THE GEOLOGICAL SURVEY OF WYOMING

Gary B. Glass, State Geologist

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WYOMING GEO-NOTES was first published in July, 1977, as a semi-annual newsletter for the Geological Survey. It had a very shaky start which ended abruptly with a single issue, designated Volume 1, Number 1. The recent success of our quarterly Minerals Update for Wyoming, however, has been so overwhelming that it will now form the backbone for a rejuvenated Wyoming Geo-Notes. The newsletter will be published quarterly and expanded to include Staff and Survey activities and projects.

MINERALS OVERVIEW

by Gary B. Glass, State Geologist
Wyoming Geological Survey

Finally there are some really optimistic signs for many of the State's mineral industries indicating that at least some declining mineral production may have bottomed out and already turned upward. Preliminary 1983 production figures for natural gas, coal, and trona all show increases above 1982 production levels. Oil production, which is very close to matching 1982 production, has offset the gradual annual decline in production that has typified Wyoming's oil production since 1978.

The real significance of 1983's production gains is not the number of tons, cubic feet, or barrels, but the fact that oil, gas, coal, and trona production all exceeded production forecasts for 1983. But why is that significant? Forecasters are not infallible by any means. Consider, however, that forecasting a turnaround point is one of the most difficult things to do. Everyone knew that production declines or slowing growth would eventually bottom out, but would that occur in one year, two years, or five years and at what levels. There is now every indication that four of the State's major mineral industries are on the upswing. This should substantially improve future forecasts of mineral production since the uncertainty of the turnaround point is gone.

In the last quarter of 1983 and first quarter of 1984, both gypsum and bentonite production have

shown gains as well. Only uranium and iron ore production have continued to decline. While uranium production is a shadow of what it was several years ago, the State's last iron ore mine has closed permanently. These latter two industries, however, are not simply the victims of the recent recession. The deteriorating domestic uranium and iron ore industries are a different matter altogether, and need not deter an optimistic outlook for the rest of the State's mineral industries.

The first quarter of 1984 seems an appropriate time for a more in-depth prognosis for Wyoming coal. Earlier this year the U.S. Department of Energy estimated Wyoming coal production at 116 million tons, and a well publicized press release noted that Wyoming had out-produced West Virginia to become the second largest coal-producing State. Wyoming's actual 1983 coal production, however, turned out to be 112.2 million tons, which is less than the 115.1 million tons produced by West Virginia. The ranking of the two states, therefore, remains as last year with Wyoming in third place.

Whatever Wyoming's national ranking, it is more significant that the State's coal producers increased overall production four percent in 1983 at a time when most indicators suggested production would be lucky to match 1982. The 1983 production of 112.2 million tons was only eight percent below estimated contract demand (122.6 million tons), not the 12 percent that we forecast. Eight percent is also an improvement over 1982 production which was nine percent below contract.

Admittedly much of coal's gains occurred in the last two months of 1983 partially because cold

weather had depleted many stockpiles. These gains, however, were substantially greater than seasonal increases in 1982, and probably reflect a renewed trend for demand to at least keep pace with contract minimums. The gains also occurred despite layoffs in both southern and northeastern Wyoming mines, and in the face of several mine closures in southern Wyoming.

Last year, we forecast 1984 coal production at 114 million tons. In view of 1983 production, our forecast for 1984 must be increased. If production remains within eight percent of contract demand or improves even further, it could easily reach 118 million tons in 1984. This would translate into another four percent production increase in 1984 and set yet another production record for the State.

The short term outlook for coal production is a 5-6 percent annual increase through 1988. Beyond 1988, there is a potential plateau in production since as much as 18.3 million tons of potential new power plant tonnage has been cancelled or postponed into the 1990's. Many of these cancelled or postponed plants were originally slated for the late 1980's and had planned to use Wyoming coal. Fortunately, production gains through 1988 are based on signed contracts for new power plants that are already under construction and coming on line between now and then, and which have been designed to burn subbituminous Wyoming coal. Although there have been some recent new contracts signed for the late 1980's, many of these are cannibalized contacts i.e., contracts that one Wyoming coal company has taken from another, and consequently represent no increase in gross tonnage.

It is probably too late for anything to alter the forecast plateau in coal production in the late 1980's because energy demand is not likely to grow quickly enough to prompt accelerated building of power plants - Wyoming's major coal market of this decade. There is also little to no chance that a synthetic fuel industry will create any significant market by the late 1980's. Of course, the "plateau" is really not a disaster considering production by the end of this decade is slated to be 152 million tons, compared to the 112.2 million tons mined in 1983. This is still a 36 percent gain, and by then power plants delayed until the 1990's will be seeking contracts for those new plants.

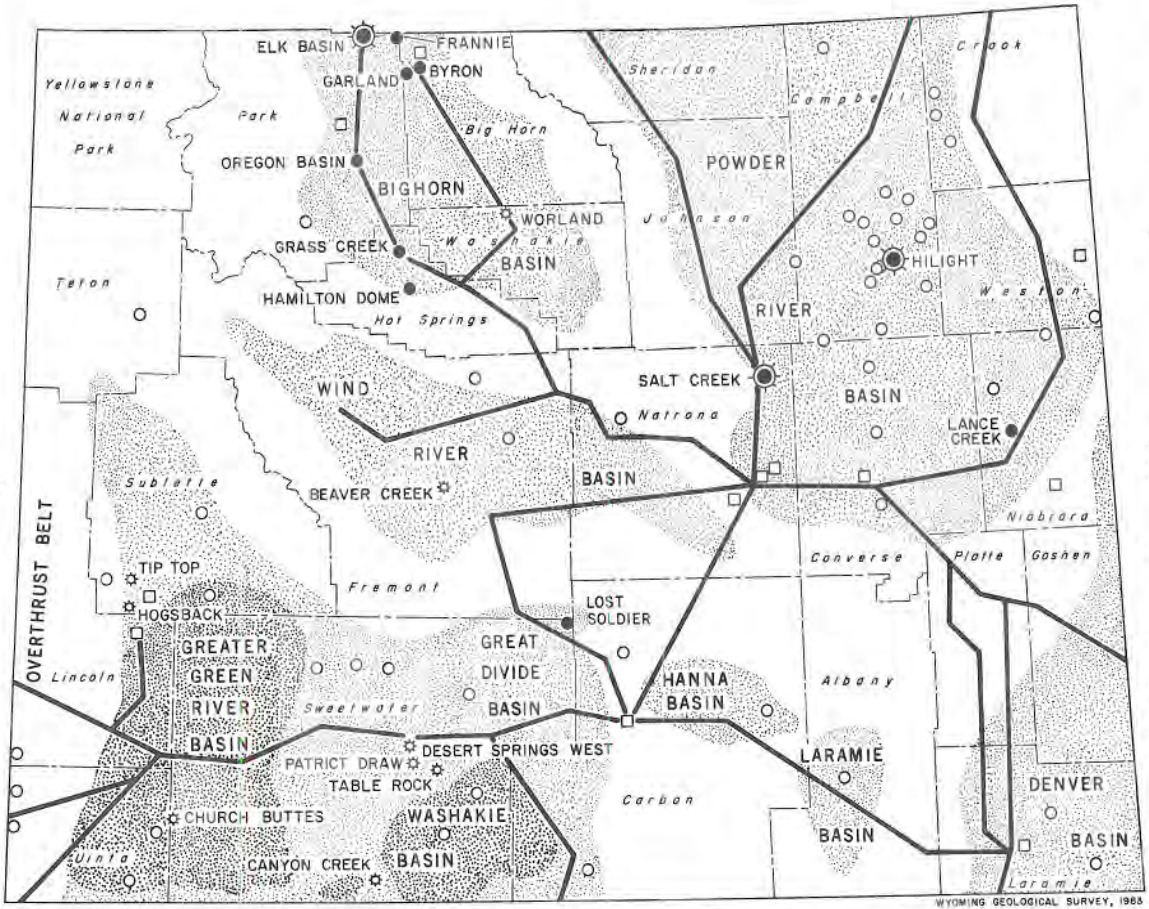
The Wyoming coal industry in the late 1980's, however, won't be marketing their coal reserves simply because they are low in sulfur. Scrubber legislation has deflated that marketing edge. Price has become the name of the game, and unless Wyoming coal producers remain competitive, they will loose more and more of the future markets. Texas already has a large lignite industry spawned to compete with the high delivered costs of Wyoming coal. Currently, Wyoming producers are forced to keep their mining costs low to offset long-haul transportation costs. They are doing this through increased productivity tied to the economy of scale made possible by the huge mines that are now commonplace in Wyoming. Eventually, size alone will not increase productivity, and mining costs will have to increase. For comparison, coal in the Powder River Basin of Wyoming still sells for $6 - $8 per ton at the mine. The national average for strip mined coal is $21.46 per ton.

Here are some facts about coal's future in Wyoming. On the long term, demand for Wyoming coal is good because the State's one trillion tons of coal represents 25 percent of the Nation's coal resources. New power plants in adjacent states or in Wyoming will remain prime markets for Wyoming coal since transportation costs are minimized by shorter distances. Lowered or stabilized transportation costs resulting from competing railroads, slurry pipelines, or possibly thermal drying or other upgrading of coal prior to shipping could also improve the situation and extend or maintain Wyoming's present market area. Eventually, the synthetic fuels industry will also provide a market, but the timing of this industry is still speculative. As a bottom line, however, short of another incident such as the Arab Embargo of the last decade, price and aggressive marketing will be key factors in the potential growth of Wyoming's coal industry in the late 1980's and 1990's.

OIL AND GAS

by Alan J. VerPloeg, Petroleum Geologist
Wyoming Geological Survey

Preliminary production figures provided by Don Basko, Supervisor for the Wyoming Oil and Gas Conservation Commission, indicate 1983 oil production will be about 117 million barrels which is only slightly below last year's production and which nearly offsets the steady decline that has been characteristic of Wyoming oil production since 1978. Initial estimates suggest natural gas production increased about 42 billion cubic feet over 1982, making 1983 production in excess of 507



EXPLANATION

Major Wyoming Basins

Oil shale occurrences

Oil and gas pipeline corridors

Refineries

1981 Oil and gas field discoveries

Oil field with cumulative production[1] greater than 100 million barrels

Gas field with cumulative production[1] greater than 200 billion cubic feet

Oil and gas field with cumulative production[1] of oil greater than 100 million barrels and cumulative production of gas greater than 200 billion cubic feet

[1] CUMULATIVE PRODUCTION IS THROUGH 1981

[2] CUMULATIVE OIL PRODUCTION OF HILIGHT FIELD WAS 70 MILLION BARRELS THROUGH 1981

GENERALIZED OIL AND GAS INDEX MAP OF WYOMING

billion cubic feet. Development of western Wyoming's Thrust Belt accounts for much of these increases.

Rocky Mountain well completions dropped 35 percent in 1983, from 8,214 wells in 1982 to 5,444 in 1983 according to Petroleum Information Corporations year-end statistics. The completion figures for Wyoming are listed below:

WYOMING 1983 WELL COMPLETIONS

	New field wildcats				All wells			
	Oil	Gas	Dry	Total	Oil	Gas	Gas	Total
1983	23	13	305	341	698	152	550	1,400
1982	68	28	404	500	1,029	272	827	2,128

Wyoming's 34 percent decline is identical to the decrease recorded for the overall Rocky Mountain region. With 1,400 total completions, Wyoming was second to Colorado's 1,508 total. Because of gas price regulations and oversupply, exploration and development have substantially shifted to oil.

After topping 140, the rig count in Wyoming has dropped back to 115 (February 27, 1984). This drop, however, is attributed to the usual winter lag, and the general concensus is that oil activity in Wyoming is now on the upswing.

In February, the State Land Board demanded royalty payment on flared gas from two Newcastle companies, and stated that these demands would continue until the industry proves that the State

is wrong in laying claim to flared gas. By early March, the Board revised that decision and said their demand would be on a case-by-case basis as there are circumstances where flaring is not waste and where alternatives to flaring would result in less revenue to the State and unwarranted economic hardship to operators.

A nearly four month old moratorium on federal oil and gas lease lotteries was lifted by Secretary of the Interior William Clark on January 31st. The moratorium followed allegations of mismanagement of leases by the U.S. Bureau of Land Management (BLM) in the Amos Draw area. Procedures for identifying Known Geologic Structures (KGS's) and adjacent leases have been expanded to prevent known valuable tracts from being included in the lottery system rather than the competitive bid system. Secretary Clark estimated that it would be 4 to 6 weeks before the lottery resumes.

The February, 1984, BLM lease sale in Wyoming totalled $7 million in successful bids. One bid by Amoco totalled $6.1 million for a Thrust Belt parcel 10 miles south of Evanston. Another parcel near Amos Draw field in Campbell County brought $858,640 as the high bid by Amoco.

Wyoming, which replaced its oil and gas lease lottery with an auction, netted $4.5 million from its two auctions in 1983 and an additional $2.3 million in January of this year. Wyoming's next auction, which is by oral bidding, is scheduled for March, 1984. For comparison, in six month's the State received $6.8 million dollars in auction bids for 388 parcels, which is $1.5 million more than generated by the 375 parcels offered in the last six months of the lottery. Each auction has included about 100,000 acres of land.

In late December, 1983, the Frontier Pipeline began delivering Thrust Belt crude oil to the Amoco refinery in Casper. Although the line will initially deliver 5,000 - 15,000 barrels of oil per day, its capacity is 77,000 barrels per day, expandable to 150,000 barrels per day. Initial delivery volumes could be expanded if other refineries in Casper make arrangements to purchase Thrust Belt crude.

In late December, Amoco announced completion of a Permian Phosphoria discovery in a sub-granite structure near the shallow-producing Sheep Creek field northwest of Muddy Gap. Production tests indicated 5-172 barrels of oil and 85,000-180,000 cubic feet of gas per day on pump. This is another important sub-thrust discovery similar to the Teepee Flats discovery on the east side of the Wind River Basin.

Celsius Energy announced completion of a high volume gas discovery in the southeast corner of the Washakie Basin, four miles north of Cedar Breaks field. This well was completed in the Upper Cretaceous Mesaverde Formation for 10 million cubic feet of gas per day from a depth of about 12,500 feet.

Louisiana Land and Exploration recently completed a high volume oil producer in the Mexican Springs field, two miles south of Turnercrest, Wyoming. The well was completed in the Lower Cretaceous Dakota Sandstone, flowing 2,241 barrels of oil and 3.3 million cubic feet of gas per day. This is the fifth high volume well completed in the field since its discovery in mid-1983, indicating another significant addition to the oil reserves of the Powder River Basin.

The Wyoming Oil and Gas Conservation Commission's hearings on new seismic rules, originally set for January, 1983, was postponed until March 13th. In response to numerous comments that have been received, an alternative set of new rules were proposed by the staff of the Commission. In essense the alternative rules require a permit for all seismic lines using shot holes and blasting. Under the proposed rules, in addition to fining companies that fail to properly plug holes, the Commission would be able to revoke or deny permits to those companies that ignored plugging rules. At the hearing in early March, the Commission accepted written and oral comments on its proposed seismic rules, and hopes to issue final rules before April.

At press time, the 1984 Wyoming Legislature was considering an appropriations bill that would fund an Enhanced Oil Recovery Research (EOR) Center at the University of Wyoming. The bill contained $233,410 for the EOR Center, which would be housed at the University's Petroleum Engineering Department. Wyoming has an estimated 10 billion barrels of oil recoverable by enhanced recovery techniques[1].

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[1] Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 pages.

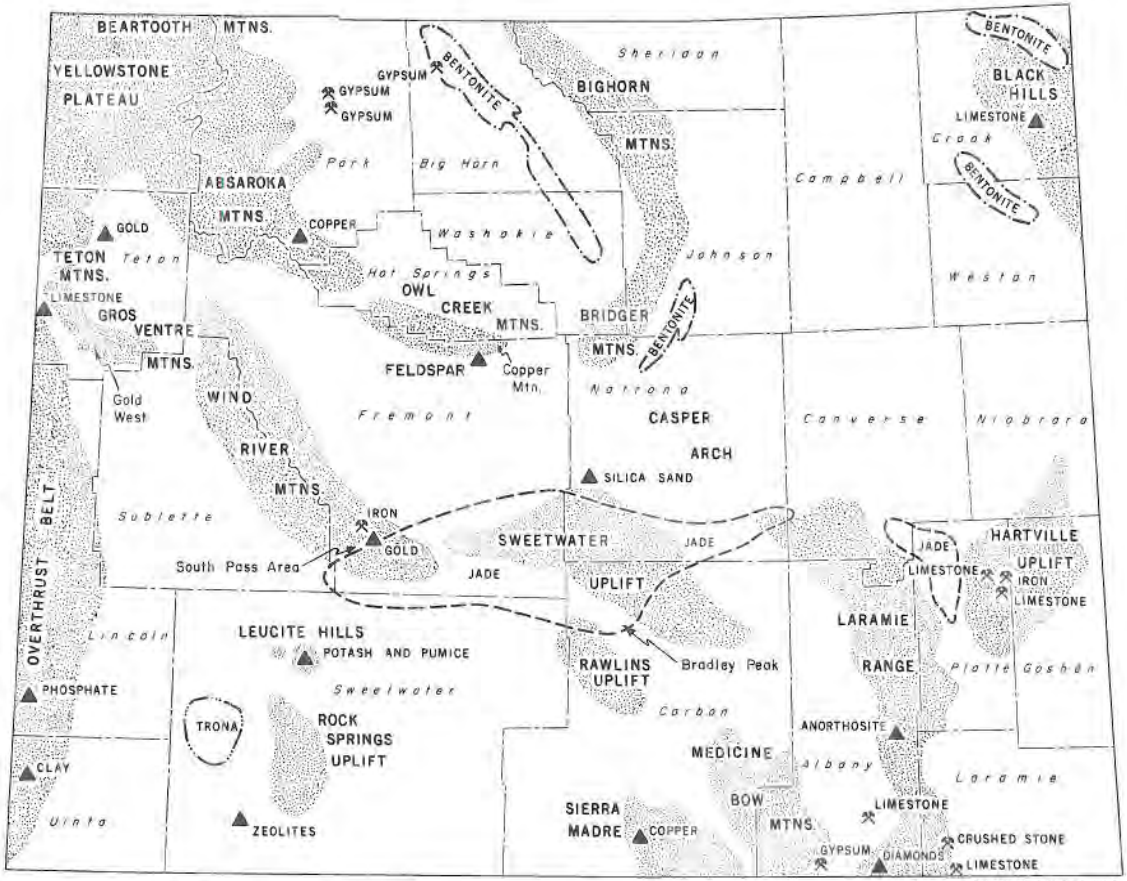
METALS AND PRECIOUS STONES

by W. Dan Hausel, Deputy Director
Wyoming Geological Survey

During the first quarter of 1984, weather slowed exploration activities for metals and diamonds. There was some drilling for strategic metals in the State when the weather permitted, and a local prospector made an apparent rich lode gold discovery at an undisclosed location in Wyoming. Numerous samples containing visible free gold have been recovered. Otherwise, most companies were simply planning their exploration projects for the coming field season.

Some mineral deposits, probably targeted for exploration in 1984, were described in Geological Survey of Wyoming Reprint 44 entitled, "Metallogeny of some Wyoming deposits". This paper was reprinted from the 1983 Colorado Mining Association Yearbook, and includes a discussion of exhalitive stratiform gold deposits. The important auriferous quartz veins and iron-formations discovered in 1981 at Bradley Peak in the Seminoe Mountains were of this type. According to preliminary field work by the Geological Survey of Wyoming, similar exhalitive deposits may also occur in the Hartville Uplift and in the Copper Mountain area of the Owl Creek Mountains.

In the Copper Mountain area, south of Thermopolis, a minimum of eight miles of fairly continuous iron-formation, and possibly as much as 12 miles of continuous iron-formation were mapped by the Geological Survey of Wyoming. Because sediments covered a portion of the iron-



SELECTED MINERAL AND ROCK OCCURRENCES

formations, their total extent is uncertain. At some localities, the iron-formations exhibit evidence of remobilization and contain zones enriched in copper and iron sulfides. Although no gold has been detected in these iron-formations, they have not been adequately sampled. At a few localities near the iron-formations, nearby stratiform quartz veins, or cherts, that have been sampled for base and precious metals yielded interesting values in both copper and gold. At the historic DePass mine on the eastern edge of Copper Mountain, reconnaissance surface and underground mapping have identified potential copper, gold, and silver resources.

In 1984 Cominco American Incorporated will continue to explore for diamondiferous kimberlite in Wyoming. Diamond exploration by the Geological Survey of Wyoming is also planned for the 1984 field season. The Survey's stream sediment sampling program identified two regions particularly worthy of further investigation - the Sheep Rock and Happy Jack areas of the southern Laramie Range in Albany and Laramie counties. These areas will receive considerable attention in 1984.

COAL

by Richard W. Jones, Coal Geologist
Wyoming Geological Survey

Preliminary figures from the State Inspector of Mines indicate that Wyoming's coal production for 1983 was 112.2 million tons (Table 1), an increase of almost 4 percent over 1982's record production of 108 million tons. Our earlier forecast that

TABLE 1: 1983 WYOMING COAL PRODUCTION BY COUNTY AND BY COAL BASIN[1]

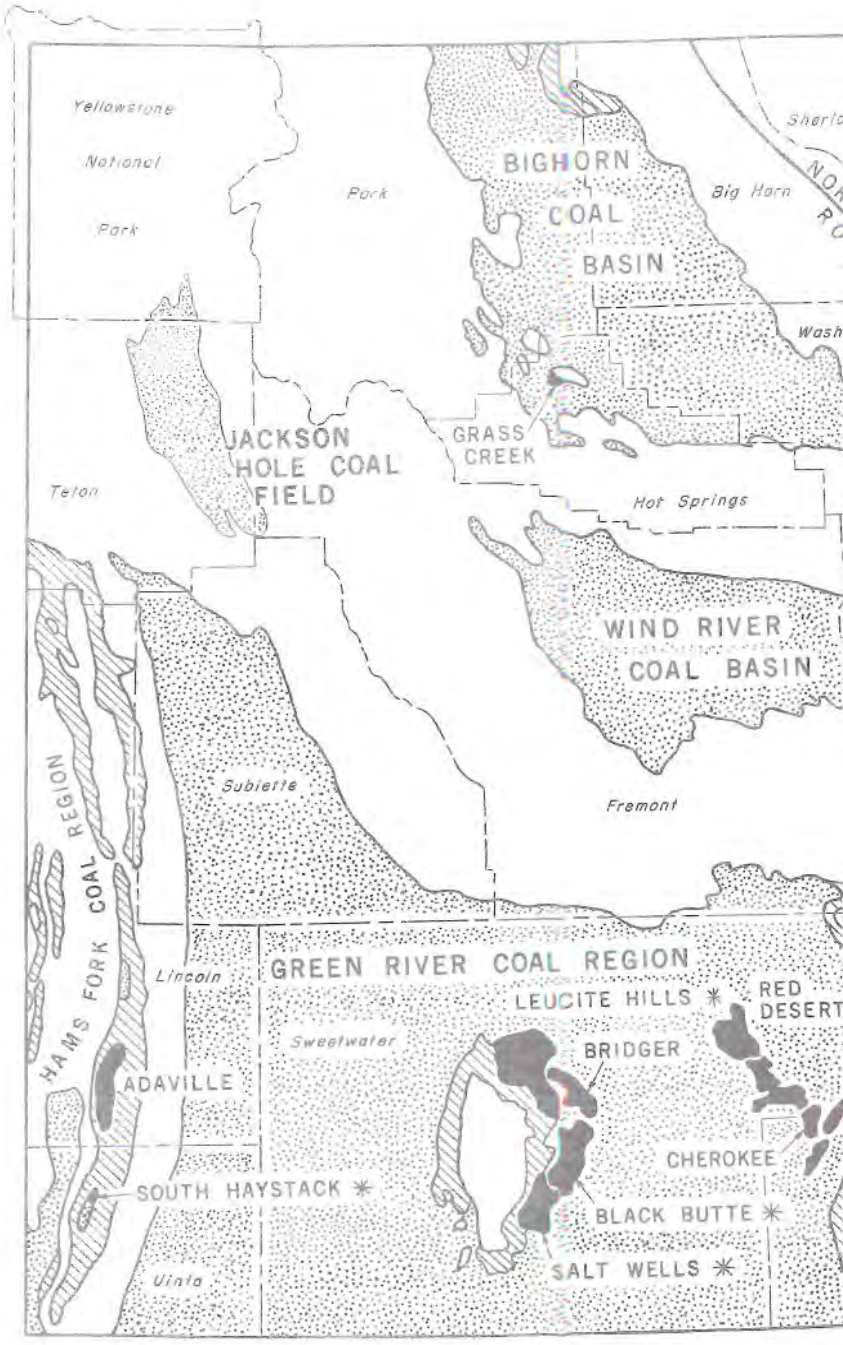
County	Production	Percent of Total Production	Number of Mines	Number of Employees
		POWDER RIVER BASIN		
Campbell	88,180,758	78.6	14	2,610
Converse	2,684,011	2.4	1	247
Sheridan	2,947,698	2.6	2	214
TOTAL	93,812,467	83.6	17	3,071
		GREEN RIVER BASIN		
Sweetwater	9,471,416	8.4	3	994
		HAMS FORK REGION		
Lincoln	4,040,435	3.6	2	477
		HANNA BASIN		
Carbon	4,818,465	4.3	6	767
		BIGHORN BASIN		
Hot Springs	45,091	<0.1	1	4
TOTAL WYOMING	112,187,874	100	29	5,313

[1]Source: Wyoming State Inspector of Mines, preliminary data from 1983.

1983 coal production would be about the some as 1982 production has turned out to be 3.7 percent too low. In retrospect, the increase in Campbell County was greater than expected (we predicted a 6 percent increase -- the actual increase was nearly 9 percent) and more than offset production decreases in southern and southwestern Wyoming of nearly 10 percent. On a monthly basis, production was almost identical to that of 1982 until the last two months of the year. November and December production increased substantially, and accounted for much of the 4.2 million tons above our original estimate.

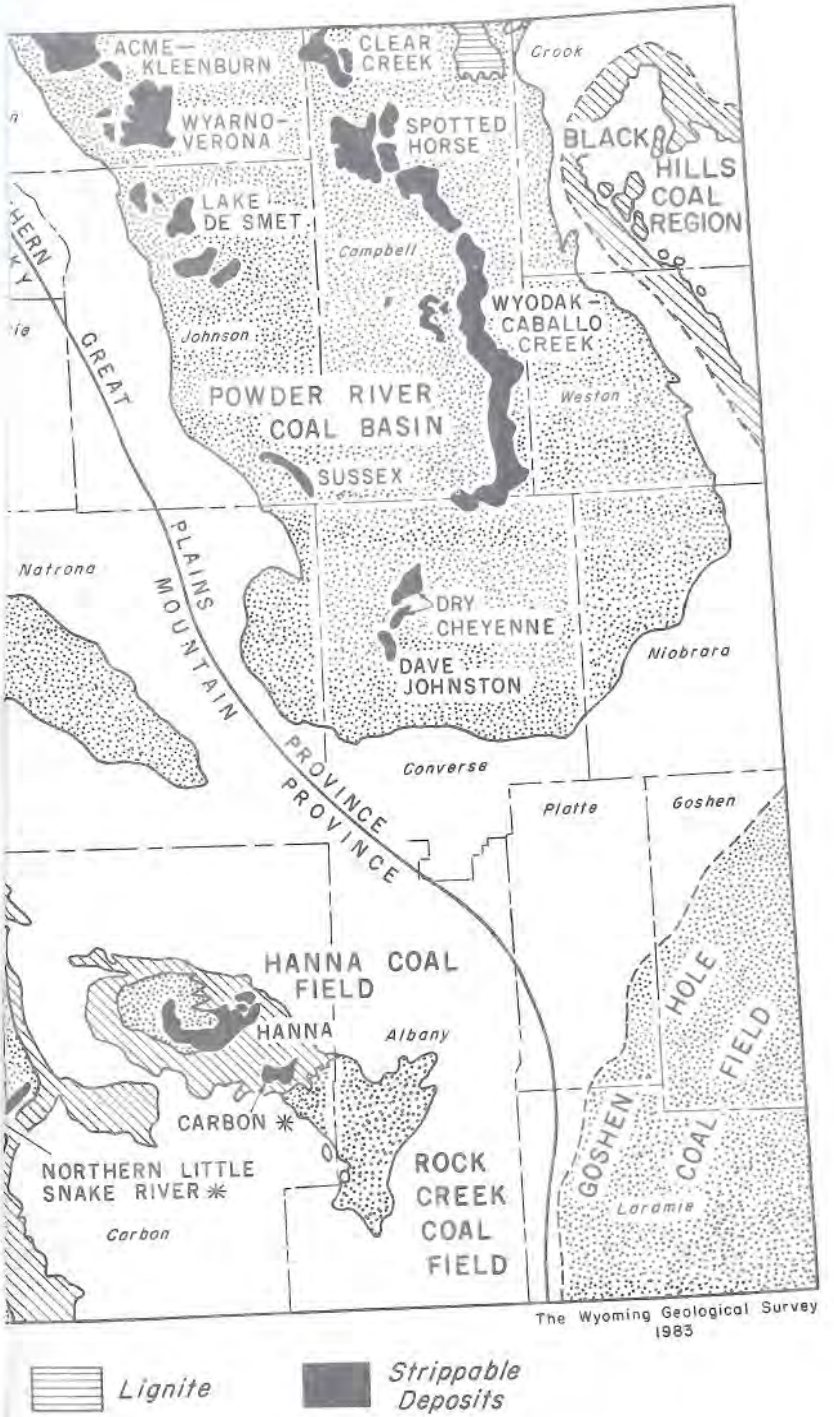
For the second year, the largest mine in Wyoming and in the United States, was Black Thunder at 15.2 million tons. Black Thunder was followed by Belle Ayr, Jacobs Ranch, Eagle Butte, and Cordero mines. These mines all produced in excess of 10 million tons each; 9 other coal mines in the State produced over 2 million tons each. A total of 29 mines operated in the State in 1983 and employed 5,313 people, a decrease of 334 from 1982. In the Powder River Basin, the North Antelope coal mine in southern Campbell County began production in late 1983. In the Hanna Basin, the Vanguard No. 2 underground mine, which was active only in early 1982, was not active in 1983; the Rimrock pits were closed in early 1983 after only two months of production; and the Seminoe No. 1 mine, which did report production in 1983, was closed in early 1984.

Government and industry exploration for coal continued in 1983, but with fewer drill holes and less footage than in past years. Most of the drilling by the Federal government was designed to evaluate specific tracts in anticipation of future coal leasing; several holes were drilled for



* Preliminary: based on company data

COAL-BEARING



The Wyoming Geological Survey
1983

Lignite

Strippable Deposits

research and correlation purposes. There was no Federal coal exploration done under contract in Wyoming last year. The Geologic Division of the U.S. Geological Survey (USGS) drilled a total of 3,169 feet in three drill holes in Campbell and Sheridan counties. Of this total, 229 feet in one drill hole were cored.

The U.S. Bureau of Land Management (BLM) drilled seven coal exploration holes in the Hanna Basin, eight in the Great Divide Basin, ten in the Wind River Basin, eleven in the Bighorn Basin, and fourteen in the Powder River Basin. These 50 holes totalled 19,797 feet; of these totals, 12 core holes were drilled and 1,691 feet of core were recovered. Collectively, the USGS and BLM drilled 53 holes totalling 22,996 feet; of this total, thirteen holes were cored for a total of 1,920 feet of core.

In 1983, coal exploration by private industry on Federally-owned coal resulted in the drilling of 506 drill holes for a total of about 94,830 feet. These Federal statistics do not include development drilling and blast hole drilling on leases currently in production, nor do they include drilling of water observation wells, soil test boring, or drilling for the delineation of burned-out coal areas (clinker areas). Drilling statistics on State- and privately-owned coal were not available.

Only seven federal exploration licenses, held by six companies, were in effect at the end of 1983. Those companies included Sparrow Coal, Ark Land, Rocky Mountain Energy, NERCO, Anaconda Minerals, and Northwestern Resources, and their licenses encompassed an area of abut 56,850 acres. During the year, nine exploration licenses

covering 59,924 acres expired, and four exploration licenses covering 6,877 acres were issued. An additional seven applications for Federal exploration licenses, totalling 23,530 acres were awaiting approval, and one application was rejected.

Coal exploration activities in the State may be affected by the temporary moratorium on Federal coal leasing which began in October 1, 1983. The moratorium will continue at least until the middle of May, 1984, three months after the Linowes Commission's report on coal leasing is submitted to Congress. The commission was formed as a result of other investigations of Federal coal leasing policy that followed the controversial 1982 Powder River Basin coal lease sale.

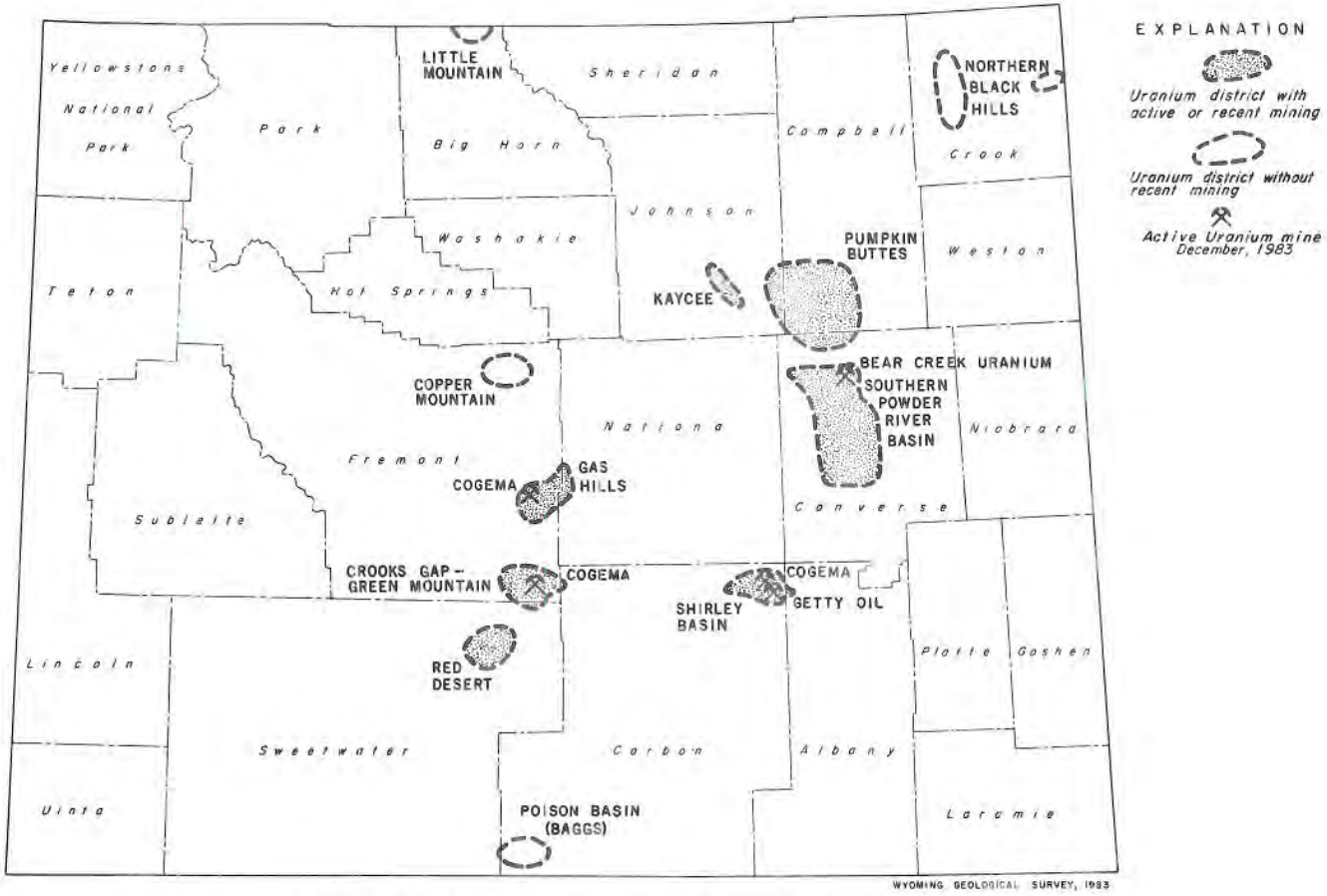
URANIUM AND INDUSTRIAL MINERALS

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

Uranium

Five uranium mines continued production in Wyoming as of March 1, 1984. There have also been layoffs by Pathfinder and Exxon. Pathfinder at the Pathfinder-COGEMA Lucky Mc Mine in the Gas Hills of Fremont County laid off 26 workers. Also, rather than operating continuously, the mine will shut down 4 days out of every 10 days.

Exxon, which continued to process uranium at the Highland Mill in Converse County, laid off 25 workers as operations there work toward a complete



MAJOR ACTIVE AND INACTIVE URANIUM DISTRICTS

shut down. The mine was closed in late 1982, but Exxon continues to process stockpiled ore.

The U.S. Department of Energy (DOE) is changing its uranium enrichment procedures to allow for less expensive processing techniques. Processing uranium oxide to nuclear fuel at a lower cost may lower fuel costs to users and would also increase the amount of foreign uranium enriched by the United States. The uranium enrichment process increases the content of the fissionable isotope U_{235} from 0.74 percent found in natural uranium to three percent for reactor grade fuel (compared to more than 90 percent for weapon grades). These changes are expected to take effect after industry comments are received.

Because uranium mills in Wyoming produce uranium oxide, the effect of DOE's decision on the Wyoming uranium industry is likely to be very small and indirect. It is possible that lowered fuel costs might stimulate some renewed interest in Wyoming's ores. The decision is not likely to affect uranium prices which are now $20.50 per pound, compared to $23.00 in 1983.

In 1983, exploration of uranium in Wyoming was principally conducted in known uranium districts. Companies, including Adobe, AGIP, American Nuclear, COGEMA, Everest, Homestake, Rocky Mountain Energy, Sequoyah, Teton, Union Carbide, Uranerz, Uranium Resources, and Western Nuclear drilled exploratory wells in the Gas Hills, Crooks Gap, Red Desert, Poison Basin, Shirley Basin, Southern Powder River Basin, Pumpkin Buttes, and the Northern Black Hills districts. Malapai Resources continued development drilling on their Petersen Ranch properties in the southern Powder

River Basin. Buttes Oil and Gas conducted exploratory drilling along the east margin of the Green River Basin southeast of Green River, and Sequoyah drilled a possible unconformity-related uranium target east of Rawhide Buttes in east-central Wyoming. Drilling activity was about the same as last year with less than 20 rigs active at any one time - a change from 1978 when literally hundreds of rigs were active. A few companies, including Atlas and Homestake, continued to conduct basic uranium reconnaissance in Wyoming.

The Geological Survey of Wyoming is also conducting research on the uranium deposits of the State. There is a potential for nonconformity-related, paleoplacer, and various types of igneous uranium deposits. This research should assist the search for large, high-grade uranium deposits in Wyoming. The discovery of high-grade uranium deposits would enhance the chances for successful competition with Canadian, Australian, and other foreign uranium producers.

Thorium and rare elements

The United States Geological Survey announced the results of research into the large thorium and rare-earth element reserves in the Bear Lodge Mountains near Sundance in northeastern Wyoming[2].

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[2] Staatz, M.E., 1983, Geology and description of the thorium and rare-earth deposits in the southern Bear Lodge Mountains, northeastern Wyoming: U.S. Geological Survey Professional Paper 1049D, 52 p.

Research at the Geological Survey of Wyoming has located other areas in the Bear Lodge Mountains that may contain rare-earth and thorium occurrences[3]. Tantalum, niobium, and rare-earth element occurrences in the northern Bighorn Mountains also attracted some industry interest in 1983.

Trona

Preliminary production figures released by the Wyoming State Inspector of Mines show that last year's trona production increased to 11,589,345 tons, about 6 percent more than 1982 production. Although this production is below the record years of 1979, 1980, and 1981 when production was closer to 12,000,000 tons, it has reversed the trend of declining production. Most of the production gains in 1983 occurred during the fourth quarter with December production 20 percent greater than December of 1982.

FMC's proposed solution mining of trona has been opposed by Tenneco, which has challenged the legality of solution mining on environmental grounds. The outcome of this dispute has not been resolved.

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[3] Harris, R.E., 1983, Bedrock geologic map of the Bear Lodge Mountains alkaline complex, Crook County, Wyoming: Geological Survey of Wyoming Open File Report 83-3, 1 sheet.

Other industrial minerals

The production of gypsum and bentonite increased toward the end of 1983 reflecting an upturn in the national and regional economy. While gypsum production reflected increased housing construction, bentonite production increased because of greater steel production from Minnesota taconite.

The production of sand and gravel, crushed rock, and clinker reflected seasonal lows in construction for the region.

In 1983, there was continued exploration for industrial minerals currently produced in Wyoming as well as for some commodities that may be produced in the future. Producers of trona, bentonite, gypsum, construction aggregates, limestone and dolomite, sodium sulfate, and sugar rock developed their reserves as the economy improved, and production of all of these materials increased.

There was some exploration for silica deposits in the State, particularly in southern Wyoming where the production of soda ash from trona would make a glass plant economically attractive.

A few companies were active in the anorthosite area of southeastern Wyoming. The anorthosite may be a suitable substitute for nepheline syenite, currently imported from eastern Canada. This material is used in glass and ceramics, mill fluxes, and as a source of alumina. Alcoa maintained its property position in the anorthosite, and continues to test the rock for its use as an

aluminum ore.

Phosphate in the Permian Phosphoria Formation in the Thrust Belt of western Wyoming continued to attract interest as phosphate leases were renewed and new areas leased in 1983. Stauffer Chemical Company continued to process phosphate at Leefe, Wyoming, from material mined in Idaho.

There was increased interest in zeolite exploration in 1983. Wyoming contains large natural zeolite reserves in the Washakie Basin, Lysite Mountain, and Beaver Rim areas. Many companies explored and acquired properties in these areas.

NEW SURVEY PUBLICATIONS

Self-guided tour of the geology of a portion of southeastern Wyoming, by W. Dan Hausel and Richard W. Jones, Public Information Circular No. 21, 1984 ($6.00, add $2.00 if mailed First Class).

Oil shale sample locations and analyses, southwest Wyoming and northwest Colorado, by Donna J. Sinks, Laurence G. Trudell, and George F. (Pete) Dana, Public Information Circular No. 22, 1983 ($6.00, add $2.00 if mailed First Class).

Metallogeny of some Wyoming deposits, by W. Dan Hausel and Ray E. Harris, Reprint No. 44, 1983 ($3.00, add $1.00 if mailed First Class).

Geothermal Resources of Wyoming, by H.P. Heasler, and others, colored map, 1:500,000 scale, 1983 (Free, except for $2.00 mailing charge).

WYOMING URANIUM PRODUCTION FORECAST TO 1990[1]

Calendar Year	Gross Uranium Production (millions of tons)
*1981	4.6
*1982	2.1
1983	1.6
1984	1.0
1985	0.8
1986	0.8
1987	0.9
1988	0.9
1989	1.0
1990	1.3

*These are actual values for comparison.

[1]*Forecast by Wyoming Geological Survey, December, 1983.*

WYOMING TRONA PRODUCTION FORECAST TO 1990[1]

Calendar Year	Gross Trona Production (millions of tons)
*1981	11.8
*1982	10.1
*1983	11.6
1983	10.4
1984	10.5
1985	10.6
1986	10.6
1987	10.7
1988	10.7
1989	10.9
1990	11.1

*These are actual values for comparison.

[1]*Forecast by Wyoming Geological Survey, March, 1984.*

PERCENTAGE OF WYOMING"S TOTAL MINERAL VALUATION BY COMMODITY FOR 1983 AND 1973

	1983*		1973	
Oil	56.5%		75.5%	
Gas	20.1%		9.0%	
Total Hydrocarbons		76.6%		84.5%
Coal	19.8%		4.0%	
Trona	2.2%		3.3%	
Uranium	0.8%		5.2%	
Iron	0.2%		1.7%	
Bentonite	0.2%		0.5%	
Sand and Gravel	0.1%		0.1%	
Phosphate	-0-		0.2%	
All others	Less than 0.1% (Limestone, Dolomite, Gypsum, Sugar Rock, Clay, Sodium Sulfate, Feldspar, Decorative Stone, Cement Rock, Scoria, and Ballast.		0.4% (Dolomite, Gypsum, Clay, Sodium Sulfate, Feldspar, Decorative Stone, Cement Rock, Scoria, and Ballast)	
TOTAL VALUATION	$5,624,803,530		$511,953,563	

Notable in the above figures are the relative declines in the proportions of uranium and iron to the total, and the relative increases in the proportions of coal and natural gas. *Valuation is based on 1982 production.

WYOMING OIL AND GAS PRODUCTION FORECAST TO 1990[1]

Calendar Year	Natural Gas production (billions of cubic feet)	Oil Production (millions of barrels)
*1980	450.6	126.4
*1981	455.4	122.1
*1982	465.1	118.7
1983	507.8	117.9
1984	516.5	118.0
1985	526.0	118.6
1986	553.0	119.1
1987	579.0	117.5
1988	619.0	116.0
1989	679.0	114.5
1990	739.0	113.0

*These are actual values for comparison.

[1]*Forecast by Wyoming Geological Survey, March, 1984.*

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1983)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	13.7 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	21.3 billion barrels
Remaining Reserve Base (January 1, 1983)	
Measured reserves (Proved reserves)	0.9 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[3]
Total	3.7 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1983)	
Discovered	21.0 trillion cubic feet[1]
Undiscovered (there is another 35 trillion cubic	

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feet of noncombustible CO_2 gas)	58.0 trillion cubic feet[1]
Total	79.0 trillion cubic feet
Remaining Reserve Base (January 1, 1983)	
Measured reserves (Proved reserves)	10.2 trillion cubic feet[2]

COAL

Remaining Resources (January 1, 1983)	
Identified (Discovered)	136.6 billion tons[4]
Undiscovered	800.0 billion tons[5]
Total	936.6 billion tons
Remaining Reserve Base (January 1, 1983)	
Demonstrated strippable (Measured and indicated reserve base)	27.7 billion tons[4]
Demonstrated underground-minable (Measured and indicated reserve base)	38.4 billion tons[4]
Total	66.1 billion tons

TRONA

Original Resources

Trona	81.7 billion tons[6]
Mixed trona and halite	52.7 billion tons[6]
Total	134.4 billion tons

URANIUM

		U_3O_8
Remaining Resource (January 1, 1983)		995,000 tons[7]
Remaining Reserve Base (January 1, 1983)	ORE	U_3O_8
Ore recoverable at $30 or less/ton	29.4 million tons	39,700 tons[7]
Ore recoverable at $30.01-$50.00/ton	225.1 million tons	151,500 tons[7]
Ore recoverable at $50 or less/ ton	254.5 million tons	191,200 tons

OIL SHALE

Original Resources (January 1, 1983)

Identified (Discovered)	320 billion barrels of shale oil [8]

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[1] Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.

[2] American Petroleum Institute, 1983, Basic petroleum data book: Volume III, no. 2, May.

[3] Modified from Barlow and Doelger (1983), footnote 1.

[4] Wyoming Geological Survey, December, 1983. (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 Reort 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.

WYOMING COAL PRODUCTION FORECAST TO 1990 (MILLIONS OF TONS)

	1981[1]	1982[1]	1983[1]	1984	1985	1986	1987	1988	1989	1990
Campbell County	71.6	81.2	88.2	93.4	103.2	110.5	117.2	112.0	122.8	123.8
Converse County	3.6	3.4	2.7	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Sheridan County	2.8	3.0	2.9	2.9	2.2	2.2	2.5	3.0	3.0	3.0
Carbon County	8.5	5.0	4.8	4.6	4.6	3.7	3.8	5.1	5.6	5.6
Sweetwater County	11.2	11.0	9.5	10.0	8.1	9.1	9.1	11.0	11.0	11.0
Lincoln County	5.0	4.3	4.0	4.1	4.4	4.6	4.9	5.2	5.2	5.2
Hot Springs County	M[2]	M	M	M	M	M	M	M	M	M
Total Wyoming	102.8	107.9	112.2	118.3	125.8	134.4	141.8	149.6	150.9	151.9
Increase per year	9%	5%	4%	5%	6%	6%	5%	5%	1%	1%
Estimated contracted production	110.0	119.0	122.6	128.6	137.1	142.6	147.6	149.6	150.9	151.9
Below contracts	7%	9%	8%	8%	8%	6%	4%	-0-	-0-	-0-

[1]These are actual values for comparison. [2]M means minor tonnage (less than 0.1 million tons). Forecast by Wyoming Geological Survey, March, 1984