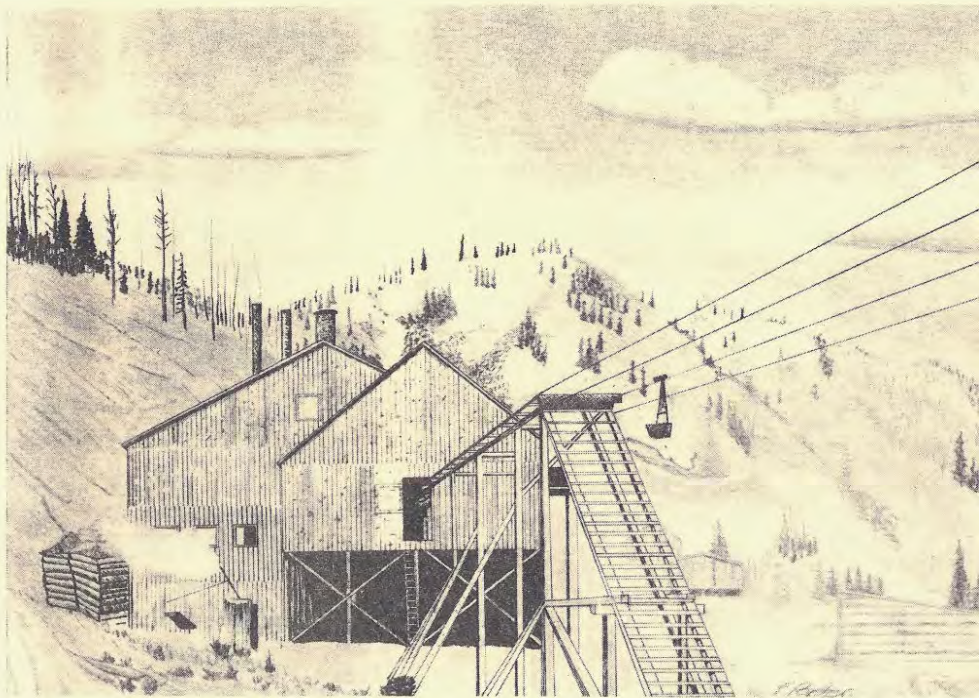


THE GEOLOGICAL SURVEY OF WYOMING  
Gary B. Glass, State Geologist

# WYOMING GEO-NOTES NO. 14



LARAMIE, WYOMING

April, 1987

## THE GEOLOGICAL SURVEY OF WYOMING

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### WYOMING GEO-NOTES

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

**Front cover:** Station No. 2 along the Ferris-Haggarty tramline in the Sierra Madre, southern Wyoming, as it probably looked in 1902. The construction of the Ferris-Haggarty tram was considered to be one of the greatest engineering feats of the early 1900s. The line began at the Ferris-Haggarty mine on the western flank of the Sierra Madre, crossed the 10,690-foot-high Continental Divide and ran down the eastern slope to the Boston-Wyoming smelter at Riverside, for a distance of about 16 miles. The line supported 840 ore buckets, which could each haul about 2.5 tons of ore. The tramline was designed for year-round operation.

Ore from the Ferris-Haggarty mine varied from 30 to 40 percent copper, carried some silver, and 0.1 to 0.37 oz/ton gold. Read pages 38 and 39 of this volume for more information about this historic mine and mining district.

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This and other publications available from: The Geological Survey of Wyoming  
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## MINERALS UPDATE

### OVERVIEW

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

The first quarter of 1987 provided more than a few pleasant surprises. Posted crude oil prices went from \$14.75 in December, 1986, to \$17.25 in March, 1987, although the increases were not a smooth upward trend. While these prices will not really accelerate exploration activity, they are certainly an improvement over the lower prices in the last half of calendar year 1986. Natural gas (methane) production for 1986 was substantially higher than predicted at an estimated 565.6 billion cubic feet. In addition, an estimated twenty-five billion cubic feet of carbon dioxide were produced at Exxon's Shute Creek gas plant in Sweetwater County. Coal production was also slightly more than expected at 135.7 million tons (about 0.7 million tons above estimates).

The Wyoming State Legislature also provided some tax relief to both the oil and gas industry as well as portions of the coal industry. In the case of oil and gas, bills passed that (1) lowered the severance tax rate on new wildcat wells drilled before 1990, (2) expanded the definition of stripper wells, (3) allowed a severance tax credit for companies using carbon dioxide produced in Wyoming, and (4) exempted certain unmarketed natural gas used at the wellhead or lease from severance tax assessments. A bill to provide a tax break to oil companies that employ and locate professional geologists, engineers, and others in Wyoming failed to pass.

In the case of coal, the Legislature set a cap on the taxable value of a ton of coal for severance tax purposes. A bill to delete Federal Black Lung and Reclamation taxes before calculating the taxable value of coal for severance tax purposes was defeated.

Also of considerable interest to natural gas producers and the State is a jointly proposed pipeline project by Williams Natural Gas Pipeline Company and Tenneco, Inc. Their Kern River pipeline project is one of several proposals before the Federal Energy Regulatory Commission (FERC). FERC must select one of these competing proposals to supply natural gas to new markets in Kern County, California. Indications are that the California market could increase to 1.09 billion cubic feet per day by 1990.

If FERC selects the Kern River Project, the pipeline would start in southwestern Wyoming and then run diagonally southwestward to California. Wyoming fields would probably supply half of the initial 700 million cubic feet per day needed in California. A project of this size in southwest Wyoming would go a long way toward finding markets for excess gas supplies now available in that area, would create numerous jobs, would provide an incentive for Exxon to proceed with

Phase Two of its Shute Creek gas plant project, and would help prevent exacerbation of the balance of payments problem by eliminating the need for importing large volumes of gas from Mexico or Canada (a significant part of some alternative plans). In late March, Governor Sullivan presented Wyoming's support for the Kern River Project in a public hearing held in Salt Lake City.

Another item of interest to Wyoming was the U.S. Department of Energy's call for proposals for siting a huge "supercollider". This \$4.4 billion project involves the construction of a nearly circular tunnel (52 miles in circumference) in which scientists will accelerate two beams of protons in opposite directions at near the speed of light, using 10,000 superconducting magnets installed in the tunnel. This research project is designed to answer many fundamental scientific questions. In Wyoming, a site has been proposed for the northern Red Desert Basin (about 40 miles north of Wamsutter). This site reportedly meets most if not all the geological criteria set forth in the Department of Energy's guidelines.

*Wyoming mineral production forecast to 1991<sup>1</sup>.*

Calendar Year	Oil Production <sup>2</sup>	Natural Gas Production <sup>3,5</sup>	Carbon Dioxide Production <sup>5</sup>	Coal Production <sup>4</sup>	Trona Production <sup>4</sup>	Uranium Production <sup>4</sup>
*1981	122.1	455.4	--	102.8	11.8	4.6
*1982	118.7	465.1	--	107.9	10.1	2.1
*1983	120.9	539.7	--	112.2	10.5	3.0
*1984	127.8	600.1	--	130.7	11.0	1.6
*1985	131.0	597.9	--	140.4	10.8	0.6
*1986				135.7		
1986	123.0	565.6	25.0		11.5	0.3
1987	115.5	605.0	75.0	149.0	11.7	0.3
1988	107.5	629.0	100.0	143.0	12.1	0.4
1989	100.0	664.0	100.0	146.0	12.1	0.5
1990	93.0	699.0	100.0	150.0	12.2	0.5
1991	86.5	730.0	100.0	151.0	12.5	0.6

\*Actual values for comparison, <sup>1</sup> Geological Survey of Wyoming, March, 1987, <sup>2</sup> Millions of barrels, <sup>3</sup> Billions of cubic feet, <sup>4</sup> Millions of tons, <sup>5</sup> Production estimates for natural gas are the only ones changed since January, 1987.

*Production history of selected other mineral commodities<sup>1</sup>.*

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

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

## OIL AND GAS UPDATE

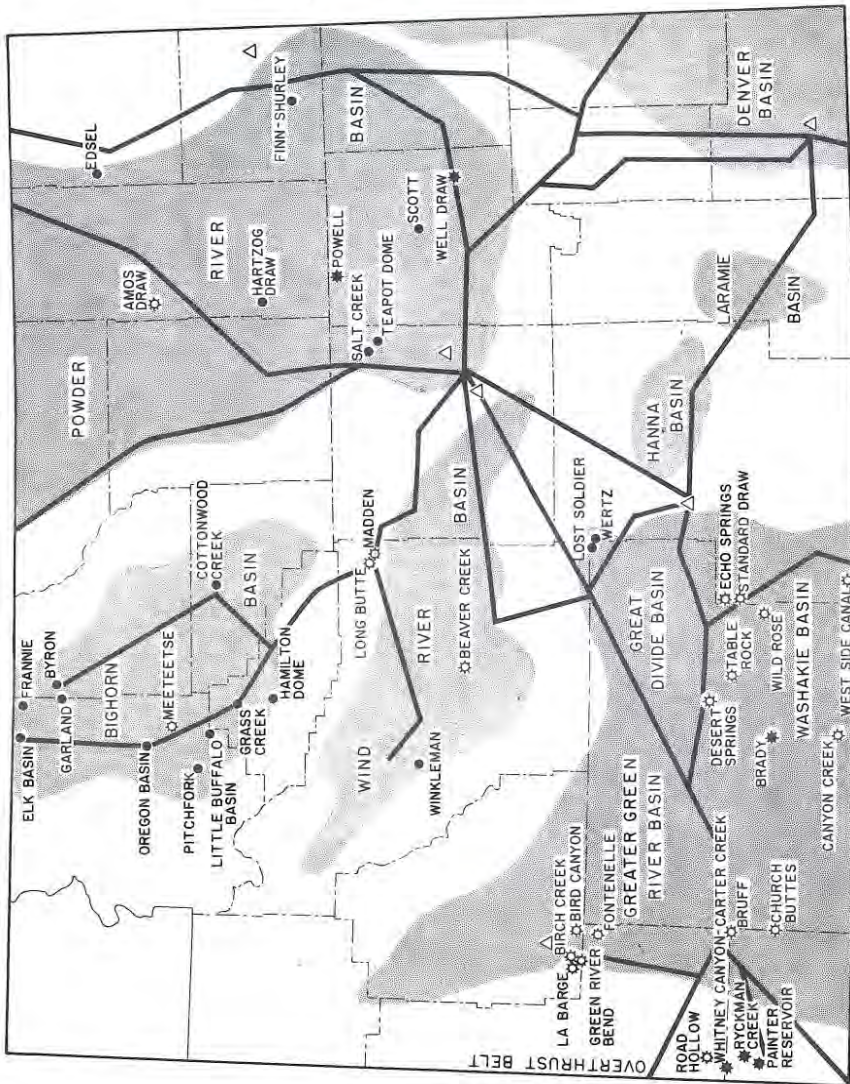
by Rodney H. De Bruin, Petroleum Geologist, Geological Survey of Wyoming

Since mid-December of 1986, the average posted price for Wyoming Sweet crude oil rose rapidly from \$14.75 to \$17.25. The price dropped back to \$16.25 in the second half of February when there was some concern that OPEC might abandon their production-price agreement because some OPEC members were apparently cheating on their quotas. Luckily, OPEC weathered that crisis and posted prices for Wyoming Sweet crude have returned to the \$17.25 level. The next three months will be a critical period for the OPEC agreement because of the decreased demand for crude oil near the end of the winter heating season. If OPEC is able to keep their production down through this period, prices should stay near their current level or possibly increase somewhat for the rest of 1987. Although this is good news for the domestic oil and gas industry, \$17 to \$18 for a barrel of oil is not enough to stimulate high levels of exploration and development drilling in Wyoming or the rest of the United States.

Four bills designed to provide some tax relief for Wyoming's beleaguered oil and gas industry were passed by the 1987 Legislature. The first bill subtracts the severance taxes paid by carbon dioxide producers from the severance taxes of oil producers using the carbon dioxide for Tertiary recovery projects in Wyoming. In a second bill, unmarketed natural gas used at the wellhead or lease was exempted from severance taxes. A third bill reduces the severance tax paid on the first four years of oil and gas production from wildcat wells drilled before 1990. The severance tax rate for this production was reduced to two percent. A fourth bill redefined stripper wells so that more low-production wells would qualify for the two percent severance tax break associated with "stripper" production.

Although these tax relief bills will not cause a boom in drilling activity, their passage does show that Wyoming is willing to provide some incentives to increase production and to help preserve a viable domestic petroleum industry. Unfortunately, the Federal Government seems unwilling to make any new concessions to help domestic producers. A recent six-month study for the Administration, finished in mid-March, found the United States will be importing half of its oil by the 1990s, posing a clear risk for national security unless steps are taken to boost domestic production. Figures from the Department of Energy for 1986 show that the U.S. imported 33 percent more oil in 1986 than in 1985, an increase of over one million barrels per day. Figures from the first 2.5 months of 1987 show that the U.S. imported around 30 percent more oil than for the comparable period in 1986, while domestic production for the 2.5-month period dropped an average of 750,000 barrels per day.

Faced with overwhelming evidence that the U.S. has become increasingly dependent on unstable sources of foreign oil at the expense of



GENERALIZED OIL AND GAS INDEX MAP OF WYOMING

WYOMING GEOLOGICAL SURVEY, 1986



domestic producers, Energy Secretary John Herrington has asked the White House to propose a major tax break for the oil industry in the form of a 27.5 percent annual depletion allowance for all oil- and gas-producing properties. However, as recently as two years ago, President Reagan called the depletion allowance a general production subsidy that does not provide an efficient incentive for resource production. He has also rejected the idea of an oil import fee. In addition, Congressional delegates from populous oil-hungry states are unlikely to endorse any measure that will raise the price of oil for their constituents. Many of these same Congressmen insist that curbing consumption rather than increasing domestic production is the way for our country to decrease its dependence on foreign oil. Opponents of this view insist that conservation measures are only effective during crisis situations such as the oil embargoes of the 1970s when oil was in short supply and when prices were rising dramatically. The bottom line is that the future of the Wyoming oil and gas industry is more dependent on the OPEC production agreement than on any energy policy in this country.

The U.S. Bureau of Land Management did announce that stripper wells could remain temporarily shut-in past an original one-year deadline without threatening lease forfeiture. The State will apparently follow the same guidelines to help prevent premature closure of stripper or other marginally-economic wells.

Preliminary production figures from the Wyoming Oil and Gas Conservation Commission show 1986 oil production at 121.3 million barrels. In past years, the final production figures have been greater than the preliminary figures due to late reporting of some production. Final production will probably be around 123 million barrels which is still a decrease of 6.1 percent or 8 million barrels from 1985 production. Preliminary natural gas production is estimated at 590.6 billion cubic feet, however, about 25 billion cubic feet of that total is carbon dioxide production. Natural gas production (excluding CO<sub>2</sub>) drops to 565.6 billion cubic feet, a decrease of 32.3 billion cubic feet or 5.4 percent below 1985 production (see table on page 2 and graph on page 9).

The rig count averaged 23 for the first three months of 1987. It should increase somewhat in the coming months if prices remain fairly stable. Traditionally, the count is low during the first few months of the year and then increases in later months (see graph on page 8).

The proposed Kern River pipeline is one of three pipeline routes being considered by the Federal Energy Regulatory Commission and the California State Land Commission to provide 700 million cubic feet of natural gas per day to southern California for use in Tertiary oil recovery projects and electrical generation. The Kern River line would originate near Opal, Wyoming. The line would carry at least 350 million cubic feet of gas per day from Wyoming. The other two pipelines that have been proposed would transport gas from Texas and the Southwest. If the Kern River proposal is chosen, Wyoming gas production would increase by nearly 130 billion cubic feet per year.

TOP 25 GAS FIELDS IN WYOMING BASED ON 1985 PRODUCTION

Name	Year dis- covered	1985 Production (MCF)	Cumulative pro- duction through 1985 (MCF)
Whitney Canyon - Carter Creek	1978	109,834,127	304,509,213
Painter Reservoir	1977	71,903,356	272,395,994
Brady	1973	21,350,632	219,310,370
Table Rock	1946	20,451,870	384,260,489
Echo Springs	1976	18,247,865	99,531,473
Ryckman Creek	1976	16,402,064	67,077,892
Powell	1954	14,525,391	44,957,832
Standard Draw	1979	13,032,332	61,867,786
Madden	1969	11,257,510	220,036,657
Bruff	1974	10,833,216	78,713,861
Long Butte	1982	10,319,659	32,707,991
Amos Draw	1982	10,056,546	17,284,308
Beaver Creek	1938	9,083,218	534,722,318
Wild Rose	1975	8,612,453	53,834,294
Church Buttes	1956	8,217,578	336,599,451
Desert Springs	1958	6,515,804	238,213,340
Road Hollow	1981	6,261,810	10,223,515
La Barge	1925	6,193,973	202,329,406
Meeteetse	1954	6,087,908	9,373,618
Birch Creek	1957	5,801,310	153,740,282
West Side Canal	1964	5,211,606	120,160,813
Canyon Creek	1941	4,759,211	233,266,085
Green River Bend	1958	4,579,841	166,550,082
Bird Canyon	1971	4,556,636	26,207,313
Fontenelle	1974	4,296,180	34,701,440
<b>TOTAL</b>		<b>408,392,096</b>	<b>3,922,575,823</b>

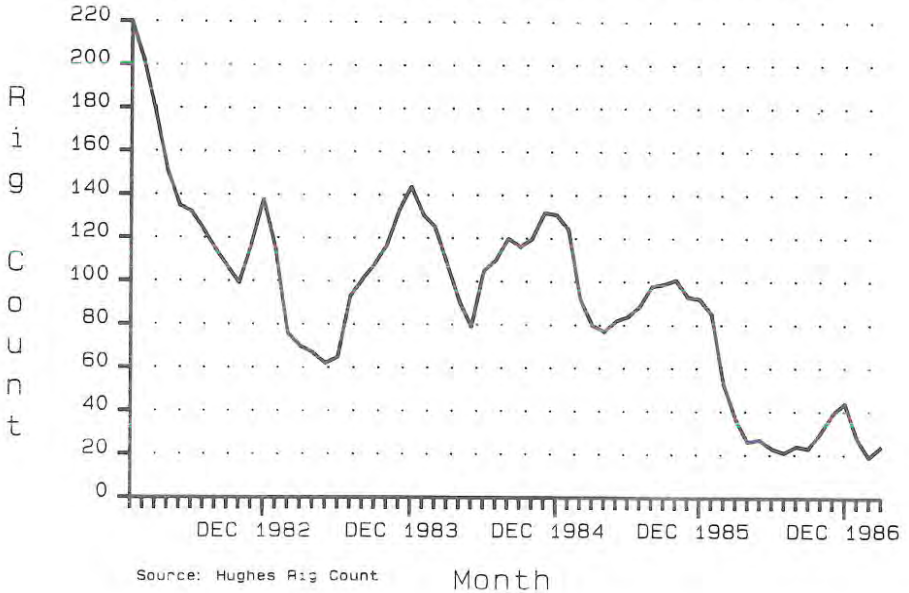
TOP 25 OIL FIELDS IN WYOMING BASED ON 1985 PRODUCTION

Name	Year dis- covered	1985 Production (Barrels)	Cumulative pro- duction through 1985 (Barrels)
Oregon Basin	1912	9,671,706	360,112,778
Painter Reservoir	1977	7,711,152	37,996,305
Salt Creek	1889	6,114,941	610,625,925
Hartzog Draw	1976	5,221,538	46,477,313
Little Buffalo Basin	1914	3,894,253	109,493,484
Powell	1954	3,511,650	11,494,722
Brady	1973	3,487,542	47,037,899
Hamilton Dome	1918	3,266,556	221,237,338
Elk Basin	1915	3,209,906	423,163,041
Lost Soldier	1916	2,891,876	202,639,471
Garland	1906	2,871,820	154,800,791
Grass Creek	1914	2,468,906	177,606,460
Wertz	1921	2,385,066	90,618,339
Byron	1918	2,066,748	116,537,485
Whitney Canyon - Carter Creek	1978	2,005,344	4,053,463
Frannie	1928	1,807,888	108,245,845
Winkleman	1917	1,387,341	82,895,832
Ryckman Creek	1976	1,356,207	13,764,438
Scott	1979	1,277,113	8,801,583
Pitchfork	1930	1,121,636	29,505,530
Teapot Dome Naval Reserve	1922	1,076,595	16,894,643
Edsel	1981	1,046,569	1,850,800
Cottonwood Creek	1953	956,203	50,259,079
Finn-Shurly	1965	912,705	6,121,096
Well Draw	1973	896,280	24,891,927
<b>TOTAL</b>		<b>73,210,302</b>	<b>2,957,125,587</b>

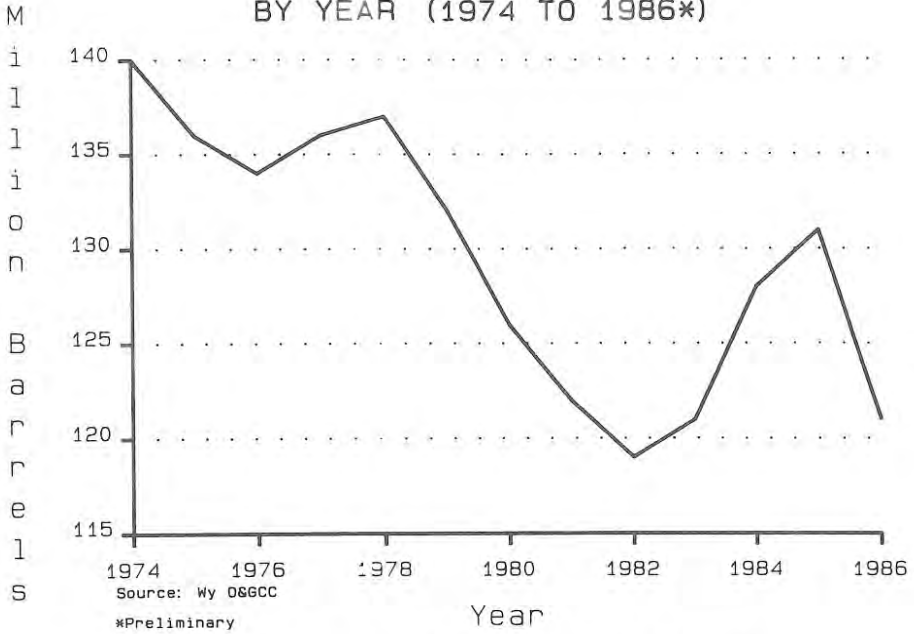
WYOMING RIG COUNT  
 AVERAGED BY YEAR (1974 TO 1986)



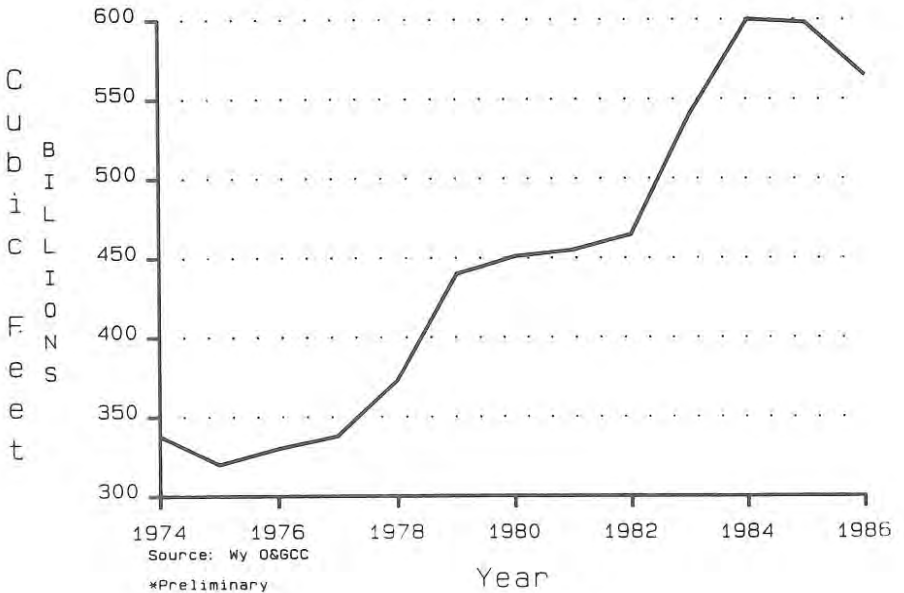
WYOMING RIG COUNT  
 AVERAGED BY MONTH (1982 TO PRESENT)



WYOMING OIL PRODUCTION  
BY YEAR (1974 TO 1986\*)



WYOMING NATURAL GAS PRODUCTION  
BY YEAR (1974 TO 1986\*)



Lease sale revenues and average prices per acre sold have rebounded somewhat from the extreme lows experienced in late 1986. The Wyoming Board of Land Commissioners has held two sales since the last issue of *Wyoming Geo-notes*. The January sale drew high bids of \$300,404 for 74 tracts covering 32,606 acres, an average of \$9.21 per acre. American Oil and Gas, Las Vegas made the high per-acre bid of \$2,300 for a 40-acre tract in section 13, T.49W., R.70W. in Campbell County. The tract is on the south side of Moran Field, a Minnelusa oil producer. Bids for the two top tracts in this sale accounted for 66.5 percent of all generated revenue.

The Wyoming Board of Land Commissioners' March sale received high bids of \$270,234 for 35,770 acres. Of the 200 tracts offered, only 83 received bids with an average bid of \$7.55 per acre. The high per-acre bid of \$100 was made by Exxon for a 440-acre tract in the overthrust belt, section 28, T.15N., R.120W. The parcel is about one mile from Yellow Creek Field. Bids for the two top tracts generated 36.9 percent of the total revenue for this sale; 43 of the tracts received the minimum bid of \$1 per acre. These two sales are summarized in the table on page 11.

The Bureau of Land Management's (BLM's) February sale drew high bids of \$814,653 on 64 of the 78 tracts offered. The average bid was \$52.43 per acre for the 15,537 acres sold. Powder River Basin leases accounted for the top seven per-acre bids, and Lario Oil and Gas made the sale's top bid of \$1,226.56 an acre for an 80-acre parcel in section 32, T.50N., R.69W. The lease is in the southwestern part of Brennan Field which produces oil from the Minnelusa Formation. For comparison with past sales, see the table on page 11.

Luckey Ditch Field in Uinta County continues to expand. Sun Exploration and Production recovered 2.8 million cubic feet of gas and 311 barrels of oil during a 21-hour production test of the Dakota at the 5 Luckey Ditch Federal-C well in section 9, T.12N., R.114W. Sun is now drilling the 8 Luckey Ditch Federal-F in section 10, T.12N., R.114W. Diamond Shamrock tested their 33-3 Taylor Ranch Unit-Federal well in section 3, T.12N., R.114W. for 72 barrels of condensate and 1.26 million cubic feet of gas per day from the Dakota (see *Wyoming Geo-notes No. 13*, pages 12 and 13 for an index map and more information on Luckey Ditch Field). Sun recently opened a natural gas processing plant in the field, with a capacity of 20 million cubic feet per day, to handle gas production from Luckey Ditch wells.

Thermal Exploration has confirmed their Dakota discovery in Lincoln Road Field with the completion of the 2-9 Lincoln Road well in section 9, T.24N., R.111W. The well flowed 8.3 million cubic feet of gas and 387 barrels of condensate per day. Thermal's discovery well in section 10, T.24N., R.111W. flowed 6.99 million cubic feet of gas and 323 barrels of condensate per day. In section 15 of the same township, Thermal is waiting on a completion unit at their 2-15-A Lincoln Road well. Texaco is testing its 1 Govt-C.E. Brehm in section 3, T.24N., R.111W. and has staked two more Dakota tests in the area.

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
<b>TOTAL</b>	<b>\$13,735,154</b>	<b>999</b>	<b>772</b>	<b>331,177</b>	<b>232,854</b>	<b>\$ 58.99</b>	<b>\$ 2,609.53</b>
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
<b>TOTAL</b>	<b>\$ 7,265,390</b>	<b>776</b>	<b>583</b>	<b>211,350</b>	<b>152,428</b>	<b>\$ 47.66</b>	<b>\$ 3,313.13</b>
1987							
February	\$ 814,653	78	64	18,866	15,537	\$ 52.43	\$ 1,226.56

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
<b>TOTAL</b>	<b>\$ 5,891,224</b>	<b>1,299</b>	<b>723</b>	<b>539,652</b>	<b>277,959</b>	<b>\$ 21.19</b>	<b>\$1,700.00</b>
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
<b>TOTAL</b>	<b>\$ 2,448,160</b>	<b>1,199</b>	<b>522</b>	<b>483,326</b>	<b>205,757</b>	<b>\$ 11.90</b>	<b>\$ 370.00</b>
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

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

In an important test on the Owl Creek uplift, W.A. Moncrief Jr. has gauged a flow of one million cubic feet of gas per day at the 12-2 Steffin Hill II Unit well in section 12, T.39N., R.93W. The well was tested in an unstimulated Frontier interval at about 20,000 feet. Plans call for the well to be acid-treated before future tests are run.

McAdams, Roux, and Associates' Little Missouri Field in Crook County has added two new producing wells. The discovery well, the 1-5 Fowler in section 5, T.54N., R.67W. pumped 575 barrels of oil per day from an untreated Minnelusa interval. The discovery was confirmed with the completion of the west offset 3-5 Fowler also in section 5, T.54N., R.67W., which pumped 80 barrels of oil and 46 barrels of water per day from the Minnelusa. A northwest offset, the 1-32 Federal in section 32, T.55N., R.67W. was completed, pumping 256 barrels of oil per day from the Minnelusa. The company is drilling a fourth test and has staked locations for two more in the area.

In another important discovery in the Powder River Basin, Phillips Petroleum has projected an initial production rate of 229 barrels of oil per day based on a drillstem test of the Frontier at their discovery well, the Phillips 1 Nutcracker-A in section 8, T.38N., R.75W. Phillips has scheduled seven other wells to test the Frontier as well as the Muddy and Dakota near the indicated discovery.

Amoco Production plans to test the Darwin sandstone Member of the Amsden Formation by reentering a dry hole in Little Buffalo Basin Field in the Bighorn Basin. The well is in section 12, T.47N., R.100W. There is no production from the Darwin in the area.

A Tulsa, Oklahoma, firm was awarded the contract for Phase II construction of a carbon dioxide processing and injection facility near Bairoll. An Amoco spokesman said the project will require a peak work force of 160 and should be completed by late summer. Phase I was completed last fall and included the construction of injection and pressurization facilities and construction of a 19-mile-long pipeline spur. Some carbon dioxide from Exxon's Shute Creek plant has already been injected into Wertz Field. The Phase II construction work will be for facilities to recycle the carbon dioxide that is produced with the oil.

Under a bill introduced in the U.S. House of Representatives, oil shale claims on 56,000 acres of Federal land in Lincoln County, Wyoming, would be vacated or converted into Federal mineral leases for oil shale only. The legislation was prompted by a Federal court decision that allowed the sale of 82,000 acres of Federal land in Colorado at \$2.50 per acre. Representative Rahall of West Virginia said present claims are preventing other mineral development and are being held for speculation, not for development.

## COAL UPDATE

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

Final 1986 coal production figures for Wyoming show that the State produced about 135.7 million short tons of coal. This ranks the State second in the Nation in coal production for the second year in a row. Kentucky continued to lead the Nation in coal production with over 160 million short tons produced in 1986 while West Virginia remained third with almost 130 million tons. Total U.S. coal production of 888.2 million short tons in 1986 was up about 0.5 percent from 1985's 883.6 million tons. Wyoming coal producers accounted for about 15 percent of the Nation's total in 1986, down slightly from the State's 16 percent share in 1985.

The production decrease in Wyoming in 1986 is the first decrease in coal production recorded in the State in 18 years. The 1986 production is a decrease of 3.6 percent or 5.0 million tons from 1985's record-breaking production of 140.7 millions. Despite the decreased production overall, ten of the State's coal mines did show production gains in 1986 (see table on page 14). The largest increases occurred at the State's two newest coal mines, Antelope Coal Company's Antelope mine and Rochelle Coal Company's Rochelle mine (see figure on page 15 for mine locations). Both these mines are located in the southern part of the "Gillette strip" in the eastern Powder River Basin and 1986 is the first full year of production for each mine.

Although Powder River Basin coal production was about two percent less in 1986, the basin still increased its share of the State's production from 85.3 percent in 1985 to 86.3 percent in 1986 (see table on page 16). In this coal basin, Campbell County production decreased by about 2.6 percent in 1986. Sheridan County experienced a much larger decrease (43 percent) due to a million ton production drop at the county's primary mine, Big Horn Coal Company's Big Horn mine north of Sheridan (see figure on page 15 for mine locations). Converse County production increased about 1.2 million tons in 1986 as the Antelope mine came on line. Production from the Antelope mine more than offset a 0.5 million ton decrease at Glenrock Coal Company's mine north of Glenrock. This mine, which is captive to Pacific Power and Light Company's (PP&L) nearby Dave Johnston power plant, was forced to cut production (and to permanently lay off 100 coal mining personnel) in response to a decrease in power generation at the Dave Johnston plant. It was announced in late March, 1987, that full electrical output from Dave Johnston, as well as the Wyodak coal-fired plant east of Gillette, would be restored; a decision on whether or not to rehire the 100 coal miners at Glenrock is still pending.

Eight of the top ten coal-producing mines in the State were located in Campbell County in 1986; six of these mines produced in excess of ten million tons of coal each, and Thunder Basin Coal Company's Black Thunder mine produced over 20 million tons. The Black Thunder mine has been the State's and the Nation's leading coal-producing mine



1985 and 1986 WYOMING COAL PRODUCTION AND EMPLOYMENT<sup>1</sup>

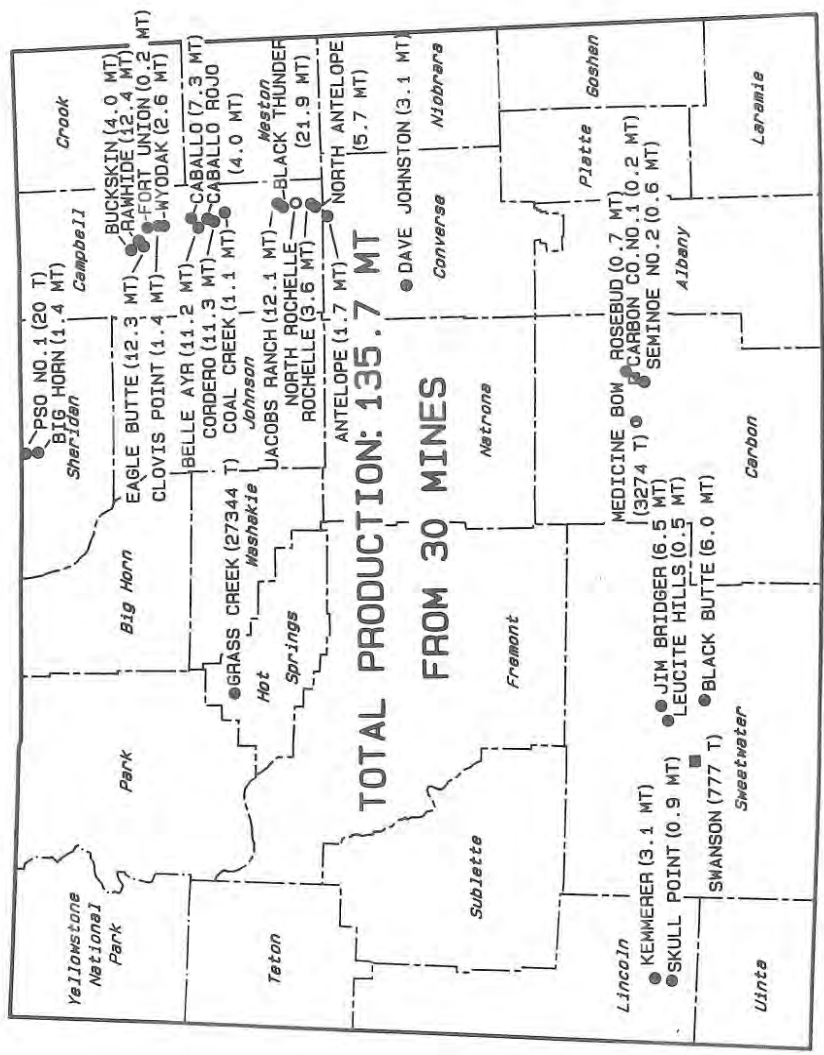
Company	Mine Name	1985		1986	
		Employees	Production (short tons)	Employees	Production (short tons)
<b>POWDER RIVER BASIN</b>					
Amax Coal Company	Belle Ayr (strip)	358	12,829,379	343	11,245,901
	Eagle Butte (strip)	293	11,808,014	287	12,278,000
Antelope Coal Company	Antelope (strip)	31	66,344	36	1,709,497
Ash Creek Mining Company	PSO No. 1 (strip)	1	2,989	1	20
Big Horn Coal Company	Big Horn (strip)	201	2,400,000	123	1,360,805
Carter Mining Company	Caballo (strip)	184	8,977,927	194	7,272,741
	Rawhide (strip)	186	12,236,695	181	12,403,975
Cordero Mining Company	Cordero (strip)	271	10,085,299	252	11,314,275
Fort Union Coal Company	Fort Union (strip)	36	532,716	15	219,313
Glenrock Coal Company	Dave Johnston (strip)	284	3,508,059	175	3,051,331
Kerr-McGee Coal Corporation	Clovis Point (strip)	78	1,423,649	75	1,435,045
	Jacobs Ranch (strip)	336	12,967,996	319	12,050,711
Mobil Coal Producing, Inc.	Caballo Rojo (strip)	117	4,221,574	109	3,989,622
North Antelope Coal Company	North Antelope (strip)	136	5,720,425	130	5,689,608
Rochelle Coal Company	Rochelle (strip)	14	206,565	43	3,569,806
Thunder Basin Coal Company	Black Thunder (strip)	621	23,207,616	504	21,868,336
	Coal Creek (strip)	56	2,608,592	28	1,111,305
Triton Coal Company	Buckskin (strip)	104	3,958,420	90	3,996,492
Wyodak Res. Develop. Corp.	Wyodak (strip)	68	3,163,026	65	2,600,000
<b>TOTAL</b>		<b>3,375</b>	<b>119,924,885</b>	<b>2,972</b>	<b>117,166,783</b>
<b>HANNA BASIN</b>					
Amar <sup>2</sup>	Seminole No. 2	11	37,721	16	96,362
Arch Mineral Corporation	Seminole No. 1 (strip)	15		30	
	Seminole No. 2 (strip)	144	1,256,586	106	543,071
Carbon County Coal Company	Carbon No. 1 (deep)	278	1,060,367	21	163,700
Medicine Bow Coal Company	Medicine Bow (strip)	13	288,425	14	3,274
Rosebud Coal Sales	Rosebud (strip)	92	613,832	85	707,021
<b>TOTAL</b>		<b>553</b>	<b>3,256,931</b>	<b>272</b>	<b>1,513,428</b>
<b>GREEN RIVER BASIN</b>					
Black Butte Coal Company	Black Butte (strip)	496	5,508,428	494	5,984,526
Bridger Coal Company	Jim Bridger (strip)	422	7,224,977	419	6,480,450
Prospect Point Coal Company	Laucite Hills (strip)	62	417,075	50	474,200
Western Wyoming Fuels	Swanson (deep)	2	894	1	777
<b>TOTAL</b>		<b>982</b>	<b>13,151,374</b>	<b>964</b>	<b>12,939,953</b>
<b>HAMS FORK REGION</b>					
FMC Corporation	Skull Point (strip)	106	911,196	101	905,893
Pittsburg and Midway Coal Mining Company	Eikol and Sorenson (strip)	355	3,418,392	358	3,127,668
<b>TOTAL</b>		<b>461</b>	<b>4,329,588</b>	<b>459</b>	<b>4,033,561</b>
<b>BIGHORN BASIN</b>					
Northwestern Resource Company	Grass Creek (strip)	3	31,208	4	27,344
<b>TOTAL</b>		<b>3,374</b>	<b>140,693,986</b>	<b>4,671</b>	<b>135,681,069</b>

<sup>1</sup> Sources: Wyoming State Inspector of Mines, 1985 Annual Report and 1986 preliminary data; Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division, 1986 Annual Report.

<sup>2</sup> Auger mining operation under contract with Arch Mineral.

EXPLANATION

- Active surface coal mine
  - Active underground coal mine
  - Inactive or recently closed surface coal mine
  - ◻ Inactive or recently closed underground coal mine
  - Surface coal mine under construction
- MT = millions of tons  
T = tons



1986 WYOMING COAL PRODUCTION BY COUNTY AND COAL BASIN<sup>1</sup>

County	Production	Percent of Total Production	Number of Producing Mines	Number of Employees
POWDER RIVER BASIN				
Campbell	111,045,130	81.8	15	2,635
Converse	4,760,828	3.5	2	213
Sheridan	1,360,825	1.0	2	124
TOTAL	117,166,783	86.3	19	2,972
GREEN RIVER BASIN				
Sweetwater	12,939,953	9.5	4	964
HAMS FORK REGION				
Lincoln	4,033,561	3.0	2	459
HANNA BASIN				
Carbon	1,513,428	1.1	4	272
BIGHORN BASIN				
Hot Springs	27,344	<0.1	1	4
TOTAL WYOMING	135,681,069		30	4,671

<sup>1</sup>Source: Wyoming State Inspector of Mines, preliminary data for 1986.

since 1982. Carter Mining Company's Rawhide mine took over second place in State coal production, followed by Amax Coal Company's Eagle Butte mine and Kerr-McGee Coal Corporation's Jacobs Ranch mine. Cordero Mining Company's Cordero mine was the State's fifth leading coal producer and Amax Coal Company's Belle Ayr mine, usually the second or third largest mine in the State, dropped to sixth place in 1986. Four of these top six coal mines recorded decreased coal production that ranged from 1.0 to 1.7 million tons less than 1985; two of these top six mines, the Cordero mine and the Rawhide mine, reported increased production. Other mines in the Powder River Basin reporting significant production decreases in 1986 included Carter Mining Company's Caballo mine (down 1.7 million tons), Thunder Basin Coal Company's Coal Creek mine (down 1.5 million tons), and Wyodak Resource Development Corporation's Wyodak mine (down 0.6 million tons).

Coal production from the Hanna Basin (Carbon County) in 1986 was about 54 percent below that of 1985 and is now at its lowest level since 1969. Although four coal mines in this basin did report coal production in 1986, only the Seminole No. 2 and the Rosebud mine were actively mining coal at the end of the year. The State's only major underground mine, the Carbon County No. 1, produced only a small amount of coal in early 1986, as did the Medicine Bow mine. Mines in this basin once accounted for nearly half the State's coal production (in 1973) but now only account for about one percent of the total.

Four mines in the Green River Basin (Sweetwater County) accounted for almost ten percent of the State's total coal production in 1986. Overall production for this basin was down slightly from 1985 production. Coal production at Black Butte Coal Company's mine increased by about 0.5 million tons while Bridger Coal Company's Jim Bridger mine reported a 0.7 million ton decrease in production. The two mines mentioned above were the eighth and ninth largest mines in the State in 1986.

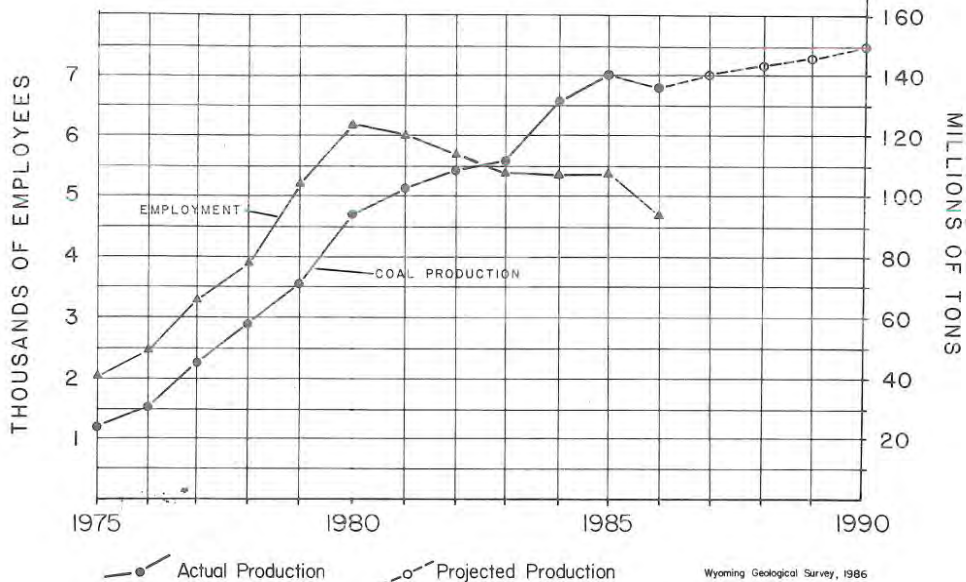
In the Hams Fork Region (Lincoln County), both mines reported a decrease in their production in 1986; the region accounted for about three percent of the State's production for that year. Northwestern Resource Company's Grass Creek mine in the Bighorn Basin remained the only active coal mine in northwestern Wyoming.

Employment in the State's coal mines also decreased in 1986. The 703 fewer employees in 1986 is a decrease of about 13 percent from 1985 and is the highest rate and amount of decrease recorded since the State's coal mine employment began to drop in 1981 (see figure on page 18). Only seven coal mines in the State reported increases in employment in 1986 (see table on page 14); two of these seven mines were the newest Powder River Basin mines, the Rochelle and Antelope mines. Although employment in the State's coal mines is at its lowest level since 1978, the amount of coal each employee accounts for has risen from 26,108 tons/miner in 1985 to 29,045 tons/miner in 1986.

The most significant employment decreases in 1986 occurred in the Hanna and Powder River Basins. The closure of the Carbon County No. 1 mine in the Hanna Basin resulted in the loss of 257 jobs and contributed greatly to the loss of half the coal mining jobs in Carbon County. The employment situation in the Hanna Basin worsened with the announcement that 15 hourly employees at Rosebud Coal Sales Company's Rosebud mine would be laid off in early January, 1987. The Powder River Basin experienced the loss of 403 jobs in 1986. The greatest losses in this basin occurred in Campbell County where 223 jobs, including 117 at the Black Thunder mine, were lost. Big Horn Coal Company in Sheridan County reported 78 fewer employees in 1986 and Glenrock Coal Company reported 109 fewer employees at the Dave Johnston mine in Converse County (see *Wyoming Geo-notes No. 12*, p. 25 and p. 28). In a related development, PP&L announced in February that 12 positions at the Dave Johnston power plant were being eliminated in a cost-cutting measure.

The outlook for coal production in the State still remains optimistic (see figure and table on page 19). Coal production for 1987 is expected to increase a modest three percent above the 1986 level. This increase in production will probably follow the expected national increase in coal production of three percent. Increases in the State's coal production in years beyond 1987 are expected to follow the national increases in demand for electrical power. Many experts believe that additional electrical generating capacity needed in 1987 will be met, as it was in 1986, primarily by the opening of new nuclear generating plants (under construction in the early 1980's). By 1988, most of the planned new nuclear generating capacity will have

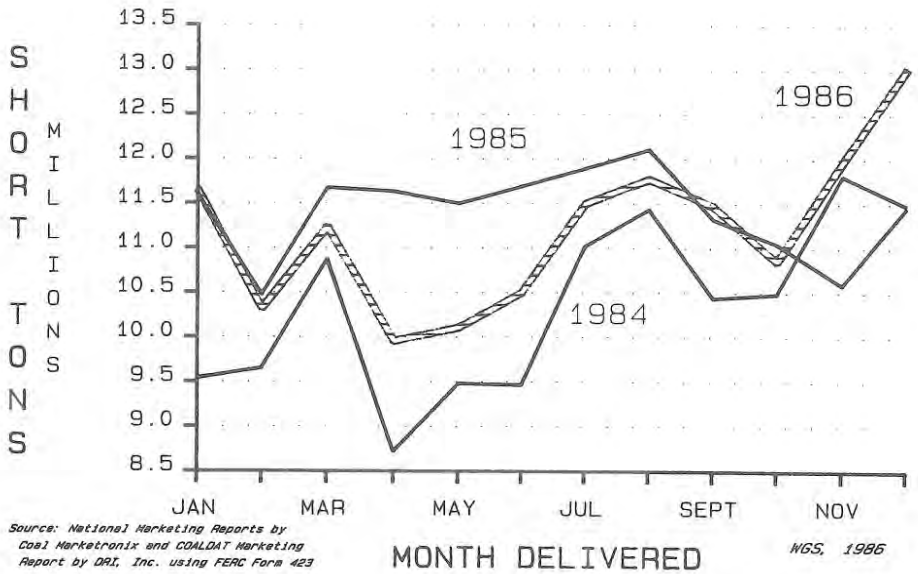
## WYOMING COAL PRODUCTION AND EMPLOYMENT



been placed on line and new coal-fired generating plants will have to provide the majority of the needed additional generating capacity for that year as well as for future years.

Monthly coal deliveries for the last quarter of 1986 were somewhat larger than expected earlier (see *Wyoming Geo-notes* No. 13, p. 24-26): although cumulative deliveries lagged about five million tons behind 1985 deliveries throughout most of the year (see table on page 22), monthly deliveries in November and December were higher than 1985 deliveries for the same months. In fact, December, 1986, deliveries reached the highest monthly level yet reported, over 13 million tons (see figure on page 19). As a result, total delivered tonnage for 1986 was only 2.5 million tons less than 1985's tonnage. However, the total tonnage produced in 1986 was still about five million tons less than that produced in 1985 because unreported coal deliveries for 1986 were much less than those for 1985. The increased coal deliveries in November and December can be attributed, in part, to a resurgence of spot market sales. In June and July, 1986, spot sales accounted for only 2.5 and 1.8 percent of the total deliveries, respectively; by December, 1986, spot sales accounted for 9.1 percent of the total deliveries. About four percent of the total coal delivered in 1985 (or 5.8 million tons) was sold on the spot market. In 1986, spot coal sales accounted for five percent of the total coal deliveries. The next issue of *Wyoming Geo-notes* will include an analysis of the distribution and utilization of Wyoming coal deliveries in 1986.

# REPORTED DELIVERIES FROM WYOMING COAL MINES



Source: National Marketing Reports by  
Coal Marketronix and COALDAT Marketing  
Report by DRI, Inc. using FERC Form 423

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

	1981 <sup>1</sup>	1982 <sup>1</sup>	1983 <sup>1</sup>	1984 <sup>1</sup>	1985 <sup>1</sup>	1986 <sup>1</sup>	1987	1988	1989	1990	1991
Campbell County	71.6	81.2	88.2	106.8	113.9	111.0	114.1	116.4	119.7	122.9	125.4
Converse County	3.6	3.4	2.7	3.3	3.6	4.8	6.2	6.8	7.5	8.7	8.7
Sheridan County	2.8	3.0	2.9	2.5	2.4	1.4	2.0	1.5	-	-	-
Carbon County	8.5	5.0	4.8	5.1	3.3	1.5	1.9	1.5	1.3	0.8	0.3
Sweetwater County	11.2	11.0	9.5	8.9	13.2	12.9	12.0	12.3	12.5	12.5	12.5
Lincoln County	5.0	4.3	4.0	4.1	4.3	4.0	3.8	4.5	5.0	5.1	5.1
Hot Springs County	M <sup>2</sup>	M	M	M	M	M	M	M	M	M	M
Total Wyoming	102.8	107.9	112.2	130.7	140.7	135.7	140.0	143.0	146.0	150.0	152.0
Annual change	9%	5%	4%	16.5%	7.7%	-3.6%	+3.2%	2%	2%	3%	1%
Estimated contract- ed production	110.0	119.0	122.6	137.7	145.2	149.2	149.4	151.5	148.6	150.6	152.0
Below contract	7%	9%	5%	5%	3%	9%	6%	6%	2%	-	-

<sup>1</sup> These are actual values for comparison. <sup>2</sup>M means minor tonnage (less than 0.1 million tons).  
Forecast by Geological Survey of Wyoming, January, 1987.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1986)

Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques) <sup>1</sup>	13.4 billion barrels <sup>1</sup>
Undiscovered	7.6 billion barrels <sup>1</sup>
Total	21.0 billion barrels
Remaining Reserve Base (January 1, 1986)	
Measured reserves (Proved reserves) <sup>2</sup>	0.62 billion barrels <sup>2</sup>
Indicated and inferred reserves <sup>3</sup>	2.8 billion barrels <sup>3</sup>
Total	3.62 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1986)

Discovered	19.2 trillion cubic feet <sup>1</sup>
Undiscovered (there is at least another 115 trillion cubic feet of noncombustible CO <sub>2</sub> gas) <sup>9</sup>	58.0 trillion cubic feet <sup>1</sup>
Total	77.2 trillion cubic feet <sup>1</sup>
Remaining Reserve Base (January 1, 1986)	
Measured reserves (Proved reserves)	9.88 trillion cubic feet <sup>2</sup>

COAL

Remaining Resources (January 1, 1986)

Identified (Discovered)	136.2 billion tons <sup>4</sup>
Undiscovered	800.0 billion tons <sup>5</sup>
Total	936.2 billion tons
Remaining Reserve Base (January 1, 1986)	
Demonstrated strippable (Measured and indicated reserve base)	27.3 billion tons <sup>4</sup>
Demonstrated underground-minable (Measured and indicated reserve base)	38.4 billion tons <sup>4</sup>
Total	65.7 billion tons

TRONA

Original Resources (1983 estimate)

Trona.....	81.7 billion tons <sup>6</sup>
Mixed trona and halite.....	<u>54.7 billion tons<sup>6</sup></u>
Total.....	134.4 billion tons

URANIUM

Remaining Resource (January 1, 1983).....	995,000 tons <sup>7</sup>
Remaining Reserve Base (January 1, 1983)	<u>ONE</u> U3O8
Ore recoverable at \$30 or less/ton.....	29.4 million tons..... 39,700 tons <sup>7</sup>
Ore recoverable at \$30.01-\$50.00/ton.....	<u>225.1 million tons..... 151,500 tons<sup>7</sup></u>
Ore recoverable at \$50 or less/ton.....	254.5 million tons..... 191,200 tons

OIL SHALE

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

- 1 Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, *Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.*
- 2 Energy Information Administration, 1985, *U.S. crude oil, natural gas, and natural gas liquids reserves: 1984 Annual Report, October.* (1984 and 1985 production has been subtracted).
- 3 Modified from Barlow and Doelger (1983), footnote 1.
- 4 Wyoming Geological Survey, March, 1985. (Modified from Berryhill, H.L., Jr. and others, 1950, *Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.*)
- 5 Averitt, Paul, 1975, *Coal resources of the United States: U.S. Geological Survey Bulletin 1412, p. 15.*
- 6 Culbertson, W.C., 1983, *Genesis and distribution of trona deposits in Wyoming (abstract) in Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19, p. 34.*
- 7 U.S. Department of Energy, 1983, *Statistical data of the uranium industry: Open-file Report GJO-100-(83), 77 p.*
- 8 Knutson, C.F., and Dana, G.F., 1982, *Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.*
- 9 Derived from Exxon information.



COAL DELIVERIES BY MONTH FROM WYOMING MINES

	1982 MONTHLY	1982 CUMULATIVE	1983 MONTHLY	1983 CUMULATIVE	1984 MONTHLY	1984 CUMULATIVE	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE
JANUARY	7,676,600	7,676,600	10,313,000	10,313,000	9,540,200	9,540,200	11,601,200	11,601,200	11,646,300	11,646,300
FEBRUARY	7,201,100	14,977,700	8,719,700	19,032,700	9,654,600	19,194,800	10,473,900	22,075,100	10,317,700	21,964,000
MARCH	8,407,200	23,384,900	9,051,200	28,083,900	10,875,000	30,069,800	11,614,900	51,790,000	11,250,520	51,202,520
APRIL	8,292,000	31,676,900	8,195,000	36,276,900	8,721,400	38,991,200	11,612,800	47,382,800	9,954,170	43,156,690
MAY	8,071,600	40,548,500	8,364,600	44,643,500	9,481,500	48,222,700	11,497,900	56,880,700	10,105,520	53,262,010
JUNE	8,724,700	49,073,200	8,330,200	52,973,700	9,464,500	57,737,200	11,692,200	66,372,900	10,499,280	63,761,290
JULY	8,736,300	57,811,500	8,734,700	61,708,400	11,019,600	68,756,800	11,893,500	80,466,400	11,497,190	75,238,480
AUGUST	9,195,800	67,007,300	9,669,300	71,377,700	11,433,000	80,189,800	12,107,100	92,573,500	11,773,510	87,031,990
SEPTEMBER	8,304,200	75,311,500	9,189,700	80,567,400	10,440,000	90,629,800	11,325,000	103,898,500	11,474,820	98,506,810
OCTOBER	9,390,100	84,701,600	9,406,300	89,973,700	10,492,500	101,122,300	11,046,500	114,947,000	10,854,670	109,361,480
NOVEMBER	8,757,300	93,458,900	9,013,600	98,987,300	11,814,200	112,936,500	10,589,700	125,536,700	11,971,990	121,333,470
DECEMBER	9,346,600	102,805,500	7,680,600	106,667,900	11,486,800	124,423,300	11,459,300	136,995,000	13,025,490	134,358,960
TOTAL TONNAGE REPORTED	102,805,500		106,667,900		124,423,300		136,996,000		134,358,960	
TOTAL TONNAGE NOT REPORTED	5,148,300		5,519,300		6,322,479		3,423,446		1,322,109	
TOTAL TONNAGE PRODUCED	107,953,800		112,187,200		130,745,779		140,424,446		135,681,069	

Source: National Marketing Reports by Coal Merketronix, compiled from FERC Form 423 filed monthly by electric utilities.  
Wyoming State Mine Inspector's Annual Reports.

In coal transportation developments, competition between the Burlington Northern Railroad (BN) and the Chicago North Western Transportation Company (C&NW)/Union Pacific Railroad (UP) joint venture for Powder River Basin coal haulage contracts continued in the first quarter of 1987. It was announced in January that the C&NW/UP joint venture railroad had signed two contracts with Oklahoma Gas and Electric (OG&E) that will replace expiring transportation contracts that the utility has with BN. In February, the Lower Colorado River Authority (LCRA) announced that BN had recaptured a transportation contract that the utility had awarded to C&NW/UP a year ago. Also, the UP announced in February that they would be participating with BN in the transportation of Wyoming coal to a Public Service Company of Oklahoma (PSO) power plant.

The first contract with OG&E is a seven-year contract that calls for C&NW/UP to initially haul two million tons of coal per year, escalating to four million tons per year, from the Black Thunder mine to the Muskogee, Oklahoma, power plant. The second contract with OG&E calls for transportation of 2.5 to 3.0 million tons of coal per year from the Black Thunder mine to the utility's Sooner power plant near Red Rock, Oklahoma. This contract also includes participation by the Atchinson, Topeka, and Santa Fe Railroad (AT&SF). BN's existing contract with OG&E for deliveries to the Sooner plant is due to end in 1988, but OG&E will accept only the minimum volume of 1.5 million tons per year from BN from now until 1988 (plus additional contract termination money). OG&E expects to save a total of \$274 million in coal transportation charges through 1993 with these two new contracts.

The new transportation contract between BN and LCRA is a one year pact that calls for hauling in excess of four million tons of coal from Thunder Basin Coal Company's Black Thunder mine (and any other mines that may ship spot coal to the utility) to the Fayette Power project in Austin, Texas. LCRA expects to save from \$8 million to \$12.5 million in transportation charges with the new contract.

The agreement between UP, BN, and PSO calls for BN to haul southern Powder River Basin coal to Kansas City, and for UP to haul the coal from Kansas City to PSO's Northeastern Power Station at Oologah, Oklahoma. Before this agreement was reached, PSO had planned to build a new spur line from their power plant to the BN tracks at Kansas City. This new contract will start immediately and is expected to reduce transportation costs for the utility and its customers.

In coal contract news, several new coal supply contracts and several renegotiated contracts were signed in the first quarter of 1987. It was mentioned in the October, 1986 *Wyoming Geo-notes* (page 25) that Nerco, Inc. had signed a tentative contract with Northern States Power (NSP). In January, NSP announced that this contract called for deliveries of up to 2.5 million tons of coal per year for 15 years from Nerco's Antelope mine in northern Converse County to NSP's electric generating plants in Minnesota and surrounding states. NSP expects to reduce some of the coal deliveries contracted from Mon-

tana coal mines and use more Wyoming coal in its place. The utility expects to bring new coal-fired generating capacity on line this year.

Rochelle Coal Company recently signed a seven-year contract, which calls for delivery of 0.14 million tons of coal a year from the Rochelle mine in southern Campbell County to the City of Ames, Iowa, municipal power plant. The contract goes into effect July 1, 1987, and replaces a previous contract the utility had with Fort Union Coal Company. Transportation of the coal will be by contract with C&NW and will replace BN's current contract. The Fort Union mine is located north of the ten-mile northern extension line that C&NW and BN recently agreed to share, and is served entirely by BN.

Under a price reopener clause in their existing 20-year contract, Exxon Coal Resources U.S.A. and Omaha Public Power District (OPPD) recently renegotiated new coal prices for August 1, 1987, to August, 1990. The contract calls for Exxon to supply 1.7- to 2.5-million tons of coal per year from Carter Mining Company's Rawhide mine to OPPD's Nebraska City, Nebraska, power station. The utility reportedly saved \$6.5 million a year by renegotiating the contract. During the negotiations, OPPD ran test burns of coal from the Fort Union, Caballo Rojo, Eagle Butte, Antelope, and Rochelle coal mines in the Powder River Basin.

In January, Wyodak Resources Development Corporation and Peter Lien and Sons renegotiated a 30,000-40,000 tons per year contract. The contract, which ends in June, 1988, calls for coal deliveries from the Wyodak mine east of Gillette to an aggregate plant in Rapid City, South Dakota.

In other news related to Wyoming coal, the 1987 session of the Wyoming Legislature (which ended in early March) considered several bills on coal taxes and coal development. Bills passed by the Legislature and subsequently approved by the Governor included: a coal equity tax bill, two economic development funding bills, and a bill making major changes to the industrial siting act. HB 330, the "Coal Equity Tax Act of 1987," sets a limit of 80 cents per ton on the amount of severance tax paid on coal production. The limit applies only to new coal contracts signed between March 31, 1987 and March 31, 1989. The bill mainly benefits high-cost coal producers in southern Wyoming: severance taxes for coal that is valued at over \$7.62 per ton (assuming a 10.5 percent severance tax rate) or over \$9.41 per ton (assuming an 8.5 percent severance tax rate) could only be assessed at the 80 cents per ton maximum rate.

A bill entitled "Economic Development-STEAL Alliance" (SF 227 and Senate Enrollment Act 63) establishes a Wyoming Science Technology and Energy Authority (STEAL). The authority will promote economic development by investing in Wyoming businesses that are using new technology, by issuing bonds for these investments, and by collecting royalties from these investments to pay off the bonds. Up to \$10 million in State permanent funds is available for investment in these STEAL bonds.

Another bill (SF 181) establishes a permanent fund investment program to assist Wyoming firms involved in clean coal technology or coal enhancement projects. This bill allows investment of \$30 million already present in the State's permanent mineral trust fund. The "Charfuels" project of Carbon Fuels Corporation (see *Wyoming Geo-notes* No. 13, p. 39-40) will probably apply for \$10 million of these funds.

Finally, the "Industrial Siting Act" (HB 78) changes some of the review procedures for proposed new industrial projects, reduces some duplication of work by several State agencies in project review, and provides some exemptions for siting smaller mine developments.

Two bills considered by the Legislature, but not passed, included a bill to repeal the two percent Coal Impact Tax after the first quarter of 1987 and a bill allowing the deduction of Federal coal excise taxes (for black lung and abandoned mine land reclamation fees) from the value of coal when assessing severance and property taxes.

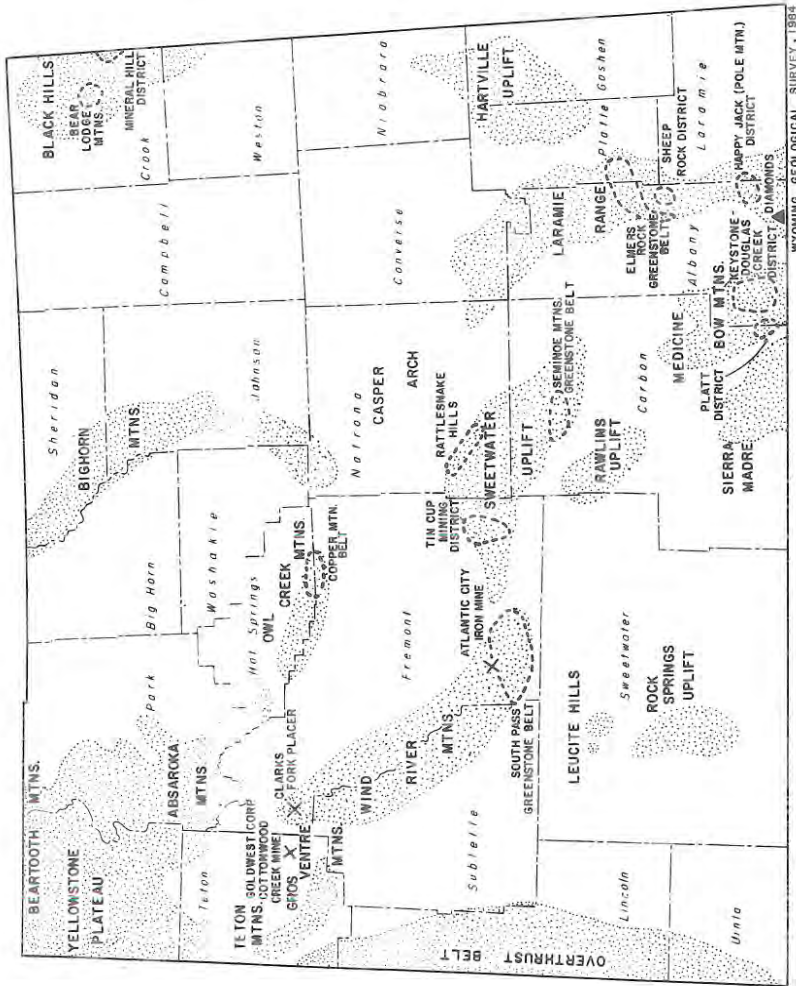
The coal impact tax was due to expire on January first of the year after the total proceeds from the tax reached \$160 million. In 1986, some Wyoming coal companies prepaid their taxes into this account in an attempt to reach the \$160 million limit and make the impact tax expire on January 1, 1987. Although the proposed bill and its amendments did not pass, the imposition and collection of the Coal Impact Tax into 1987 is still creating controversy. Coal companies that prepaid into the Coal Impact Tax Fund contend that the fund did indeed exceed the \$160 million threshold in 1986 and that the special tax should not be continued in 1987. The Wyoming Tax Commission and the State of Wyoming contend that because the \$160 million threshold was not reached in 1986 and because the bill repealing the Coal Impact Tax Act was not passed by the Legislature, that collections of the tax should proceed through 1987. At stake in the controversy is from \$20 to \$23 million in additional taxes paid into the Coal Impact Tax Fund.

Passage of the bill on the deduction of Federal excise tax on coal from the coal's valuation would have cost the State of Wyoming an estimated \$9 to \$15 million a year in tax revenues (from decreased valuation of coal).

## METALS AND PRECIOUS MINERALS UPDATE

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

Wyoming may have the greatest repository of low-grade strategic and critical mineral resources in the United States. Essentially all of the strategic and critical minerals occur in Wyoming in some quantity, but the extent of most of these deposits is not known. Because of the importance of these minerals to our Nation, the Geological Survey of Wyoming recently submitted a proposal to the Federal Government to map and sample many of these deposits over the next ten years.



WYOMING GEOLOGICAL SURVEY - 1984

REGIONS OF EXPLORATION ACTIVITY FOR STRATEGIC MINERALS

**EXPLANATION**

- X Mines and gold placers
- ▲ Diamond localities
- Mine district or supracrustal belt
- Uplifted areas

Some deposits considered top priority include:

(1) Platinum-palladium mineralization associated with shear zones along the northern margin of the Mullen Creek mafic complex (McCallum and Orback, 1968; Hausel and Harris, 1983). This mineralization is an attractive exploration target because the platinumoids may have been remobilized from the Mullen Creek mafic complex. It has been estimated that 16,870 ounces of palladium and 910 ounces of platinum were recovered from the New Rambler mine in this area between 1900 and 1918.

(2) Chromium-nickel anomalies associated with ultramafic schists in greenstone terrains in several of the State's mountain ranges. In recent years, chromium and nickel anomalies have been detected in komatiitic schists in the Elmers Rock greenstone belt (Graff and others, 1982), and in the South Pass greenstone belt (Hausel, 1987). Additionally, significant chrome-bearing schists have been identified on Casper Mountain and in the Deer Creek region of the northern Laramie Range. Based on drilling in the 1940s, at least 575,000 tons of 8.7 percent  $\text{Cr}_2\text{O}_3$  were delimited on Casper Mountain. Very little information is available on the Deer Creek property although 1,080 tons of chromite ore averaging 40 percent  $\text{Cr}_2\text{O}_3$  were mined prior to 1932 (Osterwald and others, 1966).

(3) Titaniferous-magnetite in anorthosite in the central Laramie Range. This 350-square-mile anorthosite batholith contains abundant aluminum-rich rock considered to be a gigantic low-grade aluminum resource. Pods of titaniferous-magnetite in the anorthosite batholith contain significant titanium, vanadium, and iron resources as well as anomalous manganese and chromium (Osterwald and others, 1966). This is one of the largest (if not the largest) deposit of titanium and vanadium in North America.

(4) Tungsten in quartzofeldspathic gneiss at Copper Mountain. Based on preliminary investigations, Hausel and others (1985) suggested that tungsten mineralization on Copper Mountain in the Owl Creek Range, may be stratiform in gneiss. The stratiform character of the deposits may indicate potentially large-tonnage mineralization.

(5) Diamondiferous kimberlite in the Laramie Range. The State-Line district, Wyoming-Colorado, has one of only two known occurrences of diamonds found in place on the North American Continent and the only occurrences of diamond-bearing kimberlite in the Western Hemisphere. The extent of these resources is not known, but field evidence suggests that many more kimberlite intrusives may be found in Wyoming (Hausel and others, 1979; 1985).

These are only a few of the strategic and critical mineral localities that would be investigated in detail if the Survey is granted sufficient funds. There is no question that Wyoming's strategic mineral resources not only offer possible economic diversification for the State, but they also provide a potential source of critical minerals necessary for our Nation's economic health and defense.

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## URANIUM AND INDUSTRIAL MINERALS UPDATE

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

### URANIUM

Development continues on two new *in situ* uranium mines. Everest Minerals is developing an *in situ* mine at the site of Exxon's Highland mine in Converse County. This project is scheduled to begin production in 1988, with an initial annual production of 500,000 pounds of uranium oxide (yellowcake).

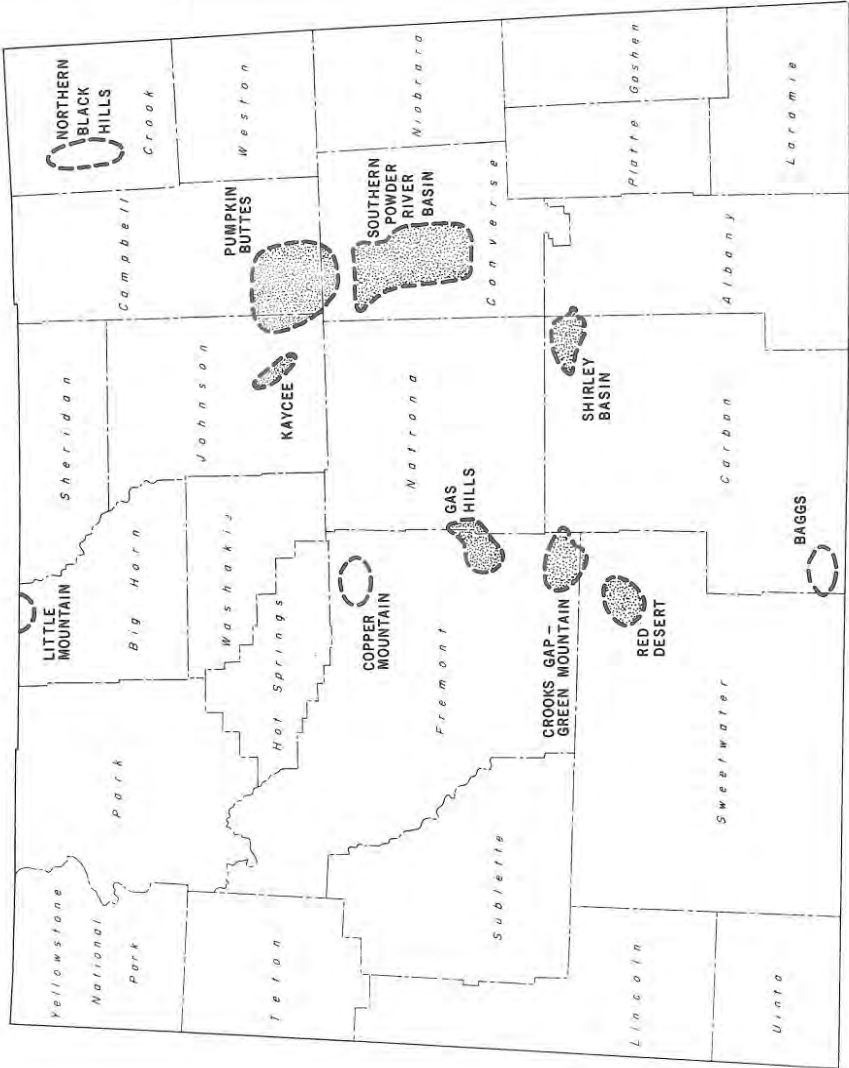
EXPLANATION



Uranium district with active or recent mining



Uranium district without recent mining



WYOMING GEOLOGICAL SURVEY, 1983

MAJOR ACTIVE AND INACTIVE URANIUM DISTRICTS



Malapai Resources Company, which is developing an *in situ* mine near the Pumpkin Buttes in Converse County, announced plans to begin production in 1988. Malapai has announced three uranium supply contracts, one for 250,000 pounds of uranium oxide per year with Societe Auxiliare D'Energie of France, one for 550,000 pounds of uranium oxide per year with Wisconsin Electric Power Company, and an undisclosed amount with a "confidential" buyer. Malapai Resources is a subsidiary of the AZP Group Inc., the holding company of Arizona Public Service Company.

Pathfinder Mines Corporation, 80 percent of which is owned by the French Company COGEMA (see related discussion on page 31) is nearing completion of its \$4 million renovation of the Lucky Mc mill in the Gas Hills. This project was scheduled for completion in early 1987. As of March 15, 1987, however, no date has been set for reopening the Gas Hills operations. Pathfinder-COGEMA is still producing uranium from the Shirley Basin, an operation that currently employs about 125 workers.

Uranium exploration should increase somewhat this summer as the reduction of uranium stockpiles by utility companies continues. Utility companies have maintained large stockpiles of uranium ordered in the 1970s for power plants that were never constructed. Existing nuclear plants (there are over 100 operating in the United States) have used fuel from these stockpiles, resulting in their gradual reduction. 1986 was the first year since 1980 that consumption of uranium exceeded production. Now, new supply contracts will have to be let to supply the existing plants. Since Congress failed to pass any import restrictions for uranium, many new contracts have been let to Canadian and Australian producers. Deposits of uranium in those two countries are higher in grade than U.S. deposits and are less expensive to mine. The production of uranium in Wyoming by *in situ* methods may be competitive with uranium mined in foreign countries.

The current spot market price of uranium (March, 1987) is \$16.75 per pound of uranium oxide, down from \$17.00 last quarter, and up from \$16.65 in February. This compares to the recent low of \$14.00 per pound in 1985.

The controversy over the disposal of uranium mill tailings (material left after uranium has been removed from the ore by the milling process) left at the old Susquehanna-Western mill near Riverton was apparently settled in early 1987. The U.S. Department of Energy and the Wyoming Department of Environmental Quality agreed to move the tailings to an abandoned mine pit in the Gas Hills. American Nuclear Corporation has offered one of its abandoned pits as a dump site to hold the tailings.

## COGEMA - WYOMING'S FRENCH CONNECTION<sup>1</sup>

All of the uranium currently being produced in Wyoming is mined by Pathfinder Mines, Inc., 80 percent of which is owned by COGEMA, a French conglomerate with company headquarters in Paris. COGEMA buys all of the uranium mined in Wyoming by Pathfinder and processes it for nuclear fuel.

COGEMA was formed in 1976 from the production division of the French Atomic Energy Commission. It is now composed of almost 30 companies that operate in every part of the nuclear fuel cycle, and it is the only company in the world that so operates. COGEMA's primary responsibility is the supply of nuclear material to France. It also provides nuclear material to the international market. About 20 percent of the world's nuclear fuel is produced by COGEMA, which is organized into four branches: natural uranium, enrichment, fuel fabrication, and fuel reprocessing.

The natural uranium branch under which the Wyoming mining company, Pathfinder, is operated, produces uranium from mines in France, Gabon, Niger, Canada, and the United States. Pathfinder's Wyoming operation provides its only U.S. production. About 75 percent of the uranium mined by COGEMA is used to fuel French nuclear power stations. France is the world's foremost user of nuclear power. In 1985, 66 percent of the electricity generated in France was produced by nuclear plants. This percentage is projected to rise to 75 percent by 1990. By comparison, 16 percent of the electricity produced in the United States is from nuclear power plants. The rest of the material produced by the natural uranium branch of COGEMA is used for other operations (medical, military, etc.) or exported.

The enrichment branch of COGEMA converts uranium oxide (yellowcake) produced by the natural uranium branch to uranium hexafluoride (a gas) for enrichment of the fissionable isotope of uranium (U-235) from 0.74 percent in most natural uranium to about three percent for nuclear fuel or to higher grades for other uses. Following the gaseous diffusion process of enrichment, this branch converts the enriched uranium hexafluoride gas to metallic fuel. The remaining (depleted) uranium hexafluoride is converted back to the metal and sold for use in armor-piercing ammunition, weights, or other uses for very heavy, dense metal.

The fuel fabrication branch of COGEMA uses the enriched uranium produced by the enrichment branch to make nuclear fuel rods or pellets. It also manufactures entire fuel assemblies including fuel rods, tubes, controls, and other components. COGEMA also makes synthetic diamonds for industrial uses, probably COGEMA's only non-nuclear product.

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<sup>1</sup> Information for this discussion was taken from White, L., 1986, *COGEMA: Engineering and Mining Journal*, v. 187, no. 8, p. 32-33 and White, L., 1986, *Uranium mining is alive and well in France: Engineering and Mining Journal*, v. 187, no. 8, p. 26-30.

The reprocessing branch of COGEMA takes spent fuel (after it has powered a reactor and becomes depleted in U-235) and reprocesses it into usable fuel for fabrication by the fuel fabrication branch. It also handles the transportation of nuclear materials in France and on French conveyances worldwide, especially ocean ship transports.

The Wyoming operation of COGEMA, through Pathfinder Mines, is a small part of this major company (\$3,000,000,000 worth of sales in 1985) which has a unique operation in the world market, with branches covering the entire nuclear fuel cycle.

## INDUSTRIAL MINERALS

The value of nonfuel mineral production in Wyoming increased in 1986 by 11 percent over 1985, according to figures released by the U.S. Bureau of Mines. This increase was due mainly to increased sand and gravel and trona production. Bentonite production decreased significantly, somewhat offsetting the other increases. In 1986, Wyoming ranked 12th in production of nonfuel minerals, up from 14th in 1985. All of Wyoming's nonfuel mineral production is industrial minerals.

### TRONA

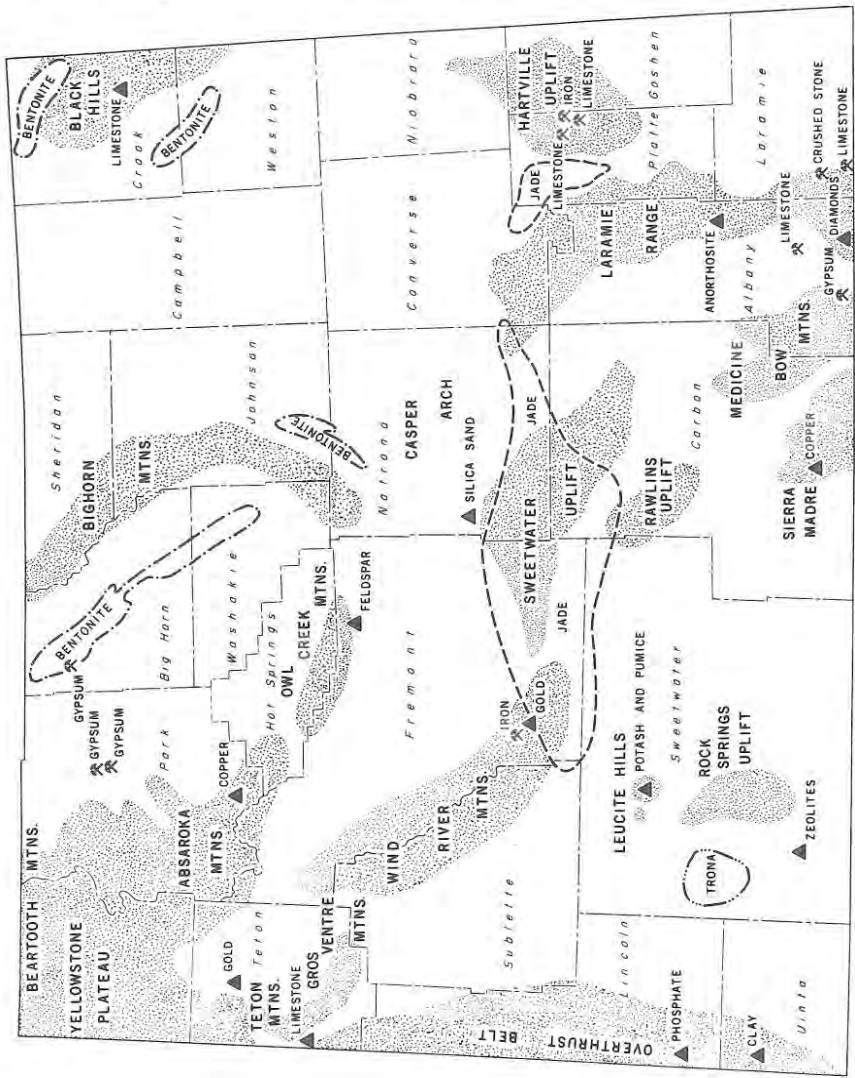
Soda ash (refined trona) production in Wyoming through October, 1986, was two percent above the 1985 figures, according to the U.S. Bureau of Mines, indicating as yet no significant increase in consumption. Increases by some producers were offset by corresponding decreases at other plants. Soda ash is used primarily in glass manufacture and also paper whiteners, water purifiers, and sodium chemicals.

Tg, Incorporated (formerly Texasgulf) filed a plan with the Wyoming Department of Environmental Quality for a permit to increase its production capacity from one million tons of soda ash per year to 1.3 million tons per year. The requested production increase is not the result of a major plant modification, but reflects small changes within the plant that permit some increases in capacity. No large production increase or increased employment are planned for the near future. The permit will not increase allowable emissions from either the trona refining plant or the company's adjoining coal-fired power plant. Tg spokesman Cam Albin was quoted as saying the plant will produce about one million tons this year.

Efforts have been made recently by the Wyoming Congressional Delegation and the American Natural Soda Ash Corporation, (ANSAC), an export cooperative of the five soda ash producers, to persuade foreign countries, particularly those in the Far East, to lower their import barriers to U.S. natural soda ash. So far, their efforts have been unsuccessful. In February, 1987, yet another trade mission combining representatives of the Congressional Delegation and ANSAC was under-

**EXPLANATION**

- Mines and quarries
- BENTONITE
- Bentonite mining district
- TROMA
- Trona mining district
- Localities
- JADE
- Jade collecting areas
- Uplifted areas



WYOMING GEOLOGICAL SURVEY, 1943

SELECTED MINERAL AND ROCK OCCURRENCES

taken. Small increases in exports to South Korea and Taiwan have been made, but so far no easing of restrictions by Japan has been announced. Mainland China continues to be the chief overseas buyer of Wyoming soda ash.

### PHOSPHATE

Domestic phosphate production increased in 1986 over 1985 production, according to the U.S. Bureau of Mines. Production increased in the Florida region and in the western States. No phosphate has been mined in Wyoming since 1977, but Chevron Minerals Company is mining phosphate north of Vernal, Utah, and shipping it by slurry pipeline to their fertilizer plant southeast of Rock Springs. This plant opened in 1986 (see *Wyoming Geo-notes No. 13*) and has been producing fertilizer since last September.

### BENTONITE

Bentonite producers continued to lose sales due to the decline in oil and gas well drilling activity in 1986 and the decline in the demand for binder clay used in taconite (iron ore) processing. Bentonite production declined 31.4 percent from 1985 levels according to data from the U.S. Bureau of Mines.

### GYPSUM

Despite the temporary closure of the Red Mountain gypsum mine at Laramie in 1986, Wyoming's production of gypsum increased ten percent over 1985 levels. Production from Celotex Corporation at Cody and Georgia-Pacific Corporation north of Greybull is used primarily for wallboard.

### OTHER INDUSTRIAL MINERALS

Missouri Basin Electric Company, which operates the Laramie River Station a coal-fired electric-generating plant, was advertising for bids (due April 1) for high-calcium limestone for use as "power rock" (limestone mixed with coal to produce even burning). Bids were submitted for rock from the Cheyenne, Laramie, and Hartville areas.

The Geological Survey of Wyoming has been working with both Holly Sugar and Western Sugar to help the companies locate a source of sugar rock (limestone) in Wyoming. Both Holly Sugar, in Torrington, and Western Sugar, which has plants in Mitchell, Scottsbluff, and Bridgeport, Nebraska, will conduct burn tests on Wyoming limestone next season.

Several Wyoming Highway Department contracts have been let for rock for construction or resurfacing projects in the coming season. At the present time, it appears that production of crushed stone and sand and gravel for highway construction will equal or surpass that of last year.

## GEOLOGIC HAZARDS UPDATE

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

### EARTHQUAKES

Earthquake activity in Wyoming for the period September, 1986, through February, 1987, has been relatively minor. All of the activity has been confined to the western and northwestern portions of the State. The Yellowstone National Park-Hegben Lake area had most of the activity although earthquakes were felt at Alpine and Smoot. A summary of activity is presented below:

Date	Location	Magnitude/Intensity
Nov. 15, 1986	Yellowstone National Park	M <sub>L</sub> 3.4; Felt Intensity IV at West Yellowstone, Intensity III at Madison Junction
Nov. 17, 1986	Alpine Area	M <sub>L</sub> 3.9; Felt Intensity III at Alpine
Nov. 24, 1986	Hegben Lake Area	M <sub>L</sub> 3.2; Felt Intensity IV at Madison Junction and Intensity II at Old Faithful
Nov. 25, 1986	Hegben Lake Area	M <sub>L</sub> 3.5; Felt Intensity IV at West Yellowstone.
Nov. 30, 1986	Hegben Lake Area	M <sub>L</sub> 2.9
Dec. 1, 1986	Hegben Lake Area	M <sub>L</sub> 3.1
Jan. 12, 1987	Eastern Idaho	M <sub>L</sub> 3.7; Felt Intensity III at Freedom, Grover, and Smoot, Wyoming. Also felt at Auburn and Afton.
Feb. 5, 1987	Hegben Lake Area	M <sub>L</sub> 3.4; Felt Intensity III at West Yellowstone
Feb. 6, 1987	Hegben Lake Area	M <sub>L</sub> 3.1; Felt Intensity III at West Yellowstone.
Feb. 8, 1987	Hegben Lake Area	M <sub>L</sub> 2.9

## UINTA COUNTY WORKSHOP

The Geologic Hazards Section participated in a one day Earthquake Hazards Workshop for Uinta County in Evanston on February 25, 1987. Previously, the Section has participated in similar workshops for Teton and Lincoln Counties. Park County will host a workshop later this year.

There are portions of Uinta County that have active faults exposed at the surface. The Bear River fault zone southeast of Evanston has had a Maximum Credible Earthquake (MCE) of Magnitude 7.3 assigned to it. Mike West of Mike West and Associates (Lakewood, Colorado) and John Black of Woodward-Clyde Consultants (Denver, Colorado) have done much of the mapping in the area. Their information was made available for inclusion in the Section's geologic hazards scenario for the county. There are a series of suspected active faults and photo lineaments that may be active faults in the vicinity of Meeks Cabin Reservoir. Work by the Geologic Hazards Section of the Geological Survey of Wyoming and the Bureau of Reclamation indicates that a MCE of approximate Magnitude 6.5 may be possible for the Meeks Cabin Reservoir area. Suspected active fault traces northwest of Evanston may yield a MCE of Magnitude 6.5-7.5 if they are all shown to be active faults in future studies. Very preliminary work by Mike West indicates that there may be some active fault traces trending from the south-central through the central portions of the county. All of the above information indicates that the seismic hazard for Uinta County may have been understated in the past. Although there has been little historic seismicity, the potential for damaging earthquakes exists and should be planned for.

Landslides are extensive in the southern half of the county. They usually occur where the Bridger Formation is capped by the resistant Bishop Conglomerate, near the exposed contact of the Green River Formation and Wasatch Formation, or where the Green River Formation or Wasatch Formation are capped by resistant terrace gravels. The potential for seismically induced landslides exists in many portions of the county. The Geologic Hazards Section has mapped and classified landslides in Uinta County.

## OTHER MAN-INDUCED OR NATURAL HAZARDS

In September, 1986, State and Federal agencies began testing the ground water and drinking water in the Brookhurst Subdivision in Evansville, due to complaints from area residents. Studies are continuing on the contamination at that site.

In February, 1987, methane and some hydrogen sulfide gas were detected in or near homes in the Rawhide Village subdivision north of Gillette. Studies of this problem are ongoing.

Also in February, 1987, the Department of Energy agreed to move radioactive uranium mill tailings away from Riverton to a location in the Gas Hills area.

In late March, 1987, a water treatment facility for the UPRR tie plant site at Laramie was nearing completion. Earlier a slurry wall was constructed around this U.S. Environmental Protection Agency superfund site to contain contaminated ground water within the site. The Wyoming Department of Environmental Quality in Cheyenne has additional information on all of the above activities.

## STRATIGRAPHY UPDATE

by Alan J. Ver Ploeg, Stratigrapher, Geological Survey of Wyoming.

The U.S. Geological Survey recently released a planning document entitled *An overview of geologic mapping needs in the United States* (Open File Report 86-573). The report describes the general geologic setting of 32 geologic provinces grouped into eight regions and assesses the need for geologic mapping within each area. The report is based on technical information provided by numerous U.S. Geological Survey scientists familiar with the described areas. As it relates to Wyoming, the report stresses the need for additional mapping in the foreland province. Work is needed in the areas of exposed Precambrian metamorphic and intrusive rock to aid in mineral exploration, as these areas are for the most part poorly understood. Specifically, the report points out mapping needs in the Bighorn Mountains, Hartville uplift, Proterozoic terrains in southeastern Wyoming, and Precambrian rocks in the northern Wind River Range and Owl Creek Mountains.

In regard to energy exploration, work needs to be done on the basins in the foreland province. The report stresses that the Green River and Great Divide Basins remain poorly understood. Detailed mapping is needed on basin-bounding structures such as the north flank-fault of the Uinta Mountains and the Wind River thrust and on intra-basinal structures like the Moxa arch.

The report was reviewed by the staff of the Geological Survey of Wyoming and additional mapping priorities were suggested. These suggestions included the need for additional mapping in the northern portion of the Wyoming overthrust belt and the volcanic sequences in the Absaroka Plateau. Also, new mapping is needed in portions of the State that were last mapped by Darton near the turn of the century. The COGEMAP project on the southeastern flank of the Bighorn Mountains is an example of one of these areas (*Wyoming Geo-notes* No. 12, page 42).

In the October, 1986, issue of *Wyoming Geo-notes* (No. 12), the Wyoming Geological Association's Nomenclature Committee's project to compile a new formal stratigraphic nomenclature chart for the State of Wyoming was outlined. In addition to that effort, the Geological Survey of Wyoming is compiling a "common usage" chart based in part on the *Geologic map of Wyoming*, which was compiled by J.D. Love and A.C. Christiansen in 1985. In its first draft, this chart will use the nomenclature developed for that map as it portrays surface bedrock.



Subsurface nomenclature is being added to the chart. A preliminary chart will be available for review and comment at the Wyoming Geological Association's field conference in Jackson in September.

Recently completed maps by the Stratigraphy Section include two geologic quadrangle maps and a set of 16 surficial structure maps covering the State of Wyoming. The *Preliminary geologic map of the Mayoworth Quadrangle, Johnson County, Wyoming* (Open File Report 87-4) and the *Preliminary geologic map of the Red Fork Powder River Quadrangle, Johnson County, Wyoming* (Open File Report 87-5) were recently completed and released. These 1:24,000 scale geologic maps are part of the COGEMAP project described in *Wyoming Geo-notes No. 12*.

The 16 maps depicting known surficial structural features in Wyoming were recently completed and were designated Open File Report 87-1 (A through P). These sixteen 1°x 2° quadrangle maps (1:250,000 scale) cover the State of Wyoming. This project was described in *Wyoming Geo-notes No. 13*. All the above maps are available from the Publication Section of the Geological Survey of Wyoming (see list of new publications on page 40).

#### THE FERRIS-HAGGARTY MINE

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

In 1897, Ed Haggarty discovered copper-stained gossan in quartzite in the Sierra Madre, southern Wyoming. In the following year, a 30-foot shaft was sunk on the gossan and intersected massive copper mineralization. The ore was hauled by wagon to the nearest Union Pacific Railroad junction and shipped to the Chicago Copper Refining Company's smelter at Chicago. The first 14.5-ton ore shipment from Ed Haggarty's prospect averaged 33.18 percent copper (Messerschmidt, 1972). This led to the development of the greatest copper mine in the Sierra Madre mountains of Wyoming, and to the establishment of the historic Encampment mining district.

The Encampment district includes the entire Sierra Madre (Harris and others, 1985). The northern Sierra Madre is underlain by a thick clastic wedge of Early Proterozoic (less than 2.5 - 1.8 billion year old) miogeosynclinal metasediments which include quartzite, metaconglomerate, metalimestone, metadolomite, and phyllite with lesser metavolcanics. The southern Sierra Madre is underlain by late Early Proterozoic (1.9 - 1.6 billion year old) eugeosynclinal metavolcanics, volcanoclastics, and gneisses. These two distinct regions are separated by a major tectonic suture known as the Mullen Creek-Nash Fork shear zone which consists of cataclastics and mylonites.

The Ferris-Haggarty mine is located in a thick quartzite of the Deep Lake Group in the miogeosynclinal terrain north of the Mullen Creek-Nash Fork shear zone. Mineralization is localized in the steeply dipping (35°S to 50°S) quartzite, which is capped by an impermeable hanging wall schist. The ore occurs as massive chalcocite and lesser chalcopyrite filling an irregular breccia zone along the con-

tact with the hanging wall schist. Ore shoots in the quartzite were reported to range from a few feet to more than 20 feet thick and to average six to eight percent copper. However, from 1902 to 1908, only the high grade ore was mined. These ores varied from 30 percent to 40 percent copper (Spencer, 1904; Beeler, 1905).

The ore was followed downdip along a dip length of 400 feet. But Spencer (1904) reported the extent of mineralization at depth had not been determined by 1903.

In addition to copper, the Ferris-Haggarty ore carries precious metal values. Beeler (1905) for example, reported that the ore contained some silver and 0.1 to 0.37 ounce/ton gold. Assays of grab samples collected from the mine dump yielded between 3.23 percent and 4.6 percent copper, and a trace to 0.61 ounce/ton silver (Hausel, 1986). The Ferris-Haggarty is presently being explored for precious metals by a Denver-based company.

It is interesting that several deposits in the Encampment district exhibit similar characteristics to the Ferris-Haggarty mine. These include the Beulah, Doane-Rambler, Echo, Finley, Gertrude, Leighton-Gentry, and Investors mines and prospects (Hausel, 1986).

The Encampment mining district in Carbon County can be reached by taking Wyoming Highway 130 south from Interstate Highway 80 at Walcott (about 21 miles east of Rawlins) and proceeding south to Wyoming Highway 70 at Riverside. There are excellent museums at Rawlins, Encampment, and Saratoga along the way. Saratoga also offers access to a natural hot spring (115-128 degrees).

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## AUTOMATED DINOSAUR EXHIBIT PLANNED

The Geology Museum at the University of Wyoming's Department of Geology and Geophysics in Laramie will host a spectacular display of automated, life-size to near life-size Mesozoic reptiles. The display is tentatively planned for June 8 - August 5, 1987, and will feature dinosaurs created by Dinamation International Corporation in San Juan Capistrano.

The exhibited specimens which stomp, move their heads and tails, blink, "breathe", roar, and squawk, are well worth seeing. Each specimen is a very realistic replica of its once-living counterpart. The six creatures slated for display depict reptiles which once roamed the lowlands of Wyoming in the geologic past.

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