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

WYOMING GEO-NOTES NO.20

LARAMIE, WYOMING
November, 1988

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: Sketch of Stephanie Aker, "the voice of the Survey for 26 years." See article on page 42. Sketch done by Fred Porter.

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

Minerals update

OVERVIEW

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

The production forecasts for 1988 in the table below are pretty firm since it is now the fourth quarter of the year. With this in mind, how have our prognostications changed since January?

In the case of oil, we have increased our January estimate of production to 117 million barrels, which is an increase of six million barrels. Our optimism that oil prices would average $15.50 in 1988 has not materialized, instead the average price never got much above $14.00 in the first two quarters, declined through the third quarter, and fell to under $13.00 at the beginning of the fourth quarter. Since there is little likelihood that oil prices will increase quickly, prices in 1989 most likely will do no more than average what they did in 1988. Barring a long run of very low oil prices (i.e. under $11.00) which we feel is unlikely, there is a good possibility that 1989 oil production will nearly match 1988 production. Most of this production strength comes from ongoing tertiary and enhanced oil recovery (EOR) projects, a modest number of discoveries in the Powder River Basin, and some in-fill drilling. Unless we are wrong about prices, a substantial decline in oil production will begin after 1989 and continue until prices do increase, providing that increases do not take too long. Prices under $15.00 per barrel or just widely fluctuating prices will continue to thwart exploration as well as new tertiary and EOR projects which are needed if the declining production from Wyoming's large, old fields is to be offset.

In the case of natural gas, we have also raised our earlier forecast for methane production. In this case, 1988 production is now estimated at 689.5 billion cubic feet, a 59.5 billion cubic feet increase over what we predicted last January. This increase probably reflects the end of the so called "gas bubble" or over supply of gas. Consequently, our estimates beyond 1988 have also been increased. While our estimates do not yet include production for a new pipeline from Wyoming to California, the chances of that pipeline being built have certainly not diminished. At least one of the companies competing for the line has already signed up several firm customers and according to members of Wyoming's Pipeline Authority, California users have recognized that they really will need new supplies of gas and maybe much sooner than they originally thought. If built, this pipeline will increase annual forecast production an estimated 100 billion cubic feet by 1991 and an estimated 200 billion cubic feet by 1992.

While we predicted gas prices might turn around in 1988, the only sign of that happening in the third quarter was an increase in the

Wyoming mineral production forecast to 1992[1].

Calendar Year	Oil Production[2]	Methane Production[3]	Carbon Dioxide Production[3]	Helium Production[4]	Coal Production[5]	Trona Production[5]	Mined Uranium Production[6]	In situ Uranium Production[7]	Sulfur Production[8]
*1981	122.1	455.4	--	--	102.8	11.8	4.6	--	0.05
*1982	118.7	465.1	--	--	107.9	10.1	2.1	--	0.07
*1983	120.9	539.7	--	--	112.2	10.5	3.0	--	0.57
*1984	127.8	600.1	--	--	130.7	11.0	1.6	--	0.63
*1985	131.0	597.9	--	--	140.4	10.8	0.6	--	0.80
*1986	122.4	563.2	23.8	0.15	136.3	13.3	0.3	--	0.66
*1987	115.9	622.7	110.5	0.84	146.5	13.6	0.2[9]	0.06	1.20
1988	117.0	689.5	110.5	0.84	153.0	15.1	0.02	3.0	1.20
1989	116.0	708.4	110.5	0.84	150.0	15.3	0.02	3.0	1.20
1990	110.0	728.0	110.5	0.84	150.0	15.5	0.02	3.0	1.20
1991	103.0	748.1	110.5	0.84	152.0	15.5	0.02	3.0	1.20
1992	96.5	768.9	110.5	0.84	153.0	16.5	0.02	4.0	1.20

*Actual values for comparison; [1] Geological Survey of Wyoming, October, 1988; [2] millions of barrels; [3] billions of cubic feet; [4] billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [5] millions of tons; [6] millions of tons of uranium ore (not yellowcake); [7] millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1987-1991 are based on company information); [8] millions of tons, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission; [9] includes previously stockpiled ore processed by the Lucky Mc mill in 1987.

spot sale price at Opal, Wyoming. If prices do not turn around substantially in 1988, they certainly should in 1989.

Our forecast increase in the production of carbon dioxide occurred although the volume for 1988 is now estimated at only 110.5 billion cubic feet, instead of our January estimate of 120 billion cubic feet. Low oil prices certainly do not help here since carbon dioxide is used for EOR projects. Again we predict little increase in CO_2 production, if any, unless oil prices increase enough to stimulate new EOR projects.

Coal is an interesting case as we really underestimated production even for 1987. Production last year was 6.5 million tons above our end-of-the-year prediction of 140 million tons. In January, we were estimating 1988 production at only 143 million tons. By July, we raised our 1988 estimate to 147 million tons. Now at the end of the third quarter, we are raising our estimate for 1988 production to show an all time record of 153 million tons. Beyond 1988, we are estimating that annual coal production from Wyoming will be between 150 million tons and 153 million tons for at least five years. In other words, we are predicting rather flat, but quite substantial, production into the early 1990's.

The prices paid for coal are tracking our predictions with spot coal sales still well under $4.00/ton in the Powder River Basin. We forecast that the average price paid for Wyoming coal will continue to decline at least through 1992 as more spot sales at low prices in the Powder River Basin offset the higher, long-term contract prices in that basin as well as the higher prices paid for coal in southern Wyoming.

Trona production has provided another pleasant surprise. Back in January, we were showing very little gain in production between 1987 and 1988 or in the years beyond for that matter. Even at the end of the second quarter, the outlook was only slightly better when we showed an expected increase of 400,000 tons over 1987. In the third quarter, an unexpected production upturn has caused us to increase our forecast for 1988 to 15.1 million tons or a 1.5-million-ton increase over 1987. A shortage of caustic soda and some increases in soda ash exports had all the trona producers running their refineries at or very near capacity at the end of the third quarter (see discussion of trona on pages 25 to 26).

The forecast for uranium is confusing, but good. After the first two quarters, we lowered our estimates for mined uranium to one-tenth of what we predicted in January or to 30,000 tons of ore. At the same time, we estimated yellowcake production from *in situ* projects at 0.75 million pounds. By the end of the third quarter, however, we lowered our mined-uranium forecast to 20,000 tons of ore and raised our July estimate of *in situ*-derived yellowcake from 0.75 million pounds to 3.0 million pounds.

In mid-October, just after the third quarter ended, Japanese officials announced that they would buy 7.5 million pounds of Wyoming yellowcake on a long-term contract with the three remaining active Wyoming producers. Whether or not this changes the annual production forecasts that we have just made remains to be seen as no contract details are yet available. A later newspaper account of the contract even suggests that not all the 7.5 million pounds will come from Wyoming.

Looking at the above comparisons between our previous and present forecasts, many things have improved while others are at least tracking expectations. Oil prices are really the only disappointment as they did not increase or even firm up. Higher than expected production, however, has at least tempered the impact of lower prices in 1988 and may help again in 1989. Predictions of future oil prices still remain a guessing game since they are manipulated by OPEC, and who can predict what OPEC will do tomorrow, let alone a year from now. There is still a good chance, however, that the price of oil will hover between $14 - $18 per barrel in the foreseeable future since this nets OPEC relatively good revenues and is still a low enough price to thwart most competition, particularly from domestic producers in the U.S. If the price stabilizes on the high end of the above prognostication, our forecast for oil production from Wyoming may be a

little low in the 1990-1992 timeframe. We are confident that our current predictions for oil production are neither overly pessimistic nor overly optimistic given what is going on today.

OIL AND GAS UPDATE

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

When averaged, the posted price for Wyoming Sweet crude oil declined each month of the third quarter in 1988. The average posted price in July was $14.75 per barrel; for August it was $14.50; and for September it dropped to $14.00. In addition, futures for next year dropped to between $12.50 and $13.00 per barrel during the first week of October. Posted prices for Wyoming crude oil will go lower if OPEC does not cut its production. Several oil analysts estimate OPEC's current production is at least one million barrels per day above demand. Agreement on a new production limit; however, will be difficult since Iran and Iraq have already stated that they desperately need more revenue to rebuild their war-torn economies.

These lower prices are reflected in the September 1988 rig count which averaged 40, compared to an average of 66 in September of last year (see graphs on page 6). The count dropped to 32 during the last last week of September, which was the lowest since early May. The low rig count will also mean fewer well completions than the 1,000 predicted in the last issue of *Wyoming Geo-notes*. Completions will probably be in the 850 to 900 range.

On a more optimistic note, the spot gas price at Opal, Wyoming increased this September. In past years, the spot price has either stayed steady or decreased in September. It may be a little early to say that the gas surplus has ended, but it appears that Wyoming gas producers will see increased demand and slightly higher prices for their natural gas in 1989.

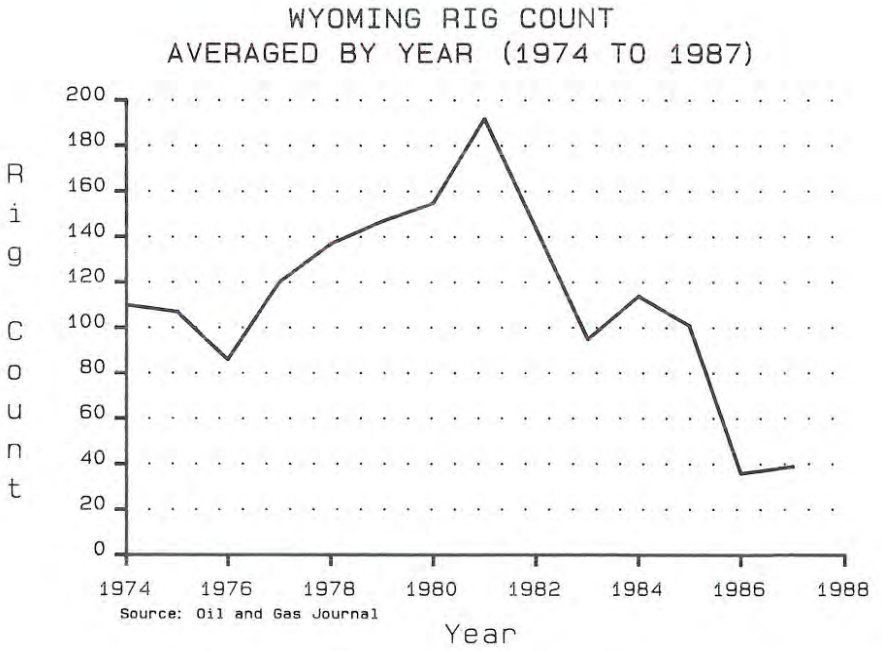
Also, natural gas production in Wyoming for 1988 is forecast at 800 billion cubic feet, which would be a nine percent increase over 1987 production. The 800 billion cubic feet includes an estimated 110.5 billion cubic feet of carbon dioxide produced at Exxon's Shute Creek plant.

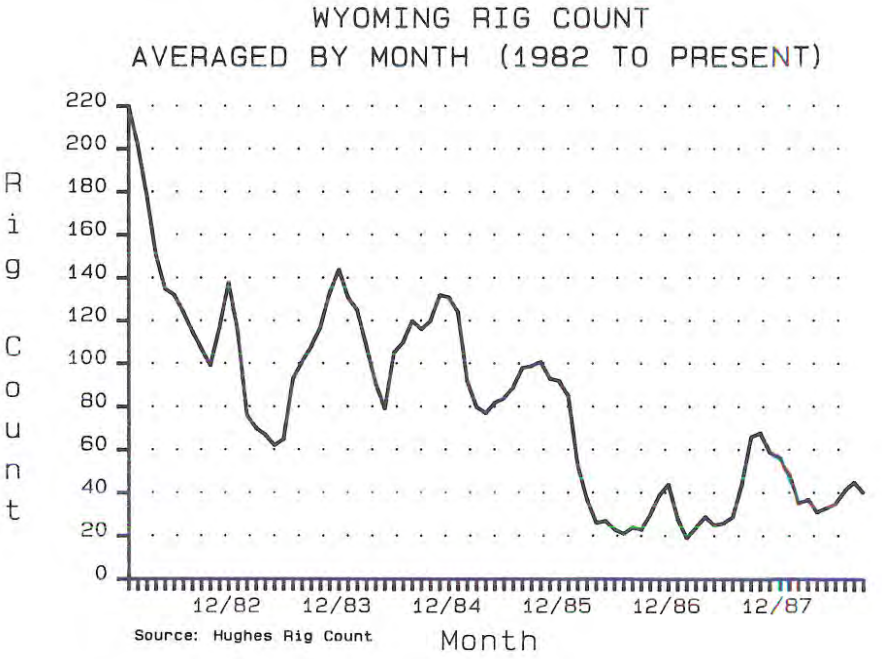
Lease sales continue to do well in Wyoming despite low oil prices (see table on page 8). The high per-acre bid at the August U.S. Bureau of Land Management (BLM) sale was $1,350 by Marathon Oil for a 428.61-acre parcel in the Powder River Basin, covering parts of sections 8 and 19, T.36N., R.75W. The parcel is about a mile and a half from production at Sand Dunes Field and is about 3 miles east of Blizzard Field.

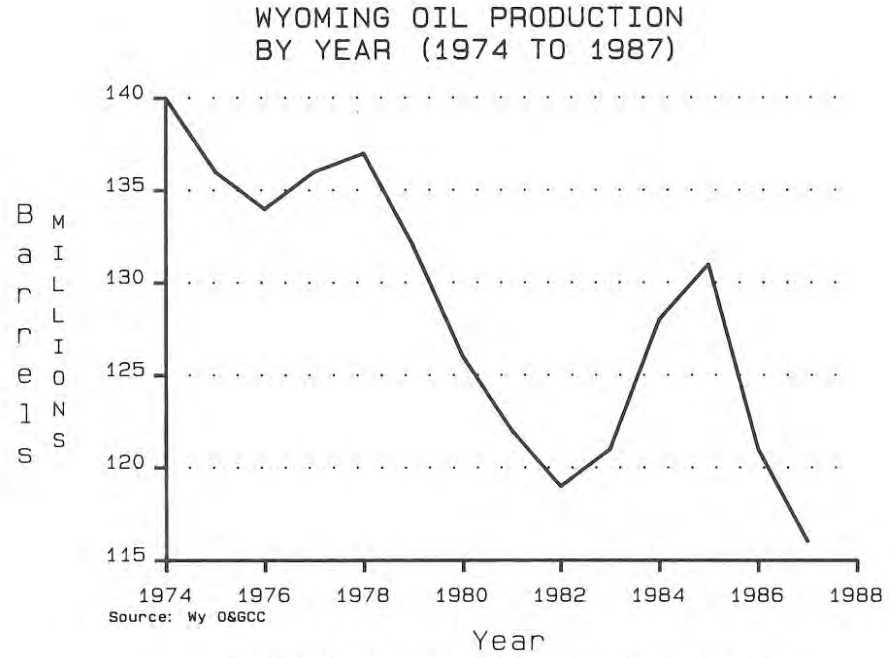
The top bid of $375 per acre at the Wyoming Department of Public Land's July sale was made by Anna Wells for a 39.7-acre lease in section 6, T.49N., R.71W. The tract, also in the Powder River Basin, is

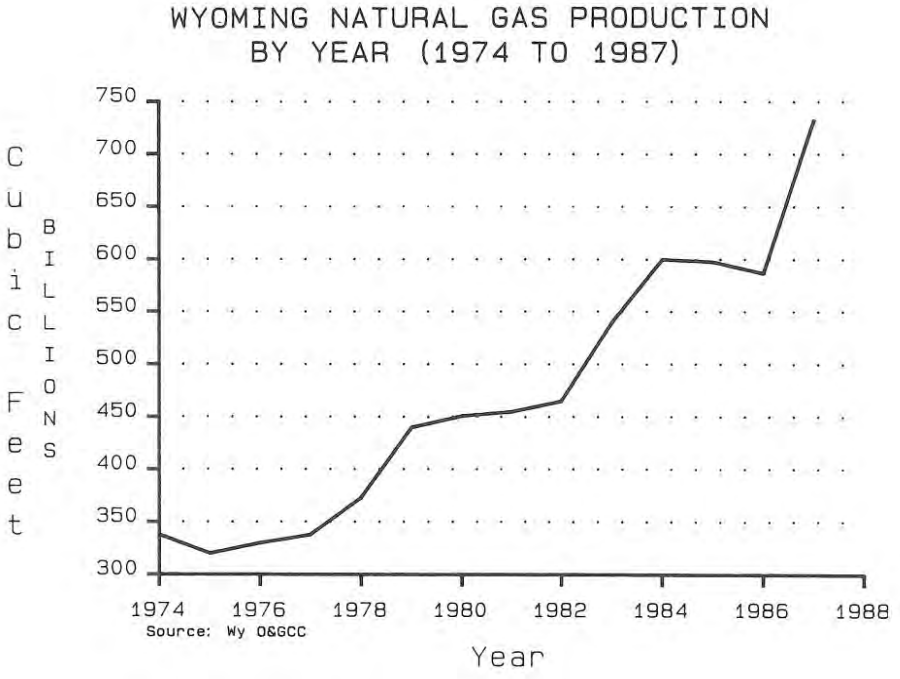
a mile southwest of AG Farm Field, a Minnelusa field discovered in 1986 which has produced over 300,000 barrels of oil. Twenty-one leases in this sale received bids of $100 or more, and the sale generated more revenue than any sale since March of 1985.

The high per-acre bid at the Wyoming Department of Public Land's September sale was $180 by Decalta International and went for a 320-acre tract in the Powder River Basin in section 36, T.49N., R.71W. The lease is near Minnelusa production at Rainbow Ranch and Timber Creek South Fields.


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)
Barrels MILLIONS
140
135
130
125
120
115
1974
1976
1978
1980
1982
1984
1986
1988
Source: Wy O&GCC
Year


WYOMING NATURAL GAS PRODUCTION
BY YEAR (1974 TO 1987)
Cubic Feet BILLIONS
750
700
650
600
550
500
450
400
350
300
1974
1976
1978
1980
1982
1984
1986
1988
Source: Wy O&GCC
Year

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	190	146	75,094	56,906	50.17	1,732.14
October	1,876,105	208	105	81,611	32,052	58.53	1,108.77
December	1,467,265	211	144	73,723	46,908	31.28	1,167.23
TOTAL	$13,735,154	999	772	331,177	232,854	$ 58.99	$ 2,609.53
			1986				
February	$ 1,992,326	211	154	58,507	38,809	$ 51.34	$ 680.00
April	1,795,890	189	116	54,136	29,938	59.99	1,881.88
June	1,332,216	86	75	27,137	24,512	54.35	437.50
August	529,184	104	88	25,686	22,725	23.29	227.63
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
June	7,564,135	820	375	755,242	293,050	25.81	575.00
August	5,827,548	847	363	827,471	278,198	20.95	1,350.00

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	362,903	200	100	82,367	44,698	8.12	210.00
November	699,027	200	127	81,865	50,540	13.83	290.00
TOTAL	$ 2,526,567	1,200	579	511,638	244,740	$ 10.32	$2,300.00
			1988				
January	$ 826,698	200	142	76,953	56,430	$ 14.65	$ 200.00
March	800,213	200	133	76,304	48,423	16.53	465.00
May	1,649,974	200	182	79,987	69,285	23.81	290.00
July	1,855,646	200	155	77,168	60,519	30.66	375.00
September	751,646	200	142	68,456	55,168	13.63	180.00

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

Top 25 oil fields in Wyoming based on 1987 production (Wyoming Oil and Gas Conservation Commission, 1988).

Name	Year discovered	1987 Production (barrels)	Cumulative production through 1987 (barrels)
Oregon Basin	1912	9,086,649	379,197,148
Hartzog Draw	1976	6,829,163	59,819,299
Salt Creek	1889	4,982,911	621,480,774
Painter Reservoir East[1]	1977	3,491,415	3,491,415
Wertz	1921	3,172,664	95,843,702
Hamilton Dome	1918	2,944,580	227,329,824
Elk Basin	1915	2,872,268	429,009,700
Little Buffalo Basin	1914	2,862,738	115,774,534
Brady	1973	2,725,373	52,982,741
Garland	1906	2,601,900	160,116,498
Powell	1954	2,443,335	16,904,165
Grass Creek	1914	2,426,463	182,487,226
Lost Soldier	1916	2,311,582	207,707,459
Pitchfork	1930	1,961,699	33,077,551
Painter Reservoir[1]	1977	1,910,939	43,053,775
Whitney Canyon - Carter Creek	1978	1,732,484	7,380,469
Frannie	1928	1,287,598	111,172,264
Luckey Ditch	1985	1,253,525	2,119,764
Byron	1918	1,243,343	119,391,917
Winkleman	1917	1,156,005	85,369,629
Teapot Dome Naval Reserve	1922	1,095,793	19,161,016
Ryckman Creek	1976	987,191	16,111,729
Scott	1979	923,473	10,776,760
Cottonwood Creek	1953	828,244	52,035,954
Steamboat Butte	1943	720,001	84,934,238
TOTAL		63,851,336	3,136,729,551

[1] Before 1987, production for Painter Reservoir and Painter Reservoir East Fields was combined under Painter Reservoir.

Top 25 natural gas fields in Wyoming based on 1987 production (Wyoming Oil and Gas Conservation Commission, 1988).

Name	Year discovered	1987 Production (MCF)	Cumulative production through 1987 (MCF)
Fogarty Creek[1]	1976	111,625,772	160,152,608
Whitney Canyon - Carter Creek	1978	99,987,425	491,514,275
Lake Ridge[1]	1981	53,461,941	57,266,187
Painter Reservoir[2]	1977	34,556,317	318,962,138
LaBarge	1925	25,648,090	243,329,565
Painter Reservoir East[2]	1977	24,134,974	24,134,974
Brady	1973	22,455,215	263,042,308
Madden	1969	21,448,856	253,193,179
Powell	1954	17,397,582	77,907,493
Ryckman Creek	1976	17,241,015	102,615,735
Clear Creek	1979	16,148,254	88,329,721
Echo Springs	1976	15,437,832	129,060,179
Standard Draw	1979	14,920,427	88,370,958
Table Rock	1946	14,235,648	414,509,389
Bruff	1974	9,541,900	102,273,383
Beaver Creek	1938	8,768,756	553,371,142
Wild Rose	1975	7,633,542	68,502,984
Amos Draw	1982	7,038,038	33,978,734
Green River Bend	1958	6,506,014	180,006,890
Church Buttes	1956	6,462,245	346,130,838
Tip Top	1928	5,603,179	327,332,099
Luckey Ditch	1985	5,434,437	9,871,072
Bird Canyon	1971	5,300,826	36,639,425
Fontenelle	1974	4,543,967	43,698,949
Grieve	1954	4,186,355	93,305,742
TOTAL		559,718,607[3]	4,507,499,967[4]

[1] Approximately two-thirds of production from this field is carbon dioxide.

[2] Before 1987, production from Painter Reservoir and Painter Reservoir East Fields was combined under Painter Reservoir.

[3] Approximately 110,000,000 MCF are carbon dioxide.

[4] Approximately 145,000,000 MCF are carbon dioxide.

Production statistics for 1987 from the Wyoming Oil and Gas Conservation Commission are now final and show oil production was 115,922,003 barrels and natural gas production was 733,210,238 MCF (see graphs on page 7). Once again the top 25 oil fields and the top 25 gas fields accounted for the majority of the production. The top 25 oil fields produced 55 per cent of Wyoming's oil and the top 25 gas fields produced 76 percent of Wyoming's natural gas (see tables on page 9). Sixteen of the top 25 gas fields were discovered after 1970. These fields accounted for 59% of Wyoming's 1987 natural gas production. Only eight of the top 25 oil fields were discovered after 1970, and these accounted for 17% of Wyoming's oil production.

Based on company data and on information compiled and published by Petroleum Information, the following significant exploration and development events occurred in Wyoming during the third quarter of 1988. [The letters in the following discussions refer to locations on the figure on page 11].

A. Exxon Corporation recently completed the westernmost producing well in Luckey Ditch Field. Exxon has not disclosed test results on the 1 Sage Creek-Federal well in section 13, T.12N., R.115W.; however, the well is producing from the Dakota and is a mile west of the nearest producing well in the field.

B. General Atlantic Energy tested their 1-15 UPRR wildcat in section 15, T.22N., R.111W. The well flowed 423 barrels of oil, 690,000 cubic feet of gas, and 298 barrels of water per day from the Dakota. The nearest Dakota production is nearly 12 miles north in Lincoln Road Field.

C. Amoco Production announced plans to drill a 9,500-foot test of the Phosphoria, Tensleep, and Madison in section 29, T.44N., R.112W. The well will be drilled on the flank of Spread Creek anticline nearly seven miles north of Sohare Field, a shut-in discovery drilled by Exxon in 1981.

D. Four stratigraphic tests will be drilled to identify the formations under the volcaniclastic rocks in the Absaroka Range. Conoco will drill the tests in sections 6 and 17, T.43N., R.102W. and in section 13, T.43N., R.103W.

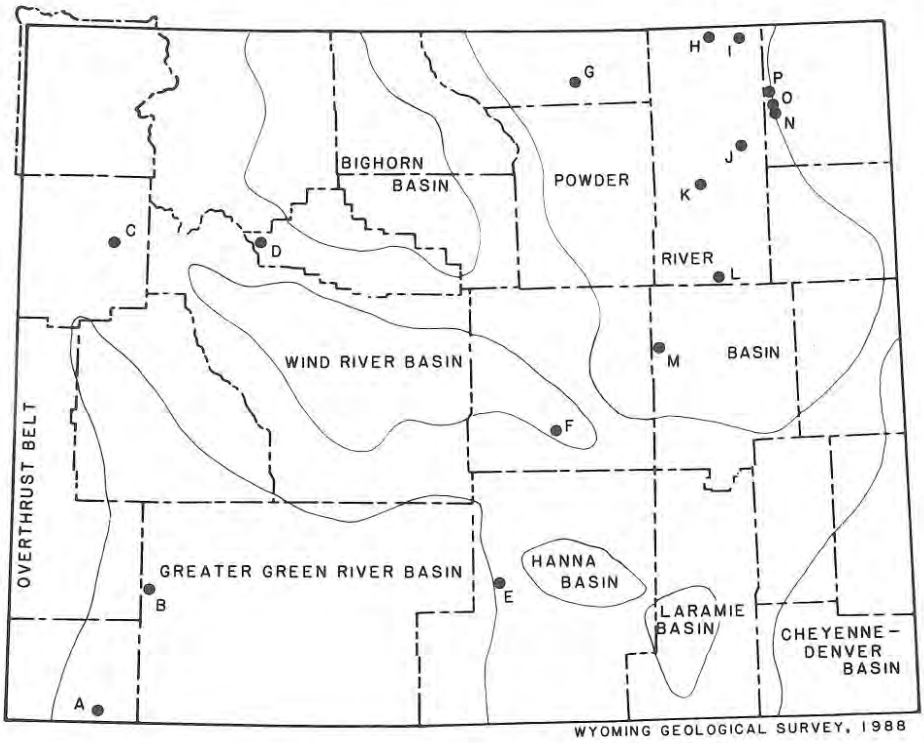
E. Global Natural Resources will drill a wildcat to test the Sundance, Nugget, and Tensleep. The well, in section 20, T.22N., R.88W., is about eight miles south of nearest production at Bell Springs Field.

F. Tenneco Oil's offset to the Austin Creek discovery flowed 730 barrels of oil and 625,000 cubic feet of gas per day on a production test. The 1-7 Schloegel-Federal in section 7, T.32N., R.84W. is just north of the discovery well, which was completed flowing 288 barrels of oil and 392,000 cubic feet of gas per day from the Muddy Sandstone.

G. Amoco Production staked two locations for Muddy Sandstone tests in Sheridan County. The locations in section 36, T.55N., R.80W. and in section 8, T54N., R.80W. are over 10 miles from abandoned Muddy production at Amp Field.

H. Lario Oil and Gas discovered oil in the Muddy Sandstone at their 1-Ute-Federal in section 15, T.57N., R.72W. Pipe recovery from a drillstem test was 2,256 feet of oil.

I. A wildcat drilled by Union Pacific Resources was completed in the Minnelusa Formation pumping 255 barrels of 21° API gravity oil daily. The 1 WECO-UPRC-Sawgrass-Federal in section 32, T.57N., R.70W. is a little over a mile from 85 Creek Field, a Minnelusa discovery drilled in 1986.



OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING

J. Maxim Drilling and Exploration completed a discovery near Wallace South Field pumping 82 barrels of 23° API gravity oil and two barrels of water a day from the Minnelusa Formation.

K. The 14-4 Geis well drilled by Coastal Oil and Gas in section 4, T.47N., R.73W. found oil in the Parkman Sandstone member of the Mesaverde Formation. The well was completed for an initial potential of 130 barrels of oil a day on pump, but it is currently producing 55 barrels of oil per day.

L. Maxus Exploration completed a Dakota gas discovery in section 6, T.41N., R.72W. flowing 417,000 cubic feet of gas daily. The 32-6 Mongoose Unit is about six miles from the nearest Dakota production at Mary Draw and Turnercrest Fields.

M. Chevron USA completed a Frontier oil and gas discovery in section 10, T.36N., R.76W. The 1-10 Blue Hill-Federal pumped 139 barrels of 40° API gravity oil, 135,000 cubic feet of gas, and six barrels of water a day. Sand Dunes Field, which is two miles away, also produces from the Frontier Formation.

N. A wildcat well, the 1 Berger, was drilled in section 17, T.53N., R.67W. by EMC Energies Inc. It was completed in the Minnelusa flowing 700 barrels of 22° API gravity oil per day. The well is a half mile from Minnelusa production at Deadman Creek Field, but it is separated from that field by dry holes.

O. Dabros Properties recovered oil on a drillstem test of the Minnelusa at the 24X-8 Hundahl well drilled in section 8, T.53N., R.67W. The well is a mile from Deadman Creek Field and a mile from the 1 Berger discovery described in the paragraph above.

P. Maxim Drilling and Exploration completed their 33-13 Brislawn well in section 13, T.54N., R.68W. pumping 220 barrels of 24° API gravity oil and 250 barrels of water per day. The Minnelusa discovery is about one mile from nearest Minnelusa production at Lad Field.

In other petroleum-related matters, the State recently refunded $1.1 million in sales taxes to Chevron USA because of overcharges by Utah Power and Light for electrical power at Chevron's Painter Reservoir gas plant in Uinta County from November of 1983 through October of 1986. Half of the refund will come from Uinta County and towns within Uinta County; the other half will come from the State's general fund.

The Sierra Club's Legal Defense Fund filed a protest on behalf of the Sierra Club and the National Wildlife Federation against a BLM oil and gas lease sale in Colorado. The protest is in response to the Ninth Circuit Court ruling in the case of Conner versus Burford which held that Government analysis of an offered lease tract must contain enough information for the public to predict what will happen if full

field development occurs. A case decided by the Tenth Circuit Court reached an opposite conclusion from the Conner versus Burford decision, so it may take a higher court to resolve the conflict. The Sierra Club has apparently decided not to pursue legal challenges to future lease sales in Wyoming at least for the time being.

COAL UPDATE

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

Wyoming coal production for 1988 appears headed for an all-time record according to mid-year production indicators. Coal deliveries for the first half of 1988 are nearly seven million tons more than deliveries made for the first half of 1987 (see table on page 14). If second half deliveries in 1988 are equal to deliveries during the same period a year ago and if unreported tonnage is the same as in 1987, coal production for 1988 could reach 153.3 million tons. Increased sales of spot and contract coal were noted by many of the State's coal mines this year as hot, dry weather maintained the demand for coal-fired electricity (for air conditioning and to replace hydroelectric power), especially in the West and Midwest.

Coal production and consumption are also up nationally. The National Coal Association revised its coal forecasts for the United States in July, predicting that national coal production would reach a record 926 million tons in 1988, a nine million ton increase over 1987's record, and that coal consumption (plus exports) would reach 932 million tons, a 15-million-ton increase from 1987. While coal production in the western U.S. was forecast at 348 million tons, an increase of 11 million tons from 1988, Eastern production was forecast at two million tons less than in 1987. Coal consumption by electric utilities was predicted to account for nearly all the increase: a record 733 million tons of utility coal will be consumed in 1988, compared with 718 million tons in 1987.

Wyoming coal production will probably drop slightly in 1989 (after peaking in 1988) as coal demand stabilizes slightly in response to more normal coal-usage by electric-generating plants (see table on page 2). Coal production should reach or exceed 150 million tons each of the next four years, possibly showing slight increases in 1991 and 1992 as new coal supply contracts are signed and expiring contracts are renewed.

The average assessed value of Wyoming coal, for tax purposes, is expected to continue downward through 1992 (see figure on page 15). Although the annual rate of decrease will be progressively less each year until 1992, valuation will continue to fall as more contracts are renegotiated or bought out at lower prices, as spot and short-term

COAL DELIVERIES BY MONTH FROM WYOMING MINES[1]

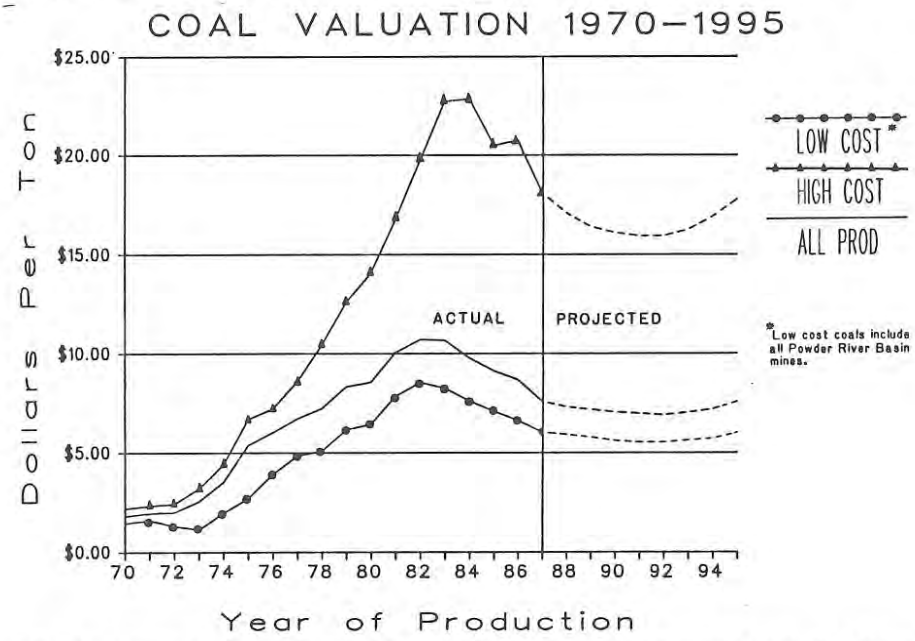
	1984 MONTHLY	1984 CUMULATIVE	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE
JANUARY	9,540,200	9,540,200	11,601,200	11,601,200	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860
FEBRUARY	9,654,600	19,194,800	10,473,900	22,075,100	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240
MARCH	10,875,000	30,069,800	11,674,900	33,750,000	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330
APRIL	8,721,400	38,791,200	11,632,800	45,382,800	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990
MAY	9,481,500	48,272,700	11,497,900	56,880,700	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490
JUNE	9,464,500	57,737,200	11,692,200	68,572,900	10,499,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970
JULY	11,019,600	68,756,800	11,893,500	80,466,400	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640
AUGUST	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	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	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	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	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	124,423,300		136,996,000		134,522,160		142,399,520			
TOTAL TONNAGE NOT REPORTED	6,322,479		3,784,154		1,782,896		4,089,128			
TOTAL TONNAGE PRODUCED[2]	130,745,779		140,780,154		136,305,056		146,488,648			

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

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

sales continue at prices substantially less than contract, and as the keen competition for coal sales in a buyers' market continues. In addition, valuation increases noted in some areas of the State will be offset by increased production of lower valued coal elsewhere. In 1992, after the average valuation of coal reaches lows of $5.53 per ton, $15.94 per ton, and $6.91 per ton, which are the averages for low cost, high cost, and "all" produced coal, respectively, valuation will begin to gradually increase as market conditions improve and coal prices rebound.

The availability of large quantities of low-priced, easily accessible coal in the Powder River Basin of Montana and Wyoming is evidently causing many utility companies and other coal buyers that have not traditionally purchased fuel from this basin to investigate how they can utilize the coal at their facilities. For example, Consumers Power Company in Michigan is buying coal from Thunder Basin Coal Company to blend with higher Btu coal from the Appalachian area in an effort to meet that State's clean air regulations (see Powder River Basin developments, below, for contract details). Eastern coal has traditionally served this area with both contract and spot sales of 12,000+ Btu/pound coal so this sale of western coal represents a potential new market that could displace up to 1.2 million tons of Eastern coal annually.



SOURCE: Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division Annual Reports.

Geological Survey of Wyoming
October, 1988

This summer, Otter Tail Power Company, operator of lignite-burning power plants in South Dakota, North Dakota, and Minnesota, tested subbituminous coal from the Rochelle mine at the Big Stone power plant in South Dakota. The utility company later announced that 50,000 tons of coal from NERCO Coal's Spring Creek mine in Montana would be tested at the Hoot Lake power plant in Minnesota and that bids were out for 125,000 to 150,000 tons of coal to be tested at the Big Stone plant. Both power plants currently burn North Dakota lignite under long-term coal supply contracts. Evidently, both the coal supply contracts and the transportation contracts are near reopener clauses or expiration dates and Otter Tail is investigating alternatives that may result in cheaper fuel and transportation costs. If Otter Tail does indeed decide to purchase subbituminous coal instead of lignite, two to 2.5 million tons per year of lignite could be displaced by 1.5 to 1.75 million tons per year of Powder River Basin coal.

Coal from the Montana portion of the Powder River Basin is also making inroads into the export markets. A Canadian utility company, Ontario Hydro, recently purchased 150,000 tons of coal from NERCO Coal's Spring Creek mine. The utility cited several factors for purchasing U.S. coal, including the need for low sulfur coal to meet sulfur dioxide emission requirements, the rising prices of western Canadian coal, and an increase in coal consumption related to electricity demand. In late July, it was announced that 24,000 tons of coal from NERCO Coal's Spring Creek mine would be exported to Japan for testing by a Japanese utility company. As was the case in the earlier sale of Wyoming coal to Taiwan (see *Wyoming Geo-notes No. 18*, April, 1988, p. 18 and *No. 19*, July, 1988, p. 1), Burlington Northern Railroad (BN) played a key role (including significant price reductions on transportation) in the sale. Besides BN and NERCO, Inc., Mitsubishi Corporation of Japan and Westar Mining Ltd. of Canada were involved in the sale. BN transported the coal to Canada's Westshore Terminal at Roberts Bank (near Vancouver, B.C.) where about half the coal was blended fifty-fifty with Canadian coal from Westar Mining and loaded directly on ships bound for Japan. It is hoped that this sale, along with the previous sale to Taiwan, will encourage future exports of Powder River Basin coal.

In coal transportation news, Chicago and North Western Transportation Company (C&NW) and the Lower Colorado River Authority (LCRA) announced in August that they had signed a new long-term coal transportation contract and that legal action taken by LCRA and the City of Austin, Texas, against C&NW had been dismissed. The long-term contract (duration unknown) is for transportation of coal from mines in southern Campbell County and northern Converse County (southern part of the "Gillette strip") to the Fayette Power Project near Halstead, Texas. The new contract replaces a one-year contract that expires on April 1, 1989. The agreement also gives LCRA and the City of Austin trackage rights to a rail line that Union Pacific Railroad Company (UP) will own after they acquire the Missouri-Kansas-Texas Railroad Company (MKT) later this year (McGraw-Hill, 1988). This will

give LCRA a choice of rail carriers into the Fayette Power Project and end LCRA's planned development of its own rail line to the project.

Another part of the C&NW - LCRA/City of Austin agreement dismissed C&NW as a defendant in a lawsuit that LCRA, other utility companies, and Energy Transportation Systems, Inc. (ETSI) had filed against several railroad companies. The lawsuit alleges that the railroad companies conspired to violate Federal antitrust laws in preventing ETSI from building a coal slurry pipeline from Wyoming to Arkansas (see related stories in *Wyoming Geo-notes No. 17*, January, 1988, p. 17 and *No. 19*, July, 1988, p. 15). Part of the settlement involves $9 million in cash payments by C&NW to Houston Lighting and Power (Copper Queen Publishing Company, Inc., 1988).

Developments in western and southwestern Wyoming

In late September, Bitter Creek Resources began coal production at the Stansbury underground mine north of Rock Springs, thus becoming Wyoming's newest mine and the third underground coal mine in the State. The mine last operated between 1976 and 1981 as a joint venture between Rocky Mountain Energy Company (now Union Pacific Resources) and Ideal Basic Industries. Earlier this year, Bitter Creek Resources, which purchased the mine in 1986, received a development loan guarantee of $950,000 (see *Wyoming Geo-notes No. 19*, July, 1988, p. 21). The first coal was shipped by truck to an unidentified industrial user in the area on September 21st and initial production of 20,000 tons per month is expected. The mine produces a high-Btu bituminous coal and employs 20 workers. Bitter Creek is currently negotiating with several other potential customers in the West and if additional contracts are procured, production could increase to 40,000 tons per month and additional miners could be hired.

A new coal market for Wyoming and Utah may be developing in the next few years as plans for a large coal-fired electrical generating project in northern Nevada were announced in September by Sierra Pacific Resources (SPR). SPR is one of eight participants in the project. The proposed $4 billion Thousand Springs Power Project would consist of eight 250-megawatt generating units located several miles north of Wells, Nevada. Each unit would cost about $450 million to construct and would require 700,000 to 800,000 tons of coal annually. Although two western coal mining companies, Coastal States Energy Company (of Utah) and Pittsburg and Midway Coal Mining Company (of Colorado) are equity participants in the project, SPR announced that coal supplies for the project would be procured competitively from a variety of sources most likely located in Wyoming and Utah. Construction of the first unit would probably begin in 1991, although no power supply contracts or coal supply contracts have been signed yet. The power generated from this project would be marketed wholesale to utility customers most likely located on the West Coast and in the southwestern United States. The Kemmerer mine in Lincoln County (operated by Pittsburg and Midway Coal Mining Company) would certainly be a

possible source for some of the coal as would the Black Butte coal mine east of Rock Springs. Black Butte Coal Company currently delivers coal to Sierra Pacific Power Company's North Valmy power plant in Nevada. If competitive rail transportation rates can be obtained, even coal from the Hanna Basin or the Powder River Basin could be available for the project.

Developments in the Hanna Basin

Third quarter developments in this area are mostly discouraging as additional layoffs have occurred and no significant new coal contracts have been announced. Rosebud Coal Sales Company announced in September that an unspecified number of the 65 employees at the Rosebud mine near Hanna would be laid off near the end of 1988. Rosebud's 15-year 500,000 ton-per-year contract with Iowa Public Service Company (IPS) is expected to end in December, 1988. The utility company has been accepting accelerated shipments from Rosebud during the year and plans to complete the tonnage requirements on the contract in December, one year earlier than planned. The contract is Rosebud's only major contract and the loss of it may force the mine to enter a reclamation phase in anticipation of permanent closure.

Another IPS contract with a Hanna Basin coal producer was due for price reopener negotiations in July, 1988, but it is not known whether or not IPS exercised this option. Energy Development Company (owned by parent company Arch Mineral Corporation) has a 10-year, 360,000 ton-per-year contract with IPS that is due to expire in 1993. The coal for this contract is mined at Arch of Wyoming's Seminoe 2 mine. Meanwhile, IPS is ordering spot coal from the Powder River Basin for test burns at the George Neal No. 3 plant in anticipation of purchasing lower priced coal after the Hanna Basin contracts are completed. IPS is also planning a test of Amax Coal Company's dried coal product from the Belle Ayr mine when it becomes available in late 1988 or early 1989. The dried coal has a heating value of about 10,800 Btu/pound, about the same as many of the Hanna Basin coals. It is anticipated that many utility companies, which currently use higher heat value coals, may want to test this dried coal product because the dried product will not require derating a generating unit's boiler system as is the case when a lower heat value coal is used.

Arch of Wyoming announced in late September that 50 employees at their Seminoe 2 mine at Hanna had been laid off. The company employed 79 workers and operated two draglines at Seminoe 2 before the layoffs; production was scaled down accordingly and one dragline was idled after the layoffs. Arch of Wyoming also operates the Medicine Bow mine northwest of Hanna and evidently the increased productivity at this mine has created a stockpile of coal that can be used to fill existing contracts and spot sales. The Medicine Bow mine reopened early in 1988 after being on standby status the year before. That mine has 23 employees. Arch has a three-year coal supply contract with Kansas Power and Light Company which expires in March, 1989, and has also

made several spot sales to the same company, including an 80,000-ton sale for the fourth quarter of 1988.

Developments in the Powder River Basin

In response to an increased demand for coal, Nerco Coal Company has applied to the State of Wyoming's Industrial Siting Council to expand the capacity of its Antelope mine to seven million tons by 1993. The original siting permit for the mine in 1981 was for 12 million tons a year, but the permit was downsized to one million tons shortly afterward because contracts had not been signed for that much coal. The permit was amended again to allow production of three million tons per year, but the prospects for additional coal contracts by 1993 have prompted Nerco to increase the mine's capacity.

Two "clean coal technology" projects involving Powder River Basin coal were recently denied Federal funds by the U.S. Department of Energy. Char-Fuels of Wyoming, Incorporated and Energy Brothers Technology, Incorporated were notified in late September that their bids for $54 million and $40 million, respectively, in Federal funds had been rejected. The $537 million in Federal funds available for the Clean Coal Technology Program were awarded to 16 proposals for retrofitting existing power plants. None of the final 16 projects were located in the western United States. The Char-Fuels project will probably be delayed because $15.5 million of the expected Federal funds were to be used to match the $16.5 million in guaranteed loans provided by the State of Wyoming. Char-Fuels is now attempting to secure private funds to qualify for those funds authorized by the State. The Energy Brothers K-Fuels project reportedly will not be affected by the denial of Federal funds.

In August, the first K-Fuel pellets were produced in a pilot plant east of Gillette. The 2,000 ton-per-year plant is intended to aid Energy Brothers in development of a 350,000 ton-per-year commercial plant. By 1992, the company hopes to have three K-Fuel plants producing 1.4 million tons of 12,500 Btu/pound K-Fuel. Wisconsin Power and Light Company has contracted to purchase one million tons of K-Fuel per year for three power plants. In turn, Fort Union Coal Company will provide two million tons of coal per year to the K-Fuel plant for this contract. The State of Wyoming has loaned $11.7 million to Energy Brothers Technology, Inc. for development of the project.

Disputes over coal contracts between Powder River Basin coal producers and utility companies are worth noting this quarter, mainly because the lawsuits usually either result in new contracts with other mines, cash settlements, or extensively revised or renegotiated contract terms. Western Fuels Association and two of its member utilities, Sunflower Electric Cooperative and Basin Electric Cooperative filed a lawsuit against Mobil Coal Producing, Incorporated in July. The utilities are seeking to cancel their contracts with Mobil and

recover alleged overcharges made by Mobil. Coal deliveries from Mobil's Caballo Rojo mine to Sunflower Electric Cooperative's Holcomb, Kansas, generating plant were halted and spot coal from Carter Mining Company was used in its place. In September, Sunflower Electric announced that 400,000 tons of coal from Elk River Resources' (Cordero Mining Company) Cordero mine would be used at Holcomb for the rest of 1988. Coal deliveries from Mobil to Basin Electric Cooperative's Laramie River plant near Wheatland continued despite the legal action. In September, Mobil filed a counter-suit against Western Fuels and the two electric cooperatives. In another matter, Western Fuels continues to pursue an equity partnership arrangement with a Wyoming coal producer to open a new mine in the Powder River Basin (see *Wyoming Geonotes No. 18*, April, 1988, p. 18).

Another lawsuit and counter-suit involves Triton Coal Company's Buckskin mine and Cajun Electric Power, operator of the Big Cajun generating plant in Louisiana. This contract dispute also involves coal prices. Deliveries to Cajun continue despite the lawsuits under a "bridge agreement" that is in effect until the lawsuits are resolved. [This litigation was apparently settled in favor of Triton early in October].

Finally, Portland General Electric (PGE) and Amax, Incorporated have filed lawsuits and counter-suits over a take-or-pay coal supply contract for PGE's Boardman, Oregon, generating plant. The Boardman plant has been inactive since 1984, but PGE's contract with Amax specifies a minimum tonnage of 1.2 million tons per year. Because PGE won't accept the coal, Amax is paid for the coal even if no deliveries to the plant occur. At issue is the price that Amax charges PGE for the coal and how the price is determined. PGE is asking for repayment of the entire $17.7 million it has paid to Amax since 1983 and Amax is asking for $14.6 million from PGE for coal that the utility was obligated to buy.

During the third quarter, coal contract activity involving Powder River Basin mines was rather brisk. A summary of new or renegotiated coal contracts follows:

1) Two small Wyoming coal users have opted to buy from out-of-state coal producers. The Holly Sugar Company's sugar beet processing plant at Torrington is purchasing 20,000 tons of coal from Kerr Coal Company at Walden, Colorado, for this season's activity. The Veterans Administration medical center in Sheridan is buying 5,650 tons of coal from Nerco Coal's Spring Creek, Montana, mine through Schultz Coal Sales, Incorporated, a coal broker in Sheridan. The latter coal will be oil-treated and is priced at $19.75 per ton delivered by truck.

2) Wisconsin Electric Power Company signed a four-year, two-million ton-per-year coal supply contract with Mobil Coal Producing, Inc. Coal from the Caballo Rojo mine will go to the utility's Pleasant Prairie plant via Western Railroad Properties, Inc. (WRPI) and C&NW rail lines. Deliveries will begin in January, 1989 and will be

completed in December, 1992. This utility company is also renegotiating their contract with Carter Mining Company's Caballo mine for deliveries to the same plant.

3) Northern Indiana Public Service Company (NIPSCO) has signed a six month contract with Amax Coal Company for an unspecified amount of spot coal from the Belle Ayr mine. The coal will be used at various NIPSCO power plants in Indiana.

4) Consumers Power Company has awarded a 250,000-ton spot coal contract to Thunder Basin Coal Company's Black Thunder mine for test burns at two Michigan generating plants. The Cobb plant at Muskegon, Michigan, will use 50,000 tons of coal; deliveries started in mid-July. This coal will be transported to Chicago by Burlington Northern Railroad (BN) and barged across Lake Michigan to the plant. The Campbell plant at West Olive, Michigan, will test 200,000 tons of coal with deliveries starting in September. This coal will also be transported to Chicago by BN; CSX railroad will make final delivery to the plant.

5) Carter Mining Company and the Lower Colorado River Authority (LCRA) signed a six-month agreement for 600,000 tons of spot coal for the Fayette No. 3 plant in Texas. Coal from the Rawhide mine will be shipped from August through January via C&NW and UP on existing transportation contracts. Price of the coal was $3.85 a ton, F.O.B. the mine.

6) Peabody Holding Company (owner of subsidiary Rochelle Coal Company) was awarded a 1.27-million-ton spot coal contract to supply LCRA's Fayette No. 1 and No. 2 generating plants in Texas. The six-month agreement will start on October 1 and will use coal from the Rochelle mine. Although Thunder Basin Coal Company's bid of 126¢/million Btu delivered ($3.72 per ton F.O.B. Coal Creek mine for 8,400 Btu/pound coal) and Carter Mining Company's bid of 127.3¢/million Btu delivered ($4.00 per ton F.O.B. Caballo mine for 8,425 Btu/pound coal) were both lower than Rochelle's bid of 128.7¢/million Btu delivered ($5.04 per ton F.O.B. the mine for 8,775 Btu/pound coal), Rochelle won the contract apparently because they asked for fewer exceptions to the solicitation during the contract negotiations.

7) Platte River Power Authority (PRPA) agreed to buy 50,000 tons of coal from Thunder Basin Coal Company in late August. The coal, mined at Coal Creek, was used for a test burn at the Rawhide Energy Station near Fort Collins, Colorado. Evidently, the 28,000 tons used for testing prior to October was enough for PRPA to discover the coal caused a problem with their scrubbers so the remaining coal deliveries were cancelled. The utility's 25-year contract with Nerco Coal Company's Antelope mine continues as before. PRPA's contract with Nerco allows solicitation of competitive bids on an annual basis.

8) Kansas City Municipal Utilities and Carter Mining Company signed an agreement for 200,000 tons of spot coal for the rest of 1988. The coal will be mined at the Caballo mine, which already has a contract for 700,000 tons per year with the utility.

References cited

McGraw-Hill, Incorporated, 1988, C&NW signs long-term contract; LCRA drops ETSI lawsuit against carrier: Coal Week, v. 14, no. 32, p. 2.

Copper Queen Publishing Company, Incorporated, 1988, C&NW makes peace with Texas utility, gets new contract: Rocky Mountain Pay Dirt, August, 1988.

INDUSTRIAL MINERALS UPDATE

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

Aggregate

Aggregate is the sized rock material mixed with cement or asphalt to form concrete or other construction material. Decorative aggregate is used for its appearance as well as for its suitability for construction aggregate. Colored precast concrete composed of colored cement with decorative aggregate, is commonly used for major buildings, highway overpasses, and other structures throughout the world. There is a developing interest in decorative aggregate in Wyoming for precast concrete, landscape rock, floor tile, and other uses. Through the assistance of the Geological Survey of Wyoming, several types and colors of rock from Wyoming are currently being tested. Several tons of decorative aggregate from Wyoming were sent to Hays, Kansas, in September, 1988. This rock was half-inch sized red granite from the Rawhide Buttes area south of Lusk. It will be used in precast concrete.

Highway construction projects in Wyoming use aggregate for road surfacing material. The most often used rock type is limestone. Granite, clinker (baked and fused rock), and "river rock" (aggregate from natural gravel deposits) are also used. During the third quarter of 1988, the production of aggregate in Wyoming not only increased over the preceding quarter, but also surpassed the same quarter of last year. Except for the seasonal slowdown during the winter months, aggregate production in Wyoming should continue to increase in 1989.

A legal decision also affected aggregate deposits this quarter. The Wyoming Supreme Court ruled that when a property is sold without selling the mineral rights, gravel is not considered a mineral and is not the property of the mineral owner. A mineral as ruled by the Supreme Court must have characteristics or properties that give the substance a special value. Property owners who do not own the mineral rights can sell gravel for construction without involving the mineral rights owner. Decorative aggregate, however, has been found to have a special value, and may be considered a mineral.

Bentonite

Wyoming's bentonite industry continues to produce far below capacity. No increase in production is projected since domestic oil and gas well drilling has remained low. Bentonite is primarily used in drilling mud. Other uses for bentonite, such as foundry castings, taconite pelletizing, and as a filler in cosmetics, have increased consumption a little.

Cement

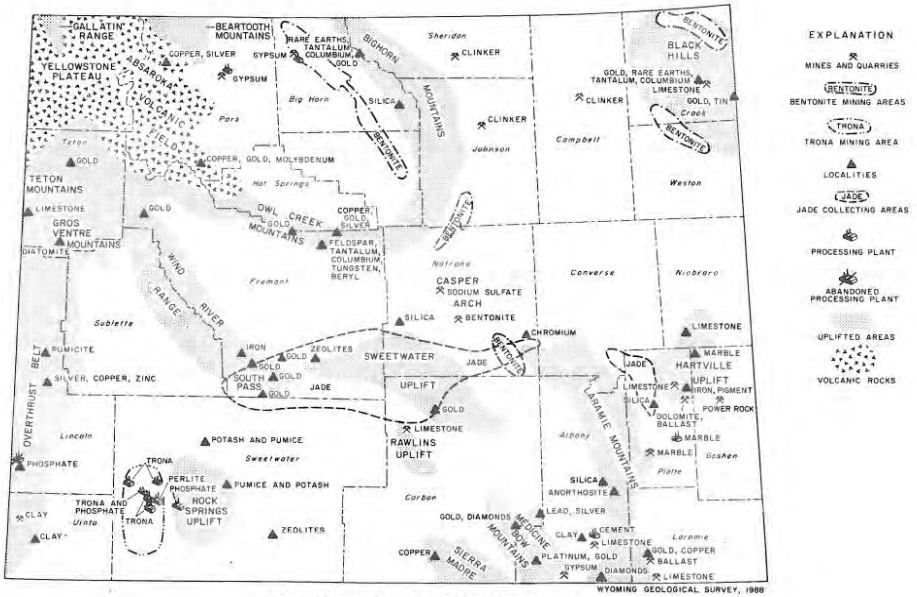
Mountain Cement Company in Laramie is Wyoming's only cement producer. Mountain Cement uses limestone, marl (shale), gypsum, and small amounts of silica sandstone and iron oxide to make cement. A recent $20 million renovation of its plant is almost completed. About 100 people will be employed at the plant when full production is reached. The construction of a new airport at Denver will require large quantities of cement, and Mountain Cement is hopeful that it will be able to supply some of that demand.

Gypsum

Gypsum is quarried in Wyoming at three locations (see figure on page 24). The two plants in the Bighorn Basin use gypsum to produce wallboard (drywall). The gypsum from the Laramie area is used to make cement. Gypsum production in Wyoming has been slowly increasing as the demand for wallboard increases. The completion of Mountain Cement's renovation (see preceding section) will also cause Wyoming's gypsum production to increase.

Limestone

Limestone is quarried, crushed, and sized in Wyoming for use in highway construction projects, cement, and for power rock. An old quarry near Hartville, in Platte County was reopened and is being used as the source of highway aggregate in eastern Wyoming and western Nebraska. Another quarry, 6 miles north of Hartville, was opened in the third quarter to supply power rock (for burn control and emissions control) to the Laramie River power plant near Wheatland. Limestone used in the refining of sugar beets in Wyoming and western Nebraska continues to be supplied from South Dakota and Montana. Limestone for the production of cement at Laramie comes from quarries 3 miles east of the plant.



SELECTED MINERAL AND ROCK OCCURRENCES

Phosphate

The production of phosphate fertilizer at Chevron's plant near Rock Springs continues at high rates due to a sustained demand for phosphate products. Phosphate is mined in Utah and shipped to the plant by slurry pipeline. Sulfur from Wyoming (see section on Sulfur) is used in the process. A plant expansion announced earlier this year is in progress. Increased production from this plant has contributed to the reduction in production of phosphate in Idaho, and the closure of several plants there. The Smoky Canyon phosphate mine, 3 miles west of the Idaho-Wyoming border near Afton, Wyoming, may also close soon.

Silica

Silica deposits in Wyoming continue to attract attention. The Geological Survey of Wyoming has assisted in providing geologic information to some companies interested in constructing a glass plant or plants in Wyoming. The proposed plants will produce glass using Wyoming silica and soda ash (see section on Trona). Two silica deposits, one near Laramie and one near Glendo, are being considered (see related article on pages 33 to 35).

Sulfur

So far, U.S. sulfur production in 1988 is out pacing production in 1987 according to figures released by the U.S. Bureau of Mines. Currently all the sulfur produced in Wyoming is a by-product of natural gas and petroleum processing. The Wyoming Economic Development and Stabilization Board; however, has awarded a grant to the City of Thermopolis to conduct surface studies on a deposit of mineral sulfur owned by the Wyoming Sulfur Corporation. The deposit is located three miles west of Thermopolis. This study is being conducted by a Canadian engineering firm.

Trona

In 1988, the brightest aspect of the industrial mineral industry in Wyoming is the increase in trona production. A combination of factors, including a shortage of caustic soda (NaOH) for which soda ash (refined trona) may be used, has caused this increased demand and resulting production. Caustic soda is produced by reacting quicklime (CaO) with hydrous sodium carbonate. Soda ash may be used instead of synthetic sodium carbonate. Exports of soda ash have also increased. These factors have revitalized the Wyoming trona mining and refining industry. Wyoming produces almost 95% of all domestic soda ash. The five plants (see map on page 24) near Green River were operating at about 80% of their full capacity at the beginning of the year, but have now increased production to their full capacity. 35,560 tons of trona are now processed each day. While this boom in the trona patch is good news for Wyoming, industry officials are not predicting a lasting boom yet.

One official, Roger Harris of Tg Soda Ash Inc., says the boom is dependent on the substitution of trona for caustic soda. If this use continues, the boom will continue. Otherwise, the production of soda ash will slip back to 1987 levels. Most industry officials are saying that the plants will be running near full capacity for at least a year.

FMC Corporation, one of the five trona refiners, announced it will construct a 60-million-pound-per-year sodium cyanide plant at the site of FMC's soda ash plant west of Green River. Sodium cyanide is used in the extraction of gold from its ore. New gold mines and mills in Nevada, California, and elsewhere have increased the demand for sodium cyanide, convincing FMC of the viability of constructing a new plant. Trona is the sodium raw material used in the production of sodium cyanide. Methane from natural gas is another raw material available from Wyoming which is used in the production of sodium cyanide.

Bonneville Transloaders, Inc. (BTI), a Riverton, Wyoming, trucking firm that hauls soda ash from Green River to the Burlington Northern Railroad (BN) at Bonneville, Wyoming, near Shoshoni, has offered to purchase the railroad line from Shoshoni to Riverton from the Chicago

and North Western Railway (C&NW). BTI is primarily interested in changing its loading facility from Bonneville to Shoshoni, saving a much longer truck haul between these two locations. The use of the remainder of the 27-mile-long segment of track formerly operated by C&NW is uncertain. Several industries in Riverton will be without rail service if this line is abandoned. Most soda ash from Green River is shipped on the Union Pacific Railroad, which has rail spurs to all of the soda ash refineries. However, BN ships some soda ash to consumers through its system. This soda ash is hauled by BTI.

Uranium

In the third quarter of 1988, uranium oxide production from the Pathfinder (COGEMA) mill in the Shirley Basin decreased while production from both Everest Minerals' Highland *in situ* mine and Malapai Resources' Irigary and Christiansen Ranch *in situ* properties in the Powder River Basin increased.

The U.S.-Canada free trade agreement and other import-related issues continue to cloud the future of uranium production in the U.S. as well as Wyoming. However, the production costs of the two *in situ* operations in Wyoming may be very similar to the production costs of uranium mined in Canada.

The uranium industry in Wyoming has asked for help from the State of Wyoming through a reduction of severance tax rates from the current 5.5 percent to 2 percent. This relief would lower the cost of doing business in Wyoming, according to officials of Pathfinder Mines Company.

Other forms of relief for the ailing domestic uranium industry included a bill passed by the U.S. Senate that contained a provision sponsored by Wyoming Senators Simpson and Wallop which provided a $750 million uranium procurement program-- $80 million of which was to be purchased from small uranium producers. One billion dollars was also provided to clean up old uranium mill tailings sites, nine of which are in Wyoming. This bill was passed by the Senate, but was defeated in the House. Wyoming Representative Dick Cheney had introduced a similar bill in the U.S. House of Representatives to buy domestic uranium and provide money for a cleanup of mill tailings. The Senate-passed legislation was the result of a House-Senate compromise between the two bills.

On a related note, the U.S. Nuclear Regulatory Commission (NRC) revoked the license of a Utah company operating a depleted-uranium processing plant in Evanston, Wyoming. Depleted uranium is the material remaining after the process in which natural uranium, containing about 0.3% of the fissionable isotope U-235, is enriched to 3% U-235 for use in nuclear power plants. Depleted uranium is used in uranium chemicals, armor piercing shells, armor, and weights. The license of the Evanston plant was revoked due to alleged violations of their permit.

METALS AND PRECIOUS STONES UPDATE

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

Several companies continue to investigate low-grade, large-tonnage, epithermal gold and rare earth deposits in Tertiary igneous rocks in the Black Hills of Wyoming. Much of the activity is in the Bull Hill and Ogden Creek areas, where disseminated gold is associated with anomalous rare earth and manganese concentrations in altered trachyte (Hausel and Sutherland, 1988). According to the 1988 *Summer quarterly report* of the Narrow Gage Scout, International Curator Resources Ltd. has recently joined in the exploration for gold in this region.

South of the Bear Lodge Mountains, the little known Hurricane district, which produced a small amount of lead, zinc, and silver during the 1940s, was briefly examined by the Geological Survey of Wyoming. This district is located in Black Buttes, a heavily vegetated group of low-lying hills six miles south of Sundance, Wyoming. One prospect examined by Survey staff consisted of Tertiary trachyte intruding brecciated Mississippian Pahasapa limestone. The breccia is cemented by galena and contains many cavities filled with hemimorphite. Minor fluorite and wulfenite are also present. Wulfenite was confirmed by x-ray diffraction, and this is believed to be the first report of the lead-molybdenum-oxide in the region (Hausel, 1988a). Mineralization was accompanied by silicification, and a distinct jasperoid is present locally. East of Black Buttes, auriferous jasperoid and feldspathic breccia are present in the Mineral Hill district (Hausel and Sutherland, 1988).

This summer, gold exploration continued at South Pass in the southern Wind River Range of western Wyoming. Schuetz Tool and Die Company drilled along the eastern edge of the South Pass granite in structurally prepared sites, and trenching and drilling were reported elsewhere in the district by other companies. Activity was not as high as expected in that some Australian companies and a Canadian company with land holdings in the district were inactive because of financial losses suffered in last year's stock market decline. Additionally Gyorvary Mining Company, which was expected to begin mining this past summer, was unable to satisfy the Wyoming Department of Environmental Quality's rules and regulations.

Placer mining continued at the Stout mine on Rock Creek through the summer, and peanut and walnut sized nuggets were recovered by prospectors at a couple of locations elsewhere in the district. The possibility of large undiscovered gold deposits at South Pass remains very plausible. For example, one landowner in the district remembers an early 1970's drilling project by Anaconda Minerals Company on a paleochannel of the Sweetwater River. According to the landowner, the property was expected to be surface minable at gold prices above $200 per ounce. Maps and reports on Anaconda's project, however, are apparently not available.

Selected samples and grab samples collected from abandoned mines in the Sierra Madre.

Sample No.	Location	Description	Cu %	Au (ppm)**	Ag (ppm)**
DEQ-17-1	NE/4 sec. 8, T.12N., R.81W	Copper-stained amphibolite gneiss from narrow shear.	1.85	nd*	18.0
DEQ 17-2	SW/4 sec. 11, T.12N., R.82W.	Shallow shaft sunk on cupriferous amphibolite gneiss intruded by granite pegmatite.	0.95	nd	11.0
DEQ 17-6	SE/4 sec. 36, T.14N., R.84W.	Two- to four-foot wide pyritiferous quartz vein in mafic schist.	0.013	19.0	4.2
DEQ 17-9	SW/4 sec. 11, T.15N., R.87W.	Shear zone in chlorite schist.	0.014	nd	4.4

*nd - not detected
**34.3 ppm = 1 ounce per ton

A couple of interesting arsenopyrite-quartz vein samples were recently collected along the Sweetwater River in the Lewiston district of the South Pass greenstone belt. Most samples collected in the greenstone belt have relatively high Au/Ag ratios, but these samples collected in the SE/4 sec. 9, T.28N., R.98W. have anomalously low ratios. The sample from the hanging wall of the vein assayed 0.85 ppm gold with 130.0 ppm silver. The second sample with abundant arsenopyrite yielded 1.73 ppm gold with 24.0 ppm silver.

The Geological Survey of Wyoming also completed the eighth 1:24,000-scale quadrangle in a series of geologic maps covering the South Pass region. The eighth map of the series, the Louis Lake Quadrangle (Hausel, 1988b), is situated along the northwestern edge of the South Pass greenstone belt. This quadrangle includes a large section of the Louis Lake batholith, a felsic gneiss complex, serpentinites, talc-actinolite-chlorite schists, hornblendic amphibolites, banded iron formation, and metagreywacke. The Atlantic City open pit iron mine, which has been closed since 1983, is near the southeastern margin of the quadrangle.

The Medicine Bow Mountains continued to receive attention for platinum, palladium, and gold. Geochemical exploration with some trenching and drilling was reported by some companies, and a fifth company recently moved into the area.

The Geological Survey of Wyoming recently examined several abandoned mines in the Sierra Madre, which are scheduled for reclamation by the Wyoming Department of Environmental Quality. Both selected samples and grab samples were collected from the mine dumps for assay. These samples (see table on page 28) illustrate two important things: (1) many of these abandoned mines contain potential metal resources, and (2) the Encampment mining district, known for its historic copper production, must have also produced significant by-product gold and silver, which historians have generally ignored.

Possibly, the most interesting of these abandoned mine sites is site DEQ 17-6, located in Purgatory Gulch south of Encampment (Hausel, 1986). Following the discovery of Purgatory Gulch in the late 1800s, reports indicated some remarkably rich gold specimens were found. Some adits were driven into veins and shear zones, and placer deposits were mined in a portion of Purgatory Gulch in 1911 and 1912.

The DEQ 17-6 sample listed in the table on page 28, consisted of milky quartz filled with limonite boxworks, No visible gold was present. Another sample collected from the vein also contains abundant limonite boxworks in milky quartz with minor pyrite and one sliver of visible gold. This sample is available for inspection at the Geological Survey during normal working hours by contacting Dan Hausel at (307) 766-2286.

Turning to the Hartville uplift, various companies throughout the 1980's have explored that area for massive sulfides and unconformity deposits. Much of the attraction of the Hartville uplift is due to the variety of mineral deposits occurring there and to its exposed, extensive gossans. For example, there is the one-half mile long stratiform gossan found along 'gossan hill' in McCann Pass (sec. 26, T.28N., R.65W.).

Unconformity deposits in the uplift were targeted by Kerr-McGee Corporation in the uplift during the early 1980's. At one location (NW/4 sec. 13, T.27N., R.66W.) Kerr-McGee drilled and sampled an unconformity between Precambrian dolomite and Devonian to Mississippian quartzite and limestone. In one surface prospect, the exposed unconformity is stained with copper.

Samples taken along the unconformity contained copper carbonates with minor cerargyrite (AgCe), umangite (Cu_3Se_2), electrum (Au, Ag), and native gold. According to Kerr-McGee Corporation, this is only one of a few known localities in the world where the mineral umangite has been identified. Because of the significance of this discovery, Kerr-McGee Corporation recently donated a 7-page report on this deposit to the State Survey. This report is now available for free examination at the Wyoming Geological Survey Building on the University of Wyoming Campus. Photocopies can be purchased through the mail for $1.50, which covers copying charges and first class postage.

During the past eight years, the Metallic Minerals Division of the Geological Survey of Wyoming has been involved in a research project to locate anomalous regions in the State that potentially could host diamond-bearing kimberlite intrusives. The success of this project has exceeded all expectations, and to date more than 1,000 stream-sediment samples have been collected over a 800-square-mile region in the Laramie Mountains.

These stream-sediment samples were collected and panned in the field and the panned concentrates were later processed in the Survey's laboratories. These concentrates were microscopically examined for pyrope garnet and chromian diopside (two indicator minerals). More than 100 anomalies have been identified principally within three areas: (1) Happy Jack-Eagle Rock; (2) Middle Sybille Creek; and (3) Hallack Canyon-Laramie River (Hausel and others, 1988). In addition to the kimberlite indicator minerals, some other heavy minerals of interest were also noted such as gold, sapphire, and ruby.

The Metallic Minerals Division is planning a half-day seminar next spring for prospectors, geologists, rock hounds, and other people interested in how to locate kimberlite deposits and how to look for diamonds. Other topics will include gold prospecting and claim staking. For further information, contact Dan Hausel at (307) 766-2286.

References cited

Hausel, W.D., 1986, Mineral deposits of the Encampment mining district, Sierra Madre, Wyoming-Colorado: Geological Survey of Wyoming Report of Investigations 37, 31 p.

Hausel, W.D., 1988a, Black Buttes wulfenite: Geological Survey of Wyoming unpublished mineral report MR 88-1, 1 p.

Hausel, W.D., 1988b, Revised geologic map of the Louis Lake Quadrangle, Fremont County, Wyoming: Geological Survey of Wyoming Open File Report 88-12, scale 1:24,000.

Hausel, W.D. and Sutherland, W.M., 1988, The geology and metal resources of the Black Hills uplift, Wyoming: Wyoming Geological Association, 39th Annual Field Conference Guidebook, p. 285-293.

Hausel, W.D., Sutherland, W.M., and Gregory, E.B., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 11 p., 4 plates.

Narrow Gage Scout, 1988, Summer quarterly report: published by R.D. Odell, 243 South Center, Casper, Wyoming.

STRATIGRAPHY UPDATE

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

Division personnel have completed the field work for the Tallon Spring and Turk Springs Quadrangles. These preliminary geologic maps, which are part of a cooperative mapping project with the U.S. Geological Survey (COGEOMAP), will be released as open file reports after the first of the year. A total of five quadrangles have been released to date (see index map and list on page 32 and 33 of *Wyoming Geo-notes No. 19*). Several interesting problems relating to the Tensleep-Amsden contact, the Big Trails Fault System, and the pinchout of the Bighorn Dolomite were examined this field season.

The contact between the Tensleep Sandstone and the Amsden Formation in the Bighorn Mountains is problematic, and there is some disagreement among workers as to where to place the contact and what criteria to use. Many of the various interpretations are summarized by Sando, et al (1975). Most workers would agree that the contact is transitional. The contact in this case would be where the dominantly sandstone facies of the Tensleep changes to predominant limestone and shale of the Ranchester Limestone Member of the upper Amsden. However, in the area of the present study that upper limestone and shale sequence of the Amsden appears to be predominately sandstone with some interbedded thin carbonates and shale. The sandstones are marine, medium to fine grained, dense, and buff to tan in color. Those sandstones locally contain chert zones. The overlying Tensleep Sandstone is usually lighter in color, fine to medium grained, and more porous and permeable than the sandstones in the upper Amsden. This permeability and porosity difference is illustrated by the numerous trees growing on the Tensleep rocks and the lack of trees on the sandstones believed to be in the Ranchester Limestone Member of the Amsden Formation. Also the chert zones appear to be limited to these Amsden sandstones and interbedded carbonates. This placement of the contact is consistent with the contact described by Darton (1906), who named the Amsden Formation. In his 1906 report, Darton described the upper member of the Amsden on Otter Creek on the Tallon Spring Quadrangle as being primarily "buff to gray slabby sandstones with a moderate amount of chert near the top". Therefore, for the purpose of these preliminary maps, this upper member of the Amsden Formation or Ranchester Limestone Member is interpreted as a facies change from carbonates and interbedded shales to predominately sandstone. The contact, therefore, is shown as transitional and placed at the above described change in character in the sandstones.

The Big Trails fault system runs diagonally through the east half of the Tallon Spring Quadrangle. This fault system was examined during this field season and additional evidence was gathered to support the theory that the fault system is predominately strike-slip in nature combined with locally significant amounts of vertical offset. The main fault system trends N25°E. The fault is interpreted as being

right-lateral, i.e., the west block moved north relative to the east block. The numerous en echelon "horse-tail" faults that splay off the main fault system, are probably the result of drag on the main strike-slip system. Several localities along the main fault system exhibited slickensides which ranged from horizontal to 45° from horizontal, also implying prominent strike-slip motion. Two anticlinal folds were noted within a fault block bounded on the east and west by what are believed to be major strike-slip faults. These folds are oriented at an acute angle to the faults and plunge toward the west. The folds probably formed as a result of lateral movement and drag on the fault block. Also, in two localities along the major strike-slip system, estimates were made of the dip on the fault plane. These estimates were in the range of 80° to 85°, which is consistent with strike-slip faulting.

Fieldwork on the Turk Springs Quadrangle indicated an apparent pinchout of the Bighorn Dolomite toward the southeast corner of the quadrangle. The exact location of the pinchout is difficult to determine since the lower unit in the Madison Limestone is also a dolomitic limestone and the outcrop characteristics are quite similar. Paleontologic data is needed to identify an outcrop as either Bighorn Dolomite or Madison Limestone. Unfortunately, fossils are not always present. Preliminary work indicates the pinchout runs across the southern quarter of the quadrangle. Sando (1976) described a section of the Madison Limestone in Blue Creek Canyon on the southeast corner of the map and indicated that the Madison Limestone rested directly on Gallatin Limestone, with the Bighorn Dolomite apparently missing at this locality.

Next field season, the Division will concentrate efforts on the Horse Butte Quadrangle, immediately south of the Tallon Spring Quadrangle. Work on this quadrangle will allow further examination of the Big Trail fault system, to the south.

An interesting article relating to Laramide deformation in the Rocky Mountain region and more specifically Wyoming, was recently published in the Geological Society of America Bulletin. The article, *Paleogeographic and paleotectonic setting of Laramide sedimentary basins in the central Rocky Mountain region*, by W.R. Dickinson, et al, presents a synthesis of the history of sedimentation within several key Laramide basins in the region, including all the major Wyoming Laramide basins. Timing of Laramide deformation, Laramide paleodrainage, post-Laramide landscape, and implications of plate tectonics are addressed in this paper. This is an interesting summary article well worth reading.

References cited

Darton, N.H., 1906, Geology of the Bighorn Mountains: U.S. Geological Survey Professional Paper 51, 129 p.

Dickinson, W.R., et al, 1988, Paleogeographic and paleotectonic setting of Laramide sedimentary basins in the central Rocky Mountain region: Geological Society of America Bulletin, v. 100, p. 1023-1039.

Sando, W.J., Mackenzie, G., and Dutro, J.T., 1975, Stratigraphy and geologic history of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming: U.S. Geological Survey Professional Paper 848-A, 83 p.

Sando, W.J., 1976, Madison Limestone (Devonian and Mississippian), east flank of Bighorn Mountains: Wyoming Geological Association, 28th Annual Field Conference Guidebook, p. 45-52.

A NEW THRUST BELT FORMATION

by William E. Frerichs, Department of Geology and Geophysics, University of Wyoming

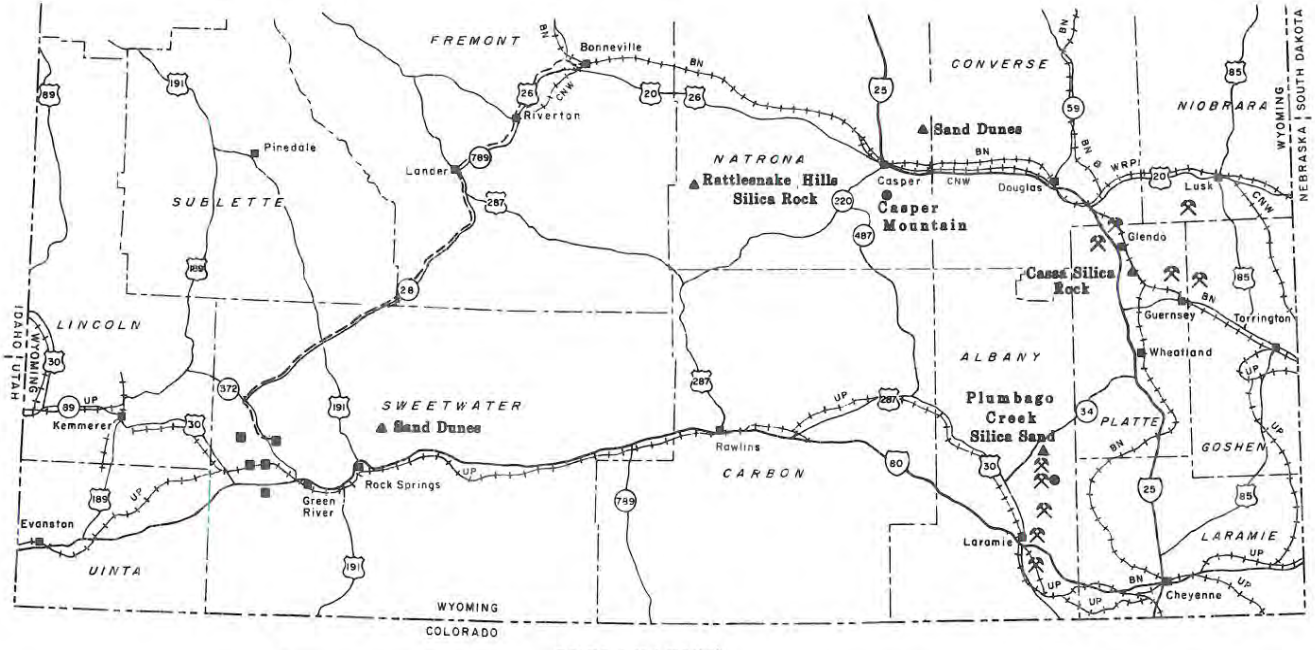
Mr. Nick Caparco is presently finishing a thesis project at the Department of Geology and Geophysics, University of Wyoming. His thesis is a study of Late Jurassic foraminifera from the Thrust Belt. One very important result of his work has been the recognition that the lower part of the Ephraim Formation, below the oldest major coglomerate in the formation, is a Late Jurassic marine sequence. The marine portion of the Ephraim (Lower Ephraim of some authors) will be named the Salt River Formation with the type locality at Salt River Pass just south of Smoot, Wyoming. The formation is overlain by the redefined Lower Cretaceous Ephraim Formation and overlies the Upper Jurassic Stump Formation. The age of the unit is Oxfordian and it is equivalent to the Redwater Shale of eastern Wyoming.

TWO SILICA DEPOSITS IN WYOMING

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

The two major raw materials used in the manufacture of glass are silica and soda ash. 95% of all soda ash produced in the United States comes from five soda ash refineries west of Green River, Wyoming (see figure on page 34). These refineries make soda ash by processing mined trona. If suitable silica deposits, the other major raw material of glass were located in the State, the possibility of starting a glass manufacturing industry becomes quite feasible.

Following up on this idea, two independent mineral owners approached the Geological Survey of Wyoming in 1986 and 1987 for assistance in evaluating their silica properties. With the help of the Survey, both were able to obtain funding for preliminary resource estimations and economic studies of their properties. Funding was obtained by the respective local governments through the planning-only block grant program administered by the Wyoming Economic Development and Stabilization Board (EDSB).



EXPLANATION

- ▲ Silica rock and silica sand occurrences
- ■ Soda ash refineries
- ● Feldspar deposits
- ⚒ Limestone deposits

Principal railroads
BN = Burlington Northern
CNW = Chicago and Northwestern
UP = Union Pacific
WRPI = Western Railroad Properties Inc. (UP & CNW)

Principal highways

Route of Bonneville Transloaders, Inc.

0 10 20 Miles
0 10 20 30 Kilometers

One silica deposit is located in Albany County, 30 miles northeast of Laramie. This locality contains a friable sand averaging about 80% SiO_2 (silica). The Survey was contacted by the mineral lessor (the deposit is located on State land) in late 1986 for assistance in determining the silica potential of the property. At the Survey's suggestion, the lessor met with the Albany County Board of Commissioners, who agreed to request funding from the EDSB. This funding was approved in January 1987, and, the property was drilled in July of 1987.

The Geologic Survey mapped the property before drilling and located 6 drill sites based on the site geology. Chemical analyses of samples from the drilling program were provided to the Survey in November 1987. The Survey provided a preliminary report on December 31, 1987, and the final report, Report of Investigations 40, *The Plumbago Creek silica sand deposit, Albany County, Wyoming*, was published in March of 1988.

A silica deposit in Platte County had a similar history. High-silica sandstone was known to be present on State land southeast of Glendo. Two individuals sought the assistance of the Survey to evaluate the silica sandstone. Assays of surface samples taken by a State Survey geologist showed that the sandstone contained more than 95% SiO_2. Upon advice from the Survey, the two individuals asked the Platte County Board of Commissioners to apply for an EDSB grant similar to that approved for Albany County. The commissioners approved a grant request in September, 1987, the grant was approved by the EDSB in November, and the property was drilled in December, 1987. The State Survey mapped the area prior to and following the drilling. The final report, Report of Investigations 42, *The Cassa silica rock deposit, Platte County, Wyoming*, was published in June, 1988. Reports on both deposits are available from the Geological Survey of Wyoming. For ordering information see page 43 and the inside back cover.

Based upon these studies, these two areas each contain large silica deposits with the potential of supplying silica for glass or related products. The deposits are different. The Plumbago (Albany County) deposit is of lower grade, but it is easily disaggregated and processed to higher grade material. The estimated silica resources at this site are at least 64 million tons. The Cassa (Platte County) deposit is of very high grade, but it is in harder rock requiring more processing. An estimated 34 million tons of silica exist on the surface at Cassa and many more million tons are present at depth. Both deposits are located near water, power, and transportation, which are necessary for the development of a viable glass industry.

Several silica producers have already reviewed the reports on both the deposits and some have been on one or both sites. Presently there is some consideration being given to either the production of plate glass or the production of a glass product in pellet form. Glass pellets are easily transported and can be made into all kinds of glass products at other locations, including overseas. The production of container glass (bottles) has been suggested, but transportation costs (shipping bottles includes shipping a lot of air) may preclude this product. The production of special glass for use in the transport and storage of hazardous materials, and the production of ferrosilicon, silicon fret, and other products is also being investigated by several companies.

HELIUM RESOURCES IN WYOMING

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

Helium is a valuable inert gas that has many uses. It is mainly used for breathing mixtures for divers, cryogenics, welding, pressurizing and purging systems, controlled atmospheres, and leak detection. Helium occurs naturally in the Earth's atmosphere, but the cost to extract it with existing technology is prohibitive. The only commercially produced helium at the present time is separated from natural gas, purified, and liquefied or compressed for shipment.

The U.S. Bureau of Mines has analyzed over 700 samples of natural gas from Wyoming fields for helium content (Moore and Sigler, 1987). Although most of the analyzed samples had at least a trace of helium, a few natural gas fields in the State had enough helium to favor the establishment of a helium extraction plant.

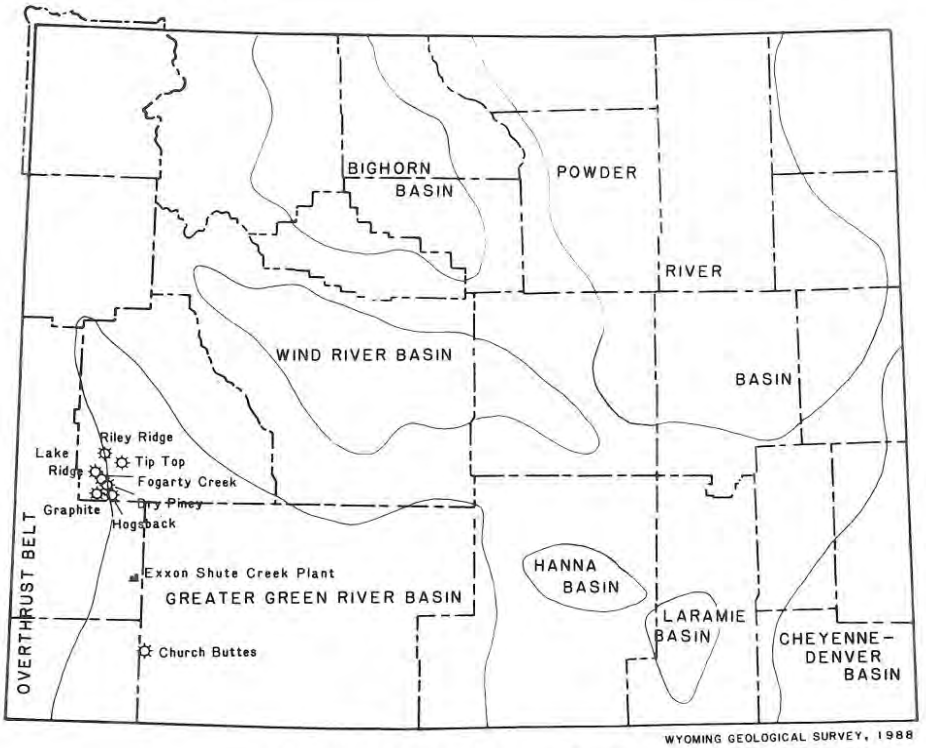
The only helium production in Wyoming at the present, however, is from Exxon's Shute Creek gas processing plant in southwestern Wyoming (see figure on page 37). Exxon's production of helium is around 840 million cubic feet per year. This helium production is a significant increase in the world's supply of this element. If Exxon's plant runs at capacity throughout its planned 50-year life, it will produce about 42 billion cubic feet of helium. There is a possibility that the plant's production capacity may be doubled. In that case, helium production could increase to 1.68 billion cubic feet per year and to 84 billion cubic feet over the life of the plant. The helium processed at Exxon's plant is coming from natural gas produced from the Madison Limestone at Lake Ridge, Fogarty Creek, and Graphite Fields (see figure on page 37). Average helium content of the gas at these field is 0.5 percent.

Other fields with the potential to produce significant amounts of helium include Dry Piney, Hogsback, Riley Ridge, and Tip Top. All of these fields are located near the fields which produce helium for Exxon's plant, and the helium from these fields also occurs in the Madison Limestone (see figure on page 37). Estimates of recoverable helium from these fields are 9 billion cubic feet at Dry Piney, 14 billion cubic feet at Hogsback, 20 billion cubic feet at Riley Ridge, and 40 billion cubic feet at Tip Top. In addition, there is an estimated 66 billion cubic feet of recoverable helium in the Madison in adjacent lands that are not yet unitized (U.S. Bureau of Land Management and others, 1983).

Church Buttes Field in southwestern Wyoming (see figure on page 37) also contains 17 billion cubic feet of recoverable helium in the Madison Limestone (Carr and Madden, 1975).

When the recoverable helium is added for all of the fields discussed above, Wyoming has a total of 250 billion cubic feet. This is more

than enough to supply the United States' demand for helium well into the next century.



HELIUM RESOURCES IN WYOMING

References cited

Carr, F.H., and Madden, D.M., 1975, Reserves and geologic study of helium-bearing Madison Formation, Church Buttes Unit, Uinta and Sweetwater Counties, Wyoming: Unpublished report to Branch of Helium Resources, U.S. Bureau of Mines, 15 p.

Moore, B.J., and Sigler, Stella, 1987, Analyses of natural gases, 1917-1985: U.S. Bureau of Mines Information Circular 9129, p. 1014-1069.

U.S. Bureau of Land Management, U.S. Forest Service, and Environmental Research and Technology, Inc., 1983 Draft environmental impact statement on the Riley Ridge natural gas project, Sublette, Lincoln, and Sweetwater Counties, Wyoming, U.S. Government Printing Office, p. 1-15 and 1-16.

RADON

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

It has been nearly impossible to read a newspaper in recent weeks without finding an article on radon. The U.S. Environmental Protection Agency (EPA) has estimated that in certain portions of the country a significant number of homes have indoor radon levels that exceed the EPA "action level" for radon. The "action level" is 4 picocuries per liter of air.

Radon, like radium and uranium, undergoes radioactive decay. When such elements decay, they release alpha particles (two protons and two neutrons), beta particles (identical to an electron), or gamma rays. A picocurie represents the decay of 2.2 atoms of radon per minute, which results in the release of 2.2 alpha particles. The alpha particles released by the decay of radon and the further decay of radon's decay products, can be especially damaging to lung tissue (see *Wyoming Geo-notes No. 13*, January, 1987, for a more detailed explanation). Lung cancer can result from long-term exposure to the alpha particles.

There are, however, other factors to consider besides the mere presence of radon in the home. Those factors are the rate of exposure and the length of time over which the exposure occurs. In *A citizen's guide to radon* released by EPA in August, 1986, a radon risk evaluation chart was presented. This is the same chart which has appeared in many newspaper and magazine articles. The chart infers that home radon exposure at 4 picocuries per liter has a lung cancer risk slightly greater than would arise from 200 chest x-rays per year. However, the chart does not specify over what length of time a person has to be exposed to radon to have the estimated effect. That question is answered in another section of the EPA pamphlet. It is stated that the risk estimates assume that 75 percent of a person's time is spent at home breathing radon at a specific level. The pamphlet also states that the risk estimates are based upon exposure for 70 years. Radon risk estimates for a specific level of radon therefore, are based upon being exposed eighteen hours a day for seventy years. If a person spends less time than that at home, the risk estimates will be different than stated in the radon risk evaluation chart.

A 1987 Consumer Report's book by Bernard Cohen, titled *Radon: a homeowners guide to detection and control*, has addressed some of the controversial issues surrounding radon. Health effects in the home have been based upon studies of levels of radon exposure and resultant lung cancer cases in uranium miners. Dr. Cohen has estimated that the lowest exposure rates (not total dose) for miners in the study were fifteen times higher than for a person with a radon concentration of 6 picocuries per liter in his home. However, a lifetime exposure to levels in excess of 10 picocuries per liter in the home would produce total lifetime exposure doses that would be in the same range as the

exposure doses at which lung cancer was found in uranium miners. It is not known whether total exposure is the only factor that counts, or whether the exposure rate is also important.

EPA has assumed that risk is linear or proportional to exposure. In other words, five times the exposure means five times the risk. It is with this assumption that the EPA has inferred health effects in the home from health effects seen in uranium miners. Dr. Cohen states that "the validity of this assumption has not been tested experimentally, especially at low doses." This is not to say that radon does not pose a risk to health. Living habits, rates of exposure, level of exposure, length of exposure, age, and smoking habits have to be taken into account when determining a specific radon risk for your home.

For a copy of *A citizen's guide to radon* contact the Denver Region of the U.S. EPA, Suite 1300, One Denver Place, 999 18th Street, Denver, Colorado, 80202. Copies can also be obtained from Julius Haes, Wyoming Department of Health and Social Services, Hathaway Building, 2300 Capitol, Cheyenne, Wyoming 82002.

SELENIUM IN WYOMING

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

Selenium is a naturally occurring element that is present in many geological formations and soils in Wyoming. As a result, it is also present in some surface water, ground water, and vegetation. Certain types of vegetation growing on seleniferous soils or bedrock can accumulate selenium. Early researchers felt that some vegetation required selenium to grow to maturity, resulting in the term "primary selenium indicator plants". While subsequent research has not confirmed that the selenium indicator plants require selenium for proper growth, the term "indicator" may still be applicable, although the term "accumulator" may be more appropriate.

The primary selenium indicator (accumulator) plants generally grow in areas of measurable selenium content, and in many cases can be associated with seleniferous geologic formations, which were defined by early researchers. In fact, the formations were roughly ranked based upon the levels of selenium found in the selenium accumulating plants growing on them. The geologic formations or equivalents of geologic formations that were felt to support primary selenium indicator plants that may be highly toxic to grazing animals in localized areas are as follows: Browns Park Formation, Wagon Bed Formation, Pierre Shale, Steele Shale, Cody Shale, Niobrara Formation, Hilliard Shale, Baxter Shale, Morrison Formation, and the Phosphoria Formation. Many other geologic formations have been roughly associated with less toxic selenium accumulating vegetation.

Certain ponds, lakes, or streams that are located on or flow over seleniferous geologic formations have levels of selenium that exceed recommended limits for human or animal consumption. Selenium levels are also elevated in ground water in certain areas of the State. Additional sampling and analyses are needed in order to properly define the distribution of selenium in surface and ground water in Wyoming.

Selenium has a dual nature, being both an essential micronutrient for human and animal health as well as a potential toxin. Early researchers reported that massive livestock kills associated with selenium occurred between 1907 and 1934 in the vicinity of Medicine Bow and Rock River. However, no detailed pathology was reported at the time of death, and current researchers feel that it is possible that other toxic, nutritional, infectious disease, or environmental factors may have been prevalent. In fact, the deaths occurred before a precise and reliable method of analysis for selenium was developed. As such, many of the early reports must be considered to be anecdotal.

No scientifically defensible reports of selenium toxicity in livestock or domestic animals are on file at the Wyoming State Veterinary Laboratory. If selenium toxicity in livestock or domestic animals has occurred, it has not been well reported or documented. Research is in progress on documenting the level and effects of selenium on fish and waterfowl in select areas of the State.

Acute and chronic poisoning of animals have been observed in controlled experiments. However, some poisoning thought by early researchers to be induced by selenium, may be associated with other elements or toxins. For example, what has been called "blind staggers" by early researchers can be partially induced by feeding certain animals specific types of seleniferous vegetation. Selenium alone has not induced the same set of symptoms, leading current researchers to postulate that other toxins in the vegetation may be responsible for the observed effects. Many of the observed symptoms may also be attributed to other disease processes such as polioencephalomalatia.

Most selenium researchers have as many questions as they do answers about selenium and its relationship to animal and plant systems. Much research is needed on nearly all aspects of selenium before any firm conclusions can be drawn.

U.S. GEOLOGICAL SURVEY'S CORE RESEARCH CENTER

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

The U.S. Geological Survey has moved their core research center to a new expanded facility at the Denver Federal Center. All cores which were formerly stored at the old core library at the Ward Road location

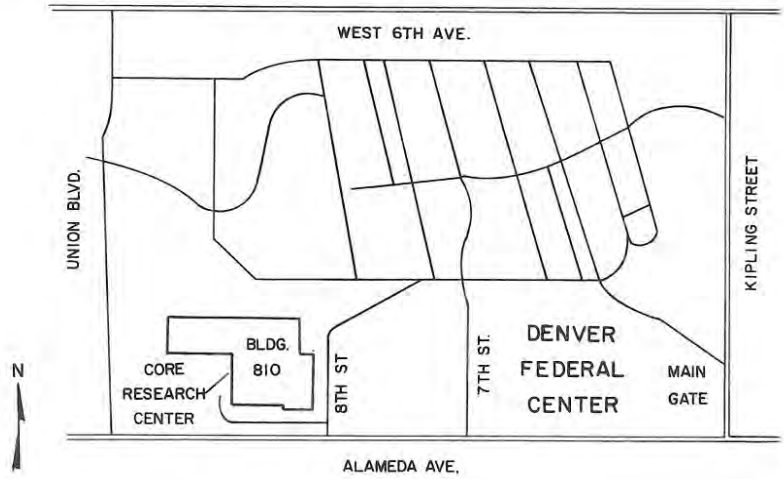
have been moved to Building 810 at the Federal Center (see figure on page 41). A temporary office is located at Entrance S-22 until new offices, a saw room, and an examination room are constructed (estimated completion date is March, 1989). Anyone who wishes to examine cores may do so at a temporary examination area. The U.S. Geological Survey cautions that access to individual core samples will be time-consuming until all cores are properly arranged and slabbing of core samples will be impossible until the new saw room is completed. A small trim saw is available for those who need samples for thin-sections. The U.S. Geological Survey encourages use of the new facility, but requests that anyone who wishes to examine cores should limit the number of cores they want to see and should call well in advance so the cores can be laid out in an efficient manner.

The core research center will continue to accept properly documented cores from anyone who would like to donate them. The new shipping address is:

U.S. Geological Survey
Core Research Center
Building 810, Entrance S-22
Denver Federal Center
Lakewood, Colorado 80225

Anyone who needs further information or anyone who wants to get cores set up for examination should contact the U.S. Geological Survey at the following address or telephone number:

U.S. Geological Survey
Core Research Center
Mail Stop 975, Box 25046
Denver Federal Center
Lakewood, Colorado 80225
(303) 236-1930



STEPHENA AKER RETIRES

Mrs. "Stephanie" Aker, a long-time resident of Laramie, officially retired from the Geological Survey of Wyoming on September 30, 1988 (see sketch on cover). Mrs. Aker has been the Administrative Secretary for the State Survey for 26 years. She began her long career with the State of Wyoming in 1962 when the Survey was still quartered in the Geology Building on the University of Wyoming Campus. Over these years, Mrs. Aker was the secretary to four State Geologists: the late Horace D. Thomas, Donald L. Blackstone, Jr., Daniel N. Miller, Jr., and Gary B. Glass. In 1976, she moved with the Survey into its new building beside the Geology Department. During her tenure, Mrs. Aker was a part of the Survey's growth from a one- or two-person operation to an Agency with 25 employees.

Many people recognize Mrs. Aker as the pleasant "voice of the Survey", who has greeted and routed incoming callers for over two and one-half decades. Many Wyoming alumni remember her for typing their theses or dissertations, especially the geology majors. More than 250 persons who came, went, or stayed on at the Survey as employees between 1962-1988 remember Mrs. Aker as the person who brought them on board, who answered their many questions, and who handed out their paychecks each month.

Survey employees hosted Mrs. Aker for lunch on September 22nd. In addition to being presented with a plaque and Certificate of Appreciation, Mrs. Aker was given a VCR recorder/player in recognition of her many years of service.

Although Mrs. Aker will stay on in Laramie, she plans to visit Seattle for awhile, where she will look after two of her grandchildren.

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).

*Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming, W.D. Hausel, W.M. Sutherland, and E.B. Gregory, Open File Report 88-11, 1988, ($12.00).

*Revised geologic map of the Louis Lake Quadrangle, Fremont County, Wyoming, W.D. Hausel, Open File Report 88-12, 1988, ($3.00).

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

*Analyses and measured sections of seven coal samples from the Rock Springs district, Green River Basin coal field, southwestern Wyoming, G.B. Glass and J.T. Roberts, Report of Investigations 41, 1988, ($4.00).

*Cassa silica rock deposit, Platte County, Wyoming, R.E. Harris, Report of Investigations 42, 1988, ($4.00).

*Geologic road log of part of the Gros Ventre River valley including the Lower Gros Ventre Slide, J.D. Love and J.M. Love, Reprint 46, 1988, ($6.00).

---

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

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

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. There is no postage charge on prepaid orders.

---------- Order Form ----------

Send this order to:

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

Your name, address, zip:

_____

_____

_____

_____

_____

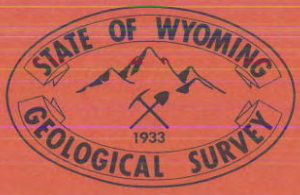
Price quoted – mailed fourth class. First class add $1.00 for every $5.00 of purchase. ($1.00 minimum – $5.00 maximum) Rolled maps, add $1.50 for tube.

No postage charged on prepaid orders

---------- Order Form ----------

Quantity	Title	Price	Total Price
	FIRST CLASS POSTAGE & ROLLED CHARGES		
		Total	

[No tax on State publications]


STATE OF WYOMING
1933
GEOLOGICAL SURVEY