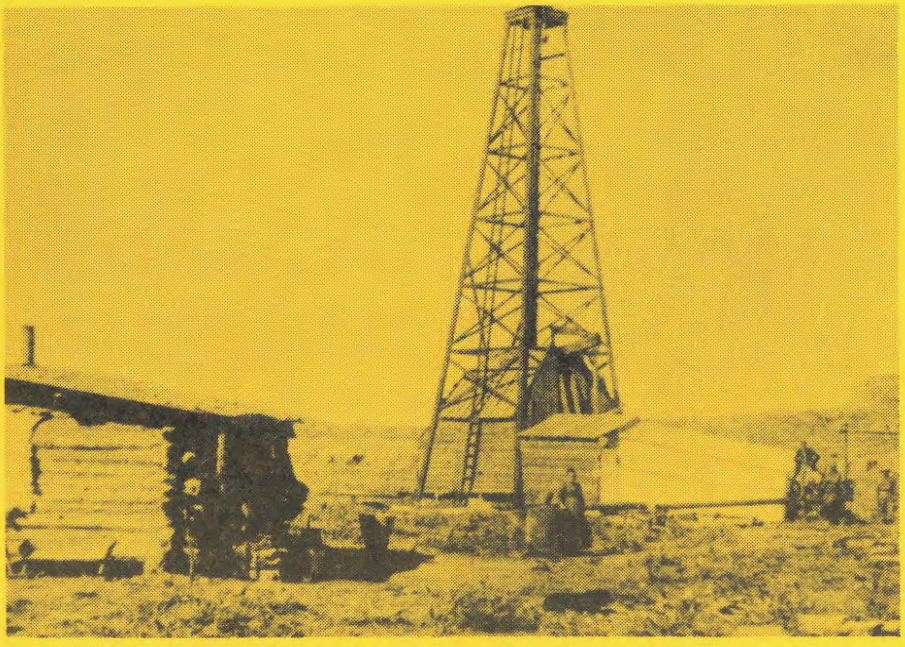
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES
NO. 23



LARAMIE, WYOMING
July, 1989

THE GEOLOGICAL SURVEY OF WYOMING

Gary B. Glass, *State Geologist and Director*

ADVISORY BOARD

Ex Officio

Mike Sullivan, *Governor*

Terry P. Roark, *President, University of Wyoming*

Donald B. Basko, *Oil and Gas Supervisor*

Appointed

D.L. Blackstone, Jr., *Laramie*

Michael Flynn, *Sheridan*

Jimmy E. Goolsby, *Casper*

Robert S. Houston, *Laramie*

Bayard D. Rea, *Casper*

STAFF

Administrative Services
Susanne G. Bruhnke - *Secretary*
Rebecca S. Hasselman - *Bookkeeper*

Publications Division
Sheila Roberts - *Editor and Head*
Teresa L. Beck - *Publications Assistant*
Frances M. Smith - *Sales Manager*
Fred H. Porter, III - *Cartographer*
Phyllis A. Ranz - *Cartographer*

Coal Division
Richard W. Jones - *Head*

Geologic Hazards Division
James C. Case - *Head*

Industrial Minerals and Uranium Division
Ray E. Harris - *Head*

Laboratory Services
Jay T. Roberts - *Laboratory Technician*

Metals and Precious Stones Division
W. Dan Hausel - *Deputy Director and Head*

Oil and Gas Division
Rodney H. DeBruin - *Head*

Stratigraphy Division
Alan J. VerPloeg - *Head*

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. Two-year subscriptions are accepted.

Front cover: This year marks the 100th anniversary of the discovery of oil in Natrona County. P.M. Shannon drilled the first producing well in 1889. The well, shown on the cover, was drilled less than a mile north of what would later be known as Salt Creek Field. Production of 5 to 10 barrels of oil per day was established from this well at 700 feet in the Shannon Sandstone (named after the discoverer). Salt Creek has produced from 12 different zones since its discovery in 1889 and its cumulative production is over 630 million barrels of oil. This total production makes Salt Creek the largest field in Wyoming; last year the field produced over five million barrels of oil. Amoco Production may conduct a carbon dioxide recovery project in the field, which could extend Salt Creek's production into the next century.

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

Table of Contents

	Page
Minerals update	1
Overview	1
Oil and gas update	5
Coal update	12
Developments in the Hanna coal field	18
Developments in western and southwestern Wyoming	19
Developments in the Powder River Basin coal field	20
Coal contracts - Powder River Basin	20
Industrial minerals update	22
Aggregate	22
Bentonite	22
Cement	22
Clinker	23
Limestone	23
Phosphate, sulfur, and fertilizer production	23
Silica	23
Trona	23
Uranium update	24
Metals and precious stones update	25
Status of tertiary recovery projects in Wyoming	26
Summary of oil and gas drilling and seismic permits	27
U.S. Geological Survey publishes new coal resource data	29
Geologic mapping and stratigraphy	32
Testing radon in Laramie	34
Defense Nuclear Agency picks Texas site instead of Wyoming	35
Recent and new publications	36

- Please note -

PHONE NUMBER CHANGE

The Geological Survey of Wyoming
now has only one phone number:

(307) 766-2286

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

So much for predicting who is Number One in coal production! Despite my doubts last quarter, Wyoming did produce enough coal in 1988 to make it Number One among the coal-producing states. Kentucky lost its long standing first place by more than two million tons. If production in the first three months of 1989 are any indication, Wyoming will set another record this year (Table 1). With the wildcat strikes that began in June in the eastern coal fields, Wyoming's chances of remaining on top are even better.

In regard to oil prices, the outlook remains guardedly optimistic. The posted price has hovered around $19 per barrel throughout the second quarter. The purchase price for most Wyoming oil, however, is about $1.00 - $1.50 less than the posted price due to gravity adjustments. First and second quarter prices are certainly an improvement over the prices at the end of last year. In fact prices haven't been this high since the middle of 1987. It is notable that prices have risen much faster in 1989 than they did back in 1987. Now the main concern is how long prices will stay up around $19. If the trend of 1987 is any indication, the price may not hold for more than three months. Only time will tell on this one.

In regard to natural gas, everyone is waiting to see who will build a pipeline from Wyoming to the California markets. While most of the players are the same as in the last quarter, there is a new entrant as well as a new coalition of old players to complicate anyone's chances of forecasting the outcome. The bottom line is that there is now much less doubt that one or more pipelines will indeed be built. With the entry of the Altamont Group, the Canadians have set the stage for a Canada to Wyoming to California pipeline. The Altamont Group wants to tie their line into the Kern River or WyCal line at Opal, Wyoming. What's more, this proposed project would be capable of delivering nearly twice the gas of any other proposal.

If that isn't enough to excite the imagination, the Kern River and Mohave Pipeline Projects have formed a coalition rather than fight each other. It's no wonder that some of the members of the Wyoming Pipeline Authority are beginning to wonder if Wyoming's proposed low-interest loan will be necessary at all.

In a related item, Governor Mike Sullivan has become the Chairman of the Interstate Oil Compact Commission (IOCC), which is a federation of 29 oil-producing states. A major effort of the IOCC is to gain support for a National Energy Policy. The IOCC's 1989 Report of the Committee in Support of a National Energy Policy included one illustration that is worth a thousand words in explaining why an energy policy is needed (Figure 1). For comparison, Wyoming had 14,863 producing wells in 1987 with a daily average production per well of 21.4 barrels.

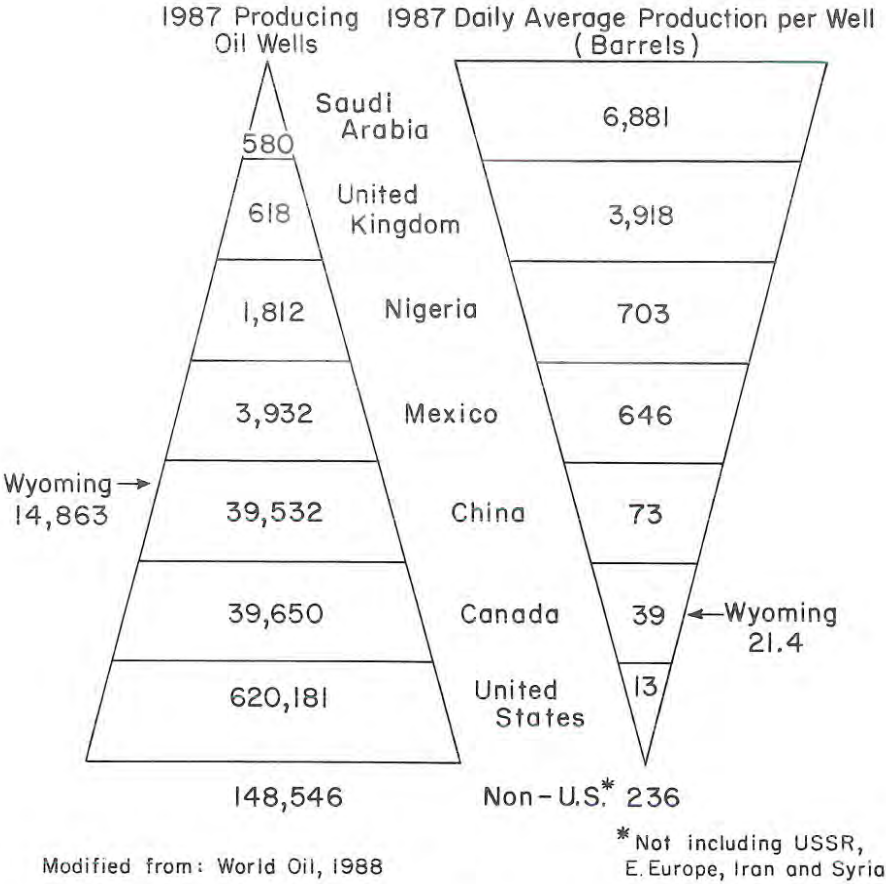


Figure 1. TOTAL PRODUCING WELLS VS. DAILY PRODUCTION PER WELL FOR SELECTED COUNTRIES AND WYOMING (1987).

That same report showed that Wyoming is also one of only six states in which production from stripper wells (less than 10 barrels of oil per day) accounts for less than 50% of its production. Only 32% of Wyoming's production comes from stripper wells. In fifteen of 29 oil-producing states, stripper production is greater than 75% of the total production - the nationwide average is 73%.

The second quarter of 1989 also documented continued high demand for soda ash from the trona patch in Sweetwater County. Cement production from the Mountain Cement Company in Laramie was running at plant capacity. And there is a resurgence of interest in Wyoming's uranium deposits, principally in the application of solution mining techniques.

Table 1. COAL DELIVERIES BY MONTH FROM WYOMING MINES[1]

	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE
JANUARY	11,601,200	11,601,200	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020
FEBRUARY	10,473,900	22,075,100	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160
MARCH	11,674,900	33,750,000	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490
APRIL	11,632,800	45,382,800	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990		
MAY	11,497,900	56,880,700	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490		
JUNE	11,692,200	68,572,900	10,499,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970		
JULY	11,893,500	80,466,400	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640		
AUGUST	12,107,100	92,573,500	11,773,510	87,195,190	13,460,470	92,150,870	15,041,090	101,533,730		
SEPTEMBER	11,325,000	103,898,500	11,474,820	98,670,010	12,651,550	104,802,420	13,433,610	114,967,340		
OCTOBER	11,048,500	114,947,000	10,854,670	109,524,680	12,248,080	117,050,500	13,696,190	128,663,530		
NOVEMBER	10,589,700	125,536,700	11,971,990	121,496,670	12,340,720	129,391,220	13,889,890	142,553,420		
DECEMBER	11,459,300	136,996,000	13,025,490	134,522,160	13,008,300	142,399,520	14,540,510	157,093,930		
TOTAL TONNAGE REPORTED	136,996,000		134,522,160		142,399,520		157,093,930			
TOTAL TONNAGE NOT REPORTED	3,784,154		1,782,896		4,089,128		6,494,270			
TOTAL TONNAGE PRODUCED[2]	140,780,154		136,305,056		146,488,648		163,588,200			

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

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

Table 2. WYOMING MINERAL PRODUCTION FORECAST TO 1992[1].

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[9]	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; [1]Geological Survey of Wyoming, April 1989; [2]millions of barrels; [3]billions of cubic feet; [4]billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [5]millions of tons; [6]millions of tons of uranium ore (not yellowcake); [7]millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1988-1992 are based on company information); [8]millions of tons, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission; [9]includes previously stockpiled ore processed by the Lucky Mc mill in 1987.

Table 3. PRODUCTION HISTORY OF SELECTED WYOMING MINERAL COMMODITIES[1].

	1980	1981	1982	1983	1984	1985	1986	1987
Ballast[2,3]	1.65	1.72	0.81	0.99	2.43	0.67	0.61	1.09
Bentonite[2]	3.58	4.81	2.35	2.18	3.08	2.59	1.82	2.16
Clay[4]	42.0	23.2	15.7	36.4	59.6	35.9	23.2	1.31
Decorative Stone[2]	0.05	0.05	0.05	0.07	0.08	0.09	0.07	0.06
Dolomite[2]	1.67	0.87	0.61	0.66	0.86	0.87	0.81	0.46
Feldspar[4]	0.20	0.03	0.17	----	----	----	----	----
Gypsum[2]	0.30	0.28	0.26	0.33	0.33	0.35	0.41	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	0.34	0.42
Sand and Gravel[2]	5.06	5.21	4.74	5.00	4.76	4.71	3.53	2.57
Scoria[2,6]	0.03	0.08	0.08	0.07	0.23	0.13	0.04	----
Shale[4]	----	----	----	----	20.3	14.7	9.88	0.49
Sodium Sulfate[4]	----	3.20	3.17	3.19	3.25	2.71	2.03	----

[1] Source: Ad Valorem Tax Division. [2] Millions of short tons. [3] Includes granite, scoria and other rock. [4] Thousands of short tons. [5] Includes limestone used for cement rock, sugar beet refining, and other uses. [6] Baked and fused rock, also called clinker.

OIL AND GAS UPDATE

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

A major new pipeline proposal that would help supply the California natural gas market was announced near the end of May. The Altamont Group, comprised of Amoco Canada Petroleum Company Ltd., Mobil Oil Canada, Petro-Canada Inc., and Shell Canada Ltd., proposed a 30-inch diameter pipeline that would originate in Wildhorse, Alberta, Canada, cross Montana and Wyoming, and terminate at Opal, Wyoming (Figure 2). The pipeline would have an initial capacity of 700 million cubic feet of natural gas per day and would give the Altamont Group the option to supply gas to the Midwest, to the South, and to the Northwest through existing pipeline systems and to supply California markets through the proposed Kern River or WyCal pipelines which would have to increase their capacities to 1.2 to 1.5 billion cubic feet per day. According to Altamont, under their proposal Wyoming gas producers could

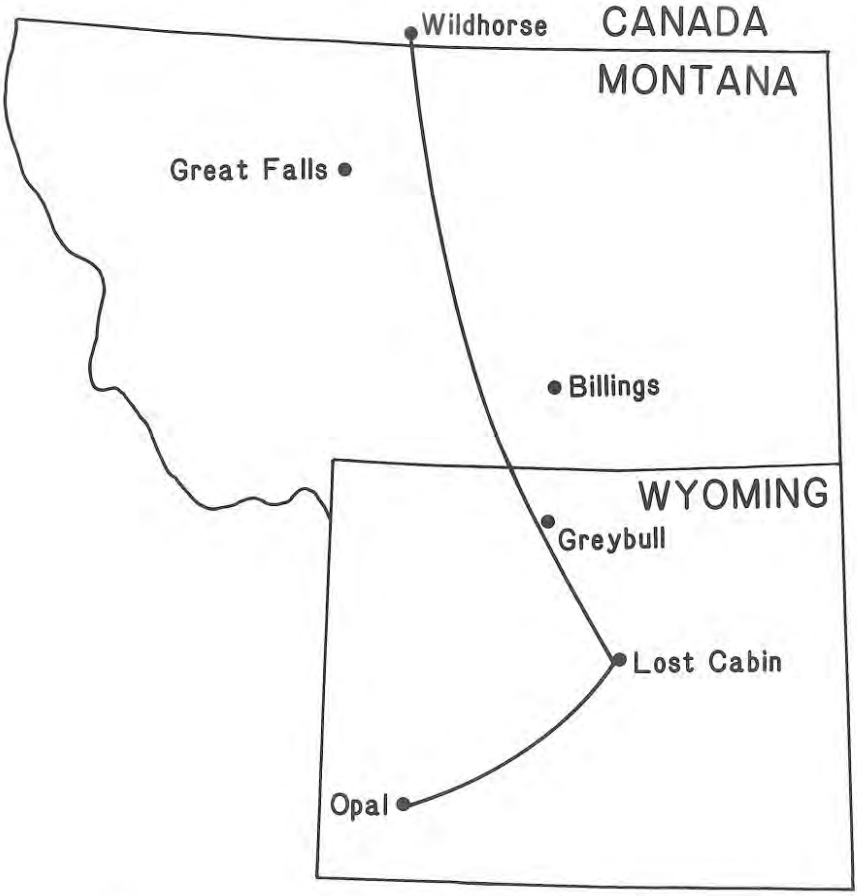


Figure 2. ALTAMONT GROUP'S PROPOSED PIPELINE ROUTE

get as much as a 15¢ per thousand cubic feet (MCF) discount on transportation costs to California. This compares with an estimated 6-7¢ per MCF discount on transportation costs if the State provides a low-interest loan to Kern River or WyCal. The individual members of the Altamont Group produce 31 percent of all Canadian gas. The group plans to file an application with the Federal Energy Regulatory Commission (FERC) in June, 1989, and expects to begin construction by late 1992 if FERC approval is timely. Construction of the line would create an estimated 3,000 seasonal jobs for Montana and Wyoming workers. Altamont also projects $7 million in property tax payments in Wyoming and Montana.

In a related item, Southern California Edison Company, which serves 3.8 million customers in central and southern California, signed a letter of intent to transport a minimum of 50 million cubic feet of gas per day for 15 years on the WyCal system. WyCal also signed a 20-year agreement with Pacific Gas and Electric Company for 50 million cubic feet of gas daily.

Mojave Pipeline Co. and Kern River Transmission Co. have agreed to coordinate their efforts to deliver natural gas to California. The agreement calls for Kern River to build their pipeline from Opal, Wyoming, and Mojave to build their pipeline from Topock, Arizona. The two lines would merge at Barstow, California, and continue to the oil fields of Kern County. The two companies will submit a final settlement agreement to the FERC by August 31, 1989.

Even though the average posted price for Wyoming Sweet crude oil increased steadily between November of 1988 and April of 1989 (Figure 3), the Wyoming rig count dropped during that time period (Figure 4). Although there has been a small seasonal increase in rig count in May and June, the count still has not responded to the higher prices. In past years these prices would have stimulated higher explora-

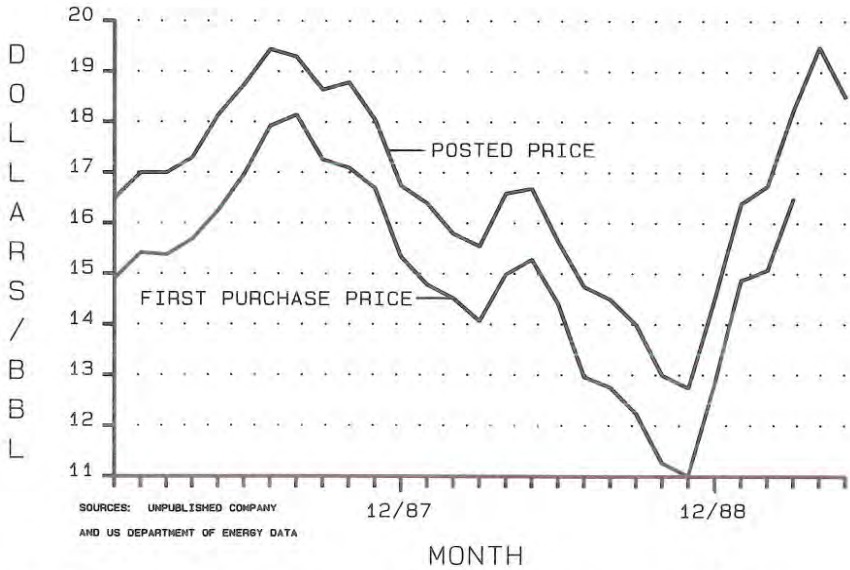


Figure 3. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987 TO PRESENT).

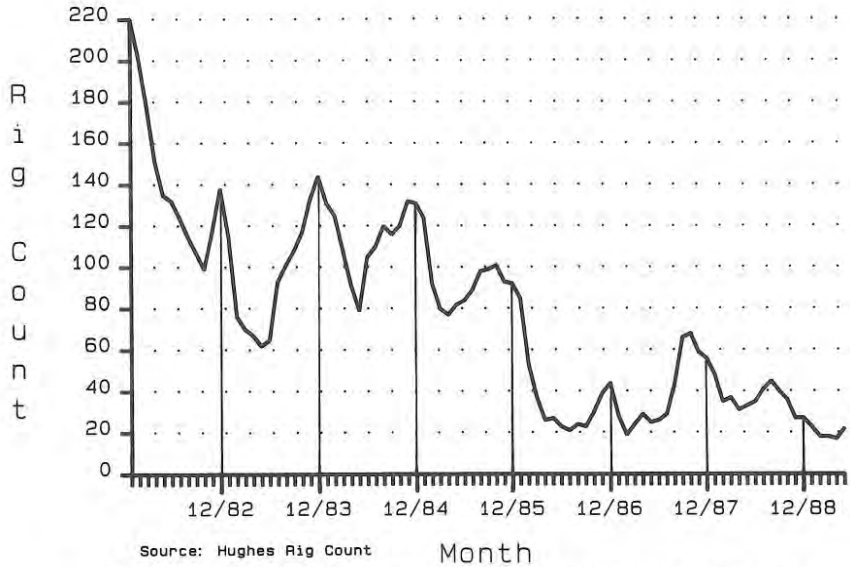


Figure 4. WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT).

tion activity, but most companies seem to have adopted a wait-and-see attitude. It is apparently hard to forget the lower prices brought on by OPEC overproduction in 1986, 1987, and 1988. Many oil companies appear to be planning for conditions which are likely to occur over the next ten years rather than on the short-term price behavior. If OPEC's June production agreement holds, prices for Wyoming crude oil should stabilize in the $18 to $20 range over the next few months.

True Oil Company's plans to drill 13 wells in Sublette County have been delayed by concerns over the effects the drilling may have on Colorado cutthroat trout in the Green River. A 1988 Environmental Analysis (EA) of the proposed wells found that an environmental impact statement was unnecessary, but subsequent reviews uncovered concerns that drilling could endanger the trout's habitat. A supplement to the earlier EA will have to be written. The U.S. Forest Service hopes to have the issue resolved by August 15, 1989.

Lease sales in the State are still doing well despite the low drilling activity (Table 4). The high per-acre bid at the Wyoming Department of Public Land's May sale was $155 by Yates Petroleum for a 280-acre parcel in section 35, T.50N., R.71W., which offsets Minnelusa oil production in AG Farm Field. Farmer Energy also paid $155 per acre for a 40-acre lease in section 21, T.53N., R.69W. This lease is about a mile north of Minnelusa oil production at Candy Draw Field. Hanson and Strahn paid $150 per acre for a 560-acre parcel in section 36, T.48N., R.72W. about a mile east of Minnelusa oil production at Oxbow Field. Yates Petroleum of Artesia, New Mexico, was the most successful bidder in the sale as they picked up 47 tracts.

The high bid at the April U.S. Bureau of Land Management (BLM) sale was $390 per acre by Enron Oil and Gas for a 75.7-acre lease in sections 13 and 24, T.28N.,

Table 4. WYOMING FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES

BLM SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				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
April	$2,334,604	732	227	557,643	145,055	$16.09	$390.00
June	$1,673,150	758	163	962,929	138,691	$12.06	$160.00

STATE SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				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
May	$512,736	199	129	76,396	51,919	$9.88	$155.00

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

R.113W. Enron recently announced plans to double production in this area (see *Wyoming Geo-notes No. 22*, p. 4). Yates was once again the most successful bidder as they leased another 47 tracts at this sale. Paul Sawyer made the high per-acre bid of $160 at the BLM's June sale for a 200-acre lease in section 20, T.49N., R.73W. The lease is about two miles northeast of Minnelusa oil production at Lewis Field and about two miles southwest of Muddy Sandstone production at S-Bar Field. Yates Petroleum was the high bidder on 51 parcels. The bids at the June sale may have been smaller than normal because the sale was protested by the Wyoming Wildlife Federation and the National Wildlife Federation. Bidders were given a list of 68 tracts on which the Wyoming Wildlife Federation felt the BLM's stipulations were inadequate. A BLM spokesman said that if there was merit to the protest, the leases will not be issued.

In June the U.S. Senate approved the removal of all Federal price controls on natural gas by 1993. The House passed a version of the bill earlier this year. Both versions would phase out price caps on gas produced from fields developed before April, 1977. The legislation would probably affect the price of only about six percent of domestic gas production. The price of most domestic gas was decontrolled in 1978.

The BLM will waive restrictions on oil and gas drilling on the 125,000-acre Rattlesnake antelope and deer winter range west of Casper if vegetation and weather conditions are favorable. The BLM has allowed winter drilling for the past two years. The waiver will be made only upon request and on a case-by-case basis.

Unocal Corporation joined a long list of oil companies that have transferred workers from Wyoming. While the company announced that it will transfer about 35 exploration personnel to other offices, the number of production personnel will probably remain the same or possibly increase slightly.

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 second quarter of 1989. The letters preceding the following discussion refer to locations on Figure 5.

A. The 2 Wadsworth-Federal 5-32 discovery well in section 5, T.12N., R.113W., produced 20 barrels of oil and 1.5 barrels of water on an eight-hour swab test of the Dakota. Reportedly, the productive zone will be stimulated with a sand-hydraulic fracture treatment. The well is about four miles northeast of Dakota production at Luckey Ditch Field and three miles southeast of Dakota production at Henry South Field.

B. Texaco, Inc. completed a discovery well, the 1 Federal-24 in section 24, T.24N., R.111W. The well flowed 5.1 million cubic feet of gas and 420 barrels of condensate per day from the Dakota during tests; however, during the first month of production, the well produced an average of 5.8 million cubic feet of gas and 294 barrels of 60.3° API gravity condensate per day. The well is nearly a mile east of the nearest Dakota producer in Blue Forest Field.

C. Drilling activity in the Bighorn Basin has picked up recently. Terra Resources is producing oil from the Phosphoria Formation at their 32-26 Sagebush Federal discovery in section 26, T.51N., R.92W. No further details are available. Terra will

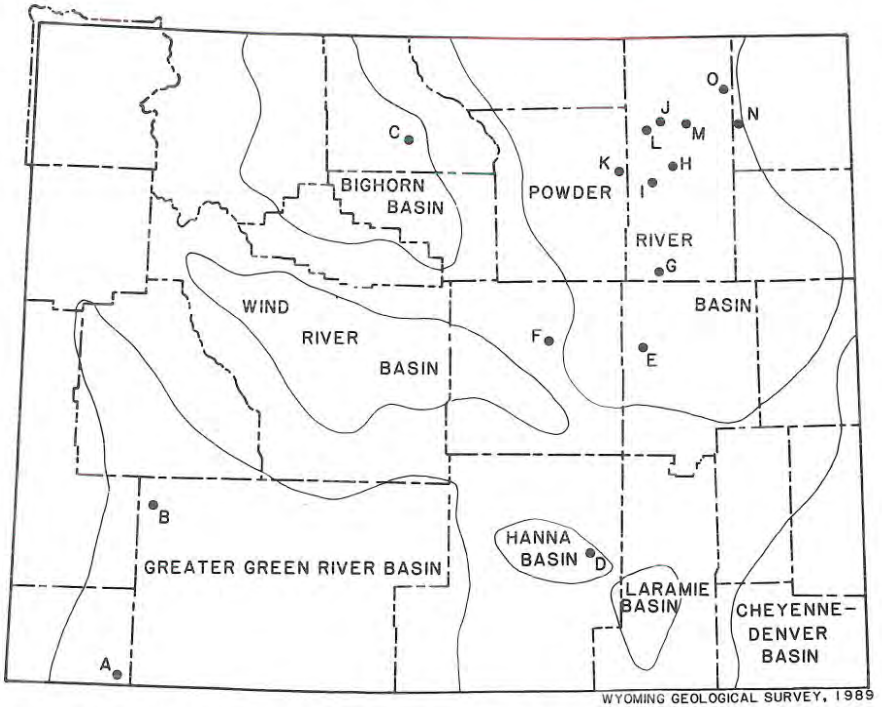


Figure 5. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING.

try to confirm their discovery at the 11-25 Sagebush Federal in section 25, T.51N., R.92W. Texakoma Oil and Gas plans to drill a Madison test in section 13, T.51N., R.92W., two miles northeast of Terra's discovery.

D. Coastal Oil and Gas scheduled a Dakota test on the east side of the Hanna Basin in section 21, T.22N., R.80W. Thus far, this township has had no production. The well is about five miles northeast of past production from the Frontier, Muddy, and Dakota at Simpson Ridge Field and about 6 miles northwest of Morrison and Nugget gas production at Chapman Draw Field.

E. W.A. Moncrief's 28-1 Popskull well in section 28, T.35N., R.75W. was completed for an initial flowing potential of 90 barrels of oil and 34 MCF of gas per day from the Muddy Sandstone. Nearest production is from the Frontier Formation about five miles west at V-Two Draw Field. Sun Exploration and Production will drill a well a little over two miles northeast of the 28-1 Popskull which will test the Frontier, Muddy, and Dakota.

F. True Oil is planning to drill a Madison test in section 17, T.37N., R.82W. on a structure that may have been created by a meteor impact. The well is six miles northwest of Casper Creek North Field. There have been two previous unsuccessful tests in the area.

G. Kerr-McGee Corporation has drilled another very good well in North Buck Draw. The 31-18 North Buck Draw Unit in section 18, T.41N., R.73W. flowed 1,725 barrels of 44° API gravity oil, 2.7 million cubic feet of gas, and three barrels of water per day from the Dakota. The company is drilling another well about a mile to the north. North Buck Draw Field had been shut in recently until hydrocarbon gas could be injected into the Dakota to maintain reservoir pressure and increase recovery. Since that project started, production from 11 wells averaged over 8,500 barrels of oil and over 2.7 million cubic feet of gas per day during the first three months of 1989.

H. Yates Petroleum, the most active bidder in recent Wyoming lease sales, has an apparent Minnelusa producer in the Einer Field area south of Gillette. The 42-9 Saunders well in section 9, T.49N., R.72W. was drillstem tested between 10,310 and 10,335 feet. Recovery was 272 feet of oil and 372 feet of oil and water-cut mud. This well is a north offset to the 43-9 Saunders well in the same section, which was completed last year pumping 190 barrels of oil and four barrels of water per day from the Minnelusa.

I. Also in the Powder River Basin, Conoco will attempt to extend the Minnelusa productive trend to the southwest. The company staked a 12,600-foot test in section 23, T.47N., R.74W. Nearest Minnelusa production is about eight miles east in the Hawk Point Field area.

J. The first commercial, coal bed methane, gas field in the Powder River Basin is now on stream. BETOP, Inc. is producing the gas from four shallow wells with an average depth of 400 feet at their Vandekoppel prospect six miles northwest of Gillette. The producers are the 3-20 Rawhide, the 2003 DEQ, the 7-20 Rawhide, and the 2002 DEQ in section 20, T.51N., R.72W. Production is from about 140 feet of subbituminous coal (Wyodak coal bed) in the Fort Union Formation. BETOP plans to complete three additional wells in the area which will bring production from the field to 2.5 million cubic feet of gas per day. Phillips 66 Natural Gas Co. built a four-mile pipeline to collect the gas at the BETOP field.

As a side note, this field is producing gas in the vicinity of the former Rawhide Village subdivision, which was abandoned in 1987 due to the surface venting of methane gas.

K. Coastal Oil and Gas plans to drill three coal bed methane wells in T.48N., R.77 and 78W. to test a coal in the Fort Union Formation at depths that range from 1,240 to 1,620 feet. These tests are in the vicinity of a thick coal designated Seam 14 (Ayers, 1986) or "Big George" (Kent, 1986). "Big George" is reportedly up to 200 feet thick and averages 113 feet in thickness (Kent, 1986).

L. BETOP will drill another coal bed methane test in section 13, T.50N., R.73W. The well will be a 730-foot Fort Union test. The targeted Wyodak coal bed is 60 - 80 feet thick in this area (Ayers, 1986). Coal bed methane wells in the Powder River Basin, as well as in other areas of the U.S., are on the rise because there is a tax credit for production from such wells. Because the tax credit is due to run out in the near future, companies with coal bed methane prospects are eager to drill their acreage before the deadline.

M. NICOR Exploration has a new producer in South Marnie Field. The 23-24 Kuehne in section 24, T.51N., R.70W. was completed pumping 340 barrels of oil and

3 barrels of water per day from the Minnelusa. The discovery well, the 31-25 Kuehne in section 25, T.51N., R.70W., was completed pumping 229 barrels of oil daily, and the confirmation well, the 14-24 Kuehne in section 24, T.51N., R.70W., was completed pumping 102 barrels of oil and six barrels of water daily.

N. Quintana Petroleum completed an offset to their West Prong area discovery. The new producer, the 2-35 West Prong-Federal in section 35, T.51N., R.68W. pumped 335 barrels of oil per day from the Minnelusa.

O. No details have yet been disclosed on a wildcat well drilled by Quintana Petroleum other than it has been completed as a Minnelusa discovery. The 1-35 Shippy in section 35, T.54N., R.70W. is about a mile east of Booten Field and about 1.5 miles northwest of Pownall Ranch Field, both Minnelusa oil fields.

References cited

Ayers, W.B. Jr., 1986, Coal resources of the Tongue River Member, Fort Union Formation (Paleocene), Powder River Basin, Wyoming and Montana: Geological Survey of Wyoming Report of Investigations No. 35, 22 p.

Kent, B.H., 1986, Evolution of thick coal deposits in the Powder River Basin, northeastern Wyoming *in* Paleoenvironmental and tectonic controls in coal-forming basins of the United States: Geological Society of America Special Paper 210, p. 105-122.

COAL UPDATE

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

Final coal production figures released by state agencies during the second quarter of 1989 confirm that Wyoming was the nation's leading coal-producing state in 1988. Kentucky's coal production of 161.2 million short tons in 1988, as reported by the Kentucky Department of Mines and Minerals, was about 2.4 million tons less than Wyoming's record 163.6 million tons (reported by the Wyoming State Inspector of Mines). This is not only the first time Wyoming has led the nation in production, but it is also the first time in 15 years that Kentucky has not led the nation in coal production.

National coal production in 1988 was about 959 million tons, which breaks the previous record of 915 million tons set in 1987. Most coal forecasters are expecting 1989 national coal production to be about the same or slightly above 1988 production. Wyoming produced about 17 percent of the nation's coal in 1988. Wyoming's coal production should continue to gradually increase for several years (Table 5 and Figure 6).

Average productivity at Wyoming mines, defined here as the ratio between the number of tons produced and the number of employees, increased in 1988, as each

Table 5. 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[3]	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

[1] These are actual values for comparison. [2] M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, April, 1989. [3] Totals may not equal sum of components because of independent rounding.

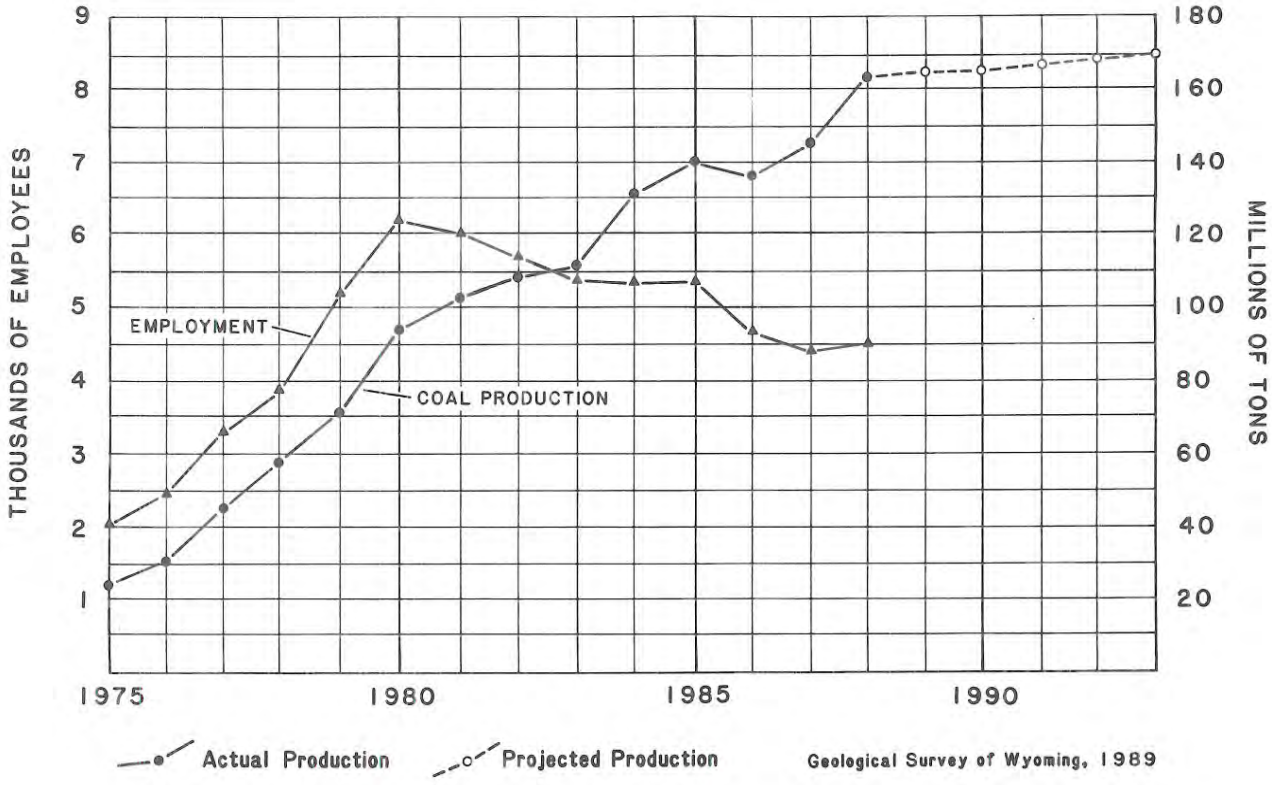


Figure 6. WYOMING COAL PRODUCTION AND EMPLOYMENT.

employee accounted for 36,088 tons of coal produced. In 1987, each employee accounted for 33,119 tons of coal produced. At mines in the Powder River Basin, each employee in 1988 accounted for 51,083 tons of coal (compared to 44,290 tons in 1987); in southern Wyoming mines, each employee in 1988 accounted for 12,869 tons of coal production (compared to 11,764 tons in 1987). Historical employment trends in Wyoming since 1975 are also shown on Figure 6.

Recently available data on the distribution and utilization of coal in 1988 (Energy Information Administration, 1989) indicates that Wyoming coal was used in 22 states (Figure 7). As in years past, Texas was the largest consumer of Wyoming coal in 1988, followed by Wyoming, Kansas, Oklahoma, and Arkansas. Compared with

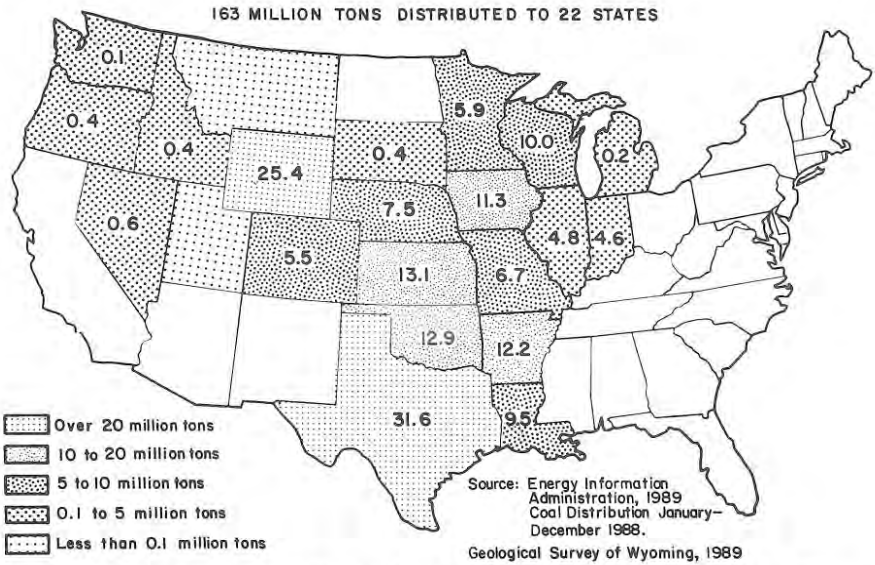


Figure 7. DISTRIBUTION OF WYOMING COAL IN 1988 (IN MILLIONS OF TONS).

coal distribution in 1987 (see *Wyoming Geo-notes No. 19*, July, 1988, p. 15), only the states of Louisiana, Illinois, Minnesota, and Washington used less coal in 1988. Significant increases in usage of Wyoming coal were recorded in Texas (4.3 million tons more), Wyoming (3.3 million tons more), Missouri (2.3 million tons more), Arkansas (1.7 million tons more), and Oklahoma (1.5 million tons more). Seven states each consumed over 10 million tons of coal. Four states consumed over 50 percent of Wyoming's coal and nine states consumed over 80 percent of Wyoming's coal.

Electric utility companies located in 19 different states used 97.6 percent of Wyoming's total coal production in 1988 to fuel steam-electric generating plants (Figure 8). Fourteen different states used Wyoming coal to fuel industrial boilers, and 11 states used Wyoming coal for residential/commercial heating. About 1.4 million

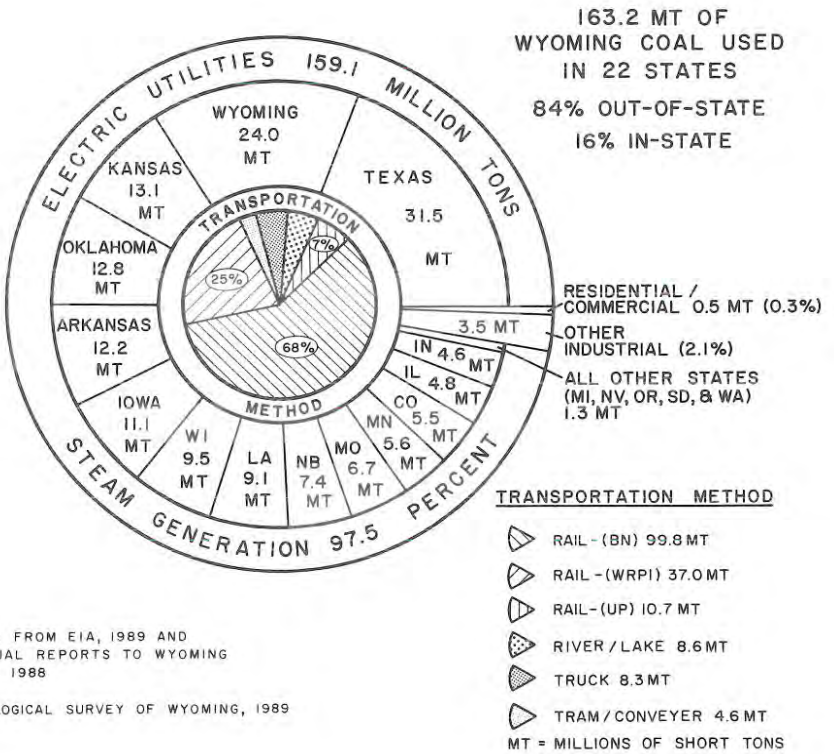


Figure 8. UTILIZATION AND TRANSPORTATION OF WYOMING COAL IN 1988.

tons in the "other industrial" and "residential/commercial" categories went to Wyoming coal users, mostly other mineral-related industries. Four of Wyoming's five trona plants in southwestern Wyoming used coal to generate steam for use in the refining process and in some cases, to produce electricity; many of the State's bentonite plants used coal in their refining process; and Mountain Cement Company used coal in their Laramie plant (Figure 9). Additional coal was used in synthetic coke plants, including FMC Corporation's formcoke plant in Lincoln County (noncoking, Wyoming, subbituminous coal is converted to formcoke through the company's patented process), and in a sugar beet processing plant at Torrington. Although about 84 percent of Wyoming's coal was shipped out-of-state, a small amount of coal (128,500 tons) was imported into the State from Colorado, Montana, Utah, and Pennsylvania.

Transportation of Wyoming coal in 1988 (Figure 8) was primarily by rail (92 percent); coal transported by river/lake refers to coal that reached its final destination by barge after originating on a railroad. Although the 147.5 million tons of coal transported by rail in 1988 increased by 14.6 million tons (or 11 percent) over 1987, the proportions of coal carried by each railroad were the same as in 1987. Burlington Northern Railroad (BN) accounted for 68 percent of the total, followed by Western Railroad Properties, Incorporated (WRPI) with 25 percent of the total, and Union

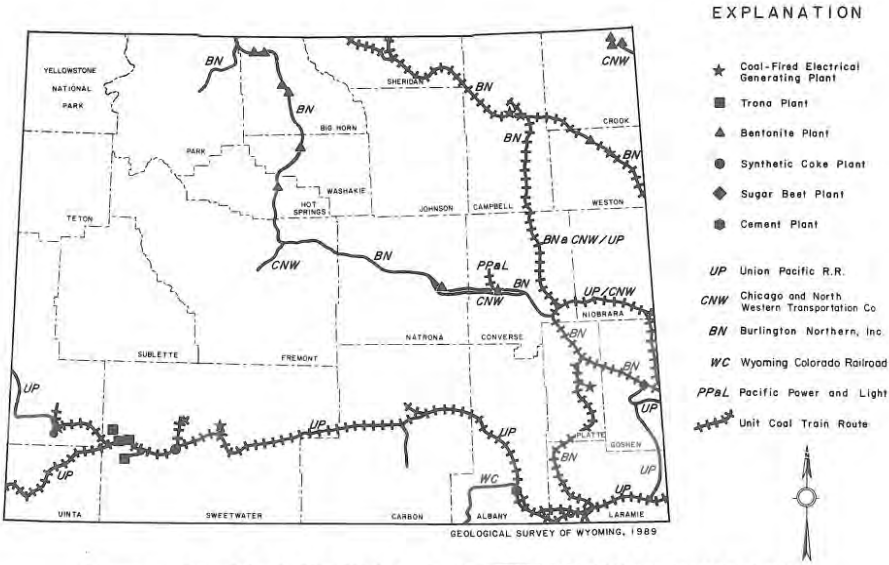


Figure 9. RAILROAD ROUTES AND MAJOR COAL USERS IN WYOMING.

Pacific Railroad Company (UP) with 7 percent of the total. WRPI, which reports tonnages carried by the Chicago and North Western Transportation Company (C&NW)/UP joint-venture railroad out of the Powder River Basin, carried 4.3 million tons (14 percent) more coal in 1988 than in 1987. BN and UP both recorded a 10 percent increase in coal tonnage in 1988.

The total tonnage of coal transported by rail in 1988 represents 92 percent of all railroad freight that originated in Wyoming in 1988. A total of 1,458,280 coal cars (averaging about 100 tons each) were loaded at Wyoming coal mines in 1988. Because 100,406 of those coal cars (carrying 10.0 million tons of coal) were unloaded at the various coal-burning facilities within the State (Figure 9), this left 1,357,874 coal cars that exited the State. If a unit train contains 110 coal cars, then 12,344 unit trains were required to move coal out of Wyoming in 1988. This amounted to 33.8 unit trains of coal leaving Wyoming each day as well as another 33.8 unit trains returning!

In another development related to coal transportation, it was announced in early June that CNW Corporation (CNW), the parent company of Chicago and North Western Transportation Company (C&NW), had approved a $1.6 billion buyout offer from Blackstone Capital Partners L.P. The buyout offer ended a hostile takeover bid by Japonica Partners, an investment banking firm holding an 8.8 percent majority interest in CNW. The Blackstone Partners consist of Blackstone, a New York investment banking firm; CNW management; Donaldson, Lufkin, and Jenrette, Incorporated, a New York securities firm; and Union Pacific Corporation. The buyout must be approved by the Federal government. If the buyout/takeover offer is completed, Blackstone Capital Partners L.P. would be merged into CNW Corporation, with Blackstone holding controlling interest in the corporation. CNW management; Donaldson, Lufkin, and Jenrette, Incorporated; and Union Pacific Corporation

would all hold minority positions in the corporation. It is thought that the Blackstone deal will further support the C&NW/UP joint venture railroad out of the Powder River Basin as well as give UP access to Chicago and nine midwestern states (McGraw-Hill, Inc., 1989).

The Wyoming legislature completed its 1989 session in the first quarter, 1989, with the following actions on several coal-related topics:

1) Governor Sullivan signed a bill that exempts from taxation any coal burned in the processing or treatment of other coal at the same mine. This benefits coal companies involved in thermal drying and beneficiation of coal, such as Amax Coal Company's coal drying plant at the Belle Ayr mine.

2) A bill prohibiting further State investment in clean coal technology was vetoed by Governor Sullivan. The bill was vetoed because in the Governor's opinion it showed a lack of State support for current and proposed clean coal/coal enhancement processes.

3) A bill extended the 80¢ per ton cap on severance tax on new contracts signed prior to April, 1991, for two more years. The bill also makes the severance tax cap valid even if deliveries on the new contract do not begin until after April 1991. This bill is designed to assist producers of high cost coal: surface mined coal taxed at the current rate of 8.5 percent and valued at over $9.41 per ton and underground mined coal taxed at the current rate of 5.25 percent and valued at over $15.24 per ton will not be liable for severance taxes of more than 80¢ per ton. The only mines in Wyoming affected by this severance tax cap are the high cost mines in southern Wyoming, the Big Horn mine in Sheridan County, and the Grass Creek mine in Hot Springs County.

4) A bill introduced by Campbell County legislators that provided for a 50 percent reduction on half of a coal mine's coal taxes if production increased by 50 percent in a base year did not make it out of the Senate Revenue Committee. This bill was aimed at providing tax relief for companies able to substantially increase production and was primarily designed to help Powder River Basin coal mines unable to take advantage of the 80¢ per ton severance tax cap.

Developments in the Hanna coal field

In April, Arch of Wyoming began hiring additional employees at their Medicine Bow mine west of Hanna in response to new coal sales (see items in *Wyoming Geo-notes No. 21*, January, 1989, p. 20-21; *Wyoming Geo-notes No. 22*, April, 1989, p. 17-18; and items below). Arch is shifting production from the Seminoe No. 2 mine, which produced 1.6 million tons in 1988, to Medicine Bow, which produced 0.4 million tons in 1988 (Figure 10).

In April, it was announced that Kansas Power and Light's 9-month contract with Medicine Bow for 650,000 tons of coal in 1989 could be expanded by up to 150,000 tons per month if the coal were available. The coal will be distributed to the utility's Lawrence plant (two-thirds of the tonnage) and Tecumseh plant (one-third of the tonnage) both in Kansas.

Pacific Power and Light Company (PP&L) has also purchased unspecified amounts of spot coal from Medicine Bow for test burns in the Jim Bridger power plant

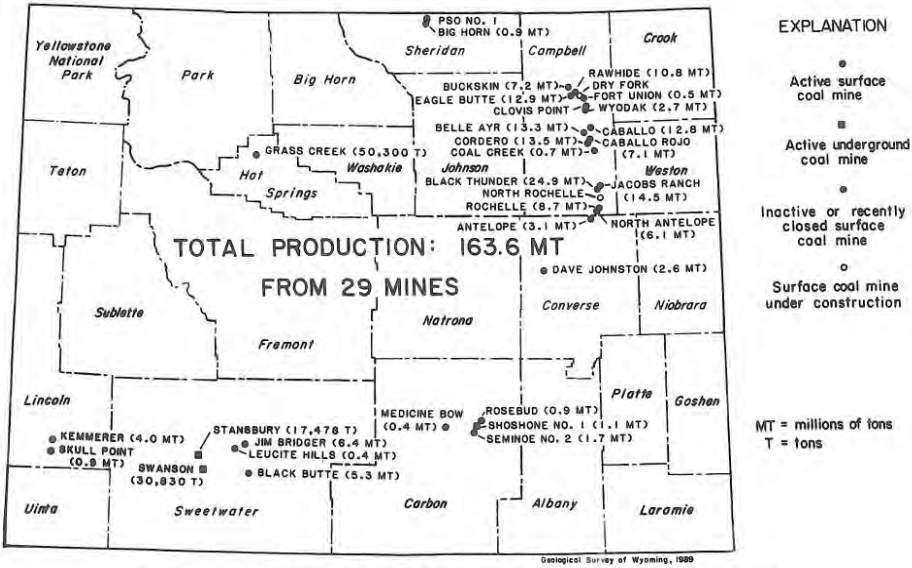


Figure 10. WYOMING COAL MINES AND PRODUCTION IN 1988.

east of Rock Springs. The coal from Medicine Bow is being delivered to Jim Bridger via truck.

Public Service Company of Colorado will purchase 150,000 tons of spot coal from Medicine Bow for the Valmont power plant near Boulder. Union Pacific will be the carrier for this coal. In a related development, the State of Colorado has offered a $1.00 per ton tax rebate to Colorado utility companies that burn more Colorado coal in 1989 than they did in 1988. How this will affect future coal sales from Wyoming coal mines remains to be seen.

Developments in western and southwestern Wyoming

In February, Bridger Coal Company's Jim Bridger mine began construction on a 4-mile long overland conveyor system that is expected to reduce current hauling distances to the Jim Bridger power plant by more than 10 miles. The 48-inch wide conveyor system will be lengthened as the mine expands to the east. In a further effort to increase efficiency at the mine, Bridger is adding larger scrapers and bulldozers for overburden removal, replacing older rock/coal haulers with 8 new 85-ton capacity trucks, and using cast blasting techniques (by angle drilling) to better place overburden.

Black Butte Coal Company is apparently expanding their operations at their Pit 22 property, formerly Prospect Point Coal Company's Leucite Hills mine (see *Wyoming Geo-notes No. 19*, July, 1988, p. 20). The mine will be expanded from a 0.5 million ton-per-year operation to 1.5 million tons per year. Acquisition of this property increased Black Butte's coal reserves by 21 million tons and added 6,550 acres of coal land to its holdings. Additional mining equipment from the Black Butte's existing property south of Pit 22 was moved onto the new property last summer.

Black Butte also installed a truck loadout facility and a radial stack loader at their main property to the south. The coal company is now supplying coal to PP&L's Jim Bridger plant under a short-term contract. The coal is being delivered to Bridger by 40-ton capacity coal trucks subcontracted from Savage Trucking.

Developments in the Powder River Basin coal field

Several developments involving Powder River Basin coal were announced in the second quarter, 1989. First, Fremont Iron and Steel, Inc. has proposed a mini-steel mill for a site located near the Wyodak power plant east of Gillette. If they can raise $30 million to build the mill, the mill would recycle scrap metal in the area and employ 110 people at full capacity. The decision to locate the mill near Gillette was based on the proximity of the site to an electrical power source (the coal-fired Wyodak power plant) to power the electric-arc furnaces as well as access to highway and rail transportation. Second, Perkins Power Company of Sheridan and Petro Oil and Gas, Inc. of California announced a joint venture to construct a polyurethane plant/cogeneration unit near Sheridan. The $50 million project would use a coal gasification process combined with Petro Oil and Gas' plastics production technology to produce 50 tons of polyurethane a day as well as 12 megawatts of power through cogeneration. Petro Oil and Gas will provide construction financing and their technology (the company has a similar plant currently operating in Spain and four plants under construction in China). Perkins Power will provide the plant site, a 12-megawatt power plant (formerly the Acme power plant), and a 20-million-ton coal deposit located to the north in Montana (purchased from Chevron USA).

In early June, the mining plan submitted by the recently formed Dry Fork Coal Company, a limited partnership between Western Fuels Association (WFA) and Phillips Coal Company, was given final approval by both the State of Wyoming and the Federal government's Office of Surface Mining Reclamation and Enforcement. Construction of the 3-million ton-per-year Dry Fork mine northeast of Gillette (Figure 10) was expected to begin immediately. Dry Fork plans to ship its first coal from the mine in August, 1990.

Coal contracts - Powder River Basin

Coal contract activity involving Powder River mines during the second quarter, 1989, are summarized below:

1) A long-term contract between Mobil Coal Producing, Incorporated and WFA to supply Laramie River Power Station with 1.3 million tons of coal per year has evidently been cancelled (Pasha Publications, Inc., 1989). The long-term contract was due to expire in 2013, but now coal shipments from Mobil's Caballo Rojo mine to the power plant near Wheatland will continue only through 1990. It was reported earlier that WFA and two of its member utilities were filing a lawsuit to cancel this contract and that Mobil was filing a countersuit (*Wyoming Geo-notes No. 20*, November, 1988, p. 19-20).

2) In May, American Electric Power (AEP) announced that it would purchase 5 million tons of coal from unspecified Powder River Basin mines located in Wyoming instead of 3.5 million tons of eastern coal. The coal is for the new Rockport II unit in Indiana that AEP owns jointly with Indiana Michigan Power

Company. No specific supplier(s) and no specific contract(s) have been announced yet. Carter Mining Company currently supplies coal to Rockport I on a contract that runs through 2014.

3) Northern Indiana Public Service Company (NIPSCO) continued to purchase spot coal on a monthly basis. Amax Coal Company's Belle Ayr mine provided 60,000 tons of coal in April, 110,000 tons of coal in May, and 30,000 tons of coal in June to unspecified NIPSCO generating plants in Indiana. Mobil Coal Producing, Incorporated's Caballo Rojo mine also provided 20,000 tons of coal to unspecified plants in April.

4) Big Horn Coal Company recently supplied 15,000 to 20,000 tons of coal to Otter Tail Power Company's Hoot Lake power plant in Minnesota. In the summer of 1988, Otter Tail Power Company tested coal from a Montana mine and coal from the Rochelle mine in Campbell County (see *Wyoming Geo-notes No. 20*, November, 1988, p. 16). The Hoot Lake plant is currently contracted to use North Dakota lignite through 1995, but the contract is evidently approaching reopener clauses.

5) Cordero Mining Company's Cordero mine will be supplying from 0.6 million to 1.2 million tons of spot coal to Iowa Public Service's Neal No. 3 unit at Council Bluffs, Iowa. Deliveries began April 15 and will continue through the end of the year via C&NW and UP railroads.

6) Amax Coal Company's Belle Ayr mine will supply from 75,000 to 150,000 tons of coal to Kansas Power and Light Company's (KP&L's) Tecumseh, Kansas, plant for a test burn starting in August, 1989. Evidently Amax and KP&L signed a contract in 1986 for up to 1.4 million tons of coal per year between 1991 and 2013; the test burn is apparently in preparation for this contract.

7) Rochelle Coal Company will supply Wisconsin Public Service Company's Weston No. 3 unit with 220,000 tons of coal during the second half of 1989. Transportation of the coal will be by C&NW and Soo Line Railroad.

8) Thunder Basin Coal Company, a coal mining subsidiary of ARCO Coal Company [a company owned by Atlantic Richfield Company (ARCO)], recently signed an agreement with Lower Colorado River Authority (LCRA) for 2.5 million tons of coal per year through 2001. The contract supplements the 1.5 million ton-per-year contract ARCO already had with LCRA, lowers the base tonnage price from $18 per ton to $15 per ton (F.O.B. the mine), and prices the additional tonnage at $5.25 per ton until 1992. After 1992, the coal will be priced according to the prevailing market level. The coal will be supplied by ARCO's Black Thunder mine via the C&NW Railroad to LCRA's Fayette Power Project in Texas. The utility had previously asked for bids on 2.5 million tons of spot coal (*Wyoming Geo-notes No. 22*, April, 1989, p. 20), but after awarding the long-term contract to ARCO, LCRA asked for bids on only 238,000 tons of spot coal instead (yet to be awarded).

References cited

Energy Information Administration, 1989, Coal distribution, January-December, 1988: Energy Information Administration DOE/EIA - 0125 (88/4Q), 179 p.

McGraw-Hill, Inc., 1989, Union Pacific to get C&NW share: strengthens reach to PRB, Midwest: Coal Week, v. 15, no. 24 (June 12, 1989), p. 9.

Pasha Publications, Inc., 1989, Mobil Coal cancels Western Fuels contract: Coal Outlook, March 27, 1989.

INDUSTRIAL MINERALS UPDATE

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

Aggregate

Pursuant to its seasonal usage, the production of construction aggregate (sand, gravel, and crushed rock) in Wyoming increased in the second quarter and will peak in the summer months. Highway projects consume most of Wyoming's construction aggregate.

The National Park Service (NPS) has begun a project to locate construction aggregate for road and other construction projects in Grand Teton National Park. The Industrial Minerals and Uranium Division of the State Geological Survey is helping the NPS locate sites. Although Jackson Hole has some of the best gravel resources in Wyoming, there is a problem finding suitable aggregate sites for NPS projects. Because much of the area is used solely for recreation and(or) wildlife, careful siting of gravel pits is a must for the NPS. It appears at this time that a site near the Jackson Hole Airport will serve the needs of the NPS. This site provided aggregate for the construction of the airport. A site on Spread Creek, which is resupplied with gravel from the creek each year, is another possible source that may also meet NPS' siting requirements.

Bentonite

Bentonite production continues to recover slowly from a recession caused by a decline in oil well drilling. Most of the bentonite mined in this country is used in oil well drilling muds. The uses of bentonite as a sealant in waste-disposal sites and as an ion-exchange agent in the cleanup of toxic-waste sites, however, are increasing. The major bentonite mining regions are in the Black Hills, Bighorn Basin, and Powder River Basin near Kaycee (Johnson and Natrona Counties).

Cement

Mountain Cement Company operates a cement plant in Laramie. This plant was recently modernized and upgraded to a capacity of 500,000 tons of cement per year. Limestone, gypsum, marl, and iron ore found near Laramie are used to make various cement products. This plant is currently operating at full capacity. Nationally, however, cement production is slightly lower than at the same time in 1988, according to the U.S. Bureau of Mines.

Clinker (baked and fused rock; scoria)

Clinker (baked and fused rock; scoria) is the red rock that caps buttes and hills in the Powder River Basin near Sheridan, Lake De Smet, Buffalo, and north and south of Gillette. It is also found at Hanna and near Wamsutter. It is produced when heat from underlying and burning coal beds, bake and melt overlying shale and other rock. Clinker is used in the Powder River Basin as construction aggregate for highway surfacing, as a surfacing material for gravel roads, and as a light-duty railroad ballast. It is also produced for use as decorative landscape rock. About 150,000 tons were quarried in 1988 for all of these uses.

Limestone

Limestone quarried in Wyoming is used in the manufacture of cement, for construction aggregate, and for emissions control at power plants. Limestone quarries are currently operating near Laramie, Hartville, Lusk, Glenrock, Sundance, Newcastle, and Sheridan.

Phosphate, sulfur, and fertilizer production

The phosphate calcining plant formerly at Leefe, west of Kemmerer near Sage Junction, has been dismantled. There is currently no phosphate mined in Wyoming. Utah phosphate, however, is combined with sulfur from Wyoming at Chevron Chemical Company's fertilizer plant at Rock Springs.

Silica

There is continued interest in Wyoming's silica raw materials. Silica (SiO_2) is the primary ingredient in glass manufacture. Since the other raw materials used to make most kinds of glass (soda ash, feldspar, and limestone) are also found in Wyoming, state and local government agencies have met with private companies and individuals to look for ways to generate venture capital for the establishment of a glass manufacturing plant in Wyoming. At least two private companies are still interested in developing a glass industry in the State.

Two silica deposits, one near Glendo and one near Laramie, are being considered. Local governments obtained funds to investigate these deposits through the Wyoming Economic Development and Stabilization Board's Block Grant Program. The Wyoming Geological Survey has published information obtained on these deposits in two different reports (Harris, 1988a and Harris, 1988b). A third silica source near Lovell may also be of interest.

Trona

Production at the trona mines is increasing, and employment in the soda ash plants increased by about 200 from 1987 to 1988. In fact, the production of soda ash and other products from mined trona are at record levels (Table 6). The five producers near Green River are operating at capacity and are attempting to increase production by increasing efficiency. Additional construction and expansion plans are under consideration.

Table 6. WYOMING TRONA PRODUCTION[1]

Year	General FMC	Stauffer Chemical[2]	Chemical	TG Inc[3]	Tenneco	Total
1980	4,418,258	3,109,019	2,658,377	1,973,587	-0-	12,159,241
1981	4,684,744	2,909,953	2,645,599	1,547,435	-0-	11,787,731
1982	3,575,678	2,499,689	2,180,962	1,171,071	646,290	10,073,690
1983	3,102,074	2,818,826	2,570,190	807,475	943,852	10,242,417
1984	3,400,458	2,600,611	2,333,364	1,386,933	1,249,843	10,971,209
1985	3,164,611	2,466,095	2,191,952	1,603,339	1,350,307	10,776,304
1986	3,508,739	2,703,227	2,527,460	1,807,974	1,372,130	11,919,530
1987	3,518,916	2,947,438	2,699,833	1,747,327	1,508,741	12,422,255

[1] Source: Ad Valorem Tax Division.
[2] Formerly Allied Chemical.
[3] Formerly Texasgulf.

The causes for this increased activity are an increase in the domestic requirements for soda ash, primarily for the manufacture of glass, and an increase in demand by industrial users that are substituting soda ash for caustic soda. Caustic soda, NaOH, is produced synthetically from lime and sodium carbonate. There has been some interest in producing caustic soda from trona (refined to sodium carbonate) and lime from limestone. Limestone, however, is not found in the immediate vicinity of the trona mines. The closest high-grade limestone is at Rawlins, 120 miles east; south of Sage Junction, about 80 miles west; or south of Manila, Utah, 50 miles south.

FMC closed their pilot *in situ* solution trona mine in May. While FMC officials say that the operation may be reactivated at some future time, for now, they want to evaluate the results of their pilot study.

References cited

Harris, R.E., 1988a, The Plumbago Creek silica sand deposit, Albany County, Wyoming: Geological Survey of Wyoming Report of Investigations 40, 32 p.

Harris, R.E., 1988b, The Cassa silica rock deposit, Platte County, Wyoming: Geological Survey of Wyoming Report of Investigations 42, 38 p.

URANIUM UPDATE

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

There are now four companies producing yellowcake (uranium oxide, U_3O_8) in Wyoming. Yellowcake is the mill product that is further refined into the fuel-grade uranium used in nuclear power plants. COGEMA's Pathfinder Mines extracts uranium by open pit methods in the Shirley Basin and then mills it into yellowcake.

Everest Minerals and Malapai Resources produce yellowcake from *in situ* solution mining operations at the Highland and Irigaray-Christiansen Ranch properties, respectively. In addition, U.S. Energy-Crested Corporation has been evaluating methods to produce yellowcake from stockpiled ore at Crooks Gap.

The uranium industry in Wyoming may expand in the near future. Uranez, Inc., a German company, has applied for permits to construct two *in situ* solution mines in the Powder River Basin. CEGB Exploration, which has acquired the former Cleveland-Cliffs Ruby Ranch property and the former Teton Exploration Leuenberger Ranch property, may produce uranium by solution mining methods at these sites in the Powder River Basin. Rio Algom acquired properties formerly owned by Kerr-McGee and is applying for a solution mine at the Bill Smith mine site in the Powder River Basin. Other companies have announced plans to study the feasability of developing production by solution mining. Additionally, U.S. Energy-Crested Corporation is continuing to acquire permits for an underground uranium mine below Green Mountain, south of Jeffrey City.

Late in May, the Society of Mining Engineers sponsored a symposium on *in situ* solution mining. While the conference, which was held in Casper, was not limited to the solution mining of uranium, the majority of nearly 200 attendees were from the uranium industry. Solution mining methods for uranium, copper, gold, and other metals may offer a cost effective alternative to conventional underground or open pit mining. Many of the speakers at the conference elaborated on existing projects, solution mining techniques in general, and the economics of this kind of mining.

The coming independence of Namibia in southern Africa may increase uranium imports into the United States. Currently, Namibia, which is part of the Republic of South Africa, exports uranium to many countries from the Rössing mine, one of the world's largest. Exports to the United States are prohibited by the Comprehensive Anti-apartheid Act of 1986. However, Namibian independence may cause the U.S. Congress to reconsider the Anti-apartheid Act in regard to Namibia. If import sanctions are repealed, U.S. purchasers would be able to buy uranium oxide from RTZ, the operator of the Rössing mine.

METALS AND PRECIOUS STONES UPDATE

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

The Metals and Precious Stones Division of the State Geological Survey has nearly completed a final report on the South Pass mining district of Fremont County. A small scale regional map of this important gold district should be published during the next quarter. The final report, which is slated for publication before the end of the year, will include mine maps, many new geochemical analyses and assays, as well as other geologic information. Dan Hausel, the Division Head and field investigator on this project, indicates that the district has high potential for several placer and lode gold deposits, some potential for nickel and tungsten deposits, high potential for buried gold deposits, and the possibility for one or more very large gold deposits. Models for gold and nickel deposition are being developed for the area.

If you haven't seen it yet, the State Survey has published a new bulletin on the State's precious metal lode and placer deposits. This 248-page report summarizes 10 years of field, library, and archive research by the author and includes more than two dozen illustrations and photographs of mining districts, mines, prospects, occurrences, and anomalies. There are descriptions and assay data for nearly 400 mines and prospects in about 50 districts or areas. Much of this information has not been previously accessible to the public sector. The full citation to Bulletin 68 is on page 36.

The State Survey has begun its 1989 field survey for indicators of potentially diamond-bearing kimberlites. This ongoing project has already identified 150 heavy mineral anomalies that indicate possible kimberlite intrusives. In addition, samples collected from one million year old lamproites from the Green River Basin are being tested for diamond because of the similarity of these rocks to the diamondiferous rocks in the Kimberley Province of northwestern Australia. This latter effort has been considerably enhanced as a result of the Legislature's willingness to send the Head of the Metals and Precious Stones Division to Australia's Kimberley Province in 1987.

In the future, the State Survey hopes to expand this diamond project to include in-depth evaluations of the anomalies that it has found over the years. This expansion will involve detailed geologic mapping, geochemical studies of the pyrope garnet indicator minerals, and geophysical surveys.

On the national level, Senator Dale Bumpers (D-Ark.) has submitted a bill to revise the 1872 Mining Law. Bumper's proposed revisions of the hard rock mining law are anything but minor. Some of the more significant changes proposed by Bumper's bill are an 8 percent royalty, increased diligence requirements to maintain claims, and no longer patenting the surface along with the mineral patent. These revisions could spell real trouble for independent prospectors with limited capital.

STATUS OF TERTIARY RECOVERY PROJECTS IN WYOMING*

by Donald B. Basko, State Oil and Gas Supervisor, Wyoming Oil and Gas Conservation Commission

In May, there were about forty-three active tertiary recovery projects in Wyoming. Since 1987, nine new projects have been added to the list. These include Deer Fly, Garland, Lonetree Creek, Long Creek, three in Steamboat Butte, Stewart, and TA Buttes. The three projects in Steamboat Butte have been underway for some time but were just reported recently because they are on tribal lands. Over the past few years, twenty-three tertiary projects that were underway have reverted back to secondary; twelve of them in the last year. The twelve that reverted back to secondary are in Elk Basin, Frannie, Hamm, two in Kuehne Ranch, Kummerfield, two in Rozet, Swartz Draw, Tholson, Tisdale North, and Wagon Spoke.

So far during 1989, two new projects have started up; one in Garland and one in the Stewart Field. Both of these projects are polymer-augmented waterfloods. It is apparent that the decline in the oil prices is taking its toll on the tertiary recovery effort in Wyoming. The announcement by Amoco Production Company to put their CO_2 floods for Beaver Creek, Salt Creek, Little Buffalo Basin, and Elk Basin, on hold is indeed disappointing news.

Current prices for oil in the $18.00 to $20.00 range would give one the impression that there is sufficient incentive to move forward. Apparently, this is not the case.

The forty-three active projects in Wyoming, however, are a net decrease of only two over 1987 when there were forty-five projects that were considered active.

The Amoco CO_2 project at Lost Soldier Field has encountered some mechanical problems in the plant. Enthusiasm for the performance of the project is as great as ever, and the project is due to commence this summer.

---

* Excerpted from a talk given to the Fifth Wyoming Enhanced Oil Recovery Symposium held in Casper, May 10-11, 1989.

SUMMARY OF OIL AND GAS DRILLING AND SEISMIC PERMITS*

by Donald B. Basko, State Oil and Gas Supervisor, Wyoming Oil and Gas Conservation Commission

During 1986, there were 771 drilling permits issued by the State Oil and Gas Supervisor's office. The number increased slightly to 986 permits for 1987; and during 1988, the number of permits issued was 775. This drilling activity kept an average of 42 drilling rigs operating throughout 1988 and resulted in the discovery of 29 new oil and gas fields. During the first three months of 1989, there were only 116 permits issued. If this trend were to continue, there would only be 464 permits to drill in 1989. However, the State still has 15,508 producing oil and gas wells.

During 1987, seismic operators conducted seismic exploration across 3,271 miles of the State. Of that number, 1,501 miles were vibroseis lines and 1,777 were shot hole lines. During 1988, seismic operations were conducted across 2,729 miles of the State. Of that number, 1,464 miles were shot hole lines and 1,265 miles were vibroseis lines. The decline in seismic activity reflects the overall decline in oil and gas activity in Wyoming.

---

* Excerpted from a talk given to the Fifth Wyoming Enchanced Oil Recovery Symposium held in Casper, May 10-11, 1989.

Table 7. MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM	
Remaining Resources (January 1, 1988)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	13.0 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	20.6 billion barrels
Remaining Reserve Base (January 1, 1988)	
Measured reserves (Proved reserves)	0.85 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[3]
Total	3.65 billion barrels
COMBUSTIBLE NATURAL GAS	
Remaining Resources (January 1, 1988)	
Discovered	18.0 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	76.0 trillion cubic feet
Remaining Reserve Base (January 1, 1988)	
Measured reserves (Proved reserves)	10.57 trillion cubic feet[2]
COAL	
Remaining Resources (January 1, 1989)	
Identified and Hypothetical (Discovered)	1,431.4 billion tons[4]
Speculative (Undiscovered)	31.5 billion tons[4]
Total	1,462.9 billion tons
Remaining Reserve Base (January 1, 1989)	
Demonstrated strippable (Measured and indicated reserve base)	26.8 billion tons[5]
Demonstrated underground-minable (Measured and indicated reserve base)	38.3 billion tons[5]
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_3O_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] Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:500,000 scale (color) and 44 p. pamphlet.

[5] 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.

[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.

U.S. GEOLOGICAL SURVEY PUBLISHES NEW COAL RESOURCE DATA

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

A new estimate of coal resources for Wyoming indicates that the State contains a total of about 1.5 trillion tons of coal-in-place. The new resource estimate appeared in a recently published U.S. Geological Survey map and pamphlet on coal resources of North America (Wood and Bour, 1988). In this publication, new estimates of coal resources (by discrete coal deposit) have been made for each state, province, and nation in North and Central America. The new resource estimate for Wyoming is the first published since 1974 (Averitt, 1975). Figure 11 shows the major coal-bearing regions in Wyoming for which estimates were made.

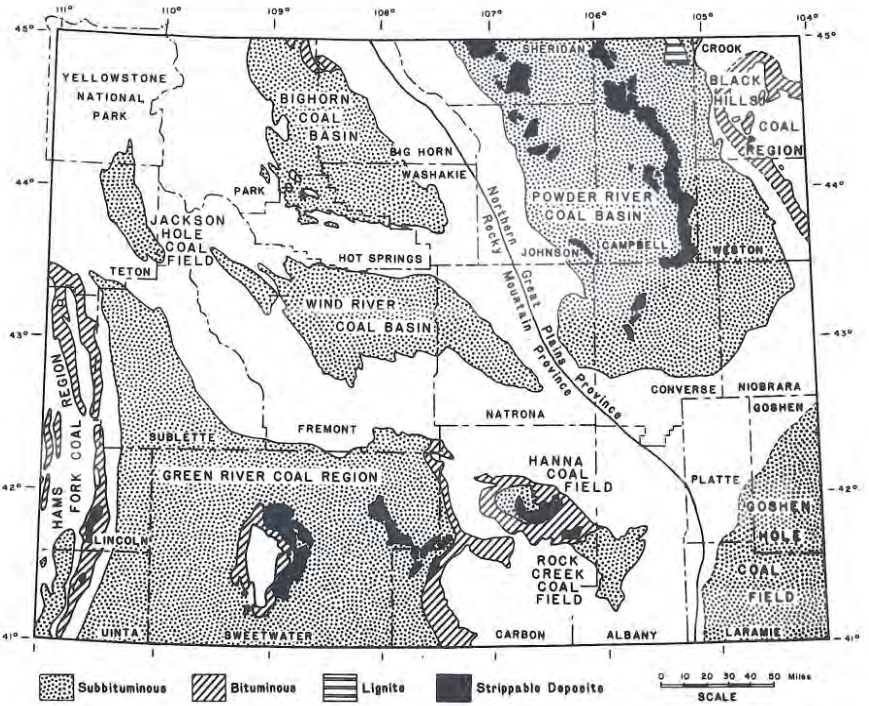


Figure 11. INDEX MAP OF THE COAL-BEARING REGIONS OF WYOMING.

A summary of the data for Wyoming coal fields appears in Table 8 and a summary of resources totals for Canadian provinces and U.S. states appears in Table 9. The coal resource estimate is for coal-in-place, which is defined as "naturally occurring concentrations or deposits of coal to all depths in the Earth's crust, in all forms and amounts, regardless of whether economic extraction may be currently or potentially feasible" (Wood and Bour, 1988). These new estimates differ from previous estimates in that coal beds to all depths and all thicknesses are

included. Previous estimates of coal resources have been restricted to coal that exists at depths only to 6,000 feet and for anthracite and bituminous coal beds more than 14 inches thick and for subbituminous coal and lignite more than 30 inches thick.

According to this new estimate, Wyoming contains about 27 percent of all coal-in-place in the United States and about 20 percent of all coal-in-place in the U.S. and Canada combined. However, recent estimates of hypothetical in-place resources in Alaska indicate that Alaska's coal resources are vastly understated by Wood and Bour (1988). Alaska may contain in excess of 5.6 trillion tons of total hypothetical coal resources (Merritt, 1988).

Table 8. WYOMING'S IN-PLACE COAL RESOURCES (IN MILLIONS OF SHORT TONS)[1]

Coal-bearing Areas	Identified Hypothetical Coal-in-Place[2]	Onshore Speculative Coal-in-Place[3]	Total Coal-in-Place
Powder River Basin	1,030,340	255	1,030,595
Black Hills	4,150	3,740	7,890
Goshen Hole	230	0	230
Rock Creek	3,400	0	3,400
Hanna Basin	23,270	0	23,270
Jackson Hole	6,340	0	6,340
Wind River Basin	81,010	0	81,010
Greater Green River Basin	237,110	0	237,110
Bighorn Basin	23,500	0	23,500
Hams Fork	22,080	27,530	49,610
Totals	1,431,430	31,525	1,462,955

[1] Modified from Table 1 of Wood and Bour, 1988.

[2] Identified-hypothetical coal-in-place is defined as "discovered coal whose location, rank, quality, and quantity are known or estimated from specific geologic evidence. Such evidence is based on coal beds penetrated to any depth and which thickness of coal measurements are not extended more than 3 miles from point of measurement" (Wood and Bour, 1988).

[3] Onshore speculative coal-in-place is defined as "undiscovered coal that may be in favorable geologic settings. All onshore speculative coal-in-place shown on the map is vaguely supported, as to existence, by very widely spaced (more than 25 miles apart) outcrop measurements and(or) by drill holes that have penetrated coal beds, is beyond the extent of known coal fields and their hypothetical extension. . . or is located beneath known coal fields in rocks of ages previously not reported . . . " (Wood and Bour, 1988).

Table 9. IN-PLACE COAL RESOURCES OF THE UNITED STATES AND CANADA (IN MILLIONS OF SHORT TONS)[1]

State or Province	Identified-Hypothetical Coal-in-place[2]	Onshore & Offshore Speculative Coal-in-place[3]	Total Coal-in-place
Canada			
Alberta	522,484	641,791	1,164,275
British Columbia	131,420	113,766	245,186
Manitoba	420	-0-	420
New Brunswick	119	10,940	11,059
Newfoundland	155	1,680	1,835
Northwest Territories	121,195	234,361	355,556
Ontario	3,670	-0-	3,670
Saskatchewan	91,630	195,870	287,500
Yukon Territory	24,987	25,505	50,492
Nova Scotia	1,712	1,860	3,572
Total Canada	897,792	1,225,773	2,123,565
United States			
Alabama and Florida	45,400	20,877	66,277
Alaska	279,172	54,772	333,944
Arizona	23,100	-0-	23,100
Arkansas	64,085	15,760	79,845
California	285	-0-	285
Colorado	430,338	8,520	438,858
Georgia	165	-0-	165
Idaho	354	-0-	354
Illinois	282,200	-0-	282,200
Indiana	37,440	-0-	37,440
Iowa	23,290	8,064	31,354
Kansas	20,852	29,710	50,562
Kentucky	119,060	-0-	119,060
Louisiana	33,990	22,600	56,590
Maryland	4,460	-0-	4,460
Massachusetts and Rhode Island	300	-0-	300
Michigan	2,450	-0-	2,450
Mississippi	58,460	39,975	98,435
Missouri	50,295	120	50,415
Montana	478,102	42,395	520,497
Nebraska	8,938	15,360	24,298
Nevada	59	-0-	59
New Mexico	310,961	36,874	347,835
New York	13	-0-	13
North Carolina	168	-0-	168
North Dakota	558,970	31,000	589,970
Ohio	52,295	-0-	52,295
Oklahoma	27,875	31,870	59,745
Oregon	392	180	572
Pennsylvania	97,090	-0-	97,090
South Dakota	12,171	-0-	12,171
Tennessee	6,180	-0-	6,180
Texas	120,655	117,285	237,940
Utah	46,810	43,125	89,935
Virginia	20,190	-0-	20,190
Washington	50,680	-0-	50,680
West Virginia	106,445	-0-	106,445
Wyoming	1,431,430	31,525	1,462,955
Total U.S.	4,805,120	550,012	5,355,132
Total U.S. and Canada	5,702,912	1,775,785	7,478,697

[1] Modified from Table 1 of Wood and Bour, 1988.

[2] See definition in Table 1, footnote 2 of this article.

[3] Onshore speculative coal-in-place is defined in Table 1, footnote 2 of this article. Offshore speculative coal-in-place is defined as "undiscovered coal whose existence is suggested by adjacent onshore coal fields (Northern Alaska, U.S.A.), whose existence is suggested by coal occurrences on adjacent islands (Canadian Arctic islands), or whose existence has been shown by very widely spaced, deep offshore exploratory wells (Hecate Strait, Canada)" (Wood and Bour, 1988). Offshore speculative coal-in-place is reported only for British Columbia (11,440 million tons), Northwest Territories (63,770 million tons), Yukon Territory (2,560 million tons), Nova Scotia (1,860 million tons), and Alaska (27,246 million tons).

References cited

Averitt, Paul, 1975, Coal resources of the United States, January 1, 1974: U.S. Geological Survey Bulletin 1412, 131 p.

Merritt, R.D., 1988, Alaska coal seam analysis and description, *in* 1988 Keystone coal industry manual: Maclean Hunter Publishing Company, Chicago, Illinois, p. 363-373.

Wood, G.H., Jr., and Bour, W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, '1:500,000 scale map (color) and 44 p. pamphlet.

GEOLOGIC MAPPING AND STRATIGRAPHY

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

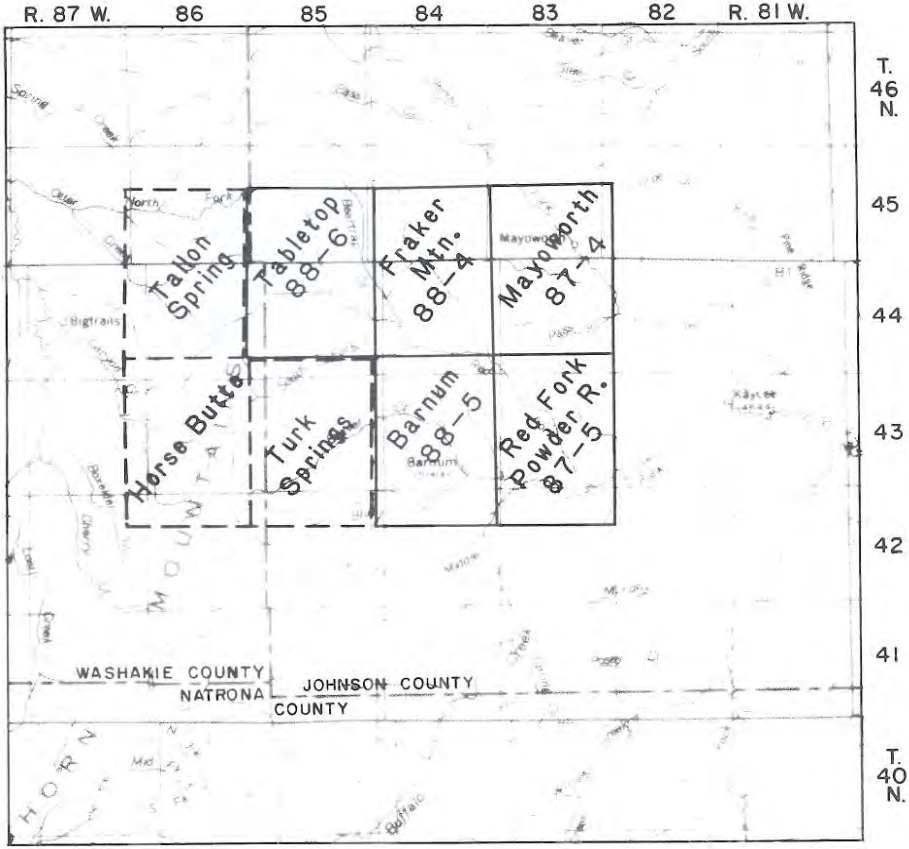
The Stratigraphy Division's southern Bighorn Mountains mapping project has had to be scaled down because the U.S. Geological Survey was unable to continue its financial support of the project after 1988. Rather than mapping a total of sixteen quadrangles, as originally planned, only seven or eight maps will be prepared. To date, five quadrangles have been completed as preliminary geologic maps and two more, the Tallon Spring and Turk Springs Quadrangles, are nearing completion. A final map, the Horse Butte Quadrangle, may be mapped during the summer of 1990. A stratigraphic report with cross sections will be written covering the entire area after the maps are all completed.

In 1989, final field checking will be completed on the Mayoworth, Red Fork Powder River, Fraker Mountain, and Barnum Quadrangles (Figure 12). Once this final check is complete, the quadrangles will be published as part of the Wyoming Geological Survey's color map series.

In support of this project, the terrace deposits along the Middle Fork and Red Fork of the Powder River will be examined to verify their correlation with one another; the Tensleep/Amsden contact may be changed as a result of mapping on the Tallon Springs Quadrangle; the Cloverly/Morrison contact may still need changing on the Barnum, Red Fork Powder River, and Mayoworth Quadrangles, to reflect a more recent interpretation; and additional work is needed on the west flank of Gardner Mountain anticline to establish the existence or non-existence of the surface trace of a reverse fault assumed to core this anticline.

The Division has also nearly completed updated versions of four MS-9 series index maps. These geologic map indices depict maps from Geological Survey of Wyoming Open File Reports, Geological Survey of Wyoming reports exclusive of Open File Reports, U.S. Geological Survey Professional Papers, and U.S. Geological Survey Bulletins. These indices should all be completed in 1989.

A final version of the Wyoming Stratigraphic Nomenclature Chart is now being prepared for printing. This final version has incorporated many suggestions



Preliminary geologic maps in the southern Bighorn Mountains, west of Kaycee

Preliminary geologic map of the Mayoworth Quadrangle, Johnson County, County, Wyoming - Open File Report 87-4

Preliminary geologic map of the Red Fork Powder River Quadrangle, Johnson County, Wyoming - Open File Report 87-5

Preliminary geologic map of the Fraker Mountain Quadrangle, Johnson County, Wyoming - Open File Report 88-4

Preliminary geologic map of the Barnum Quadrangle, Johnson County, Wyoming - Open File Report 88-5

Figure 12. INDEX MAP TO STATE SURVEY MAPPING IN THE SOUTHERN BIGHORN MOUNTAINS

submitted over the last year. The nomenclature chart will be published in colors similar to the U.S. Geological Survey's 1985 *Geologic Map of Wyoming* (1:500,000 scale). An examination proof copy of the chart should be available for inspection at the annual meeting of the Wyoming Geological Association in Casper in mid-September. The project was a cooperative effort of J.D. Love, A.C. Christiansen of the U.S. Geological Survey, and the Stratigraphy Division of the Wyoming Geological Survey.

As a final note, the U.S. Geological Survey has published an important, new stratigraphic report. The report, authored by J.D. Love, is titled, *Names and descriptions of new and reclassified formations in northwestern Wyoming,* and is designated U.S. Geological Survey Professional Paper 932-C. Three new formations in northwestern Wyoming are named, defined, and described. These include the Late Cretaceous Sohare Formation, the Paleocene Devils Basin Formation, and the Pliocene Shooting Iron Formation. In addition, the name Bivouac Formation (late Miocene) was abandoned and the included rocks are discussed individually. From oldest to youngest, they are: unnamed gravel (late Miocene), Conant Creek Tuff (early Pliocene), deposits of glaciation 1 (Pliocene), and Huckleberry Ridge Tuff (Pliocene). The report contains type sections and reference sections for the above formations along with geologic maps of the areas where the type sections and reference sections are described. This is an important clarification of the stratigraphy in northwestern Wyoming.

TESTING RADON IN LARAMIE

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

The Geologic Hazards Division at the Geological Survey of Wyoming and the Radiological Health Section at the Wyoming Department of Health and Social Services recently sampled forty homes in the Laramie area for radon. The sampling was done with radon-testing canisters supplied by the U.S. Environmental Protection Agency. More than one test was performed in some of the homes, resulting in a total of sixty-six tests.

There are a number of geologic terrains present in Laramie, each with the potential for having a different radon risk. The homes that were sampled were in part chosen because of the geologic terrain they are located on. Certain areas were more heavily sampled as previous sampling indicated a greater potential for radon occurrence in those areas. The lowest levels of the homes (typically basements) were sampled as radon tends to concentrate in those areas. In some cases unventilated crawl spaces were sampled if they had an opening into the home. In a few cases, homes without basements or crawl spaces were also sampled.

The U.S. Environmental Protection Agency has determined that if a home has a radon level of 4 picocuries per liter of air or greater, follow-up measurement is needed (further information on radon testing or terms associated with radon can be

found in *Wyoming Geo-notes No. 13*, January, 1982, and *Wyoming Geo-notes No. 20*, November, 1988). In the recent Laramie tests, the radon values ranged from less than 0.5 picocuries per liter to 14.8 picocuries per liter. The 14.8 picocuries per liter value was from an unventilated crawl space.

The average radon reading for the lower living area or basement (excluding crawl spaces) for the forty homes in the study was 2.9 picocuries per liter. Of the forty homes tested, eight (20%) had radon concentrations at or above 4 picocuries per liter. There is a general tendency for radon readings to be higher in the winter months. This being the case, the average radon reading for all those Laramie homes may be higher during that time of year. If additional radon testing canisters are made available by the U.S. Environmental Protection Agency, the area will be sampled again next winter.

For additional information on where to obtain your own radon testing canister, contact Jim Case at the Geological Survey of Wyoming (307/766-2286) or Julius Haes at the Wyoming Department of Health and Social Services (307/777-6015).

DEFENSE NUCLEAR AGENCY PICKS TEXAS SITE INSTEAD OF WYOMING

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

The Defense Nuclear Agency (DNA) announced in June that it will conduct a non-nuclear underground explosives test at a site near Del Rio, Texas. A site in Wyoming 10 miles south of Shawnee was the other site being considered by the DNA for the test (see *Wyoming Geo-notes No. 21*, p. 36 and *Wyoming Geo-notes No. 22*, p. 31). The test is designed to duplicate the effects of a surface nuclear explosion on hardened underground structures.

According to the DNA press release that announced their decision, it was felt that a dolomite layer above the proposed explosives chamber at the Wyoming site might act as a seismic reflector and reflect shock waves from the explosion onto the test structure. This would create complications in determining the effects of the explosion on the structure. Because a site with a seismic reflector may be desirable in a future test, the Wyoming site still could be used. However, the Texas site is the location for the first test.

RECENT AND NEW PUBLICATIONS

BY THE GEOLOGICAL SURVEY OF WYOMING

* Coal geology, geophysical logs, and lithologic descriptions from a drilling program at the Rawhide Village subdivision, Campbell County, Wyoming, Richard W. Jones and Paul J. Taucher: Open File Report 89-2, 1989 ($9.00).

* Background gamma radiation of the Newcastle 1° x 2° Quadrangle, Wyoming and South Dakota, Ray E. Harris: Open File Report 89-3, 1989 ($7.50).

* Tripoli (Tripolite) in Wyoming, Ray E. Harris: Open File Report 89-4, 1989 ($2.00).

The geology of Wyoming's precious metal lode and placer deposits, W. Dan Hausel: Bulletin 68, 1989 ($10.00).

Revised geologic map of the Atlantic City Quadrangle, Fremont County, Wyoming, W. Dan Hausel: Map Series-28, 1989, scale 1:24,000 ($3.00).

Wyoming geomaps, Sheila Roberts: Educational Series I, 1989 ($5.00).

Precambrian basement map of Wyoming: outcrop and structural configuration, D.L. Blackstone, Jr.: Map Series 27, 1989, scale 1:1,000,000 ($3.00).

---

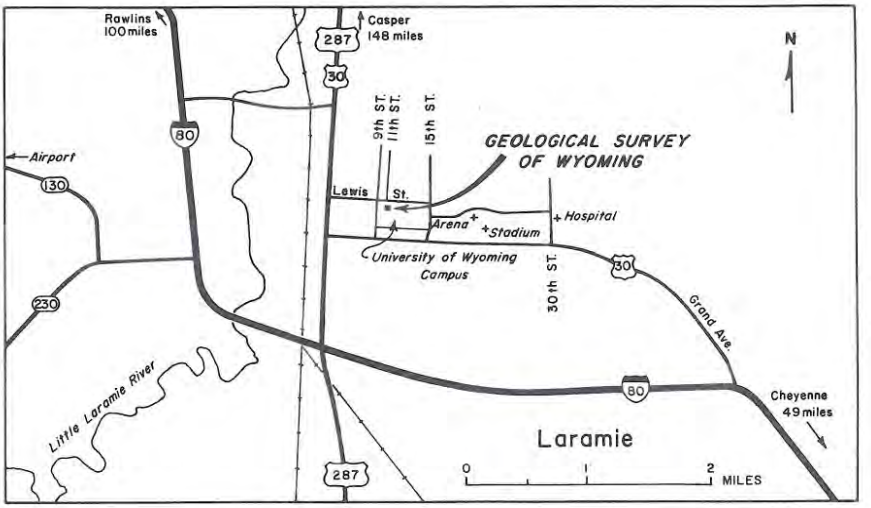
* New releases since the last issue of *Wyoming Geo-notes*.

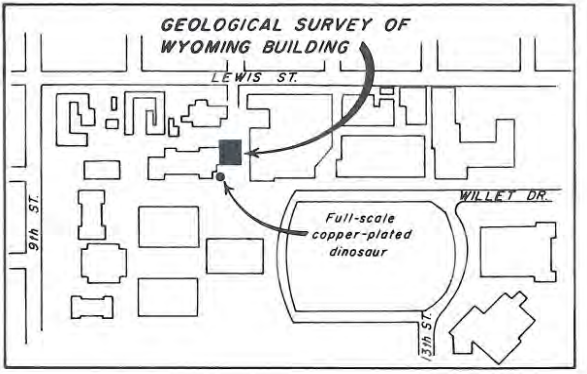
Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

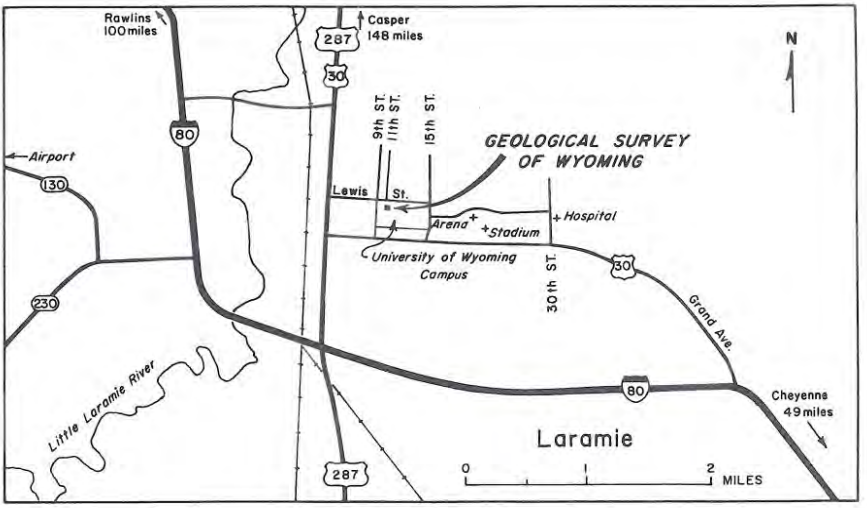
No first class postage charge for prepaid orders, unless otherwise marked.

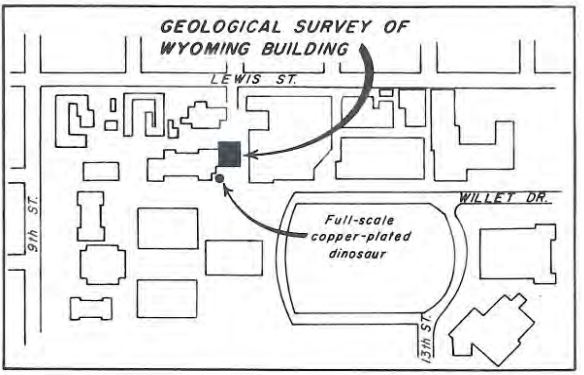
— NEW SERVICE AVAILABLE —

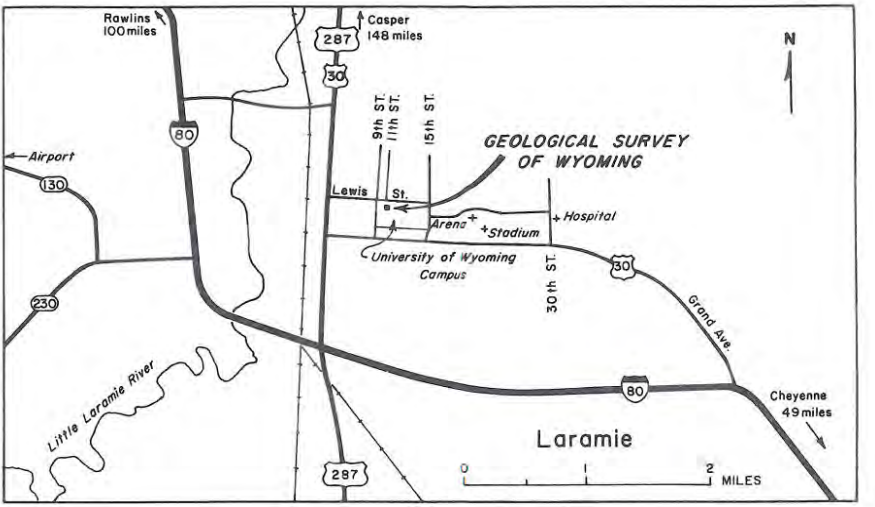
By special arrangement with the Wyoming Geological Association (WGA), the Geological Survey of Wyoming now sells all of WGA's Annual Field Trip Guidebooks as well as its Symposium Volumes. These publications are available over-the-counter at the Survey's offices on the University campus in Laramie. Although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

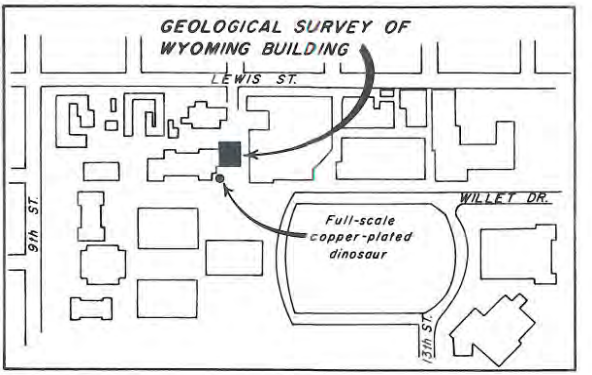

Rawlins
100 miles
Casper
148 miles
287
30
80
N
9th ST.
11th ST.
15th ST.
GEOLOGICAL SURVEY
OF WYOMING
Airport
130
Lewis
St.
Arena
Stadium
Hospital
University of Wyoming
Campus
30th ST.
30
230
Grand Ave.
Little Laramie River
80
Cheyenne
49 miles
Laramie
287
0
1
2
MILES


GEOLOGICAL SURVEY OF
WYOMING BUILDING
LEWIS ST.
WILLET DR.
9th ST.
Full-scale
copper-plated
dinosaur
13th ST.


Rawlins
100 miles
Casper
148 miles
287
30
80
N
9th ST.
11th ST.
15th ST.
GEOLOGICAL SURVEY
OF WYOMING
Airport
130
Lewis
St.
Arena
Stadium
Hospital
University of Wyoming
Campus
30th ST.
30
230
Grand Ave.
Little Laramie River
80
Cheyenne
49 miles
Laramie
287
0
1
2
MILES


GEOLOGICAL SURVEY OF
WYOMING BUILDING
LEWIS ST.
WILLET DR.
9th ST.
Full-scale
copper-plated
dinosaur
13th ST.


Rawlins
100 miles
Casper
148 miles
287
30
N
9th ST.
11th ST.
15th ST.
80
GEOLOGICAL SURVEY
OF WYOMING
Airport
130
Lewis
St.
Arena
Stadium
Hospital
University of Wyoming
Campus
30th ST.
30
230
Grand Ave.
Little Laramie River
80
Cheyenne
49 miles
Laramie
287
0
1
2
MILES


GEOLOGICAL SURVEY OF
WYOMING BUILDING
LEWIS ST.
WILLET DR.
9th ST.
Full-scale
copper-plated
dinosaur
13th ST.

Order Form

Send this order to:

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

Your name, address, zip:

_____

_____

_____

_____

_____

No postage charged on prepaid orders unless otherwise specified

Quantity	Title	Price	Total Price
	FIRST CLASS POSTAGE & ROLLED CHARGES		
	[No tax on State publications]	Total	

STATE OF WYOMING
GEOLOGICAL SURVEY
1933