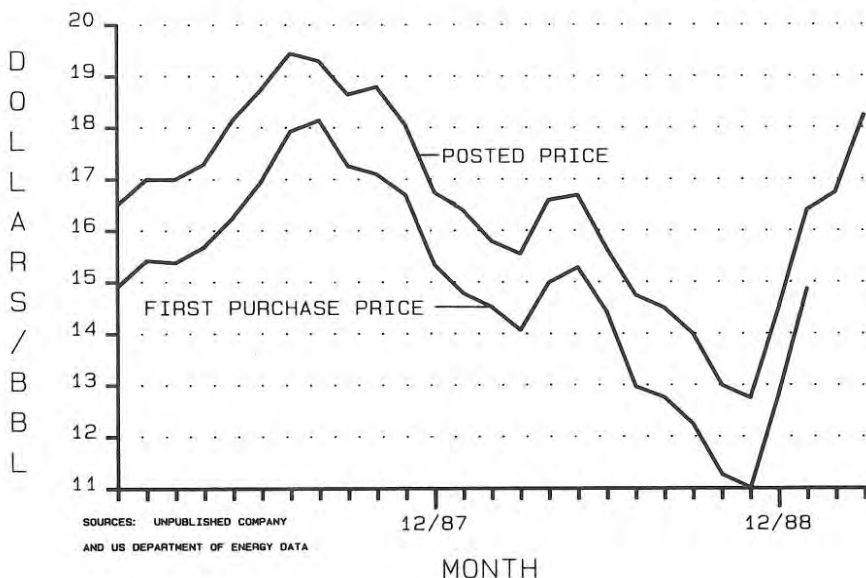
OIL AND GAS UPDATE

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

The price of Wyoming crude oil has been increasing since the OPEC production agreement was finalized at the end of November, 1988. The average posted price for Wyoming Sweet crude oil for March was \$18.25 per barrel. This compares to an average posted price of \$12.75 per barrel in November of last year before the OPEC agreement was signed. The price of crude oil over the last four months rebounded to its highest level since Fall, 1987, because OPEC adhered to production quotas, several non-OPEC countries agreed to small production cuts, and the demand for products was strong. In early April, futures prices were fluctuating around \$20 per barrel for May delivery and the posted price had topped \$19 per barrel. The average price Wyoming producers receive for their oil, however, is still over \$1 per barrel less than the average posted price. Adjustments for low gravity crude oil account for most of the discrepancy between the average posted price and the price that producers actually receive.

The figure on page 3 shows a comparison between average monthly posted prices (selected company price bulletins) and average monthly first purchase prices (unpublished figures from the U.S. Department of Energy). Average first purchase

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



prices for February and March are not available yet; however, they should be between \$15 to \$16.75 per barrel.

Very preliminary production figures (Petroleum Information, 1989) show that Wyoming produced 114 million barrels of oil and 793.4 billion cubic feet of natural gas in 1988. Gas production was approximately 110.5 billion cubic feet of carbon dioxide and 682.9 billion cubic feet of combustible natural gas.

Oil production was 3 million barrels lower than predicted for 1988 because of the very low crude oil prices in the last half of 1988. Wyoming producers received an average of \$13 or less per barrel during this six-month period (see figure above). Two very large oil fields in the State, Lost Soldier and Powell, produced a total of 1 million barrels less oil than expected. Powell had several wells shut in and reservoir pressure was being increased in Lost Soldier for carbon dioxide injection. Carbon dioxide injection at Lost Soldier Field, however, began at the end of January and an Amoco spokesman predicted substantial increases in oil production from the field by the end of 1989.

In a related item, the Legislature passed a bill which extends the existing severance tax break for enhanced oil recovery (EOR) projects. To qualify for this tax break, a company engaged in an EOR project must employ certain kinds of workers within the State or more than half its ownership or employees must live in Wyoming.

Combustible natural gas production was slightly lower than predicted due to mild winter weather in November and December. Production is still estimated at about 60 billion cubic feet higher than 1987 production (9.7 percent increase). Half

of the increase in production came from Swan, Blue Forest, and Lincoln Road Fields on the Moxa arch in southwestern Wyoming. Together these three fields produced an estimated 30 billion cubic feet more than they did last year.

There are many favorable signs that natural gas production in the State could expand tremendously in the next few years. In January, the Wyoming Oil and Gas Conservation Commission granted Union Pacific Resources' application to drill 100 additional gas wells in a 100-square-mile area of the Green River Basin (T.17-20N. and R.111-113W.). The ruling allows a second well for each square mile in the area. Plans call for two rigs to drill the first 40 wells. Those 40 wells will be evaluated before the last 60 wells are drilled. Union Pacific estimates that each new well will produce 3.5 billion cubic feet of gas.

Enron Oil and Gas recently announced plans to double production from Big Piney Field in southwest Wyoming. Plans are to drill as many as 200 wells in the next three to five years. Enron has letters of intent that call for transportation and sale of 50 million cubic feet of Big Piney gas per day in 1989 and 100 million cubic feet per day by 1992. Increased production should begin in the fourth quarter of 1989.

The possibility of a Wyoming to California pipeline is apparently increasing. After his return from a three-day trip to California, Governor Sullivan noted that Wyoming is in a very good competitive position for the natural gas pipeline to Kern County, California. Coupled with additional pipeline capacity from Canada, the California Energy Commission's report on alternate interstate pipeline projects rated Wyoming's pipeline the best. The report showed a \$14.6 billion gain to California from the pipeline and a \$6.3 billion loss if California does nothing.

The WyCal proposal to build a Wyoming to California pipeline recently won approval from the Federal Energy Regulatory Commission (FERC), and was the first to do so. It is likely that two other proposals (Kern River and Mojave) will also be approved. WyCal announced an agreement with Pacific Gas and Electric (PG&E) whereby PG&E agreed to withdraw its opposition to WyCal's pipeline proposal. WyCal will provide shippers with the option of utilizing WyCal's proposed pipeline facilities in California or of utilizing PG&E's existing pipelines within California.

In another step forward, Southern California Gas lifted its opposition to the Kern River proposal and has agreed to take delivery of some of the gas. Kern River also announced that it now has contracts and letters of intent which total nearly 400 million cubic feet per day from shippers in California. The newest letter of intent is with the city of Long Beach. This letter indicates that there is a market for Wyoming gas outside the enhanced oil recovery (EOR) market. It is estimated that a pipeline from Wyoming to California would increase Wyoming's natural gas production by 180 billion cubic feet a year.

Lease sales continue to do relatively well despite the present low drilling activity in the State (see table on page 5). The high per-acre bid at the February U.S. Bureau of Land Management (BLM) sale was \$1,225 by BTA Oil Producers for a 360-acre lease in section 20, T.13N., R.114W. near Taylor Ranch Field. Five other tracts in the sale drew bids over \$100 per acre. Yates Petroleum submitted high bids on 36 tracts. Yates picked up 55 parcels at the December, 1988, BLM sale.

The high bid at the Wyoming Department of Public Land's January sale was

**WYOMING FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES
BLM SALES**

Month	Total Revenue	Number of parcels offered	Number of parcels sold	Total acres	Acres sold	Average price per acre sold	High price per acre
1987							
February	\$814,653	78	64	18,866	15,537	\$52.43	\$1,226.56
April	\$779,821	95	68	23,338	16,214	\$48.10	\$332.00
June	\$6,436,196	123	121	26,188	25,668	\$250.75	\$6,555.00
August	\$1,327,186	81	74	22,908	21,055	\$63.03	\$800.01
October	\$3,274,611	137	129	34,858	33,828	\$96.80	\$6,031.15
December	\$3,091,692	213	190	71,264	65,658	\$47.09	\$521.00
TOTAL	\$15,724,159	727	646	197,422	177,960	\$ 88.36	\$6,555.00
1988							
March	\$7,338,210	866	336	1,073,940	315,387	\$23.27	\$525.00
June	\$7,564,135	820	375	755,242	293,050	\$25.81	\$575.00
August	\$5,827,548	847	363	827,471	278,198	\$20.95	\$1,350.00
October	\$3,913,765	820	257	994,618	282,145	\$13.87	\$6,500.00
December	\$3,045,203	766	260	761,242	182,117	\$16.72	\$330.00
TOTAL	\$27,688,861	4,119	1,591	4,412,513	1,350,897	\$20.50	\$6,500.00
1989							
February	\$2,418,295	800	230	857,475	187,012	\$12.93	\$1,225.00

STATE SALES

Month	Total Revenue	Number of parcels offered	Number of parcels sold	Total acres	Acres sold	Average price per acre sold	High price per acre
1987							
January	\$300,404	200	74	87,145	32,606	\$9.21	\$2,300.00
March	\$270,234	200	83	87,034	35,770	\$7.55	\$100.00
May	\$416,108	200	88	81,343	34,111	\$12.20	\$260.00
July	\$477,891	200	107	91,884	47,015	\$10.16	\$125.00
September	\$362,903	200	100	82,367	44,698	\$8.12	\$210.00
November	\$699,027	200	127	81,865	50,540	\$13.83	\$290.00
TOTAL	\$2,526,567	1,200	579	511,638	244,740	\$10.32	\$2,300.00
1988							
January	\$826,698	200	142	76,953	56,430	\$14.65	\$200.00
March	\$800,213	200	133	76,304	48,423	\$16.53	\$465.00
May	\$1,649,974	200	182	75,987	69,285	\$23.81	\$290.00
July	\$1,855,646	200	155	77,168	60,519	\$30.66	\$375.00
September	\$751,646	200	142	68,456	55,168	\$13.63	\$180.00
November	\$318,547	200	119	71,085	42,118	\$7.56	\$130.00
TOTAL	\$6,202,724	1,200	873	445,953	331,943	\$18.69	\$1,640.00
1989							
January	\$331,145	200	112	73,322	39,650	\$8.35	\$110.00
March	\$493,179	200	129	74,512	47,886	\$10.30	\$140.00
TOTAL	\$824,324	400	241	147,834	87,536	\$9.32	\$140.00

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

\$110 per acre for a 75.54-acre tract in section 6, T.54N., R.70W. near the Camp Creek Field area. Yates submitted the high bid on 54 tracts in this sale. The March sale's high bid was \$140 per acre for a 640-acre tract covering section 16, T.34N., R.75W. about three miles north of Muddy and Dakota Sandstone production in Glenrock Field. Yates Petroleum was once again the most successful bidder at this sale and picked up 45 tracts.

Wyoming and Exxon Corporation have reached a settlement in a lawsuit over the taxation of natural gas processed at Exxon's LaBarge Plant. Exxon paid the State \$5.6 million and Sublette County \$6.4 million in back taxes. The settlement also establishes a plan for valuing Exxon's natural gas for the next three years, which will result in severance and ad valorem taxes of around \$5 million per year. Helium sales will also be included in Exxon's revenue base.

In a somewhat related item, the U.S. Environmental Protection Agency (EPA) expressed concern over the carbon dioxide (CO₂) emissions at Exxon's LaBarge Plant. The plant generally emits 100 to 150 million cubic feet of CO₂ per day which the EPA claims is equivalent to emissions from a city the size of Casper. The EPA also is concerned that the proposed Amoco CO₂ processing plant would add to the emissions if it is built. Although CO₂ emissions are not currently regulated by the Federal government, an EPA spokesman said that he expects they will be in the future.

The U.S. Department of the Interior lowered the rent most companies pay to use Federal lands. It will charge \$1 per acre for many onshore oil and gas leases issued before 1987, instead of the \$2 to \$3 it had been charging. Leases issued after 1987 have a statutory rental rate of \$1.50 per acre for five years and \$2 per acre thereafter.

The State of Wyoming and the Joint Business Council of the Shoshone and Northern Arapaho Tribes announced a one year agreement for the collection of most taxes on oil and gas produced on the Wind River Reservation. The State will collect 1.5 percent in severance tax on reservation oil and gas production instead of the six percent rate that had been in effect. The reduction will permit the tribes to collect an extra \$2 million in 1989 without increasing the total tax burden on companies producing oil and gas on the reservation.

In a related item, the tribes received around \$1 million from British Petroleum for the right to explore for oil and gas near the Burris-Dinwoody area. Drilling should begin in May and the company will drill between eight and 18 wells.

Even though there was good news to report on crude oil prices, revenue from lease sales, and the prospect for increases in gas production, the news is not all good. Texaco U.S.A. announced that it will close its exploration and production office in Casper under a new nationwide restructuring plan. The plan will affect 44 Casper employees, nearly a fourth of Texaco's workforce in Wyoming. The restructuring should be completed by the fourth quarter of 1989.

Hotline Energy Reports, which had been in Casper since 1978, moved to Oklahoma City in February. Hotline employed 11 people in the Casper office.

Amoco Production, the State's largest crude oil and second largest natural gas producer, announced plans to transfer 22 Wyoming workers to New Mexico oil fields.

Amoco is trying to sell 35 of its Wyoming fields which they consider marginally profitable.

The rig count historically drops at the beginning of the year; however, it was lower during the first quarter of 1989 than it has been in the past (see figure on page 8). If past trends hold up, the number of rigs at work should begin increasing in April or May, especially if the price of crude oil stays in the \$18 to \$20 range and if the demand for natural gas increases as expected.

Based on company data and on information compiled and published by Petroleum Information, the following significant exploration and development events occurred in Wyoming during the first quarter of 1989. The letters preceding the following discussions refer to locations on the map on page 8.

A. Exxon Corporation set a production string at their directionally-drilled 1 Collett Creek Unit well which bottomed in section 20, T.21N., R.118W. The test was designed to test the Ordovician Bighorn Dolomite and the Mississippian Madison Limestone. Although the production string was set late last year, no additional details have been released by the company. The well is over two miles northeast of nearest Bighorn production at Road Hollow Field.

B. Chevron U.S.A. completed a Jurassic/Triassic Nugget Sandstone well in section 6, T.15N., R.119W. in East Painter Reservoir Field. The 12-5A East Painter Reservoir unit well flowed 1.5 million cubic feet of gas, 343 barrels of condensate, and 429 barrels of water per day. East Painter Reservoir Field was discovered in 1979 and is currently the fourth largest oil-producing field and the sixth largest gas-producing field in Wyoming.

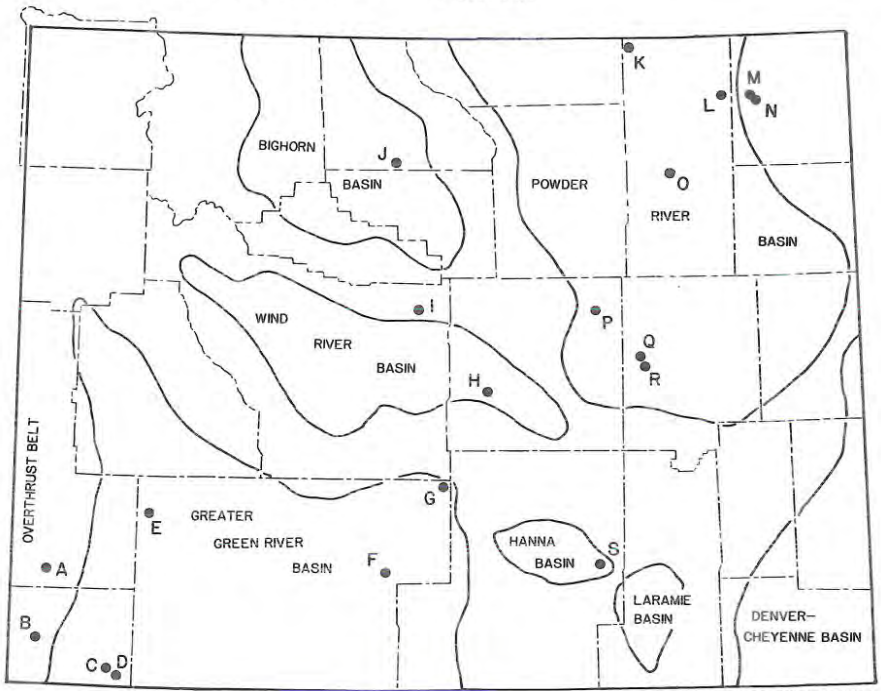
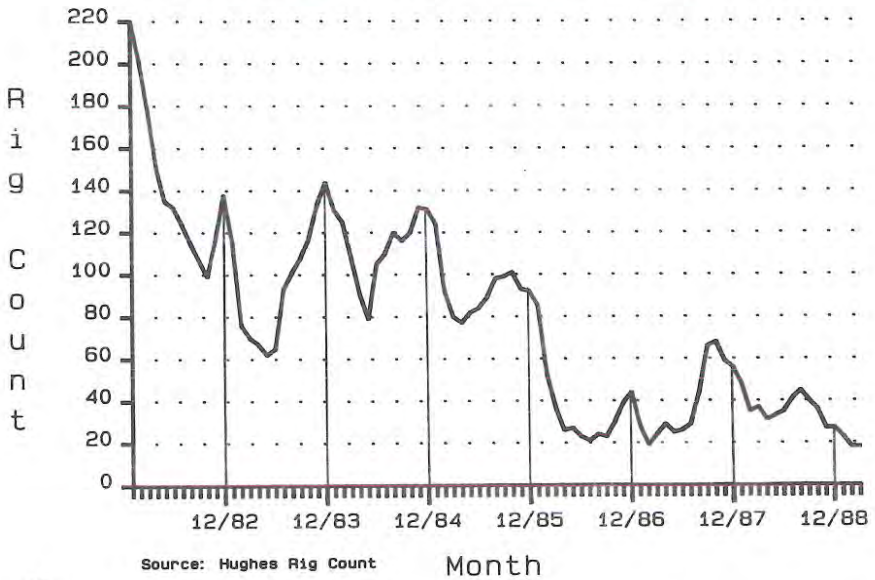
C. Anadarko Petroleum completed a new Dakota Formation producer on the southern Moxa arch in section 28, T.13N., R.114W. The 13-28 Taylor Ranch well flowed 300 barrels of oil, five barrels of water, and two million cubic feet of gas per day. The well is about two miles north of Dakota production in Luckey Ditch, Whiskey Springs, and Taylor Ranch Fields. Three weeks after this discovery, Anadarko Petroleum and Enstar Corporation purchased Maxus Exploration Company's 100 percent interest in the Taylor Ranch Unit for \$4.6 million. Anadarko and Enstar received three producing wells and about 1,900 undeveloped acres. Anadarko announced plans to drill two more tests in the area this summer.

D. Wildhorse Energy of Denver set production casing at the 2 Wadsworth-Federal 5-32 well in section 5, T.12N., R.113W. The objectives of the well were to test the Dakota, Mesaverde, and Frontier Formations. No other details are available.

E. Two new Dakota Formation producers were completed by ANR Production Company on the west side of Lincoln Road Field. The 1-17 Raptor Unit well in section 17, T.24N., R.111W. flowed 3.36 million cubic feet of gas, 635 barrels of condensate, and three barrels of water a day. The 1-18 Raptor Unit in section 18, T.24N., T.111W. flowed 587,000 cubic feet of gas and 307 barrels of condensate per day. These two new producers are a little over a mile from the nearest Dakota production.

F. Samedan Oil completed a Mesaverde step-out well from Siberia Ridge Field in section 24, T.21N., R.94W. The 1-24 Danno well flowed 400,000 cubic feet of gas and one barrel of condensate and water per day. The well is two miles east of the nearest Mesaverde production in Siberia Ridge Field.

WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT)



OIL AND GAS EXPLORATION ACTIVITY IN WYOMING

G. Amoco Production has a new Tensleep Sandstone producer in Wertz Field. The 163 Wertz ABC Unit well in section 18, T.26N., R.89W. was completed pumping

708 barrels of oil and 9,236 barrels of water per day. Wertz Field was discovered in 1921 and is presently undergoing tertiary recovery. The field topped 100 million barrels of cumulative oil production during the first quarter of 1989.

H. BHP Petroleum reported two new Muddy Sandstone producers in Sun Ranch Field. The 4-22 Sun-Federal was completed in section 22, T.33N., R.86W. for an initial flowing potential of 300 barrels of oil and 450,000 cubic feet of gas per day. The 6-22 Sun Ranch-Federal in section 22, T.33N., R.86W. was completed for an initial flowing potential of 350,000 cubic feet of gas and 750 barrels of oil per day. The Wyoming Oil and Gas Conservation Commission shut in Muddy Sandstone production in parts of sections 15 and 22 until a pressure maintenance unit can be formed.

I. BHP Petroleum is planning to build a \$25 million gas processing plant to handle gas from the Madison Limestone in its 24,000+ feet deep wells in Madden Field (the 1-5 and 2-3 Bighorn wells in sections 3 and 5, T.38N., R.90W., respectively). The plant would be located near these two wells and would initially handle 25 million cubic feet of gas per day from the two wells. BHP hopes to expand the plant at a later date to process 100-150 million cubic feet of gas per day from the two wells. The plant could be completed late in 1990 and would remove carbon dioxide and sulfur from the gas.

J. Terra Resources completed a Muddy Sandstone producer in Five Mile Field in the Bighorn Basin. The 1-32 Federal-Five Mile in section 32, T.49N., R.93W. flowed 1.4 million cubic feet of gas and 451 barrels of oil per day. The new producer is over a mile southwest of Frontier production in Five Mile Field.

K. The 22-1 Magnolia-Federal well, completed by Presidio Exploration in section 1, T.57N., R.76W., pumped 100 barrels of oil with 43,000 cubic feet of gas and two barrels of water per day. The well is nearly a mile northeast of nearest Muddy production at Fence Creek Field. Presidio staked a location half a mile southeast of the discovery in the same section. The new well is projected to the Minnelusa Formation.

L. Conley P. Smith completed an offset well to the abandoned M-D North Field discovery. The 25-15 Morel-Federal well in section 25, T.53N., R.69W. pumped 202 barrels of oil with seven barrels of water per day. The well is just southwest of the Sun Exploration and Production M-D North discovery well which was abandoned in 1984 after it produced just 228 barrels of oil.

M. Dabros Properties completed a new Minnelusa Formation discovery in Crook County. The 24X-8 Hundahl well in section 8, T.53N., R.67W. pumped 195 barrels of oil and six barrels of water per day. The new discovery is a mile north of Minnelusa production at Sidner Draw Field and a mile northeast of Minnelusa production at Deadman Creek Field.

N. Robert E. Hudson produced 12° API gravity oil on tests of the Minnelusa Formation at the 43-21X Hundahl in section 21, T.53N., R.67W. The Minnelusa was

tested through perforations between 1,878 and 1,910 feet, but the production rates were not revealed. The well is currently shut in.

O. EP Operating pumped 282 barrels of oil with 9,000 cubic feet of gas and six barrels of water per day from their 22-24 Gruenfelder well in section 24, T.48N., R.72W. The discovery is around three miles southwest of Minnelusa production at Rourke Gap Field and over two miles northeast of Minnelusa production at Oxbow Field.

P. The U.S. Department of Energy started steam injection in mid-January as the second phase of a project in Teapot Dome Field. The second phase of the project, which expands the 20 acres in the first phase to 80 acres, targets 33° API gravity oil in the Shannon Sandstone at 250 to 300 feet. The first phase of the project reduced residual oil saturation from 50 percent to 15 percent and increased oil recovery by a factor of four. Three more phases of the project will be implemented at the rate of one per year and the project will eventually cover 400 acres.

Q. Three more producers were completed in the Sand Dunes Field area during the first quarter of 1989. Kerr-McGee Corporation's 11-7 Sand Dunes-Federal well in section 7, T.36N., R.75W. flowed 471,000 cubic feet of gas and 406 barrels of oil per day from the Dakota Sandstone. Kerr-McGee's 32-25 Federal well in section 25, T.36N., R.76W. reportedly is capable of daily production of 400 to 450 barrels of oil from the Muddy Sandstone based on a drillstem test. Marathon Oil is producing 400 barrels of oil per day from the 6-19 Sand Box well in section 19, T.36N., R.75W. from an undisclosed interval.

R. W. A. Moncrief, Jr. completed the 28-1 Popskull well in section 28, T.35N., R.75W. as a new Muddy Sandstone discovery. No details are yet available on this discovery. Presently there is no production in this township.

S. Marathon Oil found a new pay in Big Medicine Bow Field. The 4-25 Big Medicine Bow Unit well in section 25, T.21N., R.79W. pumped 73 barrels of oil with 7,000 cubic feet of gas and 24 barrels of water per day from the Dakota Sandstone. The field also produces from the Sundance Formation and the Tensleep Sandstone.

Reference cited

Petroleum Information, 1989, Wyoming oil and gas production report: Houston, Texas, 1,791 p.

COAL UPDATE

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

Preliminary figures recently released by the Wyoming State Inspector of Mines indicate that Wyoming's coal mines set a new all-time high production record in 1988. The 163.6 million short tons produced in 1988 are 17.1 million tons (or 11.7 percent) higher than the previous record of 146.5 million short tons set in 1987. Wyoming's national ranking in coal production will not be known until Kentucky releases its final 1988 production report. Since West Virginia's coal production was about 142.7 million short tons in 1988, Wyoming production is well ahead of the third leading coal-producing state in the Nation.

Coal production surged in the Powder River Basin as 142.4 million tons were produced. This was a 13.8-million ton (10.7 percent) increase over 1987 production (see table below). Between 1987 and 1988, coal production in the Hanna Basin recorded the largest percentage increase (80.4 percent) of the major coal regions in the State. Production increased from 2.2 million tons to 4.1 million tons. Green River Basin production increased by about 0.4 million tons and production from the Hams Fork Region (Lincoln County) increased by 1.1 million tons. Coal production from the three underground mines operating in 1988 was 1.1 million short tons, an

1988 WYOMING COAL PRODUCTION BY COUNTY AND COAL BASIN

County	Production	Percent of Total Production	Number of Producing Mines	Number of Employees
POWDER RIVER BASIN				
Campbell	135,725,239	83.0%	14	2,540
Converse	5,748,530	3.5%	2	213
Sheridan	945,116	0.6%	1	35
TOTAL	142,418,885	87.1%	17	2,788
GREEN RIVER BASIN				
Sweetwater	12,167,361	7.4%	5	928
HAMS FORK REGION				
Lincoln	4,895,730	3.0%	2	453
HANNA BASIN				
Carbon	4,055,924	2.5%	4	355
BIGHORN BASIN				
Hot Springs	50,300	<0.1%	1	9
TOTAL WYOMING	163,588,200		29	4,533

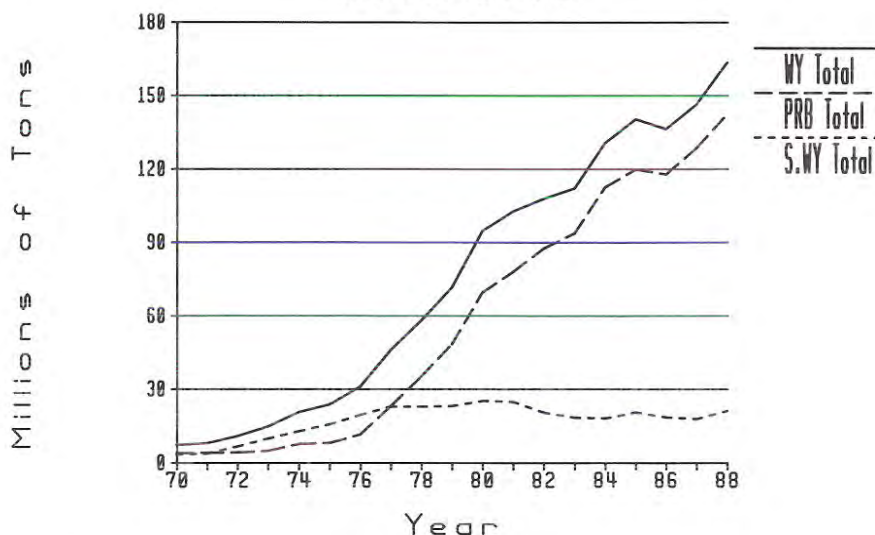
Source: Wyoming State Inspector of Mines, preliminary data for 1988.

increase of one million tons over 1987's production. Most of the increase in underground production was from Cyprus Shoshone Coal Company's mine in the Hanna Basin as this was the first full year of deliveries on their new contract. Bitter Creek Resources' Stansbury mine north of Rock Springs became Wyoming's newest coal mine and the State's third underground mine in 1988.

Coal production from Campbell County continued to increase in 1988 with the 135.7 million short tons representing an 11 percent increase over the 122.3 million tons produced in 1987. The 14 surface mines in this county accounted for 83 percent of Wyoming's total production (see table below); total production from the 17 Powder River Basin mines accounted for 87.1 percent of the State's total production in 1988. Coal production from the Powder River Basin has dominated Wyoming coal since 1977 and annual increases have been recorded each year since 1969 (see figure below). In contrast, coal production from southern Wyoming counties appears to have leveled off since reaching a peak in 1981.

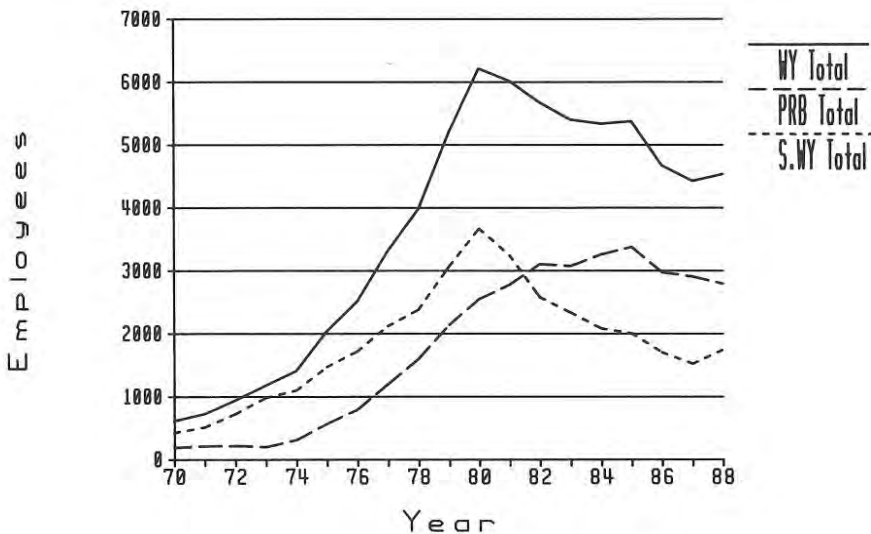
Thunder Basin Coal Company's Black Thunder mine remained the largest producer in the State in 1988 with 24.9 million short tons produced. Kerr-McGee Coal Corporation's Jacobs Ranch mine ranked second with 14.5 million tons followed by Cordero Mining Company's Cordero mine (13.5 million tons), Amax Coal Company's Belle Ayr and Eagle Butte mines (13.3 and 12.9 million tons, respectively), and Carter Mining Company's Caballo and Rawhide mines (12.8 and 10.8 million tons, respectively). Only 8 coal mines in Wyoming experienced a drop in production between 1987 and 1988, including three Powder River Basin mines: Kerr-McGee Coal Corporation's idled Clovis Point mine, the Big Horn mine in Sheridan County, and the Coal Creek mine. The Black Thunder, Jacobs Ranch, and Rochelle mines experienced the largest production increases between 1987 and 1988.

Wyoming Coal Production
1970-1988



Total employment at Wyoming coal mines increased slightly in 1988, with a gain of 110 employees (2.5 percent) over 1987 employment (see table on page 14). Employment in Powder River Basin mines continued to decrease in 1988, but employment in southern Wyoming mines increased for the first time since 1980. Ten coal mines in the Powder River Basin accounted for a loss of 116 jobs and a drop of 4 percent in employment. The increased employment in southern Wyoming was primarily caused by an expansion of underground mining in Sweetwater and Carbon Counties (see figure below). Employment in underground mines increased by 168 between 1987 and 1988; employment in surface mines decreased by 58 during this same period.

Wyoming Coal Employment
1970-1988



The surge in Wyoming coal production in 1988 has necessitated a revision of our previous five-year production forecast in *Wyoming Geo-notes No. 21*, January, 1989, p. 16 (see table on page 15 of this report). Total production in 1989 is forecast to increase slightly as the good market conditions experienced in 1988 continue. Production will level off in 1990 and then show modest yearly increases through 1993 as demand for low-sulfur coal rises in response to increased demand for coal-fired electricity. Estimates of contracted coal production are less than estimates of actual coal production because spot sales of coal will continue as a significant percentage (5.5 percent) of the total production.

Deliveries of Wyoming coal to electric utility plants in the last quarter of 1988 were well above deliveries made during the last quarter of previous years and helped account for the increased coal production for the year (table on page 16 and figure on page 17). The large amount of unreported tonnage (about 6.5 million tons) for

**1987 AND 1988 WYOMING COAL INDUSTRY EMPLOYEES AND
COAL PRODUCTION BY COAL BASIN AND MINE¹**

Company	Mine Name	Employees	1987 Production (short tons)	Employees	1988 Production (short tons)
POWDER RIVER BASIN					
Amrax Coal Company	Belle Ayr (surface)	333	13,329,591	267	13,296,739
	Eagle Butte (surface)	293	12,977,000	252	12,915,476
Antelope Coal Company	Antelope (surface)	38	2,554,333	41	3,141,088
Ash Creek Mining Co.	PSO No. 1 (surface)	1		1	
Big Horn Coal Company	Big Horn (surface)	73	1,201,093	34	945,116
Carter Mining Company	Caballo (surface)	202	11,684,193	222	12,779,942
	Rawhide (surface)	170	10,672,913	164	10,810,785
Cordero Mining Company	Cordero (surface)	227	11,943,375	227	13,541,225
Fort Union Coal Company	Fort Union (surface)	23	394,004	21	508,263
Glenrock Coal Company	Dave Johnston (surface)	173	2,546,808	172	2,607,442
Kerr-McGee Coal Corp.	Cloviss Point (surface)	62	1,508,524		
	Jacobs Ranch (surface)	326	11,158,874	371	14,532,789
Mobil Coal Prod., Inc.	Caballo Rojo (surface)	132	6,489,799	141	7,126,693
North Antelope Coal Co.	North Antelope (surface)	122	5,337,503	114	6,088,207
Rochelle Coal Company	Rochelle (surface)	80	6,436,359	113	8,684,125
Thunder Basin Coal Co.	Black Thunder (surface)	462	19,272,751	464	24,862,429
	Coal Creek (surface)	32	2,362,059	21	684,322
Triton Coal Company	Buckskin (surface)	94	5,773,967	107	7,174,718
Wyodak Res. Dev. Corp.	Wyodak (surface)	61	2,976,398	56	2,709,526
TOTAL		2,904	128,619,544	2,788	142,418,885
HANNA BASIN					
Amar	Seminole No. 2 (auger)	13	62,900	11	61,323
Arch of Wyoming	Seminole No. 2 (surface)	107	1,280,000	100	1,599,591
Cyprus Shoshone Coal Co.	Shoshone No. 1 (deep)	31	105,300	153	1,067,305
Medicine Bow Coal Co.	Medicine Bow (surface)	12	19,625	29	441,222
Rosebud Coal Sales	Rosebud (surface)	71	780,873	62	886,483
TOTAL		234	2,248,698	355	4,055,924
GREEN RIVER BASIN					
Bitter Creek Resources	Stansbury (deep)	22	17,478		
Black Butte Coal Co.	Black Butte (surface)	346	4,666,660	384	5,325,380
Bridger Coal Company	Jim Bridger (surface)	426	6,600,573	437	6,412,384
Prospect Point Coal Co.	Leucite Hills (surface)	53	538,775	53	381,280
Lion Coal Company	Swanson (deep)	8	1,242	32	30,839
TOTAL		833	11,807,250	928	12,167,361
HAMS FORK REGION					
FMC Corporation	Skull Point (surface)	92	802,930	104	937,999
Pittsburg and Midway	Elkol & Sorenson (surface)	357	3,000,000	349	3,957,731
TOTAL		449	3,802,930	453	4,895,730
BIGHORN BASIN					
Northwestern Res. Co.	Grass Creek (surface)	3	10,226	9	50,300
TOTAL		3	10,226	9	50,300
TOTAL UNDERGROUND		39	106,542	207	1,115,622
TOTAL SURFACE		4,384	146,382,106	4,326	162,472,578
GRAND TOTAL		4,423	146,488,648	4,533	163,588,200

Source: Annual Reports of the Wyoming State Inspector of Mines, 1987 and 1988.

Coal production and forecast to 1993 (millions of tons).

	1981 ¹	1982 ¹	1983 ¹	1984 ¹	1985 ¹	1986 ¹	1987 ¹	1988 ¹	1989	1990	1991	1992	1993
Campbell County	71.6	81.2	88.2	106.8	113.9	111.0	122.3	135.7	137.7	137.9	139.0	139.7	140.4
Converse County	3.6	3.4	2.7	3.3	3.6	4.8	5.1	5.7	6.0	6.2	6.6	7.0	7.4
Sheridan County	2.8	3.0	2.9	2.5	2.4	1.4	1.2	0.9	0.5	M	M	M	M
Carbon County	8.5	5.0	4.8	5.1	3.3	1.5	2.2	4.1	3.0	2.5	2.5	2.0	2.5
Sweetwater County	11.2	11.0	9.5	8.9	13.2	12.9	11.8	12.2	12.6	13.0	13.4	13.5	13.7
Lincoln County	5.0	4.3	4.0	4.1	4.3	4.0	3.8	4.9	5.2	5.4	5.5	5.8	6.0
Hot Springs County	M ²	M	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming	102.8	107.9	112.2	130.7	140.7	135.7	146.5	163.6	165.0	165.0	167.0	168.0	170.0
Annual change	9%	5%	4%	16.5%	7.7%	-3.6%	8.0%	11.7%	0.1%	-	1.2%	0.1%	1.2%
Estimated contracted production	110.0	119.0	122.6	137.7	145.2	149.2	150.0	154.9	156.0	156.0	158.0	159.0	161.0
Below contract	7%	9%	8%	5%	3%	9%	2%	-	-	-	-	-	-

¹These are actual values for comparison. ²M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, April, 1989.

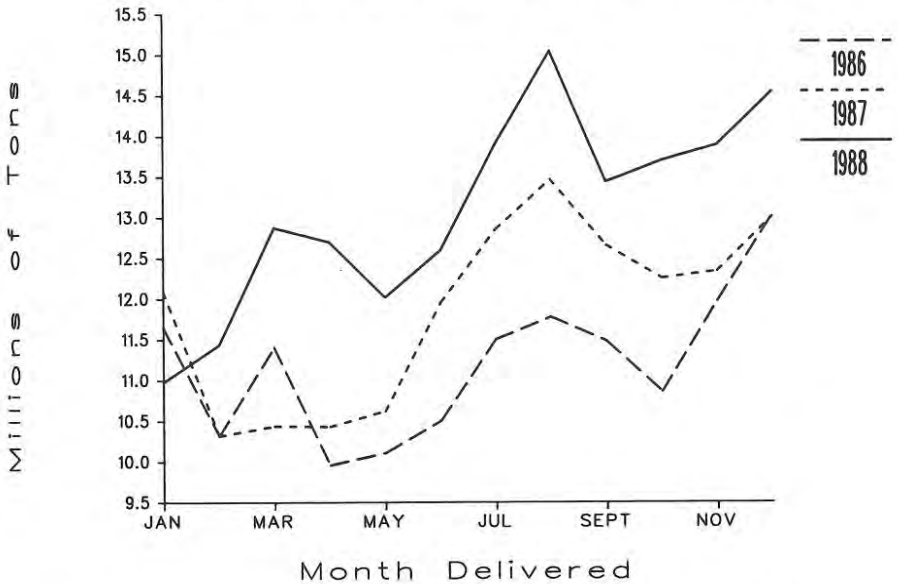
COAL DELIVERIES BY MONTH FROM WYOMING MINES¹

	1984	1985	1986	1987	1988	1989
	MONTHLY	MONTHLY	MONTHLY	MONTHLY	MONTHLY	MONTHLY
	CUMULATIVE	CUMULATIVE	CUMULATIVE	CUMULATIVE	CUMULATIVE	CUMULATIVE
JANUARY	9,540,200	11,601,200	11,646,300	12,085,570	10,976,860	10,976,860
FEBRUARY	9,654,600	10,473,900	10,317,700	10,315,680	11,431,380	22,408,240
MARCH	10,875,000	11,674,900	11,401,720	10,436,610	12,871,090	35,279,330
APRIL	8,721,400	11,632,800	9,954,170	10,429,180	12,694,660	47,973,990
MAY	9,481,500	11,497,900	10,105,320	10,619,470	12,017,500	59,991,490
JUNE	9,464,500	11,692,200	10,499,280	11,953,650	12,595,480	72,586,970
JULY	11,019,600	11,893,500	11,497,190	12,850,240	13,905,670	86,492,640
AUGUST	11,433,000	12,107,100	11,773,510	13,460,470	15,041,090	101,533,730
SEPTEMBER	10,440,000	11,325,000	11,474,820	12,651,550	13,433,610	114,967,340
OCTOBER	10,492,500	11,048,500	10,854,670	12,248,080	13,696,190	128,663,530
NOVEMBER	11,814,200	10,589,700	11,971,980	12,340,720	13,889,890	142,553,420
DECEMBER	11,486,800	11,459,300	13,025,490	13,008,300	14,540,510	157,093,930
TOTAL TONNAGE REPORTED	124,423,300	136,996,000	134,522,160	142,399,520	157,089,930	
TOTAL TONNAGE NOT REPORTED	6,322,479	3,784,154	1,782,896	4,089,128	6,494,270	
TOTAL TONNAGE PRODUCED ²	130,745,779	140,780,154	136,305,056	146,488,648	163,584,200	

¹Source: National Marketing Reports by Coal Marketronix and COALDAT Marketing Report by DRI, Inc., compiled from FERC Form 423 filed monthly by electric utilities.

²Source: Wyoming State Mine Inspector's Annual Reports.

MONTHLY COAL DELIVERIES FROM WYOMING COAL MINES



1988 reflects an increase in the use of coal for industrial and commercial purposes as well as an increase in the amount of coal delivered to utility companies in relatively small amounts for test burns in advance of spot or contract sales. In addition, deliveries to electric utility plants rated at less than 50 megawatts are not reported in the monthly deliveries. Of the total coal deliveries made to 19 different states in 1988, only Illinois and Minnesota used less Wyoming coal than in 1987. Significant increases in deliveries to electric utility plants in Texas, Wyoming, Missouri, and Indiana were noted in 1988.

In coal transportation news during the first quarter of 1989, Energy Transportation Systems, Inc. (ETSI) was awarded treble damages of \$1.035 billion from Santa Fe Southern Pacific Corporation (SFSP) following a Federal jury trial in Texas. ETSI had filed lawsuits against seven western railroad companies alleging that the companies had conspired to block ETSI's proposed 1,800-mile coal slurry pipeline back in the 1970s. Completion of the ETSI-SFSP case nearly completes the settlement of these various lawsuits brought by ETSI. Six of the other railroads involved in the litigation with ETSI have already settled out of court (see related story in *Wyoming Geo-notes No. 21*, January, 1989, p. 17); the SFSP case is the first to be decided by a jury trial. The \$1.035 billion award will apparently be reduced by \$285 million from awards made to ETSI by the other six railroad companies; this leaves SFSP owing ETSI \$750 million. SFSP announced that they would appeal the verdict.

Developments in the Hanna coal field

An earlier report that Rosebud Coal Sales Company would be laying off workers and ending major coal production (*Wyoming Geo-notes No. 20*, November, 1988, p. 18) was confirmed in January as Rosebud announced that 49 employees would be

laid off effective February, that production would be scaled back to supply retail sales only, that no trainloads of coal would be handled any more, and that the remaining workforce of 18 would be involved in reclamation work plus the retail sales. Rosebud's only major coal supply contract (with Iowa Public Service Company) expired in December, 1988. The Rosebud mine has operated since 1961 and has produced a total of 32.6 million tons of coal in that 28 years. Production peaked at 2.9 million tons in 1978 and the mine employed a maximum of 243 workers in 1979.

An earlier story on Arch of Wyoming's Seminoe 2 mine (*Wyoming Geo-notes No. 21*, January, 1989, p. 20-21) was also confirmed in late March when the company announced the layoff of 31 employees and the impending closure of the Seminoe 2 mine following expiration of a contract with Kansas Power and Light Company (KP&L). Arch also announced that a 9-month, 650,000-ton coal contract with KP&L had been signed for Arch's recently-acquired Medicine Bow mine west of Hanna. In December, Arch of Wyoming purchased Union Pacific Minerals' (UPM's) share of Medicine Bow Coal Company's Medicine Bow mine, a joint venture of UPM and Arch. Arch of Wyoming also announced that 30 additional employees would be hired at Medicine Bow as production under the new KP&L contract begins. Arch will also supply 360,000 tons of coal per year to Iowa Public Service Company from Medicine Bow. Evidently this is the 10-year contract formerly held by Energy Development Company (EDC) but taken over by Arch of Wyoming when they purchased EDC. This contract is due to expire in 1993.

Developments in western and southwestern Wyoming

In early January, the completion of the proposed merger between Utah Power and Light Company (UP&L) and PacifiCorp was announced (see *Wyoming Geo-notes No. 21*, January, 1989, p. 21). Under the merger, PacifiCorp would have two divisions, UP&L (serving 525,000 customers in Utah, western Wyoming, and Idaho) and Pacific Power and Light Company (PP&L) (serving 687,000 customers in Idaho, Wyoming, Oregon, Washington, Montana, and California).

Bitter Creek Resources' newly-opened Stansbury underground mine north of Rock Springs is apparently supplying coal to the Jim Bridger power plant east of Rock Springs. Marketing reports indicated that 8,000 tons of 10,740 Btu/pound coal was supplied to Jim Bridger in December, 1988. Delivered price for the coal was \$18.41 per ton (85.7¢ per million Btu).

Developments in the Powder River Basin coal field

In February, Western Fuels Association (WFA) and Phillips Coal Company announced formation of a limited partnership called Dry Fork Coal Company. Dry Fork plans to open a new surface coal mine north of Gillette. Construction of the Dry Fork mine is expected to begin in the latter part of 1989 and coal production is expected to start in late 1990. Initially, the mine will produce less than 3 million tons a year; capacity would presumably incrementally increase as market conditions dictate until reaching a maximum permitted capacity of 15 million tons per year. The mine is located north of the Fort Union mine, east of Eagle Butte, and southeast of the Rawhide mine and will supply coal to the Laramie River Station north of Wheatland, Wyoming.

Coal from the Dry Fork mine will initially replace coal from a 2.7-million ton-per-

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING
PETROLEUM

Remaining Resources (January 1, 1988) 13.0 billion barrels¹
 Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques) 7.6 billion barrels¹
 Undiscovered 20.6 billion barrels¹
 Total 20.6 billion barrels

Remaining Reserve Base (January 1, 1988)
 Measured reserves (Proved reserves) 0.85 billion barrels²
 Indicated and inferred reserves 2.8 billion barrels³
 Total 3.65 billion barrels

COMBUSTIBLE NATURAL GAS

Remaining Resources (January 1, 1988)
 Discovered 18.0 trillion cubic feet¹
 Undiscovered (there is at least another 115 trillion cubic feet of noncombustible CO₂ gas)⁹ 58.0 trillion cubic feet¹
 Total 76.0 trillion cubic feet
 Remaining Reserve Base (January 1, 1988)
 Measured reserves (Proved reserves) 10.57 trillion cubic feet²

COAL

Remaining Resources (January 1, 1989)
 Identified (Discovered) 135.6 billion tons⁴
 Undiscovered 800.0 billion tons⁵
 Total 935.6 billion tons
 Remaining Reserve Base (January 1, 1989)
 Demonstrated stripable (Measured and indicated reserve base) 26.8 billion tons⁴
 Demonstrated underground-minable (Measured and indicated reserve base) 38.3 billion tons⁴
 Total 65.1 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 (December 31, 1985)	1.99 billion pounds U ₃ O ₈ ⁷
Remaining Reserve Base (December 31, 1985)	
Uranium oxide recoverable at \$30.00 per pound.....	83 million pounds ⁷

OIL SHALE

Original Resources (January 1, 1983)	
Identified (Discovered).....	320 billion barrels of shale oil ⁸

- 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, 1988, *U.S. crude oil, natural gas, and natural gas liquids reserves*: 1988 Annual Report, October.
- 3 Modified from Barlow and Doelger (1983), footnote 1.
- 4 Geological Survey of Wyoming, April, 1989. (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 Energy Information Administration, 1985, *Uranium industry annual*: U.S. Department of Energy Report DOE/EIA-0478(85), 142 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.

year contract that was not renewed during a price renegotiation between WFA and Cordero Mining Company (a subsidiary of Sun Coal Company). Dry Fork Coal Company will operate the mine with Western Fuels-Wyoming (a subsidiary of WFA) as the general partner and North Gillette Coal Company (an affiliate of Phillips Coal Company, a wholly-owned subsidiary of Phillips Petroleum Company) as a limited partner. Western Fuels Association is a fuel-purchasing cooperative of consumer-owned utility companies, including Basin Electric Power Cooperative of Bismarck, North Dakota, and Tri-State Generation and Transmission Association of Denver, Colorado.

Several changes in the corporate structures of coal companies in Wyoming were noted in the first quarter of 1989. In February, Elk River Resources changed its name to Sun Coal Company, a subsidiary of the Sun Company. Cordero Mining Company, operator of the Cordero coal mine south of Gillette, remains a subsidiary of Sun Coal Company. In another corporate development, Panhandle Eastern Corporation, a partner in North Antelope Coal Company's North Antelope mine in southern Campbell County, recently agreed to sell its 50 percent interest in North Antelope to its other partner in the joint venture, Powder River Coal Company, an operating unit of Peabody Holding Company. Pan Eastern Coal Company, a wholly-owned subsidiary of Panhandle Eastern Corporation, was an operating partner with Powder River Coal Company at the North Antelope mine. Peabody Holding Company is also the parent company of its Rochelle Coal Company subsidiary that operates the Rochelle mine in the same area as North Antelope.

In the first quarter of 1989, Cordero Mining Company's Cordero mine passed a significant coal production milestone as the mine shipped its 100 millionth ton of coal. Cordero becomes the fifth coal mine in the Powder River Basin to produce more than 100 million tons. Only Amax Coal Company's Eagle Butte and Belle Ayr mines, Kerr-McGee Coal Corporation's Jacobs Ranch mine, and Thunder Basin Coal Company's Black Thunder mine have each produced more than 100 million tons of coal.

Coal contracts

In addition to the coal supply contract noted for Arch of Wyoming and the coal deliveries to Jim Bridger from the Stansbury mine, several short term or spot coal supply agreements were signed in the first quarter of 1989. A summary of this contract activity follows:

1) Mobil Coal Producing, Inc. will supply 1.3 million tons of 8,500 Btu/pound coal to Lower Colorado River Authority's Fayette No. 1 generating plant in Texas. The coal will be delivered from February, 1989, through January, 1990. Price for the spot coal sale was reportedly \$3.65 a ton F.O.B. the Caballo Rojo mine.

2) Thunder Basin Coal Company, a subsidiary of Arco Coal Company, will furnish up to 1.2 million tons of spot coal to Southwestern Public Service Company's Roy Tolk generating plant at Muleshoe, Texas, in 1989. The coal can be from either the Coal Creek mine (8,350 Btu/pound coal) or the Black Thunder mine (8,900 Btu/pound coal) and will be delivered by Burlington Northern Railroad (BN) and Santa Fe Railroad.

3) Thunder Basin Coal Company will furnish up to 650,000 tons of coal in 1989

to Nebraska Public Power District's Sheldon, Nebraska, generating plant. The agreement specifies a delivered price of \$13.76 per ton for 8,900 Btu/pound coal from the Black Thunder mine. BN will transport the coal.

4) Northern Indiana Public Service Company (NIPSCO) continued to purchase spot coal on a monthly basis. Amax Coal Company's Belle Ayr mine provided 70,000 tons of coal in February and 81,000 tons of coal in March to unspecified NIPSCO generating plants in Indiana. Cordero Mining Company's Cordero mine also provided 20,000 tons of coal in March to unspecified NIPSCO generating plants in Indiana.

5) Lower Colorado River Authority (LCRA) recently held open bids on 6- or 12-month coal supply contracts for Fayette generating units 1, 2, and 3. Although no contract has been awarded pending LCRA examining longer term arrangements, published bids for the 2.5 million tons of spot coal were received from Rochelle Coal Company's Rochelle mine, Amax Coal Company's Belle Ayr mine, Carter Mining Company's Caballo mine, and Sun Coal Company's Cordero mine. The bids were between \$3.50 - \$4.70 per ton.

INDUSTRIAL MINERALS UPDATE

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

The U.S. Bureau of Mines (USBM) has released its annual report on the mineral industry of Wyoming in 1988. According to the USBM, the value of Wyoming's nonfuel mineral production increased 17 percent over 1987 due to greater production values for soda ash and other refined trona products and a small increase in production value for bentonite. Industrial minerals account for all of Wyoming's nonfuel mineral production. Wyoming is now ranked 13th among the states in the value of nonfuel minerals, an increase over 1987's ranking of 15th.

Aggregate

The production of construction aggregate (sand, gravel, and crushed rock) in Wyoming began to increase in March, 1989, as some dryer and milder weather returned to the State following February's cold snap. Highway construction and repaving projects consume most of Wyoming's construction aggregate. Other users are building contractors, railroads (for ballast), and general contractors for defense-related projects as well as other projects.

The Nebraska Highway Department (NHD) is looking for quartzite for highway surfacing in western Nebraska. A hard quartzite known as the Sioux Quartzite is used in eastern Nebraska, and the NHD is looking for a similar rock for the western part of the State. The Industrial Minerals and Uranium Division of the State Geological Survey suggested several possible quartzites in eastern Wyoming, including a rock found in Guernsey Stone Company's quarry near Guernsey. These quartzites are now being tested by the NHD.

Bentonite

1988 bentonite production increased over 1987 levels. Figures released by the U.S. Bureau of Mines show an estimated 2,345,000 short tons of bentonite produced in 1988, compared to 2,128,000 short tons in 1987, and 1,762,000 short tons in 1986. In a related item, American Bentonite, Inc. began development of a mine near Poison Spider School, west of Casper.

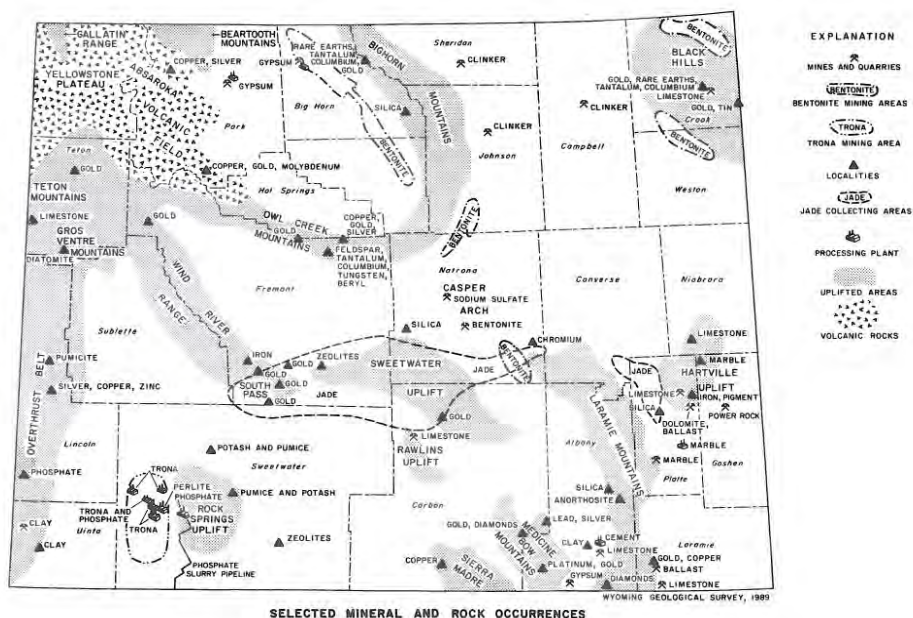
Bentonite production remained low during early 1989 due to low demand for oil well-drilling mud, the prime use for bentonite. Wyoming, however, remains the Nation's leading bentonite producer.

Cement

In early 1989, Lone Star Industries and a subsidiary of Centex Corporation formed a joint venture, Mountain Cement Company, for cement production in the Rocky Mountain region. This joint venture owns and operates the cement plant at Laramie. The plant is currently operating near its capacity of 500,000 tons per year.

Gypsum

The production of gypsum from three mines in Wyoming (see map below) continued in early 1989. The two Bighorn Basin plants manufacture wallboard while the gypsum mined near Laramie is used in the production of Portland Cement.



Gypsum production is increasing nationally and should also increase in Wyoming in 1989.

Leonardite

Leonardite is an industrial mineral used in well-drilling fluids. It is a soft, earthy, brown, diagenetic material produced from the weathering of coal or lignite. It has also been used for water treatment and in wood stain. Black Hills Bentonite began marketing this material in 1988.

Limestone

Limestone quarried in Wyoming is used for construction aggregate and for power plant emissions control. Although limestone is also used in the refining of beet sugar, the limestone used in the sugar plant at Lovell, Wyoming, comes from Warren, Montana, about 5 miles north of Frannie, Wyoming. Limestone used in the sugar plant at Torrington, Wyoming, comes from Pringle, South Dakota. Limestone used in the sugar plants at Mitchell and Scottsbluff, Nebraska, is transported through Wyoming from Warren, Montana.

Phosphate, sulfur, and fertilizer production

Phosphate and sulfur are combined with other chemicals at Chevron Chemical Company's Rock Springs plant to produce fertilizer. No phosphate is currently mined in Wyoming. The phosphate used by Chevron is mined north of Vernal, Utah, and shipped to the Rock Springs plant by slurry pipeline (map on page 21). The sulfur used at the fertilizer plant comes from the refining of Wyoming sour gas. Chevron's plant increased production in 1988 and may increase production again in 1989.

Trona

The production of soda ash and other sodium mineral products from mined trona in Wyoming increased dramatically in 1988 and should continue at record levels in 1989. This increase reflects the demand for soda ash as a substitute for caustic soda in some industrial processes. An increase in the demand for sodium cyanide (used in the refining of gold and other metals) will account for future production increases as FMC is planning to construct a 60-million-pound per year sodium cyanide plant near its soda ash plant west of Green River.

The export market for soda ash is for the production of glass. This market shrank in the 1982 recession, and although the demand for all kinds of glass is increasing, the market has not yet completely recovered.

Volcanic ash

The Geological Survey of Wyoming has determined that the product reported as "tripoli" in *Wyoming Geo-notes No. 21* (p. 28) is actually a high-silica volcanic ash of either Tertiary or Quaternary age. The State Geological Survey is continuing its study of this unusual rock in support of a block grant to the Town of Guernsey from the Wyoming Economic Development and Stabilization Board. Other volcanic ash deposits in Wyoming, including pumice and pumicite are not as white, fine grained,

or as high in silica as this deposit (Harris and King, 1986). Possible uses for this product are also under study by the State Survey, and a report on the occurrence and development potential of this product is in preparation.

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URANIUM UPDATE

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

There are currently three companies mining uranium in Wyoming. Two companies produce uranium by *in situ* methods from deposits in the Powder River Basin, and one company mines and mills uranium at a location in the Shirley Basin. Another company has announced plans to open an underground mine on Green Mountain and process ore from the Crooks Gap area, both south of Jeffrey City.

Although an early bill to reduce uranium severance tax rates from 5.5% to 2% failed to pass, a bill easing the severance tax was passed by the 1989 Legislature and signed by Governor Mike Sullivan. The bill reduces the severance tax rate from 5.5 percent to 4 percent with an additional decrease of 2 percent for new uranium production between June 8, 1989, and July 1, 1991.

Projects to reclaim abandoned uranium mining lands in the Gas Hills mining area east of Riverton may cost between \$60 million and \$85 million between now and the end of 1996. Funds for these projects will come from Federally collected coal taxes. Wyoming has received about \$400 million from these taxes, which are for reclamation of abandoned mined lands.

METALS AND PRECIOUS STONES UPDATE

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

Gold production during 1988 was minor and amounted to less than a few hundred ounces recovered from gold placers. Interest in gold, however, is picking up in Wyoming based on several companies' announced plans to conduct reconnaissance exploration in the State during the next few months. This interest is reinforced by the announcement of some gold projects in the State.

It was reported by the Mining Record (3/8/89) that Royal Gold, Inc. of Denver, signed an option agreement with Henrietta Mines, Inc. of Vancouver and Kirkwood Exploration of Casper to obtain rights to purchase Wyoming Gold, Inc. Wyoming Gold, Inc.'s principal asset is the Copper King mine located in the Silver Crown district, 20 miles west of Cheyenne in Laramie County. The Copper King mine is in a Proterozoic copper-gold porphyry hosted by quartz monzonite and granodiorite (Klein, 1974). Drilling results prior to 1973 indicated the presence of a surface-

minable deposit containing 35 million tons of ore averaging 0.21 percent copper and 0.022 ounce/ton gold. More recent drilling outlined a 4.5-million-ton deposit averaging 0.044 ounce/ton gold (Stockwatch, 1987). The Mining Record (3/8/89) indicated the Copper King has a 3.6-million-ton resource averaging in excess of 0.04 ounce/ton gold and 0.4 percent copper.

The Casper Star-Tribune (3/18/89) reported that American Mining and Milling of Gillette was planning to resubmit an application to mine gold along the western flank of the Bighorn Basin near the Clark's Fork River in Park County. At this locality, placer gold is found with abundant garnet along the Sand Coulee Creek north of Cody. The original source of the gold is unknown, but may be from conglomerates in the Willwood Formation. Similar conglomerates in the Cedar Mountain Wilderness Study Area north of Thermopolis along the southeastern flank of the Bighorn Basin were recently tested by the U.S. Bureau of Mines. These samples yielded concentrates containing 20 ppm (parts per million), 30 ppm, and 100 ppm gold (Larsen et al., 1988).

During the past quarter, several samples collected by the Geological Survey of Wyoming were assayed. By far, the more interesting samples were collected from the Penn mines in the Seminoe Mountains greenstone belt (see table below). This is the same area where the State Geological Survey collected samples in 1981 that assayed as high as 2.87 ounces/ton gold (Hausel, 1989, p. 148-150). The Survey is planning to start a research project in this greenstone belt this summer.

Assay results of some samples recently collected by the Geological Survey of Wyoming.

Sample Number	Description	Au(ppm)	Ag(ppm)	Cu(%)
BP2-88	Quartz vein with primary sulfides and some boxworks from Bradley Peak, Seminoe Mountains	28.0	18.0	0.39
BP3-88	Quartz vein with sulfides from Bradley Peak	20.0	18.0	0.38
LL11-88	Copper-stained gneiss collected from pit along Big Hermit Gulch, South Pass	0.87	ND	0.058
MD8-88	Vein from metatonalite porphyry near Highway Department Station, South Pass	2.3	19.0	0.88

ND = not detected

Several other samples were collected for assay, including selected titaniferous black sandstones from the Mesaverde Formation (Cretaceous) in the southern Bighorn Basin and conglomerates from the Flathead Sandstone (Cambrian) on the southeastern flank of the Rawlins uplift. These samples contained no detectable gold.

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MINERAL EXPLORATION SUMMARIES FOR 1988

by W. D. Hausel, R. E. Harris, and R. W. Jones, Geological Survey of Wyoming

Coal exploration summary

Exploration for coal in 1988 continued, but at a level slightly less than in 1987. Most of the coal companies operating in the State are emphasizing production of existing reserves rather than proving or acquiring additional reserves through exploration. As in the past, low coal prices, a soft coal market, and a large productive over-capacity have all decreased the incentives and the need for exploration.

Five Federal coal exploration licenses were active in 1988 and an application for an exploration license was pending. An exploration license held by Powder River Coal Company for exploration on a 40.8-acre tract in southern Campbell County was drilled in 1987; the remaining licenses were drilled in 1988. Triton Coal Company drilled a 650-acre tract in Campbell County; Kerr-McGee Coal Corporation drilled a 1,910.17-acre tract in Campbell County; Powder River Coal Company drilled a 9,527.67-acre tract near their North Antelope property in Campbell County; and Nerco Coal Company drilled a 401.9-acre tract near the Antelope mine in Converse County. A total of 12,520.54 acres of Federal coal in the Powder River Basin, Wyoming, were under exploration license in 1988.

In Wyoming, coal exploration by the Federal government apparently ceased in 1988 as neither the U.S. Geological Survey (Branch of Coal Resources) nor the U.S. Bureau of Land Management conducted drilling projects. Both these agencies have been active in coal exploration in past years, but with a downturn in Federal coal leasing and tract evaluation activities, drilling and coal analyses programs have apparently been discontinued at least temporarily.

Coal exploration drilling by private industry is tracked by the Wyoming Department of Environmental Quality through their Abandoned Drill Hole Program. Data from 1987, which became available in late 1988, indicated that exploration drilling for coal continued to decrease. Nearly all of the drilling was on active coal mine permits (development drilling in advance of mining is not included in the totals).

A total of 257 coal exploration holes were drilled in 1987, as compared with 352 holes in 1986 and 2,000 in 1985. Total footage drilled also decreased: 45,064 feet were drilled in 1987 compared with 64,572 feet in 1986. About 98 percent of the footage drilled and 90 percent of the drill holes were located in the Powder River Basin. The remainder of the drilling was in Carbon County. About 92 percent of the total footage drilled was on privately-owned surface.

Industrial minerals exploration summary

In Wyoming, 1988 exploration for industrial minerals was not only aimed at minerals already produced in the State, but also at some possible new products. American Bentonite Co. continued exploration and development plans for a bentonite deposit near Poison Spider School, southwest of Casper. Other bentonite companies maintained their property position through assessment drilling.

The five Wyoming producers of soda ash increased exploration tests for trona reserves. These tests included studies of the feasibility of *in situ* production.

Exploration continued for construction aggregate, mostly for use in highway construction. Meridian Minerals, a division of Burlington Northern, Inc., bought the ballast operation at Granite, west of Cheyenne, from Morrison-Knudsen. Meridian supplies ballast from this quarry to the Union Pacific Railroad, as did Morrison-Knudsen.

Metals and precious stones exploration summary

In 1988, precious metals activity in Wyoming was moderate with signs of interest beginning to show for volcanogenic massive sulfides and stratabound metasedimentary copper-silver-gold mineralization. A 1989 publication (Bulletin 68) by the Geological Survey of Wyoming entitled, *The geology of Wyoming's precious metal lode and placer deposits*, expresses optimism for the Cowboy State and reports that many untested gold deposits, including a few potentially giant deposits, occur in Wyoming.

In the Wind River Range of western Wyoming, gold exploration was reported at several locations in the South Pass granite-greenstone belt near the southern tip of the range. This Archean terrane consists of metamorphosed sedimentary, volcanic, and plutonic rock folded into a synclinorium. According to an ongoing study by the State Geological Survey, this belt has thousands of feet of strike length of unexplored auriferous shear zones and dozens of unexplored potential ore shoots and some untested placers. Gold in the region not only occurs in shear zones and placers, but is also found in veins, discrete veins, and Tertiary paleoplacers. In addition to gold, the belt hosts banded iron formation, abundant pegmatite, and some copper, silver, tungsten, uranium, and asbestos. Recently, a belt of high-magnesian metakomatiites with anomalous chromium and nickel was identified, as well as some anomalous tin in placers.

Potential for large tonnage, low-grade gold mineralization is also apparent in the region. A 97-foot composite chip sample collected in wallrock adjacent to one shear zone averaged 0.8 ppm gold. At another location, a 39-foot-wide shear averaged 2.66 ppm gold. One hidden shear zone discovered in 1987 averaged 1.6 ppm gold over a width of 17 feet.

At one undisclosed location in the district, several nuggets from walnut-size to smaller, were recovered from a placer. At the Stout placer mine on Rock Creek, several nuggets were also recovered with a large portion of relatively coarse flake gold. At another undisclosed location in the greenstone belt, a major mining firm exposed a 30-foot-wide shear which yielded ore-grade gold mineralization. Although another company, the Gyrovary Mining Company, continued modification of its Mary Ellen mill in the belt with hopes of starting production by summer's end, they were apparently unable to meet all the necessary State permitting requirements.

In the Medicine Bow Mountains of southeastern Wyoming, platinum, palladium, and gold were targeted by four mining companies. The principal targets are platinum reefs in two large, layered, Proterozoic mafic complexes. Along the northeastern edge of one of the complexes (the Mullen Creek layered complex), platinum and palladium were sporadically mined with copper, gold, and silver from the New Rambler mine between 1900 and 1928. The Douglas Creek gold placers, which lie between the two complexes, have periodically yielded platinum nuggets and flakes since 1868.

West of the Medicine Bow Mountains, some claim-staking activity for massive sulfide mineralization occurred in the southeastern Sierra Madre along the Colorado-Wyoming border. The activity was stimulated by rumors of a large zinc-silver discovery by Broken Hill Mining, immediately south of the border near Pearl, Colorado. Elsewhere in the range, some prospecting occurred for copper-zinc-silver volcanogenic massive sulfides and copper-silver-gold stratabound metasedimentary mineralization. A few miles north of the staking activity in the Purgatory Gulch area, the State Geological Survey identified significant gold mineralization.

In northeastern Wyoming, companies were exploring for gold in the northwestern Black Hills. Three principal Tertiary alkalic igneous complexes contain anomalous mineralization. These are the Mineral Hill, Black Buttes, and Bear Lodge complexes. Gold-bearing jasperoids, feldspathic breccias, and placers are reported in the Mineral Hills district although presently most exploration activity has concentrated on gold-tin placers. The Black Buttes district, several miles to the west, exhibits local jasperoid and silicification in the Mississippian Pahasapa Limestone. Mineralization associated with silicification includes fluorite, hemimorphite, wulfenite, and argentiferous galena. Prior to World War II, some lead, silver, and zinc were mined from this complex although there is no known activity in the district at the present time.

The Bear Lodge Mountains, north of Black Buttes and a few miles north of the town of Sundance, received considerable exploration activity for low-grade epithermal gold in 1988. This complex also includes one of the largest low-grade rare earth and thorium deposits in the United States.

The *1988 Annual report of International Curator Resources* reported that the company acquired an option from FMC Gold Company to explore the Sundance property in the Bear Lodge complex. The more than 30 holes that have been drilled to date reportedly show widespread gold mineralization in an elongate intrusive breccia 2,000 feet long by 120 feet wide. Assays of the breccia are reported to range from 0.01 ounce/ton to 0.05 ounce/ton gold with an average grade of 0.021 ounce/ton gold.

In the Bighorn Basin, activity was reported on the Sand Coulee placers north of Cody. Small detrital and chemically precipitated gold flakes occur in the stream gravels. The source of the gold is assumed to be sandstones in the underlying Tertiary Willwood Formation. A similar gold deposit was recently identified east of Winchester, Wyoming, in the southeastern corner of the basin. This gold occurrence, which is in a Wilderness Study Area, occurs in alluvial deposits overlying sandstones and conglomerates of the Willwood and Fort Union Formations. The U.S. Geological Survey reported that sample concentrates yielded 20 ppm to 100 ppm gold.

At least one company reports continued exploration and evaluation of iron-titanium-zircon black sands in Hot Springs and Washakie Counties. Increased demand for zircon has added to the attractiveness of these titanium-rich black sands.

The Geological Survey of Wyoming's exploration program for diamond-bearing kimberlite continued in 1988. More than 200 stream-sediment anomalies have been identified to date. These anomalies consist of pyrope garnet and chromian diopside, and many of the anomalies occur within the Archean craton. During the examination of samples, some other interesting heavy minerals have been recovered, including gold, aquamarine, ruby, and sapphire.

Uranium exploration summary

There was little if any change in uranium exploration activity in Wyoming between 1987 and 1988. The U.S.-Canada Trade agreement has so far neither increased nor decreased uranium exploration. Four companies continued developmental exploration, two *in situ* producers began production, and some reconnaissance exploration was conducted in known mineralized areas.

Pathfinder Mines, a wholly-owned subsidiary of COGEMA, continued production and development exploration at the Shirley Basin open pit mine and mill. Pathfinder closed the Lucky Mc Mill in the Gas Hills in 1988. The Lucky Mc Mill was producing uranium from previously mined and stockpiled ore.

Malapai Resources and Everest Minerals conducted drilling and other tests on their *in situ* properties in the Powder River Basin. Production from both of these properties began in 1988 and is expected to increase since at year's end both companies announced new supply contracts with foreign and domestic utilities.

USE-CC, a joint venture of U.S. Energy Corporation of Riverton, Wyoming, and Crested Corporation (44 percent of which is owned by U.S. Energy), developed mining plans and continued exploration on a proposed underground mine at Green Mountain, south of Jeffrey City. USE-CC acquired property and conducted assessment drilling in the Crooks Gap area, which is also south of Jeffrey City.

Union Pacific Resources conducted some surface tests and surveys on their Canning Property on Copper Mountain northeast of Shoshoni, Wyoming. Union Pacific Resources, in a joint venture with Taipower and Union 76 Minerals, also continued reconnaissance exploration studies for uranium in Wyoming.

RECENT TRENDS IN GEOLOGIC MAPPING

by Alan J. VerPloeg, Stratigraphy Division Head, and Gary B. Glass,
State Geologist and Director, Geological Survey of Wyoming

At least for the last four years, geologic mapping in Wyoming has been increasing. On the national level; however, published geologic mapping has declined almost every year for the last ten years (Fuller, 1989). Fuller's data indicate that while some individual years showed gains between 1979 and 1988, the general trend as indicated by total area mapped was a decline of almost 50 percent. Fuller's (1989) summary was based on a Geologic Map Index project by the U.S. Geological Survey. The index included geologic maps produced by Federal and State agencies (principally maps of the U.S. Geological Survey and the State geological surveys). Thesis and dissertation maps were apparently not included in the project as they did not, for the purpose of the project, meet the definition of "published".

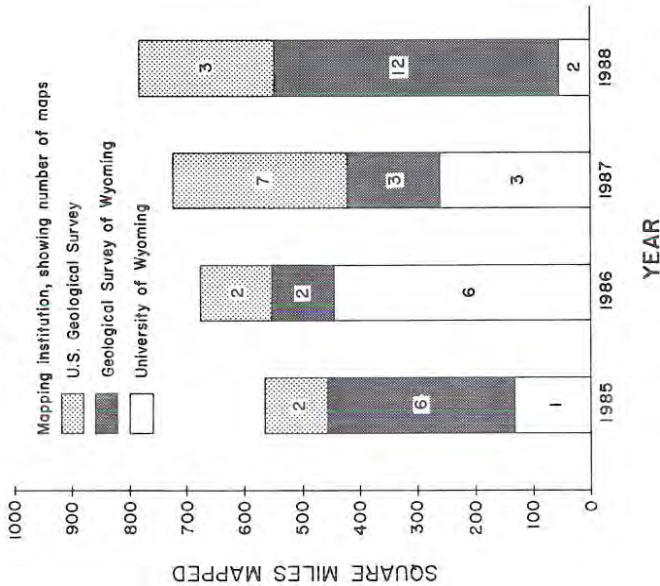
With Fuller's article in mind, geologic mapping in Wyoming between 1985 and 1988 was reviewed to compare the State trend with the national trend. For purposes of the comparison, published maps of the U.S. Geological Survey and the Geological Survey of Wyoming were tabulated in terms of the total area mapped (in square miles) and in terms of the number of maps published. In addition, thesis and dissertation maps prepared for the University of Wyoming's Department of Geology and Geophysics were also tabulated even though these maps are not in a strict sense, "published". Thesis and other maps of Wyoming done by students attending out-of-state universities and colleges were not included in the tabulations because information about them was too incomplete.

Two graphs on Wyoming mapping were prepared (see page 30). The first graph summarizes data for large-scale (1:2,000 to 1:24,000) mapping. In this graph, the number of maps seems to be proportional to the total area mapped. The second graph for small-scale (1:48,000 to 1:1,000,000) mapping suggests that there is little direct relationship between the number of maps and the total area mapped.

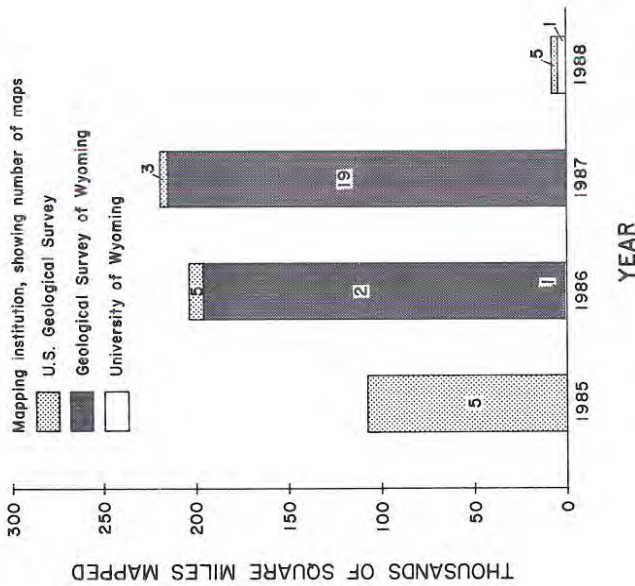
Without getting overly technical with this relatively subjective tabulation, there are some apparent trends. Looking first at large-scale maps, it is obvious that there has been a steady increase in both the area mapped each year and the number of maps published. It is also significant that the predominant mapping group varies from year to year. In 1985 and 1988, the State Geological Survey mapped the most area and produced the most maps. In 1986, the University of Wyoming accounted for the most maps and the most area mapped. In 1987, it was the U.S. Geological Survey that led in mapping in Wyoming. Clearly in the case of large-scale mapping, all three of these mapping groups are substantial contributors over the longer term. Most of the maps at these scales involved new, original mapping.

In regard to small-scale maps of Wyoming, mapping increased from 1985 through 1987, but fell drastically in 1988. Most of the maps at these scales were compilations of existing maps rather than new, original mapping, and the likelihood of annual fluctuations in mapping looks high. The one trend other than a general increase between 1985 and 1987, is that these kinds of maps are generally produced by the U.S. or Wyoming Geological Survey rather than the University of Wyoming.

**LARGE-SCALE MAPPING
IN WYOMING
(1:2,000 - 1:24,000)
1985 - 1988**



**SMALL-SCALE MAPPING
IN WYOMING
(1:48,000 - 1:1,000,000)
1985 - 1988**



Many of these maps are topical rather than the more conventional type of geologic map i.e., one that shows geologic formation boundaries. For example, in 1986 and 1987, the Wyoming Geological Survey's maps at these scales emphasized geologic hazards (i.e., landslides and windblown sand) or structural features such as faults and fold axes.

In conclusion, it looks like mapping efforts in Wyoming may not be following the national trend toward less mapping. While mapping at both the large- and small-scales are important, a recent national survey of geologic map users indicated that the more pressing need in terms of geologic mapping was for new large-scale maps (see pages 39 and 40 of *Wyoming Geo-notes No. 18*). For now it looks like all three groups of mapping entities in Wyoming are trying to meet the user needs described in the national survey.

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UNDERGROUND EXPLOSIVE TEST SITE

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

A non-nuclear, underground, explosive test site selected by the State Geological Survey for testing by the U.S. Department of Defense, the Defense Nuclear Agency, the U.S. Army Corps of Engineers, and private contractors is being drilled in April (See *Wyoming Geo-notes No. 21*, p. 36). The site is approximately 10 miles south of Shawnee, just west of the common corner between Converse, Platte, and Niobrara Counties and north of Glendo Reservoir. If core from the test well indicates that the rocks meet geologic and engineering specifications, the Defense Nuclear Agency must decide between this site, two in Texas, and two in New Mexico. Should the Wyoming site prove most favorable, further testing and construction may commence in the summer of 1989. The test and the construction of the underground site, including tunnelling and support services, may cost around \$11 million, much of which will be spent in Wyoming. The Geological Survey of Wyoming is providing technical assistance to the private contractors regarding the site geology, the logging and sampling of the core, and the monitoring of the conditions in the well between April and July.

NATIONAL EARTHQUAKE AWARENESS WEEK

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

April 2-8, 1989, was National Earthquake Awareness Week. In response to some damaging earthquakes in Wyoming within the last one hundred years, the Wyoming Emergency Management Agency, in coordination with the Geological Survey of Wyoming, has completed earthquake contingency plans for the western third of the State. Those plans include information on the potential for earthquake damage at both the county and city level. Based upon those damage scenarios, contingency plans have been developed for communications, search and rescue, shelter, food and medical services, and general restoration of public and private activities. Detailed plans have been developed for Teton, Lincoln, Park, and Uinta Counties as well as the towns of Cody, Jackson, Afton, Kemmerer, and Evanston. For further information on the plans, contact the local County Emergency Management Coordinator; Grant Sorensen at the Wyoming Emergency Management Agency in Cheyenne; or the Geologic Hazards Division of the Geological Survey of Wyoming in Laramie. Additional information on historic earthquakes, as well as the cause of earthquakes, and the potential for occurrences in the future can be obtained from the Geological Survey of Wyoming in Laramie. (See also Geological Survey of Wyoming Public Information Circular 26, *Earthquakes and related geologic hazards in Wyoming*).

A few large earthquakes have occurred in or near Wyoming. In August, 1959, a magnitude 7.5 quake occurred at Hegben Lake near Yellowstone National Park. As a result of that quake, a major landslide was initiated, which dammed the Madison River. So much material was displaced so quickly that it generated a great blast of air that blew people about like leaves. Twenty-eight people were killed by that earthquake and its effects (Witkind, 1962). As many residents in the State are aware, Yellowstone National Park is a seismically active area.

Other areas of Wyoming have also had historic earthquake damage. In November of 1897, a moderate quake occurred in the Casper area. The Grand Central Hotel was considerably damaged, with cracks in the structure up to four inches wide (Coffman, and others, 1973). In 1894 in the same area, a quake threw people from their beds. Water in the Platte River changed from fairly clear to reddish and became thick with mud as the river's banks caved into the water (Coffman and others, 1973).

In 1955, a moderate to small earthquake occurred near Woods Landing. Reflecting the fears of the time, one person thought that an atomic bomb had dropped on Denver, and the person prepared to accept the evacuees (Laramie Republican and Boomerang, May 23, 1955). In 1984, a magnitude 5.5 earthquake occurred in northern Albany County. At least seven tremors have been recorded within 30 miles of the 1984 site since 1947.

In 1934, a moderate earthquake occurred near Lander. Residents in a 10-mile radius around Lander reported that dishes were thrown from cupboards and pictures fell from walls. Cracks were found in buildings in two business blocks, and the brick

chimney of the Fremont County Courthouse was moved two inches away from the building (Casper Tribune-Herald, November 25, 1934).

In 1932, a moderate earthquake disturbed the residents of Jackson. Plaster broke off walls, foundations cracked, and because it happened at night, people were thrown from their beds. Earthquakes have also disturbed residents in Lusk, Gillette, and Sheridan. In fact, almost every county in the State has either had an earthquake located in it, or felt the effects of an earthquake.

There are many areas in the State where earthquake damage has not occurred, but the potential is present. A number of active faults have been identified, both exposed at the surface and deeply buried. Most residents of Wyoming are aware of the Teton fault near Jackson. What they may not know is that the fault has the potential of activating, resulting in a sizeable earthquake. Many scientists have suggested that an earthquake as large as magnitude 7.5 may result from a large-scale activation of that fault (Gilbert and others, 1983). If a maximum event occurred during the time of year when landslides are most likely, all access routes into Jackson could be blocked. The airport could be severely damaged, and many critical facilities could become inoperable.

The Star Valley in Lincoln County in western Wyoming is also threatened by an active fault. The Star Valley fault system occurs along the eastern margin of the valley and trends through the eastern edge of the town of Afton. A maximum event could have a magnitude as high as 7.5 and a maximum ground displacement of 10 to 20 feet (Piety and others, 1986).

The Bear River fault zone, southeast of Evanston in Uinta County, could also generate a maximum magnitude 7.5 earthquake (West, 1986). A number of oil and gas processing facilities and several pipelines are within 30 miles of the fault system.

Two segments of the South Granite Mountain fault system west of Casper are also classified as active. An earthquake with a maximum magnitude of 6.75 has been estimated for those segments (Geomatrix, 1988a). Part of the Stagner Creek fault system, located on the south flank of the Owl Creek and Bridger Mountains in central Wyoming, is active. A maximum event of magnitude 6.75 has also been estimated for that fault system (Geomatrix, 1988b).

Because some of the active fault systems are only expected to activate every 3,000 to 5,000 years, there is a tendency to forget the damage caused by past earthquakes or to ignore the potential for damage from faults that have not activated in historic times. However, the potential for a large earthquake does exist, and in many cases, scientists are not certain when the faults were last active. Similarly, faults do not always follow the recurrence intervals or magnitudes that have been assigned to them.

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HISTORY OF THE STATE GEOLOGICAL SURVEYS

This comprehensive, 499-page volume was published in November, 1988, by the Association of American State Geologists. Edited by retired Pennsylvania State Geologist Arthur A. Socolow, the hard-covered book contains the history, organization, and functions of each of the 50 State Geological Surveys in individual chapters prepared by the respective Surveys.

More than 30 of the State Surveys originated over 100 years ago and the accounts of the development and activities of America's State Geological Surveys shed light on a major component of geologic mapping and research which has been achieved in the United States. Geologists in government, academia, and industry, and all who are interested in geologic achievements, will find this illustrated publication informative and thoroughly readable.

The 19-page discussion of the Geological Survey of Wyoming was written by the Survey's Editor, Sheila Roberts. While Ms. Roberts drew heavily on William Bryans', *A history of the Geological Survey of Wyoming* (Geological Survey of Wyoming Bulletin 65, 1986), her summary is an original and informative history which stands on its own. As usual, the Wyoming section is easy to find since the histories are arranged in alphabetical order by State.

The State Geological Surveys - a history may be ordered from the Geological Survey of Alabama, P.O. Box 0, Tuscaloosa, AL 35486. The price is \$20.00 (includes shipping); make check payable to: Association of American State

Short Course on Gold & Diamond Prospecting Offered

A one-day seminar on methods used to identify gold- and diamond-bearing rock and how and where to find these deposits is being offered by the Geological Survey of Wyoming in Laramie. The course is scheduled for September 16, 12 to 4 p.m., at the State Geological Survey Building on the University of Wyoming Campus. It will be taught by W. Dan Hausel of the Survey staff.

Participants will have an opportunity to examine dozens of gold and diamond ores from Wyoming and other regions around the world; they will be shown a variety of deposits through slides, and will tour the Survey's diamond-extraction lab.

Because of limited space, only the first 15 registrants will be accepted. The cost of the seminar is only \$12.50, which covers the cost of maps used in the course. For further information, contact W. Dan Hausel (307) 766-2286.



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Geologic map of the Radium Springs Quadrangle, including the Lewiston gold district, Fremont County, Wyoming, W. Dan Hausel: Map Series 26, 1988, scale 1:24,000 (\$3.00).

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Index to U.S. Geological Survey topographic maps of Wyoming available from the Geological Survey of Wyoming: 1989, scale 1:1,000,000 (map scales shown include 1:24,000; 1:100,000; and 1:250,000), (first copy free, \$2.00 for each additional copy).

Wyoming State Geologists (postcard): 1988 (25¢ each or 5/\$1.00).

The geology and reserves of Hawk Point oil field, Campbell County, Wyoming, R.H. DeBruin: Open File Report 89-1, 1989, (\$2.50).

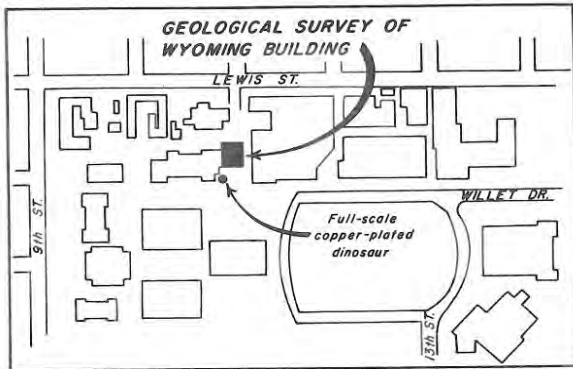
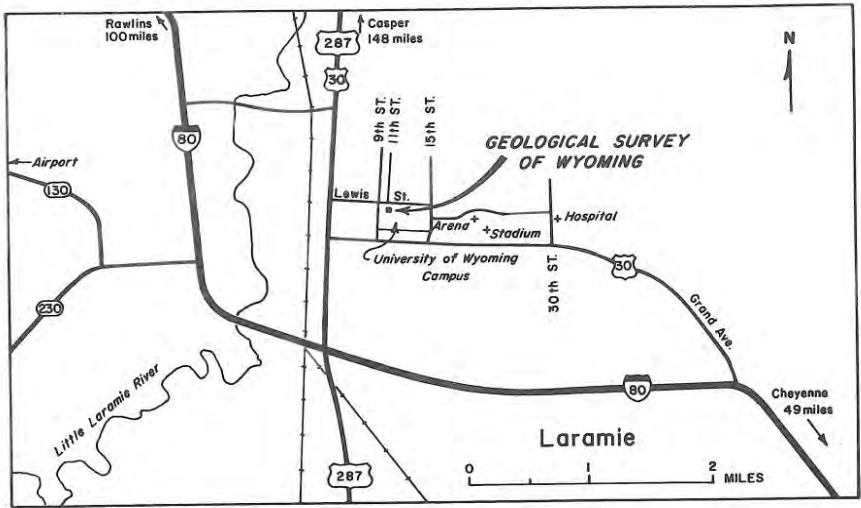
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