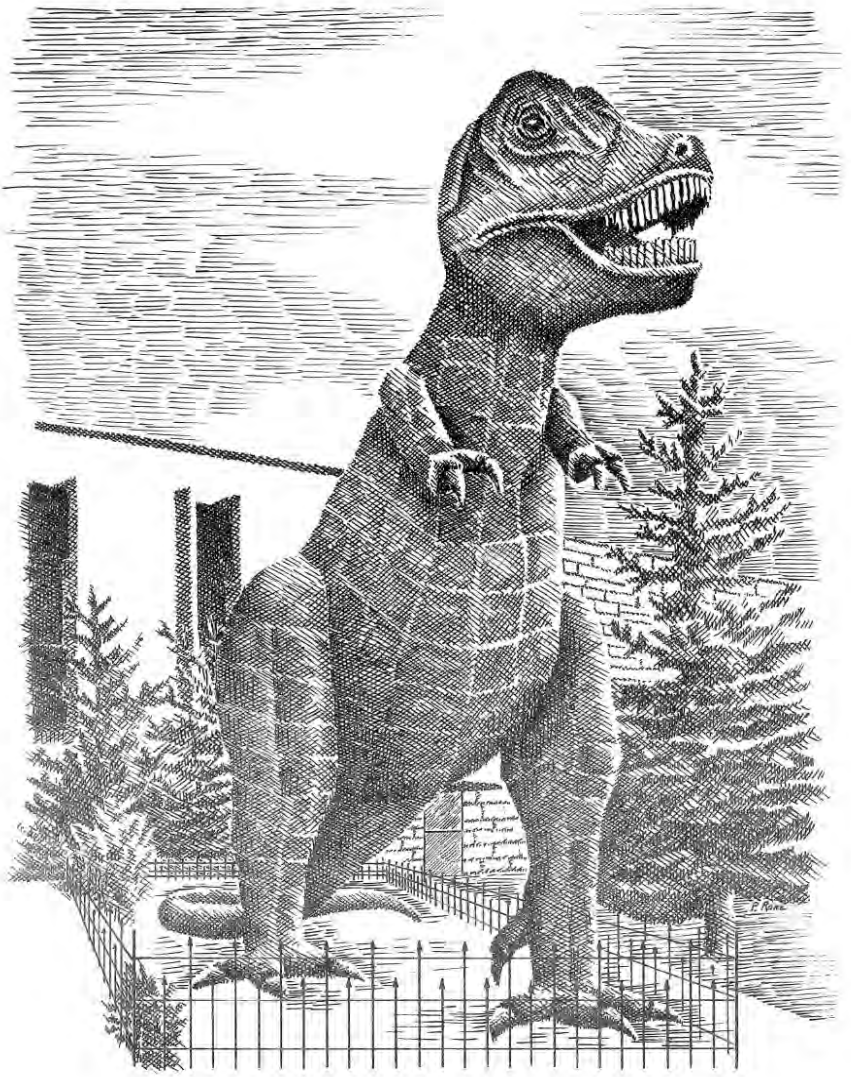
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING GEO-NOTES NO. 18



LARAMIE, WYOMING
April, 1988

THE GEOLOGICAL SURVEY OF WYOMING

Gary B. Glass, *Executive Director and State Geologist*

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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: *Tyrannosaurus rex.* This life-sized steel and copper statue, built by Dr. Samuel H. Knight in the early 1960s, guards the entrances to the Geological Survey of Wyoming and the Geological Museum in Laramie. It is 47 feet long and 18.5 feet tall. The seven-ton dinosaur was the most ferocious carnivore ever to walk the Earth. *Tyrannosaurus rex* lived in Wyoming about 70 million years ago (available as postcard from the Geological Survey of Wyoming). Drawing by Phyllis A. Ranz.

The Geological Survey of Wyoming
P.O. Box 3008, University Station
Laramie, Wyoming 82071

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Minerals update

OVERVIEW

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

So far in 1988 there have been few surprises related to mineral activities. While the rig count is higher than last year, oil production is running at least several percent below last year as expected. Oil prices have continued to fluctuate, but they probably averaged close to $16 for the first quarter. Although the big gain in natural gas production may have occurred in 1987, gains forecast for 1988 still look very probable. For the future, the Legislature gave tentative approval for a low interest loan for any company that successfully completes a Wyoming to California pipeline. If this comes to pass, a large new market for Wyoming gas is ahead.

Although first quarter information on coal production is still not available, there is no reason to believe that 1988 production will not follow our forecast of at least 143 million tons, which would be about 3.5 million tons below the new record of 146.5 million tons set in 1987. Coal production will be essentially flat for the next couple years (probably up one year and down the next), but it will gradually increase to 152 million tons by 1991. The spot price for coal in the first quarter showed little if any gain, suggesting the gradual decline in average price is not likely to reverse in 1988. Short-term contracts and spot sales of Wyoming coal were obviously a major segment of the market last year and will be again in 1988 if the first quarter provides any indication of the future as we suspect it does.

At this time it may be better to say nothing about uranium since this industry is apparently at an unsigned intersection with the Federal bureaucracy, the Court, Congress, and President each waiting for the other to move. Pessimists do not see a future; optimists do. Certainly the expansion of the *in situ* uranium operations in the State show there is some life left in the industry. Despite all the pessimism, however, some part of the industry will survive. Unfortunately it remains to be seen how much will survive given the small number of remaining domestic mines and the devastating effects of inexpensive imports.

One of the most newsworthy events in the first quarter was the apparently successful (measured in terms of dollars received) first test of the new onshore oil and gas leasing procedures. As you may remember, I expressed some doubt that the test sale would even occur. Fortunately, I was wrong. The first Federal auction of leases in Wyoming netted $7.3 million. Considering there are a number of parcels around that did not make that sale, the next sale may fare close to the first. After that, who knows! It still remains to be seen if the smaller independent operator can compete under the new system. If they can't, domestic exploration drilling may approach extinction.

Wyoming mineral production forecast to 1991[1].

Calendar Year	Oil Production[2]	Methane Production[3]	Carbon Dioxide Production[3]	Helium Production[6]	Coal Production[4]	Trona Production[4]	Mined Uranium Production[4]	Sulfur Production[5]
*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[7]	115.8	613.5	120.0	0.8	146.5	13.4	0.2	1.0
1988	111.0	630.0	120.0	0.8	143.0	13.6	0.3	1.0
1989	117.0	665.0	120.0	0.8	146.0	13.7	0.3	1.0
1990	108.0	700.0	120.0	0.8	149.0	13.8	0.3	1.0
1991	100.4	730.0	120.0	0.8	152.0	13.9	0.3	1.0

*Actual values for comparison; [1] Geological Survey of Wyoming, April, 1988; [2] millions of barrels; [3] billions of cubic feet; [4] millions of tons; [5] millions of tons converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission; [6] billions of cubic feet, based on Exxon's estimate of the average helium content (0.5 percent) in the gas produced at Shute Creek; [7] some of these values are preliminary rather than just estimates.

Already the downturn in drilling, caused by lower as well as uncertain oil prices, has apparently affected the U.S. Geological Survey's estimate of undiscovered recoverable oil and gas resources. Estimates for both oil and gas are significantly below estimates made in 1981. See pages 8 and 9 for additional information on these estimates. The point is that resources of 1981 are probably still there, but the economics of recovery have deteriorated so much that many billions of barrels of oil and many trillions of cubic feet of gas are simply no longer "recoverable". This is an alarming trend, but it is still only fought with rhetoric, not action.

OIL AND GAS UPDATE

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

Crude oil prices were relatively unstable during the first quarter of 1988. Posted prices for Wyoming Sweet averaged nearly $17 per barrel to start the quarter, fell to an average of $15 per barrel by the end of February, and recovered to an average near $16 per barrel at the end of March. The market dropped after reports of overproduction and price discounting by OPEC members. Sluggish worldwide demand

and increased inventories, due in part to an extremely mild winter in Europe, also contributed to the price slump. Prices may firm by the third quarter of 1988 as summer demand for gasoline increases, and because there are indications that OPEC as well as non-OPEC producers are eager to defend higher prices, even if it means cutting some production.

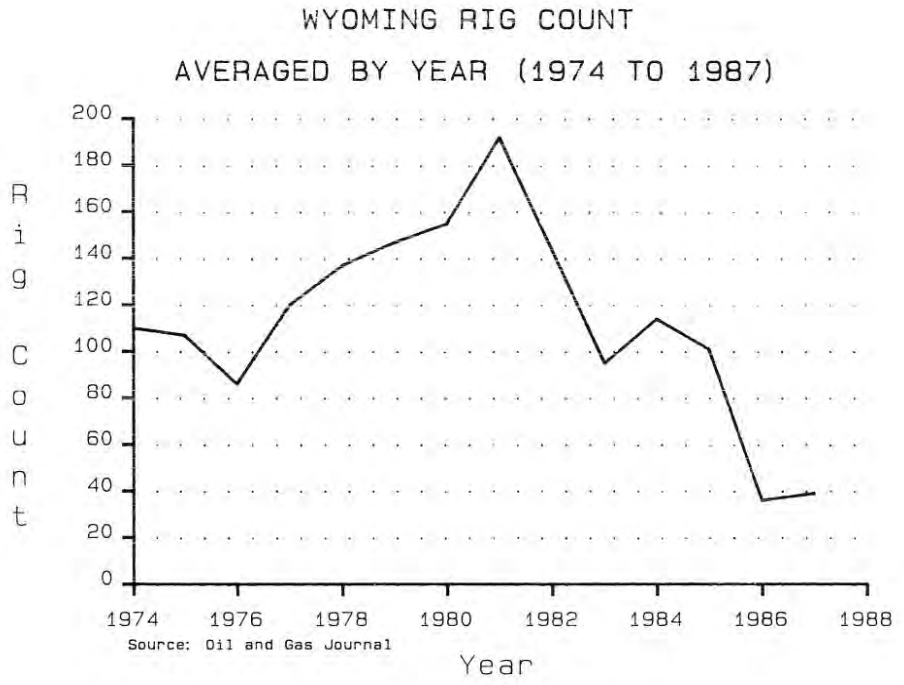
Wyoming Sweet crude oil generally sells for a price close to West Texas Intermediate, with OPEC and North Sea oil usually priced about $2 per barrel lower than West Texas Intermediate in the U.S. because of transportation costs and lower quality. West Texas Intermediate futures prices are currently over $17 per barrel for May delivery. While there are oil analysts already predicting that West Texas Intermediate crude oil will sell in the $18 to $20 per barrel range by the last half of 1988, these predictions seem overly optimistic.

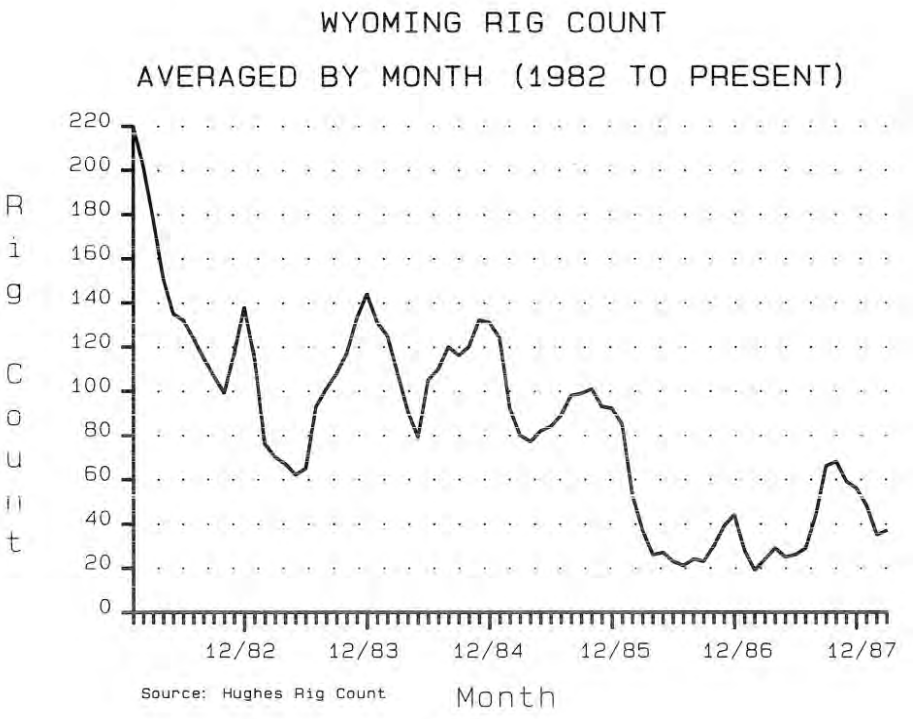
Apparently in response to anticipated higher and more stable crude oil prices, the rig count for Wyoming has averaged 40 for the first three months of 1988 compared to 23 for the first three months of 1987 (see figure on page 4). Well completions for the first three months of this year (246) are also ahead of the first three months of last year (180).

Preliminary figures show that production from Wyoming was about 115.8 million barrels of oil and 733.5 billion cubic feet of gas in 1987. Oil production dropped 5.4 percent from 1986 while natural gas production increased 25 percent from 1986. Much of the increase in gas production was due to about a 100 billion cubic feet increase in carbon dioxide production from Exxon's Shute Creek plant. Methane production also increased nearly 50 billion cubic feet (see figures on page 5 for a comparison with past years).

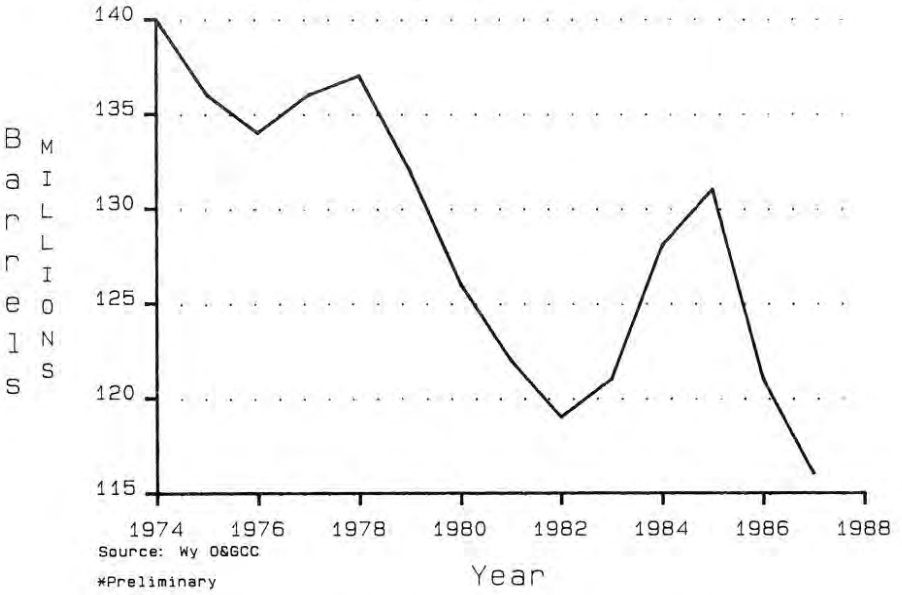
Although Wyoming's refining capacity has been stable at 165,300 barrels of crude oil per day for the last three years, it was over 209,000 barrels per day in 1981. Currently, Wyoming only has a little over one percent of the United States' refining capacity of 15.3 million barrels per day. Since 1981, seven refineries have closed, resulting in a lot of lost jobs and about 45,000 barrels per day of capacity. Refineries in Wyoming are currently only able to refine one-half of the State's crude oil production. The other half of the State's crude oil is sent to Montana, Colorado, Utah, and Midwest refineries.

Marathon Oil Company is the latest in a long list of oil companies that have reduced their number of employees in the State. Marathon will transfer 50 employees from Cody and Casper when it relocates its Rocky Mountain exploration offices to Houston around July 1, 1988. The Casper office will lose 30 to 35 exploration workers while Cody will lose 15 to 20 exploration employees. Every major oil company and many of the independents that operate in Wyoming have "streamlined" their operations in response to the oil price crash of 1986. The net result for Wyoming has been the loss of thousands of jobs in the oil and gas industry.


WYOMING RIG COUNT
AVERAGED BY YEAR (1974 TO 1987)
Rig Count
200
180
160
140
120
100
80
60
40
20
0
1974
1976
1978
1980
1982
1984
1986
1988
Source: Oil and Gas Journal
Year


WYOMING RIG COUNT
AVERAGED BY MONTH (1982 TO PRESENT)
Rig Count
220
200
180
160
140
120
100
80
60
40
20
0
12/82
12/83
12/84
12/85
12/86
12/87
Source: Hughes Rig Count
Month

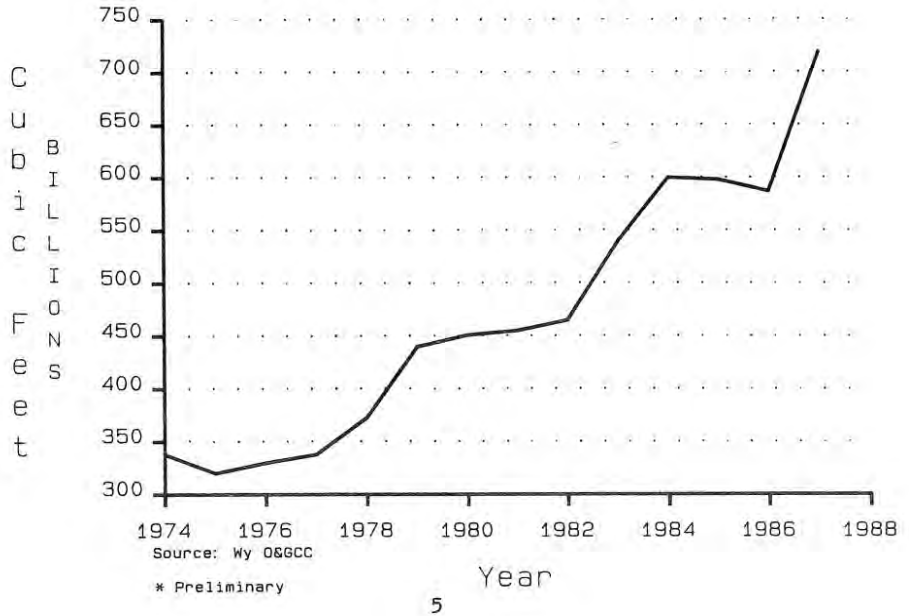
WYOMING OIL PRODUCTION
BY YEAR (1974 TO 1987*)



Source: Wy O&GCC

*Preliminary

WYOMING NATURAL GAS PRODUCTION
BY YEAR (1974 TO 1987*)



Source: Wy O&GCC

* Preliminary

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
			1985				
February	$ 3,547,273	117	115	34,948	34,028	$ 104.24	$ 1,700.00
April	2,025,793	133	128	25,497	24,056	84.21	2,609.53
June	1,963,897	140	137	40,304	38,904	50.48	2,577.15
August	2,854,821	198	146	75,094	56,906	50.17	1,732.14
October	1,876,105	208	105	81,611	32,052	58.53	1,108.77
December	1,467,265	211	144	73,723	46,908	31.28	1,167.23
TOTAL	$13,735,154	999	772	331,177	232,854	$ 58.99	$ 2,609.53
			1986				
February	$ 1,992,326	211	154	58,507	38,809	$ 51.34	$ 680.00
April	1,795,890	189	116	54,136	29,938	59.99	1,881.88
June	1,332,216	86	75	27,137	24,512	54.35	437.50
August	529,184	104	88	25,686	22,725	23.29	227.63
October	840,950	76	68	17,827	16,604	50.65	516.86
December	774,824	110	82	28,057	19,840	39.05	3,313.13
TOTAL	$ 7,265,390	776	583	211,350	152,428	$ 47.66	$ 3,313.13
			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

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
			1985				
January	$ 757,214	200	86	80,019	27,520	$ 26.51	$1,700.00
March	2,077,478	300	172	137,321	69,781	29.77	1,600.00
May	936,374	199	117	73,625	35,273	26.55	350.00
July	636,350	200	113	83,491	43,630	14.59	280.00
September	989,069	200	126	95,052	60,356	16.39	325.00
November	494,739	200	109	70,144	41,399	11.95	320.00
TOTAL	$ 5,891,224	1,299	723	539,652	277,959	$ 21.19	$1,700.00
			1986				
January	$ 630,069	200	123	83,064	49,783	$ 12.66	$ 320.00
March	773,492	199	112	77,237	44,504	17.38	370.00
May	354,941	200	70	74,128	27,543	12.89	140.00
July	418,280	200	63	86,495	25,461	16.43	234.00
September	171,975	200	80	87,017	33,738	5.10	360.00
November	99,403	200	74	75,385	24,728	4.02	120.00
TOTAL	$ 2,448,160	1,199	522	483,326	205,757	$ 11.90	$ 370.00
			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	362,365	200	100	82,367	44,690	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

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

Since the last issue of *Wyoming Geo-notes*, the Wyoming Board of Land Commissioners has held two sales (see table on page 6). The high bid at the January sale was $200 per acre made by Robert B. Knox for a 320-acre lease in section 15, T.48N., R.71W. near Rabbit Ears field, which produces from the Minnelusa Formation. The second high bid of $158 per acre was made by Shawn Hannifin for a 240-acre tract in section 21, T.50N., R.70W. just west of Minnelusa oil production at Rozet field.

The March sale's high bid by Casper Independent North Finn was $465 per acre for an 80-acre tract in section 21, T.28N., R.68W. near South Coyote Creek field. Argentia Corporation paid $200 per acre for a 160-acre lease in section 9, T.52N., R.69W. near Minnelusa production at Gibbs field.

The U.S. Bureau of Land Management (BLM) held its first sale of the year in Wyoming on March 29th and 30th in Cheyenne, Wyoming. Two hundred twenty-two registered bidders were present. This was also the first sale in Wyoming and the second in the country designed to test the new leasing procedures mandated by the Federal Onshore Oil and Gas Leasing Reform Act of 1987. Under the new system, sealed competitive bids and the lottery have been discontinued. All tracts sold at this auction were for a primary term of five years and carried a flat 12.5 percent royalty rate rather than the 12.5 to 25 percent sliding royalty rate for tracts sold under the old system. The minimum bid was $2.00 per acre, and rental was $1.50 per acre. All tracts not sold at the auction are available for over-the-counter leasing for a period of two years. The first day after the sale, there were an estimated 1,700 filings on tracts not sold at auction (BLM, personal communication, 1988). There will be a drawing to determine priority among any conflicting offers for over-the-counter parcels. For a comparison with past sales, see the table on page 6. The high per-acre bid in the sale was made by Texaco for a 640-acre tract in portions of sections 2, 3, and 10 of T.22N., R.111W. near Frontier production at Storm Shelter and Whiskey Butte fields. The second high bid of $450 per acre was made for a nearby 80-acre tract in section 9, T.22N., R.111W.

A Federal appellate court has ruled that the Department of the Interior can deny drilling along Little Granite Creek. The Little Granite Creek area has been included in the Gros Ventre Wilderness since Getty Oil Company received its drilling permit from the BLM. Texaco subsequently took over Getty, and they now hold the lease. Texaco is considering three options in regard to the lease: (1) An appeal to the Supreme Court; (2) Letting the process take its course, which would mean an environmental impact statement with a "no drilling" option; and (3) seeking compensation for lost investment in exchange for the relinquishment of their drilling rights. The court's decision in this matter is apparently unique and related to specific wording in this particular lease.

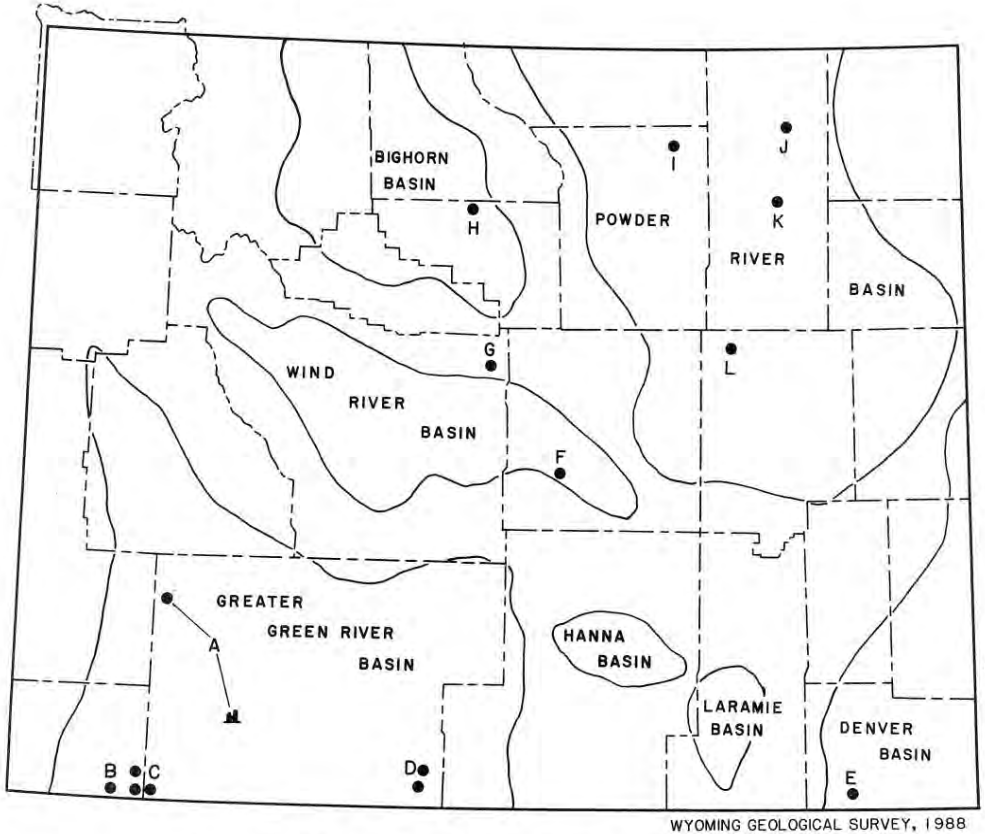
Another Federal appellate court in San Francisco has ruled that the Federal Government should have done environmental impact statements before issuing most of over 700 contested oil and gas leases issued in the Flathead and Gallatin Forests in Montana. Although the leases are in Montana, the latest ruling could affect leasing policy in Wyoming as well. This ruling contradicts a ruling handed down by an appellate court in Denver and could prompt the Supreme Court to make a ruling on the amount of environmental study required for oil and gas leasing in National Forests.

The U.S. Supreme Court has ruled that Montana cannot levy its severance and property tax on minerals owned by the Crow Indian Tribe. The ruling will probably be applied to oil and gas production from mineral rights belonging to the Shoshone and Arapahoe Tribes on the Wind River Reservation in Wyoming. Wyoming, however, may be able to avoid invalidating its taxes by providing services at a level commersurate to the taxes that are collected.

The Wyoming State Legislature recently concluded work on two pieces of legislation that will affect the oil and gas industry in the State. The Legislature authorized State officials to negotiate a $250 million low-interest (4 percent) loan to help finance a natural gas pipeline to southern California. If Wyoming gas shipments do not reach 350 million cubic feet per day, the interest rate will increase in relationship to how much Wyoming gas is shipped. The loan could be made as early as April, 1989, pending a review by the 1989 Legislature and approval by the Governor and Attorney General. The Legislature also passed a bill which limits total deductions used in gas valuation to 40 percent of the sales price of processed gas. The bill allows an exception for gas plants that show extraordinary circumstances and are valued at less than $250 million. The legislation was mainly aimed at Exxon Corporation which is essentially paying no tax on the natural gas production (methane and carbon dioxide) from their Shute Creek plant.

In a related item, the Wyoming Supreme Court upheld the State's right to apply a six percent severance tax on nonhydrocarbon gases. Amoco, Exxon, and Chevron argued that State tax laws applied to methane, but not to other natural gases such as hydrogen sulfide, carbon dioxide, and helium. The Court ruled that the term "natural gas" as used in State statutes means any gases that occur naturally in gas produced from drilled wells.

The U.S. Geological Survey held its fourth annual V.E. McKelvey Forum on Mineral and Energy Resources. The Forum, entitled "Roles of Geological Research in the Assessment of Energy Resources-1988" was held on March 1st and 2nd in Denver, Colorado. One of the most controversial topics at the forum was a new U.S. Geological Survey estimate of undiscovered recoverable oil and gas resources for the United States. Their mean estimate for oil is 33.4 billion barrels, down considerably from their 1981 estimate of 54.6 billion barrels. Their mean estimate for natural gas is 254 trillion cubic feet, well below their 1981 estimate of 427 trillion cubic feet. In comparison, the Potential Gas Committee's estimate for natural gas reserves at the



OIL AND GAS EXPLORATION ACTIVITY IN WYOMING

end of 1986 was around 400 trillion cubic feet in the categories corresponding to the U.S. Geological Survey's estimate. The figures issued at the conference are preliminary and are subject to revision after public comments are received. Extended abstracts of all the presentations are available in U.S. Geological Survey Circular 1025. The circular is free on application to the Books and Open-File Reports Section, U.S. Geological Survey , Denver Federal Center, Box 25425, Denver, Colorado 80225.

Several significant exploration and development events occurred in Wyoming during the first quarter of 1988. The letters in the following discussions refer to locations on the figure on page 9.

A. Two high volume condensate and gas wells were completed by ITR Petroleum in the Dakota Formation in the Swan-Blue Forest-Lincoln Road area on the Moxa Arch. The 22-12 Blue Forest well (section 12, T.24N., R.111W.) flowed 9.7 million cubic feet of natural gas and 507 barrels of condensate per day. The 22-13 (section 13, T.24N., R.111W.) Blue Forest well flowed 10.8 million cubic feet of natural gas and 680 barrels of condensate per day. Western Gas Processors of Denver plan to start up a 45 million cubic feet per day plant near Green River later this year to process wet gas purchased from Texaco wells in the Swan-Blue Forest-Lincoln Road area. The tail gas will be sold to Colorado Interstate Gas Corporation.

B. Luckey Ditch field continues to grow. Sun Exploration and Production completed two Dakota wells: The 7 Luckey Ditch-Federal-E (section 15, T.12N., R.114W.) flowed 3.9 million cubic feet of natural gas and 506 barrels of oil per day and the 9 Luckey Ditch-Federal-G (section 8, T.12N., R.114W.) flowed 1,466 barrels of oil per day and 2.7 million cubic feet of gas per day. Anadarko Petroleum also completed two Dakota wells: the 1-B Whiskey Springs Federal in section 33, T.13N., R.114W. flowed 3.5 million cubic feet of natural gas and 401 barrels of condensate per day and the 1-C Whiskey Springs Federal (section 5, T.12N., R.114W.) flowed 3.8 million cubic feet of natural gas and 1,993 barrels of condensate per day.

C. Sun has staked a Dakota test in section 15, T.13N., R.112W. and has set production casing and is testing the Dakota in wells in section 6, T.12N., R.112W. and in section 24, T.15N., R.113W.

D. Two new gas fields have been discovered in the Green River Basin. Samuel Gary Jr. and Associates completed a well in the Almond Formation of the Mesaverde Group (section 36, T.15N., R.95W.) which flowed 689,000 cubic feet of natural gas per day. The well is now operated by Sun Exploration and Production. Apache Corporation completed the other discovery in the Lewis Shale in section 30, T.14N., R.95W. for 539,000 cubic feet of natural gas per day.

E. Borie field, seven miles west of Cheyenne, was discovered in 1949. The field now has a new producer completed in the Muddy Sandstone by

General Atlantic Energy. The new producing well is in section 24, T.13N., R.68W. and is pumping 130 barrels of oil per day with no water.

F. Sun Ranch field, discovered in 1987, has two new Muddy Sandstone producing wells. Sun completed an offset well in section 15, T.33N., R.86W. which flowed 602 barrels of oil and 461,000 cubic feet of natural gas per day. BHP completed a well in the same section for 880,000 cubic feet of gas and 1,091 barrels of oil per day. The discovery well, also in section 15, flowed 1,048 barrels of oil and 976,000 cubic feet of gas per day. Sun and BHP have both staked additional locations for development wells.

G. BHP Petroleum is setting liner in their 2-3 Bighorn well which is at 24,250 feet (section 3, T.38N., R.90W.). The well was spudded January 1, 1987, and is about two miles east of their Madison Limestone gas discovery which was completed between 23,758 and 23,902 feet. The discovery well is currently shut in.

H. Enigma field, discovered late in 1987, has three producing wells in the Tensleep Sandstone which collectively produce 198 barrels of oil per day. Information is not yet available on three other producing wells in the field. CNG Producing has drilled all six wells in the field, which is located in sections 3 and 10, T.48N., R.91W. CNG has plans to drill five more wells in these sections.

I. Smokey Oil has staked a 13,300-foot Minnelusa test in section 35, T.52N., R.79W. The township has not been drilled before and the nearest production is from the Teapot Sandstone at Post Draw field, nearly ten miles to the east.

J. Terra Resources opened a new Muddy Sandstone field in section 18, T.53N., R.71W. The discovery well had an initial potential of 30 barrels of oil per day. Terra has drilled two more wells in the same section; however, the results are being held confidential.

K. Conley P. Smith completed a Minnelusa discovery in section 30, T.49N., R.71W. that pumped 569 barrels of oil per day. The nearest Minnelusa production is about one-half mile away at Sharp field. The Wyoming Field Names Advisory Committee has named the discovery Gap field.

L. Exxon Corporation has an indicated Dakota discovery in section 27, T.40N., R.75W. During tests, the well flowed 51 barrels of oil and 313,000 cubic feet of natural gas per day.

COAL UPDATE

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

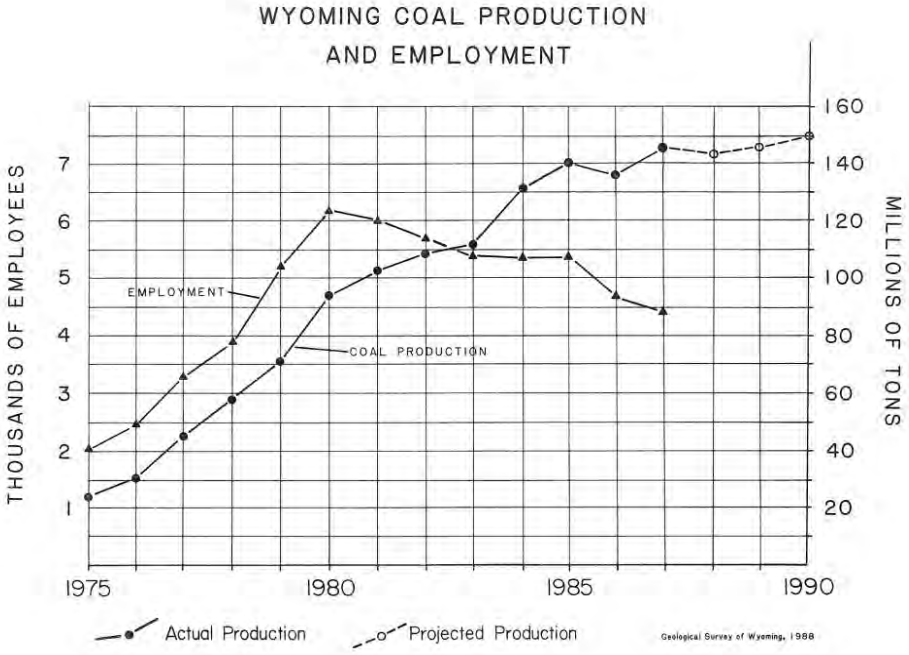
Wyoming coal production in 1987 reached an all-time high of 146.5 million short tons. The record production exceeded last year's production by over ten million tons and represented an increase of 7.5 percent over the 1986 production (see figure on page 13). The State continued as the second leading coal-producing state in the U.S. behind Kentucky with 161.5 million short tons and ahead of West Virginia which reported 136.3 million short tons. National coal production also set an all-time record in 1987 with about 910 million short tons produced. The national production broke the previous high of 896 million short tons in 1984 and exceeded 1986 production by almost 20 million short tons (an increase of about 2.2 percent). Wyoming coal mines produced about 16 percent of the Nation's coal in 1987.

National coal production (and near-record coal consumption) in 1987 was a result of increased demand for coal-fired power generation (related to abnormal weather conditions and a drop in hydroelectric power generation) as well as some stockpiling in anticipation of a possible miners' strike. Wyoming's increased coal production was also related to increased demand for electrical power brought about by a hot, dry summer and the lack of hydroelectric power generation in the northwestern U.S. As power demands rose, electric utility companies purchased additional coal under contract and through the spot market (note increased monthly coal deliveries in the second half of 1987, shown in the table on page 14).

Coal sold on the spot market accounted for 6.2 million tons or 4.4 percent of the total coal deliveries from Wyoming in 1987. Unrecorded coal sales of 4.1 million tons (generally to industrial users and numerous small spot sales) accounted for the remaining coal production. Coal deliveries to electric utilities in Minnesota, Iowa, Texas, Missouri, and Wyoming showed the greatest increases in 1987 (each increased from 1.2 to 3 million tons); deliveries to Illinois, Indiana, Colorado, and Oklahoma all decreased from 1986 to 1987.

Coal production from Powder River Basin mines in 1987 was about 10.8 million tons greater than in 1986 and represents an increase of about 9.2 percent (see table on page 15). In 1987 Hanna Basin coal production increased by 0.7 million tons over 1986 production and was the first annual increase in this basin in eight years. Coal regions in western and southwestern Wyoming decreased production in 1987: Green River Basin production dropped 8.8 percent or 1.1 million tons, Hams Fork Region production dropped 5.7 percent or 0.2 million tons, and Bighorn Basin production dropped more than 60 percent. Two underground mines in the State produced 106,542 tons of coal in 1987; the remaining production was from 27 surface mines.

Fifteen surface mines in Campbell County accounted for 83.5 percent of the State's coal production in 1987, and the 18 surface mines in the Powder River Basin accounted for 87.8 percent of the State's coal



production (see table on page 17). Coal production from Campbell County increased 10.6 million tons or 9.5 percent from 1986 to 1987. A slight increase in coal production from Converse County (0.34 million tons) was offset by a slight decrease in production from Sheridan County. Only one mine in Sheridan County, Big Horn Coal Company's Big Horn mine, reported coal production in 1987. The County's other mine, Ash Creek Mining Company's P.S.O. No. 1, did not report production in 1987 and accounts for the decrease in the number of mines in the State from 30 in 1986 to 29 in 1987.

Based on preliminary data from the Wyoming State Inspector of Mines, Thunder Basin Coal Company's Black Thunder mine remained the State's leading coal producer with 19.3 million tons mined in 1987 (see table on page 15). This was despite its 2.6-million ton drop in production from 1986. The top ten producing Wyoming mines, in descending order, are:

1. Black Thunder
2. Belle Ayr
3. Eagle Butte
4. Cordero
5. Caballo
6. Jacobs Ranch
7. Rawhide
8. Jim Bridger
9. Caballo Rojo
10. Rochelle

COAL DELIVERIES BY MONTH FROM WYOMING MINES

	1983 MONTHLY	1983 CUMULATIVE	1984 MONTHLY	1984 CUMULATIVE	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE
JANUARY	10,313,000	10,313,000	9,540,200	9,540,200	11,601,200	11,601,200	11,646,300	11,646,300	12,085,570	12,085,570
FEBRUARY	8,719,700	19,032,700	9,654,600	19,194,800	10,473,900	22,075,100	10,317,700	21,964,000	10,315,680	22,401,250
MARCH	9,051,200	28,083,900	10,875,000	30,069,800	11,674,900	33,750,000	11,401,720	33,365,720	10,436,610	32,837,860
APRIL	8,195,000	36,278,900	8,721,400	38,791,200	11,632,800	45,382,800	9,954,170	43,319,890	10,429,180	43,267,040
MAY	8,364,600	44,643,500	9,481,500	48,272,700	11,497,900	56,880,700	10,105,320	53,425,210	10,619,470	53,886,510
JUNE	8,330,200	52,973,700	9,464,500	57,737,200	11,692,200	68,572,900	10,499,280	63,924,490	11,953,650	65,840,160
JULY	8,734,700	61,708,400	11,019,600	68,756,800	11,893,500	80,466,400	11,497,190	75,421,680	12,850,240	78,690,400
AUGUST	9,669,300	71,377,700	11,433,000	80,189,800	12,107,100	92,573,500	11,773,510	87,195,190	13,460,470	92,150,870
SEPTEMBER	9,189,700	80,567,400	10,440,000	90,629,800	11,325,000	103,898,500	11,474,820	98,670,010	12,651,550	104,802,420
OCTOBER	9,406,300	89,973,700	10,492,500	101,122,300	11,048,500	114,947,000	10,854,670	109,524,680	12,248,080	117,050,500
NOVEMBER	9,013,600	98,987,300	11,814,200	112,936,500	10,589,700	125,536,700	11,971,990	121,496,670	12,340,720	129,391,220
DECEMBER	7,680,600	106,667,900	11,486,800	124,423,300	11,459,300	136,996,000	13,025,490	134,522,160	13,008,300	142,399,520
TOTAL TONNAGE REPORTED	106,667,900		124,423,300		136,996,000		134,522,160		142,399,520	
TOTAL TONNAGE NOT REPORTED	5,519,300		6,322,479		3,784,154		1,782,896		4,089,128	
TOTAL TONNAGE PRODUCED	112,187,200		130,745,779		140,780,154		136,305,056		146,488,648	

Source: National Marketing Reports by Coal Marketronix, compiled from FERC Form 423 filed monthly by electric utilites. Annual Reports of Wyoming State Mine Inspector and Ad Valorem Tax Division.

1986 and 1987 WYOMING COAL PRODUCTION AND EMPLOYMENT[1]

Company	Mine Name	1986 Employees	1986 Production (short tons)	1987 Employees	1987 Production (short tons)
	POWDER RIVER BASIN				
Amax Coal Company	Belle Ayr (surface)	343	12,145,900	333	13,329,591
	Eagle Butte (surface)	287	12,000,280	293	12,977,000
Antelope Coal Company	Antelope (surface)	38	1,709,787	38	2,554,333
Ash Creek Mining Company	PSO No. 1 (surface)	1	20	1	
Big Horn Coal Company	Big Horn (surface)	123	1,360,805	73	1,201,093
Carter Mining Company	Caballo (surface)	194	7,272,741	202	11,684,193
	Rawhide (surface)	181	12,403,975	170	10,672,913
Cordero Mining Company	Cordero (surface)	252	11,314,275	227	11,943,375
Fort Union Coal Company	Fort Union (surface)	15	219,313	23	394,004
Glenrock Coal Company	Dave Johnston (surface)	175	3,051,331	173	2,546,808
Kerr-McGee Coal Corporation	Clovis Point (surface)	75	1,435,045	62	1,508,524
	Jacobs Ranch (surface)	319	12,050,711	326	11,158,874
Mobil Coal Producing, Inc.	Caballo Rojo (surface)	109	3,989,622	132	6,489,799
North Antelope Coal Company	North Antelope (surface)	130	5,689,608	122	5,337,503
Rochelle Coal Company	Rochelle (surface)	43	3,571,177	80	6,436,359
Thunder Basin Coal Company	Black Thunder (surface)	504	21,868,336	462	19,272,751
	Coal Creek (surface)	28	1,111,305	32	2,362,059
Triton Coal Company	Buckskin (surface)	90	3,996,492	94	5,773,967
Wyodak Res. Develop. Corp.	Wyodak (surface)	65	2,600,000	61	2,976,398
TOTAL		2,972	117,790,723	2,904	128,619,544
	HANNA BASIN				
Amar[2]	Seminoe No. 2 (surface)	16	96,362	13	62,900
Arch Mineral Corporation	Seminoe No. 1 (surface)	30			
	Seminoe No. 2 (surface)	106	543,071	107	1,280,000
Carbon County Coal Company	Carbon No. 1 (deep)	21	163,700		
Cyprus Shoshone Coal Company	Shoshone No. 1 (deep)			31	105,300
Medicine Bow Coal Company	Medicine Bow (surface)	14	3,274	12	19,625
Rosebud Coal Sales	Rosebud (surface)	85	707,021	71	780,873
TOTAL		272	1,513,428	234	2,248,698
	GREEN RIVER BASIN				
Black Butte Coal Company	Black Butte (surface)	494	5,984,526	346	4,666,660
Bridger Coal Company	Jim Bridger (surface)	419	6,480,450	426	6,600,573
Prospect Point Coal Company	Leucite Hills (surface)	50	474,200	53	538,775
Western Wyoming Fuels	Swanson (deep)	1	777	8	1,242
TOTAL		964	12,939,953	833	11,807,250
	HAMS FORK REGION				
FMC Corporation	Skull Point (surface)	101	905,939	92	802,930
Pittsburg and Midway Coal Mining Company	Elkol and Sorenson (surface)	358	3,127,668	357	3,000,000
TOTAL		459	4,033,607	449	3,802,930
	BIGHORN BASIN				
Northwestern Resources Company	Grass Creek (surface)	4	27,345	3	10,226
TOTAL		4,671	136,305,056	4,423	146,488,648

[1] Sources: Wyoming State Inspector of Mines, 1986 Annual Report and 1987 preliminary data; Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division, 1987 Annual Report.

[2] Auger mining operation under contract with Arch Mineral Corporation

Notably, Bridger Coal Company's Jim Bridger mine in Sweetwater County was the only non-Powder River Basin mine in the top ten producing mines in Wyoming. Mines that showed significant increases in coal production in 1987 included Rochelle Coal Company's Rochelle mine (an increase of 2.9 million tons), Mobil Coal Producing, Inc.'s Caballo Rojo mine (an increase of 2.5 million tons), and Triton Coal Company's Buckskin mine (an increase of 1.8 million tons). Black Butte Coal Company's mine in Sweetwater County experienced a 1.3-million ton decrease in production from 1986 to 1987. In total, 19 coal mines increased their production in 1987 and 10 coal mines decreased their production.

The 4,423 employees working at Wyoming coal mines at the end of 1987 are the lowest recorded in the last nine years. This continues a downward trend that began after employment peaked in 1980 (see figure on page 13). All the producing regions or basins and all seven coal-producing counties in the State experienced a decrease in employment from 1986 to 1987 (see table on page 15). The largest drop in employment occurred in the Green River Basin with the loss of 131 jobs in 1987. The next highest loss was 68 jobs in the Powder River Basin. In the Powder River Basin, Sheridan County employment dropped from 124 in 1986 to 74 in 1987 (see table on page 17). Campbell County employment dropped by 16 to 2,619 employees, and Converse County employment dropped by only two. The largest numbers of employees laid off in 1987 occurred at the Black Butte mine (148 layoffs), the Big Horn mine (50 layoffs), and the Black Thunder mine (42 layoffs). Significant employment increases occurred at the Rochelle and Caballo Rojo mines (increases of 37 and 23 employees, respectively) in the Powder River Basin and at Cyprus Shoshone Coal Company's newly opened Shoshone No. 1 underground mine at Hanna (21 employees were retained from the previous mine, plus 10 additional employees were added).

In the first quarter of 1988, Triton Coal, hired six entry-level positions for an anticipated increase in production from their Buckskin mine. It was reported that 450 people were in line to apply for these jobs on the day the positions were announced.

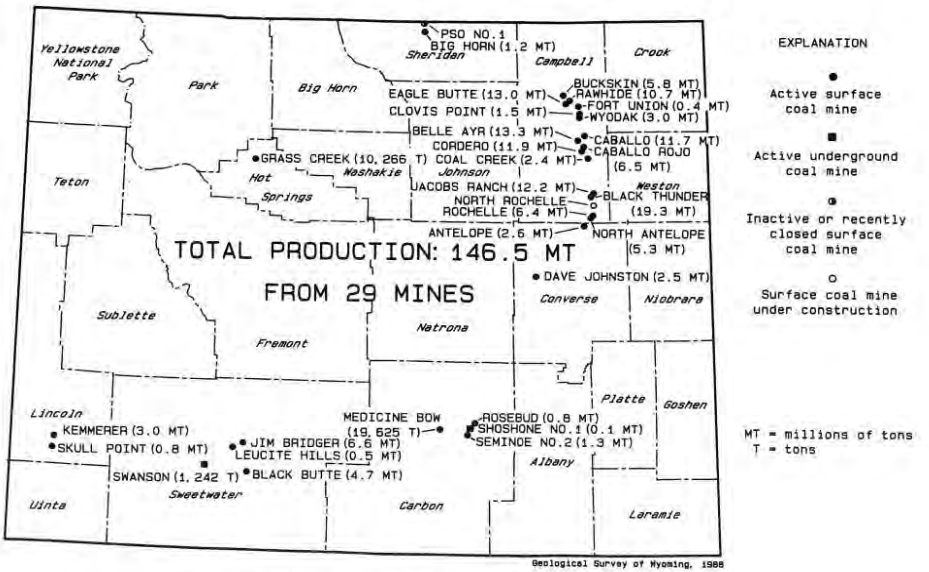
Wyodak Resources Development Corporation announced that four employees would be laid off on February 29th. The Wyodak layoffs followed six previous layoffs in the summer of 1987 and are related to the buyout of coal supply contracts by two of Wyodak's utility customers. The two contract buyouts announced by Wyodak Resources Development Corporation were with Grand Island Utilities in Grand Island, Nebraska (a 20-year contract for 6.7 million tons of coal from 1981 to 2000) and Hastings Utilities Department in Hastings, Nebraska (a 10-year contract for 2.1 million tons of coal from 1981 to 1990).

It was also announced in January that a long-term contract between Cordero Mining Company and Western Fuels Association (WFA) for coal supplied to the Laramie River Station at Wheatland, Wyoming, would be terminated. The contract, which called for delivery of 60 million tons of coal from 1979 to 2017 (1.5 million tons per year) from the Cordero mine, was canceled after Cordero and WFA could not reach agreement on a new coal price. New coal prices were being negotiated

1987 WYOMING COAL PRODUCTION BY COUNTY AND COAL BASIN[1]

County	Production	Percent of Total Production	Number of Producing Mines	Number of Employees
		POWDER RIVER BASIN		
Campbell	122,317,310	83.5	15	2,619
Converse	5,101,141	3.5	2	211
Sheridan	1,201,093	0.8	1	74
TOTAL	128,619,544	87.8	18	2,904
		GREEN RIVER BASIN		
Sweetwater	11,807,250	8.1	4	833
		HAMS FORK REGION		
Lincoln	3,802,930	2.6	2	449
		HANNA BASIN		
Carbon	2,248,698	1.5	4	234
		BIGHORN BASIN		
Hot Springs	10,226	<0.1	1	3
TOTAL WYOMING	146,488,648		29	4,423

[1] Source: Wyoming State Inspector of Mines, preliminary data for 1987.



WYOMING COAL MINES AND PRODUCTION, 1987

under a price re-opener clause of the contract. WFA has asked for bids on a new 15-year, 2.7 million tons per year contract to replace the terminated contract. By the end of March, WFA was negotiating with five of the 15 Powder River Basin coal producers that had been asked to bid on the contract. WFA has also been exploring the possibility of developing an equity, by participating in either the mine that wins the contract or in the development of a new mine in the Powder River Basin that would supply part of the contracted tonnage.

Several other important coal contract developments occurred in the first quarter of 1988. First, Mobil Coal Producing, Inc. announced in February that they had signed a 60,000 metric tons (66,000 short tons) contract for coal shipments to Taiwan Power Company. This is the first publicly-announced contract between a Wyoming coal producer and a Pacific Rim country. Coal for this contract was mined at Mobil's Caballo Rojo mine south of Gillette and was shipped via Burlington Northern to the port city of Roberts Bank, British Columbia (near Vancouver). From there, the coal was loaded on a ship and sent to Taiwan in late February. Although this contract is only for coal to be used in assessing its burning characteristics, it is hoped that the contract will eventually lead to long-term contracts for large volumes of coal.

Secondly, Cyprus Shoshone Coal Company, operator of the State's only major underground mine, is apparently having some success in selling their coal. In January, Northern Indiana Public Service Company (NIPSCO) purchased spot coal from Cyprus Shoshone to supplement contract coal at NIPSCO's Schaffer plant in Indiana. In February, 80,000 additional tons of coal were sold to NIPSCO for the same plant. Cyprus Shoshone has also delivered coal to Iowa Electric Light and Power Company's Prairie Creek plant at Cedar Rapids, Iowa. If Cyprus Shoshone can secure additional short-term contracts or a single long-term contract, the future of underground mining in the State and the future of coal mining in the Hanna Basin will certainly improve.

Two other new coal supply contracts were signed in the first quarter of 1988. The first contract was for deliveries of 30,000 tons of test coal from NERCO Coal's Antelope mine in Converse County to Central Power and Light Company's Coleto Creek generating plant near Corpus Christi, Texas. Delivery of this coal will be via the Burlington Northern and the Southern Pacific railroads. This is the first Powder River Basin coal to be used at Coleto Creek. The second contract is for deliveries of an undisclosed amount of coal from Cordero Mining Company's Cordero mine to the new Deely Unit No. 3 that will be constructed by the San Antonio City Public Service Board. A construction contract for this 500-megawatt plant was signed in January. The new unit would be an addition to the two existing 400-megawatt units already in operation at the J.T. Deely plant site. Start-up for the new Deely unit is planned for 1992, and Cordero's coal contract is due to end in 1996. Cordero currently supplies coal to the Deely No. 1 and No. 2 units, and the utility company has railroad transportation contracts with the Chicago and Northwestern Transportation Company (C&NW) and the Union Pacific Railroad (UP).

Short-term contract and spot sales activity involving Wyoming coal mines increased in the first quarter of 1988 with the following contracts:

1) NERCO Coal's Antelope mine will supply 55,000 tons of test coal to Wisconsin Public Service Company's Weston Unit No. 3 at Rothschild, Wisconsin, in the first half of 1988. Delivery will be via the C&NW or the Burlington Northern (BN) railroads.

2) Cordero Mining Company will supply 651,000 tons of spot coal from the Cordero mine to the Lower Colorado River Authority's (LCRA's) Fayette Unit No. 3 at LaGrange, Texas. The coal will be delivered between February 1 and July 31, 1988, by the BN and the Missouri-Kansas-Texas railroads. FOB mine price for this coal is $3.60 a ton.

3) Rochelle Coal Company will supply 1.4 million tons of coal from their Rochelle mine in southern Campbell County to LCRA and the City of Austin's Fayette Units No. 1 and 2. This contract is for six months beginning in April. Delivery will be by the C&NW, the UP, and the Missouri-Kansas-Texas railroads. Reported FOB mine price of this coal is $4.69 a ton.

4) Thunder Basin Coal Company's Black Thunder and Coal Creek mines will supply 50,000 tons of coal per month for up to six months to Southwest Public Service Company's Roy Tolk generating plant at Muleshoe, Texas. The utility company could take up to 500,000 tons under this contract. A January spot sale of 50,000 to 55,000 tons of coal was also made to the same utility. The coal will originate on the BN and end on the Santa Fe Railroad.

5) Pacific Power and Light (PP&L) continued to purchase variable amounts of coal from Powder River Basin coal mines for test burns at the Dave Johnston power plant near Glenrock and at the Centralia, Washington, power plant. At the Dave Johnston plant, PP&L burned 220,000 tons of coal from the Rochelle mine in January and February, and in March, coal from Mobil's Caballo Rojo mine was to be burned. Other mines will supply additional coal for test burns later. At Centralia, coal from the Rochelle mine will be blended with mine-mouth coal from a nearby mine. Earlier this year, coal from Thunder Basin Coal Company's Coal Creek mine was blended with mine-mouth coal and tested.

INDUSTRIAL MINERALS AND URANIUM UPDATE

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

Industrial Minerals

All of Wyoming's current nonfuel mineral production is classified under the term "industrial minerals". Trona, bentonite, gypsum, and sand and gravel are examples of industrial minerals. Industrial minerals from Wyoming serve all markets from local (sand and gravel),

to regional (gypsum), to national (bentonite), to international (trona). A short summary of the markets and economics of each industrial mineral recently or currently produced in Wyoming is presented in this quarter's report.

Ballast

Ballast, which refers to many different kinds of rocks, is a construction aggregate that meets durability and size specifications for weighting and holding railroad ties and track as well as providing drainage. Near Granite, Wyoming, the Morrison-Knudsen Company produces granite as ballast for the Union Pacific Railroad (UP). The UP also produces granite ballast from the same location. The Guernsey Stone Company, owned by Peter Kiewit, Inc., produced ballast (dolomite) in 1987 for the Burlington Northern Railroad (BN). Ballast production is a function of the railroads' construction/repair programs. Ballast for the UP is used on trackage from Utah to the Missouri River at Council Bluffs, Iowa. Ballast for the BN is used locally, but both the BN and the Chicago and North Western railroads import ballast into Wyoming, from Missouri and elsewhere.

Ballast production in Wyoming should decrease in 1988 since BN is reducing its purchases from Guernsey Stone. Both the BN and UP have conducted searches for ballast in Wyoming. Although both railroads have located new material that meets their specifications, neither has gone into production.

Bentonite

Bentonite is a class of clay valued for its varied properties. It expands many times when wet, it adsorbs certain chemicals, it provides a watertight seal, and it acts as a binder. It is used primarily by the petroleum drilling industry as a drilling fluid. Bentonite drilling fluids not only "float" rock chips to the surface thereby cleaning the hole, but the fluids also seal the hole preventing unwanted outflow of the drilling fluid, itself. Bentonite is also used in the refining of iron by binding ground iron ore into pellets, which are then smelted into iron.

Most bentonite is sold to these two markets in the United States. Since the domestic drilling industry is in a downturn, Wyoming's bentonite production has decreased to about one third of what it was in the record years of 1979 and 1982.

Nine companies produce bentonite in Wyoming (see table on page 21). Of these, Milwhite Company and Southern Clay Products produce small amounts of specialty bentonite (such as white bentonite used in soap and cosmetics). Because production of bentonite in the past quarter was slightly less than the same quarter of last year, 1988 bentonite production in Wyoming may be slightly less than 1987. Only a significant upturn in the domestic oil and gas industry can alter this prognosis quickly and significantly.

Wyoming bentonite producers.

AIMCOR (formerly International Minerals and Chemicals)

American Colloid Company

Federal Ore and Chemical, Incorporated

Kaycee Bentonite Corporation

M-I Drilling Fluids Company (formerly Dresser Magcobar)

Milwhite Company, Incorporated

NL Baroid Division of NL Industries

Southern Clay Products, Incorporated

Wyo-Ben Products, Incorporated

A new company, American Bentonite Corporation, announced plans to mine bentonite near Casper. This proposed mine is west of Casper on the Zero and Poison Spider roads.

Clay (non-bentonitic)

Small amounts of common clay are produced near Evanston for brick and tile manufacture in the Salt Lake City area. Two companies, Interstate Brick Company and Interpace Company have recently produced clay. These pits are worked intermittently. Only Interstate produced clay in Wyoming in 1987. Interstate is in the process of getting a permit for a new pit near Evanston and should continue to produce clay in 1988 at the same rate as in 1987.

Very small clay deposits in Wyoming are worked for local pottery operations, such as horseshoe court clay. Only a few pounds of clay are removed from these deposits each year. Clay is also mined as construction aggregate.

Clinker (scoria; baked and fused rock)

In Wyoming, clinker or scoria are terms locally used for baked and fused rock overlying burned coal beds. Clinker was produced by the rising heat generated by the burning coal. This heat fused and(or) oxidized the overlying rocks. Clinker is the distinctive red rock that caps many hills in the Powder River Basin. Since it is the hard-

est rock in that area, it is used there for construction aggregate and railroad ballast. Clinker is used as aggregate in other areas of the State as well. It is not, however, as durable as many other materials. Clinker is also used as a decorative stone.

Construction aggregate (includes sand and gravel, shale, some clays, clinker, and other crushed stone)

Construction aggregate is rock material mixed with cement to form concrete or with asphalt to form road paving material. It is classified by size as well as by use. Rip-rap refers to large blocks used for slope stability. Clay and rock flour are the smallest sized aggregates. Other classes of aggregate, such as heavy, light, colored, chemical-resistant, etc., are used for specific purposes. Highway and street construction are the major uses of construction aggregate in Wyoming.

In 1987, there were 104 producers of construction aggregate in Wyoming. Aggregate production in Wyoming has been relatively high in past years due to large construction projects such as the natural gas processing plants in the Overthrust Belt in western Wyoming and the construction of the MX missile silos and access roads in southeastern Wyoming. Although highway construction and repair work are not expected to decrease drastically in 1988, demand may be somewhat less than 1987. Projects in the Abandoned Mined Land Reclamation Program also require some relatively small quantities of aggregate, including rip-rap.

Decorative stone

Decorative stone, also known as ornamental stone, is rock used for decoration. It may be cut, crushed, or used just as it is found. Georgia Marble, which owns Basins Inc. in Wheatland, produces crushed white marble for roofing granules, driveway gravel, and ornamental planting gravel. This material is shipped to regional markets such as Denver and Rapid City.

Clinker (baked and fused rock) is used, particularly in northern Wyoming and regionally (Billings, Montana, and Rapid City, South Dakota), as ornamental stone in planters, rock gardens, and landscaping. Due to its distinctive bright red color, there is a potential regional or national market for this material. Individuals sometimes quarry small amounts of moss rock and flagstone (flat rock) for their own use in Wyoming, primarily for construction of fireplaces and walkways.

The production of ornamental stone from Wyoming should increase as regional home and business construction increases.

Gypsum

Gypsum is a soft rock composed of the mineral gypsum (hydrated calcium sulfate). Two companies in Wyoming mine gypsum and make wallboard (sheet rock) from purified and compressed gypsum. Wallboard produced in Wyoming is marketed in the northern Rocky Mountain states. Since regional construction is increasing, production of gypsum wallboard should increase as well.

Another company uses gypsum as an ingredient in cement (see table this page). Mountain States Cement in Laramie, which has expanded its cement plant, should increase its production of gypsum in 1988. This is the only cement plant in Wyoming. Although the collapse of a storage tank soon after its reopening prevented full scale production in 1987, cement production should increase in 1988. Cement from Wyoming is marketed in Wyoming, Colorado, and Nebraska.

Wyoming gypsum producers.

Company	Location	Product
Celotex Corporation	Cody	Wallboard
Georgia Pacific Company	Greybull	Wallboard
Mountain States Cement	Laramie	Cement

Limestone

Limestone is a rock primarily composed of the mineral calcite ($CaCO_3$). It is used for many purposes. In Wyoming, the primary use is for construction aggregate. It is the preferred road base and aggregate material for highway construction and surfacing. It is also used in sugar refining (sugar rock) and as a burn-control agent in coal-fired power plants (power rock). It is also used as the primary ingredient in cement. See the discussion of gypsum above for an update on the cement industry.

Phosphate

The phosphate industry in the western U.S. produces phosphate fertilizer for regional markets (the west and some Great Plains states). Although the phosphate calcining plant at Leefe, west of Kemmerer, closed in 1987, the Chevron fertilizer plant in Rock Springs has taken over markets formerly served by the plant at Leefe as well as by plants in Idaho. This has also resulted in the closure of these Idaho phosphate plants. Phosphate for the Chevron plant is mined in Utah and shipped by slurry pipeline to the plant in Wyoming.

Pigment

Small amounts of hematitic iron ore are recovered from tailings at the Sunrise iron mine east of Hartville. This ore is exported to South America for use as pigment in boxcar paint. Small shipments are planned for 1988.

Power rock

Power rock is ground rock, usually limestone, which is mixed with coal in coal-fired power plants to produce an even-burning mixture. In Wyoming, limestone from north of Rawlins is used as power rock for western Colorado power plants. Limestone from north of Fort Laramie was used by the Missouri Basin Electric power plant near Wheatland. Missouri Basin has contracted for another source of power rock for 1988 because stockpiles from the mine near Fort Laramie are about used up. The new source is about six miles north of Hartville. Production from there should begin in 1988.

Silica sand

Silica sand, a raw material that is a primary ingredient in glass and other products, is attracting attention in Wyoming. Two deposits were drilled in 1987. Report of Investigations 40, by Ray E. Harris, is available from the Geological Survey (see page 45), and describes the resources, potential uses, and other economic factors of the high-grade, low-cost silica sand deposit located near Plumbago Creek, 30 miles north of Laramie. The other deposit is located near Cassa, south of Glendo. It contains a very high-grade silica sand. A report on this deposit is in preparation. Several companies have expressed interest in silica sand and the possible construction of a glass plant, and two have visited the Plumbago site.

Sodium sulfate

Sodium sulfate (Na_2SO_4) is produced in Wyoming by one operator, and several tons are shipped to the Chicago, Illinois, area every year. Sodium sulfate is used in sodium chemicals. It is mined from an alkali lake near Natrona, which is west of Casper. After it is dried, it is stored and shipped from the large, long, barn-like storage shed that is a landmark on U.S. 26 between Casper and Shoshoni.

Sugar rock

Sugar rock is limestone used in the refining of sugar from beets. It must be sized (2 inches by 4 inches) and must meet high calcium, low silica specifications. Sugar rock has been produced in Wyoming; however, all sugar rock currently used in Wyoming plants (Lovell and Torrington) is imported from Montana (for the Lovell area) or South Dakota (for the Torrington area). Also, sugar plants in western

Nebraska import sugar rock from Warren, Montana, which is north of Frannie, Wyoming. This source is over 300 miles from the plants.

Since most of the cost for sugar rock is transportation, a closer source would help reduce sugar production costs. High calcium limestone occurs in the Hartville uplift, less than 50 miles from the Torrington and western Nebraska plants. The Geological Survey of Wyoming has been working with contractors and others to locate a suitable source of sugar rock (see special Manville report on page 32).

Sulfur

Sulfur production in Wyoming is a by-product from the refining of oil and natural gas (see page 2 for production information). Although some of this production was used by Chevron's fertilizer plant at Rock Springs, most sulfur is marketed outside Wyoming. Native (or minable deposits) of sulfur also continue to be of interest. One company is conducting exploration for minable natural sulfur in Wyoming.

Trona

Trona, sodium carbonate-bicarbonate, is the ore for soda ash, a substance with many uses. Wyoming produces 90 to 95 percent of the soda ash used in the U.S., and ships about 20 percent of its production to world markets. Five companies (see table this page) mine trona west of Green River. Trona is the most valuable nonfuel mineral produced in Wyoming in terms of employment and revenue generated.

Wyoming trona producers.

Company Name	Year of first production
FMC Corporation	1948
General Chemical Corporation	1968
Stauffer Chemical Corporation	1962
Tenneco Minerals Corporation	1982
TG, Incorporated	1976

Soda ash is used in the manufacture of glass, soap, detergent, paper processing chemicals, water treatment chemicals, and many other things. Baking soda is pure soda ash. Wyoming's trona production is at record levels. However, there are five producers now rather than the four between 1980-1982 when production was almost as great. The five plants are currently operating at less than full capacity. While trona production should set another record in 1988, increased exports are the best hope for continued production increases.

Uranium

The Wyoming uranium industry entered 1988 facing the possibilities of either increased production or a complete shut down. According to the industry, new taxes, the U.S. - Canada free trade agreement, and reclamation costs are working to end the domestic uranium industry. This is happening at the same time that companies with nuclear power plants are seeking more uranium as fuel for their plants. The U.S. Senate recently passed a bill calling for the restriction of uranium imports, providing for the cleanup of abandoned uranium mill tailings, and restructuring of the U.S. uranium enrichment program. This legislation has yet to pass the U.S. House of Representatives and faces a threatened Presidential veto. These and other uranium issues were topics for discussion at a uranium conference held in Riverton in April, and will be discussed in a future issue of *Wyoming Geo-notes*.

Meanwhile, Pathfinder Mines (COGEMA) continues to produce yellowcake at the Shirley Basin mine in Carbon County. Pathfinder shut down the Lucky Mc Mill in the Gas Hills after milling previously mined uranium stockpiles. Two *in situ* operations, Malapai Resources near Pumpkin Buttes, and Everest Minerals at the Highland mine site in the Southern Powder River Basin area continue to move forward with production.

METALS AND PRECIOUS STONES UPDATE

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

While winter conditions continued to keep exploration activities for metals and precious stones to a minimum, the Geological Survey of Wyoming's Metals Division used this time to compile field data and to process samples collected for two major research projects last field season: (1) Geology and gold mineralization of the South Pass greenstone belt, and (2) Stream sediment sampling for heavy mineral indicators of kimberlite and related rocks.

During the past quarter, the Metals Division published preliminary geologic maps for the South Pass City, Atlantic City, and Lewiston Lakes Quadrangles in the South Pass belt (see listings on page 45). The first two of the quadrangles lie within the heart of the South Pass-Atlantic City gold district and enclose a belt of fractured and faulted metatholeiites and metakomatiites that lie within a vast

region underlain by 2.8-billion-year-old metagreywackes of the Miners Delight Formation and Tertiary sandstones, siltstones, and conglomerates of the South Pass Formation.

Several historic lode and placer gold mines are found on these two quadrangles. Most lode mines were developed on ore shoots in shear zones near the contact between structurally competent mafic metaigneous rock and less competent metagreywacke and graphitic schist. Some well-developed shears occur in actinolite schist and carbonated actinolite talc schist, but for the most part, these have not been prospected. During the past five years, the State Survey has made every effort to map all accessible underground mines in detail. Samples taken in two of these previously mapped mines were analyzed during the past quarter. Both mines occur on the South Pass City Quadrangle.

The Rocky (Doc) Barr tunnel was driven into a hillside of metagreywacke apparently to test the intersection of two prominent faults. But based on surface and underground mapping, the Rocky Barr stopped 100 to 200 feet short of the intersection. The mine has 420 feet of drifts and crosscuts, and cut through a number of narrow gouge zones and quartz veins and a few permeable shears and brecciated zones (Hausel and Albert, 1984). Analyses of twenty-nine chip samples taken in the mine ranged from no detectable gold to only 1.1 ppm. The gold values were detected only in limonite-stained samples suggesting a close association of the noble metal with iron sulfides.

The Alpine mine was driven along the dip plane of a relatively thick quartz vein in metagreywacke (Hausel and Gyorvary, 1985). The vein is a maximum of ten feet thick, but contains interlayers and selvages of metagreywacke. The incline dips 31 degrees to the north and follows the vein at least 80 feet along the dip plane. Below 80 feet, the workings are flooded and inaccessible. At the 75-foot level, a drift runs 25 feet to the northwest and another runs 100 feet to the east. Analyses of sixteen composite chip samples (mostly quartz vein material) collected in the Alpine mine yielded gold values from 0.08 ppm to 101.0 ppm.

The third quadrangle completed by the Metals Division lies in a little known area along the southeastern flank of the greenstone belt a short distance east of the Lewiston gold district. This map, the Lewiston Lakes Quadrangle, encloses a group of metaigneous and metasedimentary rocks which lie in fault contact with 2.6-billion-year-old granites. The lowermost unit of the metamorphic rocks include serpentinite, tremolite-talc-chlorite schist, and amphibolite with chemistries equivalent to komatiite and mafic tholeiite (Hausel, 1986; 1987). Structurally above this lower unit is a thin belt of iron formation, andalusitic-mica schist, mica schist, quartzite, fuchsitic quartzite, and amphibolite. Lying on top of this predominantly metasedimentary formation are amphibolites with tholeiitic chemistry, and a thin interbedded layer of grunerite schist and augen gneiss. These rocks lie in fault contact with overlying metasediments of the Miners Delight Formation.

Another gold-related project undertaken by the Metals Division during the past quarter was a literature search for information on precious metal occurrences in the Wyoming portion of the Black Hills (Hausel and Sutherland, in press). Many interesting anomalies are reported in this region including low-grade gold and rare-earth mineralization associated with 38 to 55 million years old fenitized alkalic igneous rocks in the Bear Lodge Mountains. Other interesting anomalies reported in the Black Hills include gold and silver values associated with the Cambria coal bed and overlying sandstone of the Cretaceous Lakota Formation near Newcastle; visible gold and associated cassiterite in cores drilled into the Cretaceous Newcastle Sandstone in oil and gas fields along the western margin of the Black Hills; and stream sediment samples with anomalous gold values reported over large regions along the western margin of the uplift.

During the past several years, the Metals Division has been collecting and examining stream sediment samples from most major drainages and tributaries in the Laramie Range as an exploration tool to locate kimberlite and related rocks. More than 100 anomalies have been identified to date, and samples collected in the Elmers Rock greenstone belt of the central Laramie Range last summer are presently under examination. Several of these samples have yielded anomalies. One sample collected along the Laramie River, for example, yielded more than two dozen pyrope garnets and some chromian diopside. In addition to these kimberlite-indicator minerals, this same sample produced 11 pieces of gold with some kyanite, sapphire, and fluorite grains. Several other nearby samples in this region have also produced kimberlite-indicator minerals (chromian diopside, pyrope garnet, and picroilmenite).

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CARBON DIOXIDE RESOURCES IN WYOMING

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

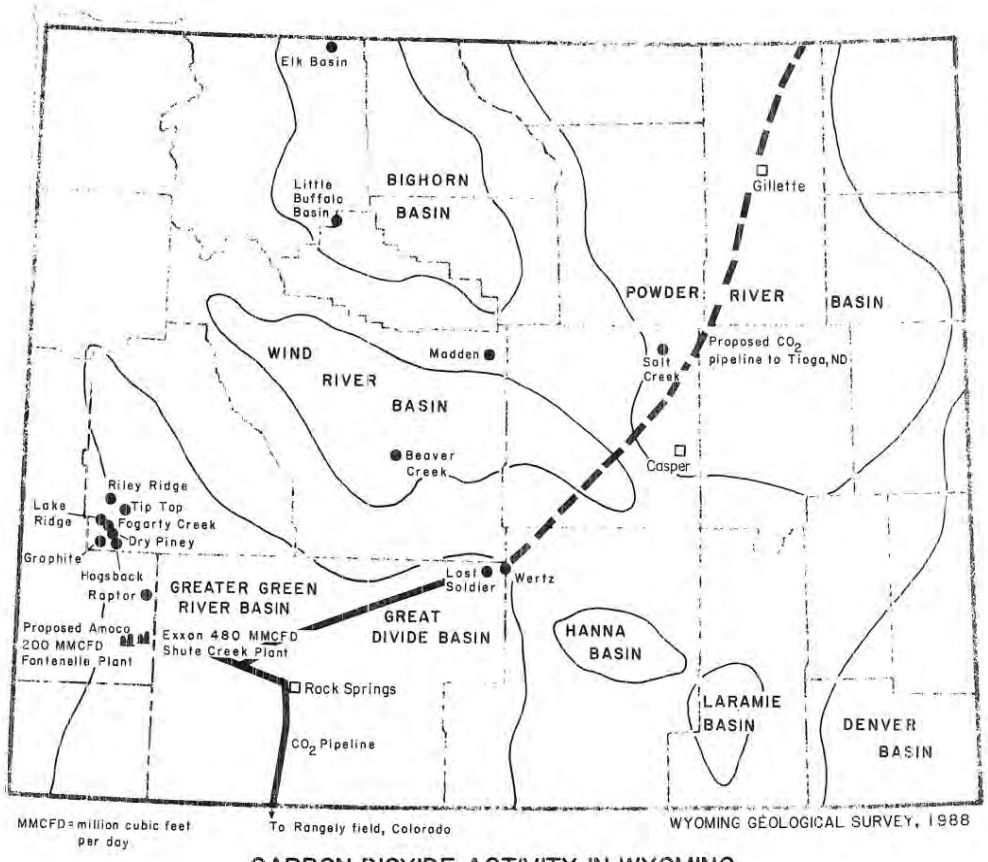
One of the most significant developments in the Wyoming oil and gas industry in the 1980s was Exxon Corporation's development of carbon dioxide (CO_2) reserves at their Lake Ridge, Fogarty Creek, and Graphite units in the southwest corner of Sublette County (see figure on page 30). In May of 1984, Exxon began construction on their 480 million cubic feet per day Shute Creek gas processing plant so that the natural gas produced at these units could be separated into its various components. The composition of this natural gas averages 66 percent carbon dioxide, 22 percent methane, seven percent nitrogen, 4.5 percent hydrogen sulfide, and 0.5 percent helium (Hunter and Bryan, 1987). The plant was completed in the Fall of 1986 and total gas production for 1987, the first full year of operation, was approximately 180 billion cubic feet. Of that total, nearly 120 billion cubic feet were CO_2.

Nineteen wells at the Fogarty Creek unit produced around 124 billion cubic feet of natural gas in 1987 or 69 percent of the total gas supplied to the Exxon plant. Average production per well at Fogarty Creek was nearly 18 million cubic feet of natural gas per day. In all, there are 24 producing wells in the three Exxon units.

While the solid form of CO_2 is dry ice and its gaseous form is most commonly associated with the fizz in soft drinks, the significance of carbon dioxide for Wyoming is its use in enhanced oil recovery projects. At the present time Exxon is supplying carbon dioxide to Chevron for an enhanced oil recovery project at Rangely field in Colorado and to Amoco for a project at Wertz field north of Rawlins. Amoco will also begin injection of CO_2 at its nearby Lost Soldier field late in 1988. So far the results of carbon dioxide injection at Wertz field are encouraging, and oil production at Wertz has increased from around 6,000 barrels per day to between 10,000 and 11,000 barrels per day. According to Amoco, an estimated 38 million additional barrels of oil will be recovered at Wertz and Lost Soldier fields by injecting CO_2 into the Tensleep Sandstone, the Madison Limestone, and the Darwin Sandstone.

The three Exxon units now producing carbon dioxide-rich gas comprise only 40,000 acres (25 percent) out of a total of 160,000 acres which are considered productive for this type of gas from the Madison Limestone in the area (U.S. Department of the Interior, 1983). American Quasar, Exxon, Mobil, and Williams operate the other units capable of producing large quantities of CO_2. These other units include Riley Ridge, Dry Piney, Tip Top, and Hogsback (see figure on page 30).

Amoco's 1986 discovery well in the Raptor field had an initial potential of over 13 million cubic feet per day of 95 percent carbon dioxide from the Madison Limestone. This discovery extends the



CARBON DIOXIDE ACTIVITY IN WYOMING

prospective CO_2-rich Madison Limestone area ten miles south of the Hogsback unit.

If Exxon is able to line up additional markets for its carbon dioxide for enhanced recovery projects in the Powder River Basin, the Bighorn Basin, the Green River Basin, and the Williston Basin in North Dakota and Montana, they are likely to construct a pipeline from the Wertz field area to Tioga, North Dakota. The pipeline could continue into Canada if markets develop there. They might also construct Phase II of their La Barge Project, which would essentially double the gas processing capacity at their Shute Creek plant. In the above listed basins, Exxon has identified existing and potential markets for 4.4 trillion cubic feet of CO_2 (Hunter and Bryan, 1987). The contracted amount of CO_2 for Wertz, Lost Soldier, and Rangely fields alone is 1.1 trillion cubic feet.

Another area with high potential for CO_2 production from the Madison is the Madden anticline on the northern edge of the Wind River Basin. This structure covers approximately 200 square miles and the discovery well, the 1-5 Bighorn (section 5, T.38N., R.90W.), tested 20 million cubic feet of gas per day from the Madison Limestone. The composition of the gas was 74 percent methane, 14 percent carbon dioxide, 10 percent hydrogen sulfide, and two percent inert gas. The confirmation well, the 2-3 Bighorn (section 3, T.38N., R.90W.), has been drilling since January 1987. One of the major problems with this source of carbon dioxide is that the Madison is below 23,000 feet, making drilling very expensive.

Amoco has tentative plans to develop its carbon dioxide reserves at Raptor field and to build a 200 million cubic feet per day processing plant at Fontenelle, near Exxon's Shute Creek plant. Amoco would use the CO_2 separated at their plant for enhanced oil recovery projects planned at Elk Basin and Little Buffalo Basin fields in the Bighorn Basin, Salt Creek field in the Powder River Basin, and Beaver Creek field in the Wind River Basin (see figure on page 30). Amoco may also choose to purchase the 565 billion cubic feet of CO_2 required for these projects from Exxon if that option proves more cost effective. Nevertheless, whichever option is exercised, CO_2 injection at these four fields would add an extra 115-200 million barrels of oil production to State totals over the life of the projects.

Although the Madden wells are exceptionally deep, all of these CO_2-rich areas in Wyoming have two things in common. All the fields with current production or prospective production are producing from the Madison Limestone where it is more than 15,000 feet deep.

The Wyoming Legislature has passed two bills which will aid enhanced oil recovery projects using carbon dioxide. One bill reduces the severance tax rate from six percent to four percent for oil produced from tertiary recovery projects. The other bill permits a credit for severance taxes paid on carbon dioxide production when the CO_2 is used in a tertiary recovery project in Wyoming.

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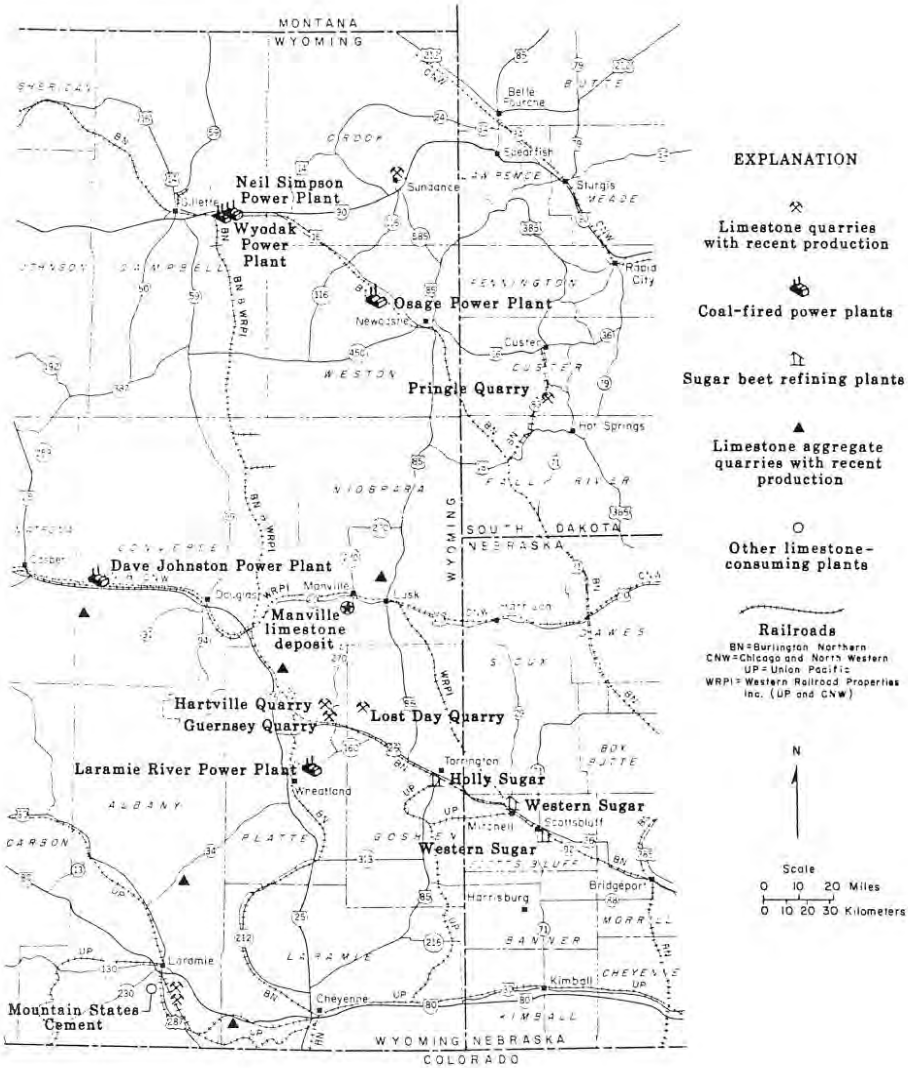
MANVILLE LIMESTONE DEPOSIT NIOBRARA COUNTY, WYOMING

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

Near Manville, a limestone outcrop forms a prominent rocky hill one-half mile west of Wyoming Highway 270 (see figure on page 33). The property had been investigated by a private company a few years ago. That company reported that most of the material was sandstone, and they expressed no further interest. The owner of the mineral lease on the property, which is mostly on State-owned land, contacted the Geological Survey of Wyoming for advice regarding the property. A preliminary surface investigation showed no sandstone, only limestone and dolomitic limestone of the Mississippian-Devonian Guernsey Formation. These carbonate units overlie a red quartzite of probable Cambrian age, which is exposed in two small areas on the west side of the hill. Surface samples of the limestone contained 99 percent or more calcium carbonate, a grade potentially useful for several industrial processes.

Since there are many potential users for a good high-grade limestone deposit in eastern Wyoming and western Nebraska, the Geological Survey of Wyoming contacted the Economic Development and Stabilization Board (EDSB) regarding State funding for a geologic project to outline the extent of the deposit, to determine the grade of the limestone and dolomitic limestone, and to provide a preliminary estimate of how many tons of limestone might be mineable. At the EDSB's suggestion, the mineral lessor and the author met with Don Whitaker, the Mayor of Lusk, and the Lusk Town Council. The Town of Lusk applied to the EDSB for a planning-only grant to determine the amount and quality of the limestone resource and its potential uses. This grant application was approved by the EDSB. Three core holes, each about 200 feet in depth, were drilled. The core was studied and described at the Geological Survey of Wyoming. Sixty samples of core were also sent to a commercial laboratory for chemical analysis.

Based on these investigations, it was concluded that the Manville deposit contains a large resource of dolomitic limestone suitable for construction aggregate. It also contains a large resource of high-calcium limestone potentially suitable for the production of lime, sugar rock, power rock for burn-control, and construction aggregate.


MONTANA
WYOMING
Neil Simpson Power Plant
Wyodak Power Plant
Osage Power Plant
Pringle Quarry
Dave Johnston Power Plant
Manville limestone deposit
Hartville Quarry
Guernsey Quarry
Lost Day Quarry
Laramie River Power Plant
Holly Sugar
Western Sugar
Western Sugar
Mountain States Cement
Belle Fourche
Sundance
Sturgis
Rapid City
Newcastle
Custer
Hot Springs
Douglas
Manville
Torrington
Wheatland
Scottsbluff
Mitchell
Bridgeport
Harrisburg
Laramie
Cheyenne
Kimball
Casper
Lusk
WYOMING NEBRASKA
COLORADO
SOUTH DAKOTA
NEBRASKA
EXPLANATION
Limestone quarries with recent production
Coal-fired power plants
Sugar beet refining plants
Limestone aggregate quarries with recent production
Other limestone-consuming plants
Railroads
BN=Burlington Northern
CNW=Chicago and North Western
UP=Union Pacific
WRPI=Western Railroad Properties Inc. (UP and CNW)
N
Scale
0 10 20 Miles
0 10 20 30 Kilometers

The underlying quartzite may be suitable for railroad ballast. It was also suggested that a stockpile of limestone from this deposit could be placed in the aggregate-poor Powder River Basin. This stockpile would provide a high-quality, durable aggregate for highway construction or other projects in that area of Wyoming.

The results of this investigations were published as Geological Survey of Wyoming Report of Investigations 39, *Geology and economic potential of a high-calcium limestone and dolomitic limestone deposit near Manville, Niobrara County, Wyoming*, by Ray E. Harris. The Wyoming Highway Department is interested in establishing a stockpile of limestone aggregate in the central Powder River Basin, but it cannot do so at present due to budgetary constraints. Western and Holly Sugar Companies have each tested samples of limestone from the locality. They found it meets their specifications for sugar rock, and both plan a burn test on the material (using 400 tons of rock) during the next sugar-processing season.

The report is available from the Geological Survey of Wyoming. For ordering information, see page 45.

MINERALS EXPLORATION SUMMARIES FOR 1987 (Excluding petroleum exploration)

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

Metals and Precious Stones

Precious metal prices in 1987 stimulated interest for gold and platinum group metals in Wyoming. Exploration for gold was reported at several localities across the State including the Wind River Range, the Medicine Bow Mountains, the Bear Lodge Mountains in the western Black Hills, and the Laramie Range. Enigmatic gold anomalies in many of Wyoming's basins were examined by an independent geologist from Laramie with some encouraging results, and a group of mining companies explored portions of the Medicine Bow Mountains for platinum group metals and gold. In addition to precious metals, one Australian company explored for diamonds.

Most of the gold exploration activity in Wyoming occurred along the southern tip of the Wind River Range in the South Pass greenstone belt. Gold is found in shear zones, veins, and in placer deposits in the metamorphic terrain, and in paleoplacers. In addition to gold, copper occurs in crosscutting vein deposits and in copper-silver stockworks. A massive sulfide has also been identified in this greenstone belt. Iron ore, asbestos, silver, feldspar, beryl, and aquamarine beryl have been recovered from the belt in past years, and anomalous chromium, nickel, and tungsten have been detected.

Limited exploration activity was reported to the south in the Dickie Springs-Oregon Gulch low-grade paleoplacer. Along the eastern

flank, at least two companies explored the Oligocene Twin Creek paleoplacer where grades are reported to be locally higher.

The greatest amount of activity was centered in the South Pass-Atlantic City district with lesser activity in the Lewiston district. At the historic Carissa gold mine, Consolidated McKinney Resources dewatered the 400-foot deep mine, and continued work on the surface and underground. The Gyorvary Mining Company continued construction on a small mill on the Mary Ellen property. Gold N' Oil from Lander continued to consolidate a land position with plans to explore the Tabor Grand mine.

The Geological Survey of Wyoming sampled several mines in the district in 1987 as part of a culminating five-year mapping and resource study of South Pass. At the Monarch (Mars) mine near South Pass City, 31 samples were taken that ranged from 0.13 ppm to 8.76 ppm gold. Thirty channel and chip samples taken in the Tabor Grand mine yielded 0.05 ppm to 58 ppm. On the surface of the Carissa mine, composite chip samples taken in the fractured wall rock over a 97-foot width had from 0.4 ppm to 2.5 ppm gold. An earlier 30-foot composite chip sample in the wall rock yielded 2.4 ppm gold. On the surface at the Duncan mine, channel samples dug over a 39-foot width yielded values from 0.53 ppm to 33.0 ppm gold.

Placer mining and prospecting were reported at several localities in the South Pass greenstone belt. The most notable localities include Atlantic Gulch, Jones Gulch, Crows Nest Gulch, Meadow Gulch, Little Beaver Creek, Rock Creek, Willow Creek, and Wilson Bar.

At least one major company continued with exploration and development drilling on a Tertiary age, low-grade gold and rare-earth deposit. The deposit is a fenitized alkalic igneous rock in the Bear Lodge Mountains.

It was reported by the *Vancouver Stock Watch* that Caledonia Resources Ltd. was drilling on the Copper King property in the Silver Crown district of the southern Laramie Range. According to the report, the Copper King deposit has a strike length of 600 to 700 feet with a 300-foot width. The deposit is interpreted as a Proterozoic gold-copper porphyry. According to the company, the early drilling results are encouraging and zones were intersected that reportedly had from 0.01 to 0.177 ounce per ton gold over substantial thicknesses.

Gordon Mariatt, an independent geologist from Laramie, continued to examine sandstone-hosted gold deposits in a couple of Wyoming's basins. In a 1986 report published by the Geological Survey of Wyoming, K.G. Albert reported many gold anomalies in some of Wyoming's basins for which there appeared to be no explanation (Geological Survey of Wyoming Open File Report 86-4). Mariatt (personal communication, 1988) has now developed a model for these deposits, and has verified anomalies in the eastern Powder River Basin, the Cheyenne-Denver Basin, and the Green River Basin.

Exploration for platinum group metals in the Medicine Bow Mountains of southeastern Wyoming continued throughout 1987. This activity was centered on two large Proterozoic layered mafic complexes. Along the northern flank of one of these complexes, platinum group metals were mined with copper, gold, and silver between 1900 and 1923. An interim progress report released by International Platinum Corporation reported that a mineralized pyroxenite continued onto their property. Vanderbilt Gold Corporation reported in the *Mining Record* (December 2, 1987) that they had delineated two geophysical anomalies that they plan to test drill next spring. Two other companies were exploring this region for platinum group metals.

In a news release from the *London Mining Journal* (October 30, 1987), Carr Boyd, an Australian company, negotiated a mining lease agreement covering five kimberlite intrusives in the Colorado-Wyoming State Line diamond district. The company is expected to explore parts of Wyoming for diamonds.

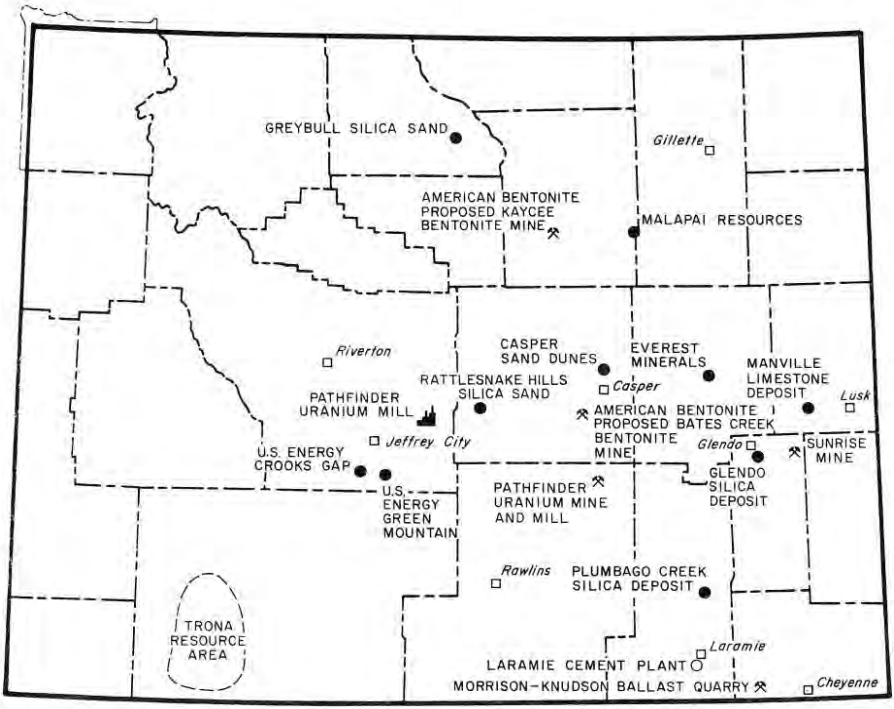
During the past ten years, the Geological Survey of Wyoming has been sampling portions of Wyoming for heavy mineral indicators eroded from kimberlite. The project has resulted in the identification of more than 100 anomalies in the Laramie Range, and in 1987, more than one dozen new anomalies were identified.

Uranium

Uranium exploration activity increased for the second year in a row in Wyoming. Two years ago, there was essentially no uranium exploration activity. In 1987, however, four companies continued exploration of properties proposed for development, and one or two companies not planning development did some reconnaissance exploration. See figure on page 37 for locations cited below.

Malapai Resources and Everest Minerals conducted drilling and other tests on their proposed *in situ* mines in the Powder River Basin. These are scheduled to begin production in 1988. Pathfinder Mines, which is wholly owned by the French nuclear fuel supply company, COGEMA, is Wyoming's only producer of uranium. They continued to do assessment drilling and property evaluation studies in Wyoming. U.S. Energy, based in Riverton, Wyoming, conducted evaluation and developmental studies on its property at Green Mountain, south of Jeffrey City, Wyoming, as well as acquiring property formerly owned by Western Nuclear, Inc., in the Crooks Gap mining area immediately west of the Green Mountain property.

Union Pacific Resources (formerly Rocky Mountain Energy Company) in a joint venture with Taiwan Power (Taipower) and Union 76 Minerals (formerly UnoCal) conducted some reconnaissance exploration for uranium in Wyoming. It is also reported that an occasional uranium prospector, affiliation unknown, was seen in uranium districts in the State. By year's end, however, uncertainty over the U.S.-Canada trade agreement and its effect on the future of domestic uranium had turned slight optimism for uranium development in Wyoming into considerable pessimism.



1987 Exploration for Industrial Minerals and Uranium in Wyoming

Industrial Minerals

Exploration for industrial minerals in Wyoming remained active in 1987, both for materials produced in Wyoming and for some possible new products. A new bentonite producing company, American Bentonite Company, announced acquisition of property near Kaycee in the Powder River Basin and at Bates Creek, south of Casper, Wyoming, following exploration throughout the region.

FMC continued developmental tests and exploration for additional trona reserves, particularly those that can be mined by solution-mining (*in situ*) methods, in the trona resource area in southwestern Wyoming. The other four soda ash companies in Wyoming were also investigating possibilities for *in situ* trona mining.

Exploration continued for construction aggregate and construction clay deposits for use in highway construction and silo construction for MX missiles, particularly in southeastern Wyoming. In southeastern Wyoming, the construction of a new airport at the Wyoming Army National Guard base near Guernsey also encouraged exploration for additional aggregate sources.

Mountain States Cement, while completing an enlargement and modernization of its Laramie cement plant, continued searching for additional sources of limestone and gypsum. A new limestone quarry was opened in 1987, about four miles southeast of the cement plant.

The Geological Survey of Wyoming published a report on a large source of limestone and dolomitic limestone near Manville in east-central Wyoming (see discussion beginning on page 32). The funding for this study was made available by a grant from the Wyoming Economic Development and Stabilization Board (EDSB) to the Town of Lusk.

Exploration for railroad ballast continued in 1987. Union Pacific Railroad continued to search for additional ballast sources to augment the current supply from the Morrison-Knudson quarry west of Cheyenne.

Small amounts of iron oxide pigment were shipped from tailings and settling pond deposits at the Sunrise mine, owned by CF&I, Inc., for use as boxcar paint. The Sunrise mill last shipped iron ore in 1975. However, large tailings and other iron-rich stockpiles are present at the mill site. Deposits of iron oxide pigment near Rawlins were also explored in 1987.

Interest and exploration for silica sand increased in Wyoming in 1987. Several glass-making companies conducted research into silica sand deposits in Wyoming, and two potential deposits, one at Plumbago Creek north of Laramie (see Report of Investigations 40 on page 45) and one near Glendo were drilled. These projects were funded by grants from the Wyoming EDSB to the Albany County Board of Commissioners and the Platte County Board of Commissioners, respectively. Technical assistance for these grants was provided by the Geological Survey of Wyoming. Other silica sand deposits receiving attention included a deposit east of Greybull, one in the Rattlesnake Hills west of Casper, and sand dunes north of Casper.

Coal

In 1987, Wyoming coal exploration continued but at a lower level than in past years. Nearly all the coal companies operating in the State emphasized production of existing reserves rather than proving or acquiring additional reserves through exploration. Despite decreased exploration, Wyoming coal production in 1987 reached an all-time high of 146.5 million short tons, an increase of 7.5 percent over 1986. Low coal prices, a soft coal market, and a large productive over-capacity, coupled with large amounts of known reserves, have all decreased the incentives and the need for exploration.

Drilling did occur on three Federal exploration licenses in 1987. All the licenses were located in the Powder River Basin. Amax Coal Company completed drilling in an area adjacent to their Belle Ayr mine, L.S. Rockefeller completed drilling in a 320-acre tract in Sheridan County as part of a proposed coal exchange, and Powder River Coal Company completed drilling on a 40.8-acre lease modification area near their Rochelle mine in southern Campbell County.

The U.S. Bureau of Land Management (BLM), operating a drill rig out of Casper, drilled 21 coal exploration holes on Federal coal for a total of 24,332 feet. Of this total 1,807 feet in five core holes recovered 557 feet of core. Most of the recovered core was coal, which was submitted for chemical analysis. In Fremont County (part of the Rawlins BLM district), BLM drilled five drill holes totaling 1,720 feet. In the Powder River Basin (Casper BLM district), 16 holes were drilled (including five core holes), totaling 22,612 feet.

The Geological Survey of Wyoming and the BLM initiated a cooperative agreement in which the Survey agreed to compile and publish the BLM's exploratory coal drilling information from past years. Under the agreement, geophysical logs, lithologic descriptions, and coal analyses will be put into standard formats and published by the Geological Survey of Wyoming as open file reports. The first reports under this agreement will be published in 1988.

Coal exploration drilling by private industry is tracked by the State of Wyoming's Department of Environmental Quality, through their Abandoned Drill Hole Program. Data for 1987 will not be available until late 1988 because drill hole reports for 1987 can be submitted up to one year after drilling is completed. Data from 1986, which became available in late 1987, indicate that exploration drilling decreased substantially from 1985 to 1986. The total number of drill holes decreased from over 2,000 in 1985 to only 352 in 1986 while the total footage drilled decreased from 420,000 feet in 1985 to only 64,572 feet. None of this drilling includes development drilling in advance of mining; however, nearly all of the drilling was on active coal mine permits.

STRATIGRAPHY UPDATE

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

The National Research Council recently published the results of a survey they designed to assess the current usage of geologic maps, to locate current unmet needs for geologic mapping by region, and to identify future needs for mapping. The questionnaires for the survey included questions about the relative needs for specific map types, the needs by map scale, the style of preferred presentation, and the type of user. These questionnaires were sent to a statistically selected sample-set of members from nine scientific and professional associations, whose members were known to include users of geologic maps.

Based on responses, private industry made up the largest group of users at 66 percent, government accounted for 16 percent, and academia, 13 percent. Industries rely on themselves for 38 percent of the maps they use. They rely on Federal agencies for 27 percent and state agencies for 18 percent. State and Federal agencies are by far the major sources for geologic maps that actually reach the general user community. In terms of mapping needs, both current and future, the Gulf Coastal Plain, the Basin and Range-Rocky Mountain, and the Great Plains-Midcontinent areas all ranked as among the most important. The area which included Wyoming and surrounding states ranked very high in terms of mapping needs. In response to the question "Is there a single most important type of geologic map you will need in the next decade?", the overwhelming response was large-scale geologic maps. The report contains many other interesting conclusions. For those interested in obtaining a copy, it is entitled *Geologic mapping: future needs* by the Board of Earth Sciences, National Research Council. The report is available from:

Board of Earth Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Three preliminary geologic quadrangles mapped by the Stratigraphy Division during the 1987 field season have been completed and are now available from the Publications Division of the Geological Survey of Wyoming. *Preliminary geologic map of the Fraker Mountain Quadrangle, Johnson County, Wyoming* is designated Open-File Report 88-4; *Preliminary geologic map of the Barnum Quadrangle, Johnson County, Wyoming* is designated Open-File Report 88-5; and *Preliminary geologic map of the Tabletop Quadrangle, Washakie and Johnson Counties, Wyoming* is designated Open-File Report 88-6 (see page 45 for ordering instructions). Photointerpretive maps are nearly complete for the Poker Butte Quadrangle and the Turk Springs Quadrangle, and the fieldwork for these maps will be completed during the 1988 field season.

Photointerpretive work on the Turk Springs Quadrangle and work done last field season on the Tabletop Quadrangle indicate some interesting relationships and possible interpretations for some of the faults on these two quadrangles. The major northeast to southwest-trending Big Trails Fault System (along the southern Bighorn Mountains) and the above mentioned faults may have considerable horizontal components to their movements. This type of movement might help explain an apparent reversal in direction of movement along at least one of the northeast-southwest faults on Tabletop Quadrangle. Further examination of these faults and the Big Trails Fault System is planned for this field season and hopefully some good evidence for strike-slip movement on these faults can be found.

The U.S. Geological Survey has recently published an interesting report relating to Wyoming. Professional Paper 1450 entitled, *New interpretations of Paleozoic stratigraphy and history in the northern Laramie Range and vicinity, southeast Wyoming* by William J. Sando and Charles A. Sandberg discusses and clarifies the Paleozoic stratigraphy of a portion of southeast Wyoming. A new formation, the Fremont

Canyon Formation, is described by the authors. Their type locality is located in Fremont Canyon at the south end of Alcova Reservoir. The Fremont Canyon Formation as defined by the authors was previously regarded as the Deadwood Formation of Late Cambrian and early Ordovician age. The authors present evidence for a Devonian age for this sandstone sequence. The paper also proposes replacement of the term "Guernsey Formation" with "Madison Limestone" in the study area.

DEBRIS FLOWS CAUSE ROAD DAMAGE NEAR YELLOWSTONE NATIONAL PARK

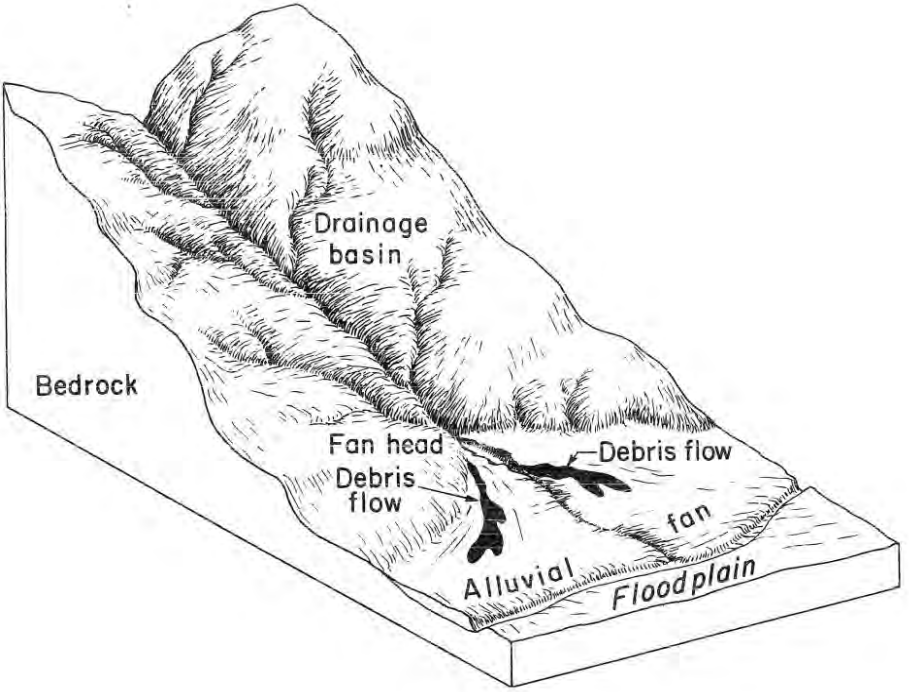
by James C. Case, Geologic Hazards Division Head, Geological Survey of Wyoming.

The Geologic Hazards Division of the Geological Survey of Wyoming has been mapping slope movements in Wyoming for the last six years. Some of the movements have damaged or destroyed roads, irrigation canals, or homes in the State. Specific types of slope movements and the effect of their movements will be discussed in this and future issues of *Wyoming Geo-notes*.

In 1987, following a period of prolonged and sometimes heavy precipitation, a series of debris flows occurred approximately five miles east of the east entrance to Yellowstone National Park. The debris flows covered U.S. Highway 14-16-20 at a number of locations. The largest debris flow came down an unnamed stream channel, incorporating trees and other debris in its mass. The debris in the flow clogged a large culvert under a highway bridge, resulting in the debris flow overtopping the bridge to a depth of at least three feet. Eventually the debris dam, which clogged the culvert, broke and the flow returned to the existing stream channel. Fortunately there was no traffic on the bridge at the time it was overtopped.

Debris flows are very rapid, very wet, and noncohesive slurry-like flows composed of at least 50 percent debris-sized particles. Debris is an engineering term for soil in which 20 to 80 percent of the fragments are larger than 2 mm (0.08 inch). Most debris is derived from erosion of bedrock, which in the case of the above debris flow was the Wapiti Formation. When saturated with water, particularly if enough water is introduced quickly enough, debris may become slurry-like and move. Torrential floods may become debris flows if enough material is picked up by the flood waters. By the same token, debris flows may drop some of their debris on flat ground and become floods.

Successive debris flows can build up alluvial fans and alluvial cones. Alluvial fans in the past have been regarded as stream laid deposits. However, recent research indicates that with the type of climate and terrain present in Wyoming, many alluvial fans and cones are composed of alternating layers of stream deposits and debris flows (see figure on page 42). Many of the fan-shaped features issuing from the numerous small stream channels feeding into the Shoshone River



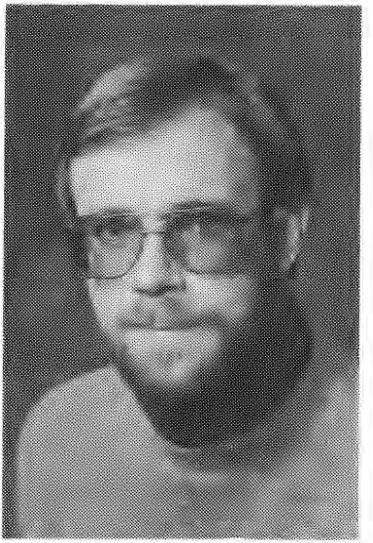
Alluvial fan/debris flow complexes (modified from Jackson, 1987).

along Highway 14-16-20 are debris flow-alluvial fan complexes. The debris flow-alluvial fan complexes are found in many other areas of the State, especially along the east side of Star Valley. In fact, Swift Creek above Afton is periodically dammed by debris flows.

Reference cited

Jackson, L.E., Jr., 1987, Debris flow hazard in the Canadian Rocky Mountains: Geological Survey of Canada Paper 86-11, 20 p.

Meet the Survey Staff

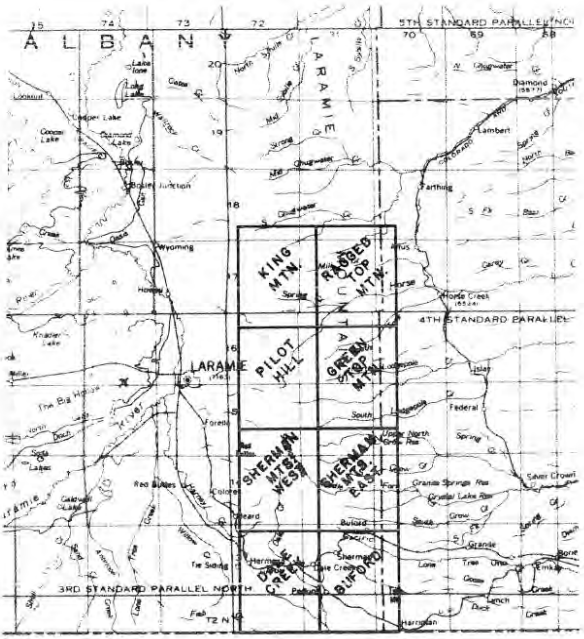


Jay T. Roberts is the Geological Survey of Wyoming's Laboratory Technician. Jay received his B.S. Degree in Geology from the University of New Hampshire in 1973 and has continued studies in the fields of geology, geophysics, and engineering since moving to Laramie in 1974. Jay joined the Geological Survey staff in 1976 working as an assistant in the Coal Division. Since 1981, Jay has headed the Survey's Laboratory Section where he has been responsible for most of the in-house analytical work performed at the Geological Survey. He also prepares most of the samples which are analyzed for the Survey by commercial laboratories.

The Geological Survey's in-house analytical capabilities include the identification and analysis of geologic materials using x-ray diffraction, atomic absorption, and a variety of physical and chemical testing procedures. While the identification of hand specimen samples of rocks and minerals are commonly done for anyone asking, analytical services may also be offered to the public if the information thus gained might further the mission and goals of the Survey. This latter analytical service generally requires that the person submitting samples be willing to disclose sample locations and provide other available information concerning the nature of the sampled area.

The public is regarded as an important source of information concerning the geology of the State and is encouraged to contact the Geological Survey of Wyoming for rock and mineral identification or possible sample analysis. There is no fee charged for the identification of hand specimens of rocks and minerals or for analytical services.

New topographic maps for the Laramie Mountains east of Laramie



Eight new 7½-minute topographic maps are now available. These maps replace 15-minute quadrangles originally produced in 1948.

Ragged Top Mountain Quadrangle (1948) has been replaced by King Mountain, Ragged Top Mountain, Pilot Hill, and Green Top Mountain (1987).

Sherman Mountains Quadrangle (1948) has been replaced by Sherman Mountains West, Sherman Mountains East, Dale Creek, and Buford (1987).

These eight topographic maps can be purchased from the Geological Survey of Wyoming. Cost of each topographic map is $2.75 mailed first-class folded.

Recent and new publications by the Geological Survey of Wyoming

*Traveler's guide to the geology of Wyoming (2nd edition), D.L. Blackstone, Jr., Bulletin 67, 1988, ($5.00).

Tectonic map of the Overthrust Belt, western Wyoming, northwestern Utah, and southeastern Idaho, showing oil and gas fields and exploratory wells in the Overthrust Belt and adjacent Green River Basin, D.L. Blackstone, Jr. and R.H. DeBruin, Map Series 23, 1987, ($5.00).

*Land inventory map of Wyoming 1987: Wyoming Department of Agriculture and the Geological Survey of Wyoming, Map Series 24, 1987, ($10.00).

Geologic map of the Newcastle 1° x 2° Quadrangle, northeastern Wyoming and western South Dakota, J.D. Love and A.C. Christiansen, Map Series 251, 1987, ($4.00).

*Guide to potentially seleniferous areas in Wyoming, J.C. Case and J.C. Cannia, Open File Report 88-1, 1988, ($3.00).

*Revised geologic map of the South Pass City Quadrangle, Fremont County, Wyoming, W.D. Hausel, Open File Report 88-2, 1988, ($3.00).

*Geologic map of the Lewiston Lakes Quadrangle, Fremont County, Wyoming, W.D. Hausel, Open File Report 88-3, 1988, ($3.00).

*Preliminary geologic map of the Fraker Mountain Quadrangle, Johnson County, Wyoming, A.J. VerPloeg, R.H. DeBruin, and P.L. Greer, Open File Report 88-4, 1988, ($3.00).

*Preliminary geologic map of the Barnum Quadrangle, Johnson County, Wyoming, A.J. VerPloeg, R.H. DeBruin, and P.L. Greer, Open File Report 88-5, 1988, ($3.00).

*Preliminary geologic map of the Tabletop Quadrangle, Washakie and Johnson Counties, Wyoming, A.J. VerPloeg and P.L. Greer, Open File Report 88-6, 1988, ($3.00).

*Revised geologic map of the Atlantic City Quadrangle, Fremont County, Wyoming, W.D. Hausel, Open File Report 88-7, 1988 ($3.00).

Geology and economic potential of a high-calcium limestone and dolomitic limestone deposit near Manville, Niobrara County, Wyoming, R.E. Harris, Report of Investigations 39, 1987, ($4.00).

*The Plumbago Creek silica sand deposit, Albany County, Wyoming, R.E. Harris, Report of Investigations 40, 1988, ($4.00).

*Shaded relief map of Wyoming, Raven Maps and Images, 1987, ($23.50 mailed, rolled only, includes cost of map tube).

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* 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. 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.

Add $1.00 for each $5.00 of purchase price if mailed First Class ($1.00 minimum). Add an additional $1.50 for maps mailed rolled.

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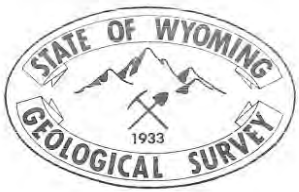
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