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

WYOMING GEO-NOTES NO.5

Laramie, Wyoming
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WYOMING GEO-NOTES

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Wyoming Geo-notes was first published in July, 1977, as a semiannual 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 now forms the backbone for our rejuvenated *Wyoming Geo-notes*. The newsletter is now published quarterly and has been expanded to include news about Staff and Survey activities.

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MINERALS UPDATE

OVERVIEW

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

In *Wyoming Geo-notes No. 4* (September 1984 issue), we provided a forecast of oil, natural gas, coal, trona, and uranium production for Wyoming. It now appears that 1984 production of oil, natural gas, and coal may exceed that forecast. Based on seven months of production records, Don Basko, Supervisor for the Wyoming Oil and Gas Conservation Commission, believes that 1984 oil production could top 125 million barrels (we forecast 124 million barrels) and that production of natural gas could be between 589-600 billion cubic feet (we forecast 580 billion cubic feet). This is good news as our forecasts in September already showed healthy increases over 1983. If these additional increases occur, oil production would be 3.4 percent above 1983 while gas production would be 9-11 percent above last year.

Coal production is far above expectations and will probably reach or exceed 129 million tons, which is 15 percent above 1983 and nine million tons above our September estimate. This also means that 1985 coal production will likely exceed 133 million tons. This surprising increase in tonnage, however, is at least partially at the expense of price. A significant portion of the production gains in 1984 are spot sales at bargain prices (some as much as 30 percent below contract prices). To take advantage of low spot prices,

many utilities are trimming the tonnages they take on long term contracts to absolute allowable minimums and then buying the difference or make-up tonnage on the spot market. Although these actions boost production, they also reduce the value of coal and consequently, company profits as well as taxes and royalties decline proportionally. As long as the coal market remains soft, these purchasing tactics are likely to continue if not increase, and the soft market is not likely to disappear before the early 1990's.

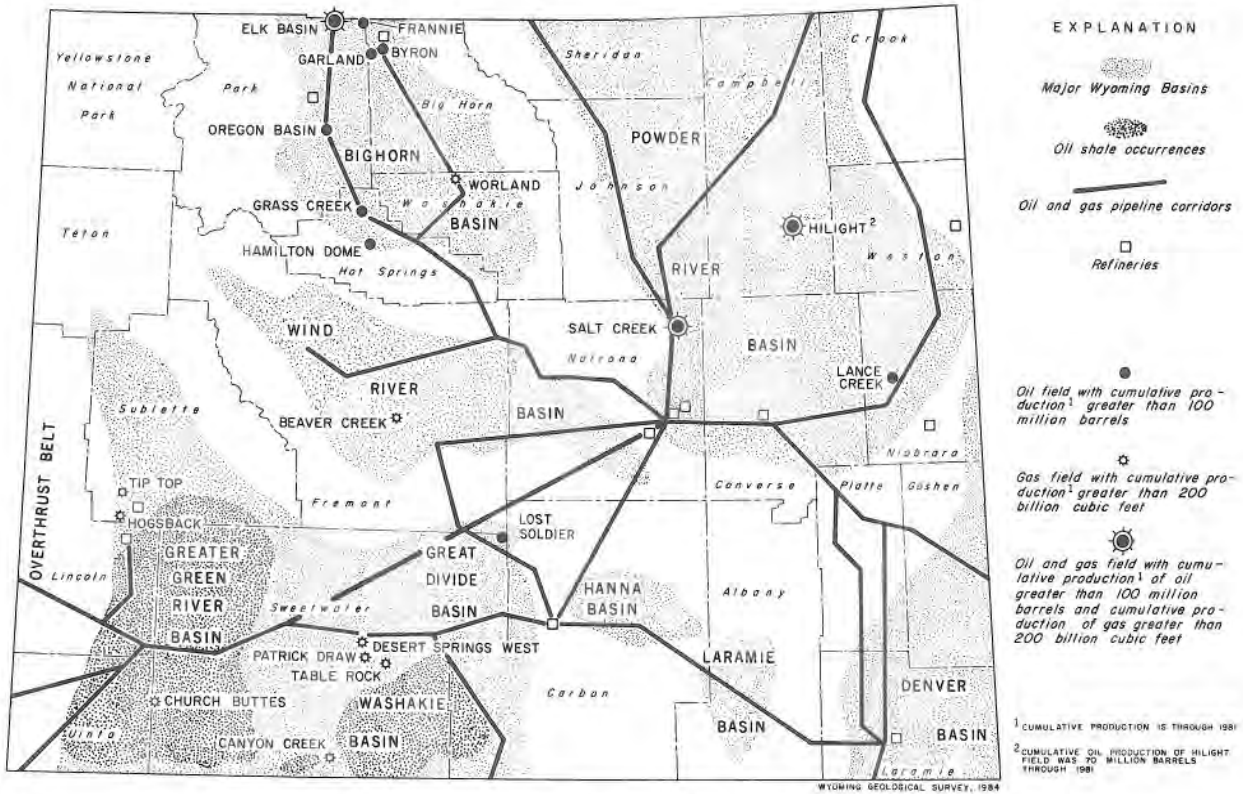
In the case of oil and natural gas, the production gains are also somewhat offset by price declines. Although prices paid for both Wyoming crude and natural gas have not fallen precipitously, there have been cuts in both the third, and fourth quarters of the year. Further cuts are probable in both the fourth quarter of this year and again next year.

OIL AND GAS UPDATE

by Alan J. VerPloeg, Petroleum Geologist, Wyoming Geological Survey

Drilling activity has continued to increase in Wyoming. As of November 12, the rig count for the State stood at 131. Allowing for seasonal adjustments during the upcoming winter months, drilling should continue to follow this upward trend, especially in the oil producing basins within the State.

The Minnelusa Formation is still the hot play in the Powder River Basin with several recently



WYOMING GEOLOGICAL SURVEY, 1984

GENERALIZED OIL AND GAS INDEX MAP OF WYOMING

EXPLANATION

Major Wyoming Basins

Oil shale occurrences

Oil and gas pipeline corridors

Refineries

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

announced discoveries. Diamond Shamrock reported a 200 barrel per day oil discovery 18 miles southeast of Gillette in early October; Lear Petroleum announced a 477 barrel per day oil discovery 16 miles southeast of Gillette in late September; Propel Energy completed a 48 barrel per day oil discovery 12 miles northeast of Gillette in late September; Donald C. Slawson, Oil Producer, completed a 236 barrel per day oil discovery 24 miles northwest of Moorcroft in early November; and Cenex completed a 758 barrel per day oil discovery 1¼ miles west of Pickrel Ranch field southeast of Gillette in late August. This northeast portion of the Powder River Basin should remain a major exploration target for months, and even years to come.

Oil companies involved with the development of Amos Draw field in Campbell and Johnson Counties, recently requested that the field be developed by conventional techniques instead of gas reinjection processes which had been under consideration. In an October application to the Wyoming Oil and Gas Conservation Commission, the companies contended that the expensive, time-consuming reinjection process would make the investment submarginal, yielding at best an unattractive 5 percent return delayed over 15 years. The application was taken under advisement by the Commission so that its staff could review the technical evidence presented at the hearing. In mid-November, the Commission announced their decision to allow conventional production techniques. Although the gas reinjection process would recover about three million more barrels of oil than the conventional techniques, the Commission ruled that leaving some oil in the ground is not wasteful if those resources are not economically recoverable.

In the Overthrust Belt, development of the giant Anschutz Ranch, East field continues with Amoco's recent completion of a new producer 14 miles south of Evanston, Wyoming. This well was tested at 12,639,000 cubic feet of gas and 1,379 barrels of 50 gravity condensate per day from the Jurassic Nugget Sandstone.

Celsius Energy completed an offset to its Dripping Rock field discovery southwest of Rawlins on the eastern side of the Washakie Basin. Production was gauged at 18,500,000 cubic feet of gas per day from the Mesaverde Formation. Celsius is the unit operator, controlling 6,200 acres within the unit and 8,500 acres of the immediate area around the unit.

Exxon's recently announced, half billion dollar Shute Creek gas plant will be one of the largest carbon dioxide producing plants in the United States. Approximately two-thirds of the plant's production will be carbon dioxide (CO_2) and one-third natural gas. Chevron, earlier this fall, contracted for up to 900 billion cubic feet of CO_2 for use in an enhanced oil recovery project at Rangely, Colorado. Amoco has contracted for 181-191 billion cubic feet of CO_2, pending its decision to use CO_2 injection in Lost Soldier and Wertz fields north of Rawlins. In a related note, Pacific Power and Light (PP&L) will provide the electricity for Exxon's Shute Creek plant according to a recent ruling by the Public Service Commission. PP&L had been in competition with Utah Power and Light for the right to service the facility.

The U.S. Department of the Interior recently announced new oil and gas rules pertaining to

audits of oil and gas royalty payments. The new regulations provide for two methods of carrying out audits. First, audit authority could be delegated to approved states with the Federal Government assuming 100 percent of the audit costs, or, secondly, a cooperative audit program between Federal and State governments could be established with the Federal Government reimbursing the participating state 50 percent of the costs. The State of Wyoming has already requested delegation of auditing authority. These new rules also clarify some of the royalty payment responsibilities, provide for a 6-year record keeping requirement and statute of limitations, and provide penalty assessments for late or erroneous reports.

The controversy over the Federal oil and gas lease lottery system remains. Opponents of the lottery noted that total filing fees were down from $13.7 million in September 1983 to $5 million in August 1984. Proponents argue that the recession and the elimination of unwanted speculators account for the decline and that the higher filing fees and advance rental payments were bound to have that effect. Most observers do not expect a quick resolution of this controversy, but Interior officials have indicated that they want to try out the new lottery system further before making any more changes.

The U.S. Bureau of Land Management's latest competitive oil and gas lease sale was held on August 29th, yielding record revenues to the Federal and State coffers. The sale of 149 tracts yielded $12.4 million surpassing the previous record of $7.2 million set in February of 1984. Exxon was the biggest spender, bidding about $8

million of the total. Two Campbell County parcels were the highest-priced, totaling $4.8 million and $2.3 million, respectively. Exxon was the successful bidder on both these tracts which are located in Ross field.

The Wyoming Oil and Gas Conservation Commission has proposed changes to their rules concerning seismic operations in Wyoming. One change would prohibit surface shooting closer than one mile to any inhabited dwelling and set a 50 pound limit on the shot size unless written consent of the owner was first obtained. The amendment also requires notification of all persons living within two miles of any shot.

Another change would require seismic companies to plug shot holes with coarse ground, sodium bentonite plugging material during winter operations (November 1 through May 1) unless a specific variance is granted. Under the proposed amendments, seismic companies and contract hole pluggers will have to commence plugging operations within 30 days after shooting unless they are granted a variance.

A hearing on these proposed changes and amendments was set for December 11, 1984 at the Commission's Hearing Room in Casper.

Bronco Oil and Gas Company is continuing efforts to develop the Trapper Canyon Tar Sand Deposit east of Greybull in the Bighorn Basin of Wyoming. They recently drilled a 1,000-foot Mississippian Madison test on the deposit in order to extend their lease another two years. Next spring, the company plans to initiate a propane

injection project to demonstrate that the oil will flow. Once the flow of oil is demonstrated, Bronco's development plan calls for mining the tar sand and removal of the tar using a solvent extraction technique. Bronco Oil and Gas has indicated that even though they have encountered numerous expenses and lease problems, the project remains financially attractive, primarily due to recent significant increases in price for asphalt. The deposit contains between one million and two million barrels of 5.5° API gravity petroleum in a 67-acre area.

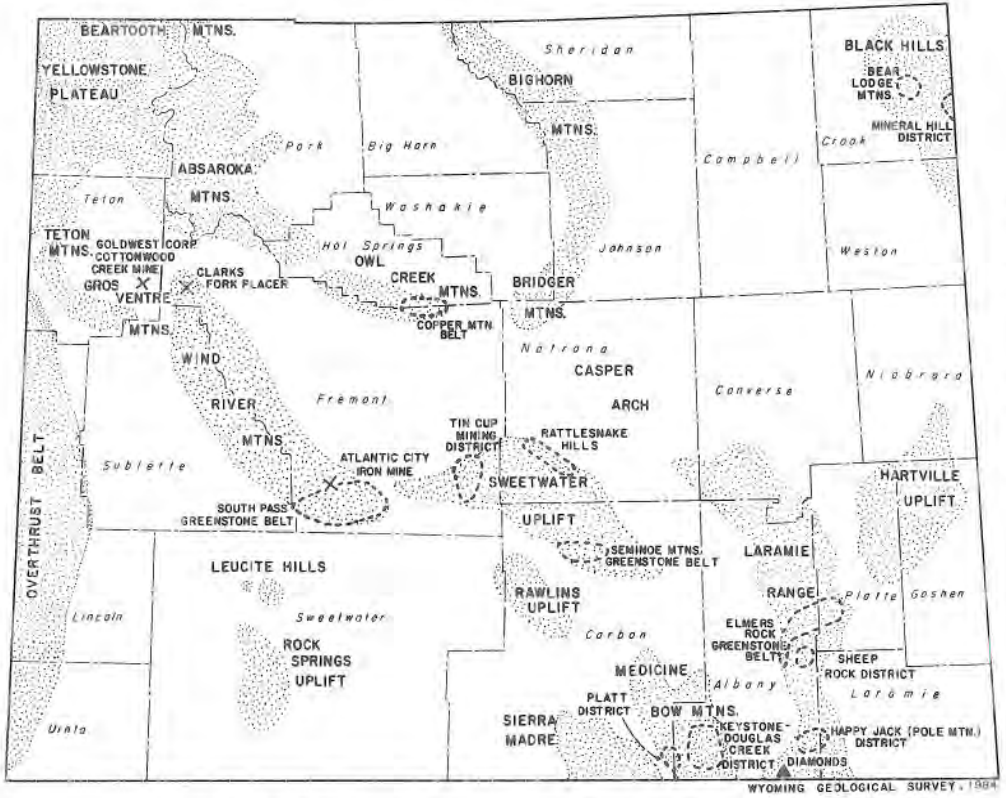
During the past field season, the Geological Survey of Wyoming initiated a field reconnaissance study of known tar sand and heavy oil occurrences in Wyoming. Fourteen different localities were examined in the Bighorn Basin, southern Wind River Basin, eastern Washakie Basin, northeast Powder River Basin, and southern Overthrust Belt. The most significant localities in terms of size were the Muddy Creek deposit in the eastern Washakie Basin and the Conant Creek and Muskrat deposits in the southern Wind River Basin. These occurrences were sampled, described, photographed, and mapped. Additional work is planned for the 1985 field season. Specifically, the Rattlesnake Mountain and Dutton Basin deposits in the southern Wind River Basin will be examined. If time and funds permit, additional occurrences will be examined in the Powder River Basin and Bighorn Basin. The results of this past summer's work and anticipated work in 1985 will be tabulated into a report in the fall of 1985. This project is funded by a grant from the U.S. Department of Energy, Laramie Projects Office.

A 1984 edition of the *Oil and Gas Map of Wyoming* is now available. Prepared by the Petroleum Section of the Wyoming Geological Survey, this 1:500,000 scale, colored map updates the 1980 edition, adding all of the new fields and field extensions of the early 1980's. The discoveries made during the last four years were numerous, and they are particularly obvious if the two editions are compared. As in the first edition of the map, each field is not only colored to show the predominant age of production, but is also annotated with the names of the producing formations. Pipelines, refineries, and gas plants are also shown on the map. Designated Map Series No. 12 (MS-12), this map is available for $10.00 over-the-counter at the Wyoming Geological Survey Building in Laramie or at the Wyoming Oil and Gas Conservation Commission Offices (Basko Building) in Casper. Add $2.00 for postage and handling if mailed folded and another $1.50 if you want a flat version mailed in a tube.

METALS AND PRECIOUS STONES UPDATE

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

Although major mining companies are searching for both large tonnage, low-grade stratiform gold deposits and low-grade "Carlin-type" micron gold deposits associated with black shales, only minor exploration activity for micron gold occurred during the past field season. This activity was centered in the Overthrust Belt of western Wyoming.



REGIONS OF EXPLORATION ACTIVITY FOR STRATEGIC MINERALS

The principal exploration activity during the past field season was for stratiform deposits in Archean (>2.5 billion years old) supracrustal rocks. Some activity occurred in the South Pass, Copper Mountain, Laramie Range, Granite Mountains, Seminoe Mountains, and Hartville Uplift supracrustal belts.

The South Pass supracrustal belt, located at the southern edge of the Wind River Mountains, has a favorable tectonic setting for stratiform deposits. Historically gold from this belt, was reportedly mined from auriferous vein and shear zone deposits (Hausel, 1980; Hausel and Harris, 1983); however, some of these deposits have characteristics of stratiform mineralization.

Several exploration groups were in the South Pass region during the past field season, and Freeport Exploration was consolidating a strong land position in the Lewiston and Miners Delight areas. It was also reported by the Laramie Boomerang (November 15, 1984), that Universal Equipment Company was negotiating with U.S. Steel Corporation to purchase the Atlantic City iron ore mine. According to the article, Universal "...is also talking with Freeport Exploration about a gold processing operation".

Placer mining activity in the South Pass region was restricted to small floating dredges, and the success of these ventures varied from individual to individual. One prospector recovered several small nuggets and considerable dust and flakes in Meadow Gulch near Miners Delight.

There was also underground exploration at several mines within the district. A local group

of miners from Atlantic City secured access and reopened a few of the old mines in order to sample the principal gold-bearing shears and veins. Some companies toured the mines and collected their own set of samples for assay.

At the Carissa Mine near South Pass City, a Salt Lake City company cleared the primary shaft of debris and began dewatering the drifts and stopes on the five levels. Historically, the Carissa Mine was one of the two largest gold producers in the district. Ore from this mine reportedly averaged 0.32 ounces of gold per ton (Hausel, 1980; 1984).

The Geological Survey of Wyoming initiated a long-term project in the district, which will eventually produce a geological map of the South Pass supracrustal belt with special emphasis on economic geology. This project is now part of a cooperative grant with the U.S. Geological Survey (see discussion on page 41). Initially the project is designed to produce 7½-minute geologic quadrangles of segments of the belt. These 1:24,000 scale maps will later be compiled into one regional map. The workings in all accessible mines will be mapped at 1:120 or 1:240 scales.

During the past field season, preliminary mine maps were prepared for the Dream and Wilson Bar adits near Lewiston; and for the Gold Dollar, Diana, Soules and Perkins, Big Chief, Mary Ellen, Tabor Grand, Doc Barr, and Carrie Shields mines near Atlantic and South Pass Cities. The historic Lewiston gold district was also mapped at 1:24,000 showing mines, prospects, and the principal veins and shear zones. During reconnaissance mapping of

the Lewiston Lake 7½-minute quadrangle, to the east of the Lewiston District, a previously unmapped banded iron formation was located.

Several samples were collected for assay from the historic gold mines, the Lewiston Lakes iron formation, and from siliceous and sulfide replacement zones in the Atlantic City iron formation. Samples were also collected from mines in the Lewiston District for alteration and geochemistry studies.

Copper Mountain, which is located in the Owl Creek Mountains near central Wyoming, consists of a homoclinal succession of volcanogenic metamorphic rocks intruded by granites. This belt contains cupriferous quartz veins, tungsten-bearing gneisses, and several miles of banded iron formation. In the past, this region has been explored for gold, silver, copper, feldspar, lithium, beryl, tungsten, uranium, and petroleum (Hausel and Graff, 1983). In the 1984 field season, the area was again explored for stratiform gold deposits.

The Geological Survey of Wyoming recently completed a regional geologic map of Copper Mountains, and several mine maps. Although the results of these field studies are preliminary, there are indications that the area has potential for stratiform gold and tungsten mineralization. The work also suggests copper, gold, and silver reserves may be present at the historic DePass Mine on the eastern flank of Copper Mountain. Mineralization at the DePass Mine is hosted by a Proterozoic mafic dike. The report and maps should be available early in 1985.

Supracrustal rocks available for exploration on the east flank of the Laramie Range near Garrett, are limited, However, over the years, this region has received a fair amount of prospecting for gold, talc, asbestos, chromite, and iron. 1984 was no exception with at least one mining company conducting exploration in the area. The Geological Survey of Wyoming also conducted some reconnaissance studies of the Garrett area. The Survey's preliminary field examination identified a northeast-trending limonite-stained micaceous quartzite within the supracrustal succession, which appears to host stratiform mineralization. Samples collected from one prospect pit within the quartzite contained pyrite and berthierite. A sample of limonite-stained, berthierite-bearing quartzite assayed 0.25 ounces of gold per ton.

In the Sierra Madre mountains of southcentral Wyoming some exploration was aimed at finding a silver deposit similar to the deposit at the Troy Mine in Montana. The Troy deposit occurs in a nearly flat-lying, 60-foot thick quartzite. The ore at the Troy mine contains both silver and copper.

The Sierra Madres were also recently explored for massive sulfides. Both Timberline Minerals and a German-owned company conducted the exploration.

Exploration by at least two companies was focused on the Ferris-Haggarty Mine. The Ferris-Haggarty Mine was developed into a thick quartzite that has a 30 to 35 degree dip. Copper mineralization appears to be stratabound and partially remobilized. The few assay reports available on

the Ferris-Haggarty ore show samples running 3.95 percent copper with a trace of silver, and 4.6 percent copper with 0.03 ounces of silver per ton. One cupriferous quartzite sample tested by the Wyoming Geological Survey assayed 0.06 ounces per ton of combined gold and silver.

During this past field season, prospectors located a gold-bearing vein along the northern edge of the Big Creek District in the southern Medicine Bow Mountains. The Wyoming Geological Survey collected a channel sample across the vein. The sample assayed 1.4 ounces of gold per ton, and the prospectors are presently applying for necessary permits to conduct economic tests.

In other metal activity, the Cottonwood Creek gold placer mine, east of Jackson, operated during the 1984 summer. No production reports are available.

The Geological Survey of Wyoming continued searching the Laramie Range for diamondiferous kimberlite. The main activity of the Survey is in the Pole Mountain-Happy Jack area to the east of Laramie and in the Sheep Rock district to the northeast of Laramie.

Several stream sediment samples collected in the Pole Mountain-Happy Jack area contained pyrope garnet, some chromian diopside, and magnesian ilmenite. This region was examined using remote sensing methods (e.g., Marrs and others, 1984) and one target, in particular, showed a distinctive vegetation anomaly and was located along a northwest-trending lineament. Samples collected from this possible diatreme produced some lower crustal

pyrope-alamandine garnets, and EM and magnetic ground surveys indicated a weak EM anomaly. This structure is still under investigation.

Apparently there is still industry interest in the Colorado-Wyoming diamond-bearing districts and in domestic diamond deposits in general. It is reported that Superior Minerals may reopen their testing plant at Prairie Divide, Colorado, to test a diatreme from an undisclosed location. Diamond exploration has also been reported in the northern Medicine Bow Mountains of Wyoming. In addition, the 1984 Regional Meeting of the American Institute of Mining and Metallurgical Engineers, held in Denver, included a session on kimberlite exploration.

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Hausel, W.D., 1984, Tour guide to the geology and mining history of the South Pass gold mining district, Fremont County, Wyoming: Geological Survey of Wyoming Public Information Circular No. 23, 1 sheet.

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Hausel, W.D., and Harris, R.E., 1983, Metallogeny of some Wyoming deposits: Geological Survey of Wyoming Reprint No. 44 (reprinted from the 1983 Colorado Mining Association Yearbook), 18 p.

Marrs, R.W., Marks, J.E., Hausel, W.D., and Albert, K.G., 1984, Detection of diamond-bearing kimberlites in the Colorado-Wyoming province: International Symposium on Remote Sensing of the Environment, Third Thematic Conference Preprint, Colorado Springs, Colorado, 11 p.

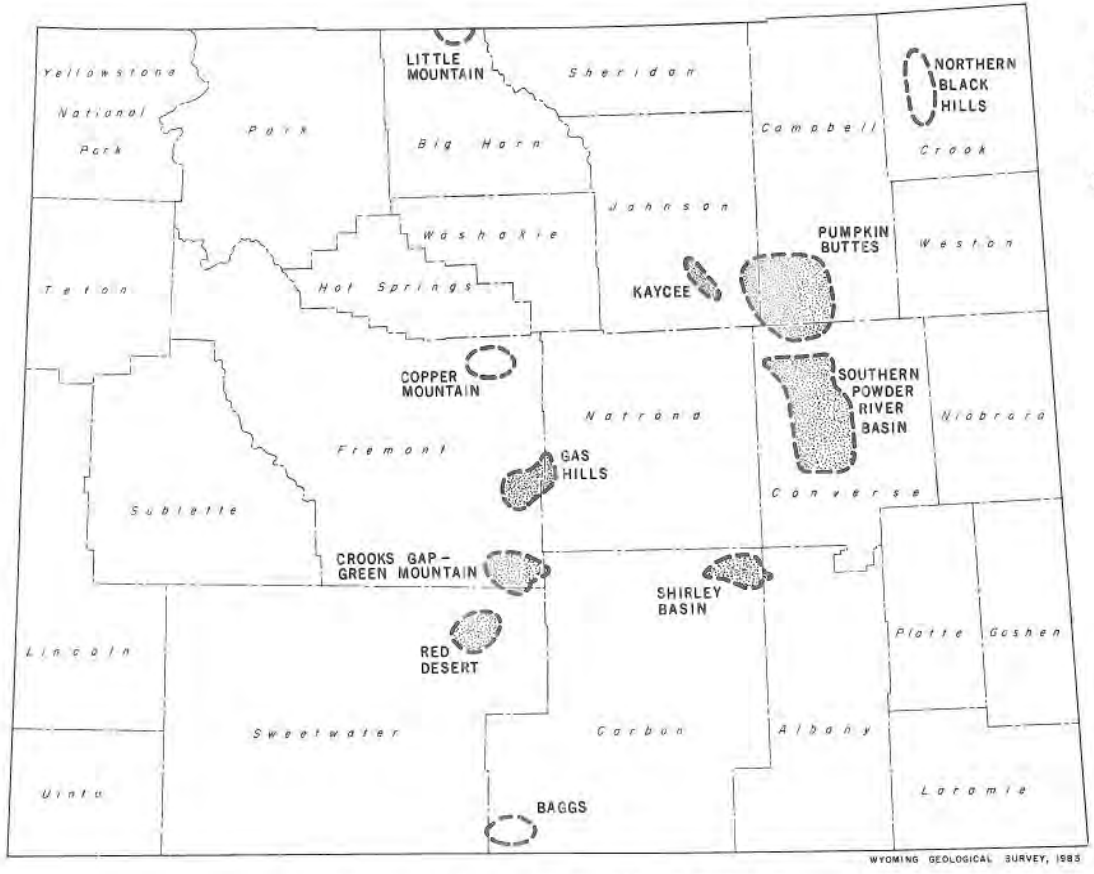
URANIUM AND INDUSTRIAL MINERALS UPDATE

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

During the fall of 1984, Exxon Minerals Company closed the Highland Uranium Mill in the southern Powder River Basin. Although the Highland Mine was closed two years ago, Exxon had been milling ore which had been stockpiled in the mine. This closure represents the final shut down of Exxon's uranium operations in Wyoming.

There remain only four active uranium operations in the State. COGEMA continues to operate the Lucky Mc Mine in the Gas Hills and their Shirley Basin Mine. Getty Oil Company continues to mine uranium at their Shirley Basin Mine, and Bear Creek Uranium continues to mine at Bear Creek in the southern Powder River Basin.

The outlook for uranium mining remains poor. No improvement for this declining industry is seen



MAJOR ACTIVE AND INACTIVE URANIUM DISTRICTS

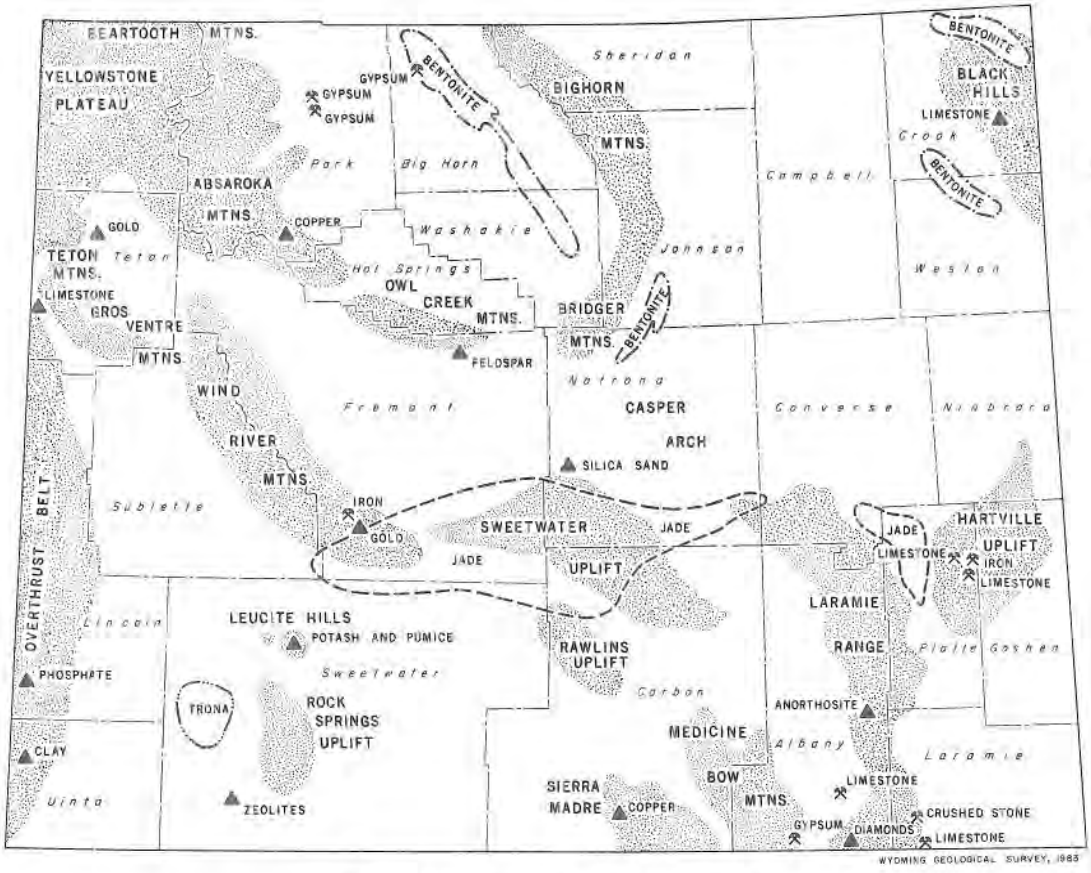
until the 1990's, and any recovery at that time depends upon the development of more favorable economic conditions as well as improved public opinion about the safety of nuclear power.

The American Mining Congress (AMC) believes the uranium industry is in its worst shape ever. Eighty percent of the national uranium industry work force has been laid off. AMC also believes that the industry has lost its viability and that there is no chance for growth. AMC closes its prediction by saying "...this country will lose the energy independence once promised by nuclear energy".

Bentonite production in Wyoming continues to increase at a slow rate. Oil well drilling usually increases toward the end of a calendar year and should increase the demand for bentonite for drilling mud. The price of bentonite, however, remains depressed since all producers are operating well below plant capacity and under very competitive conditions.

In addition, new rules on taxable value, which have been proposed by the Wyoming Attorney General's Office, could increase the taxes assessed on bentonite. The new rules may disallow deductions for transportation costs incurred between the mine and the mill. The Wyoming Mining Association notes that some bentonite is hauled as far as 70 miles before milling.

Although it is not a major use of bentonite, this clay is used for plugging seismic shot holes. In fact, Wyoming and other states require the use of bentonite slurry mixtures in many plugging



SELECTED MINERAL AND ROCK OCCURRENCES

situations for the protection of ground-water aquifers.

Under a proposed amendment to Wyoming's seismic plugging rules, seismic companys or contract hole pluggers would be required to use coarse ground bentonite for plugging shot holes during the winter months. Experiments have shown that this plugging method eliminates or greatly reduces the chance of the plugging material being blown from the shot holes. In the winter when the ground surface is frozen, blowouts can rip up the top of the hole and cause substantial surface damage that is hard to reclaim.

Coarse ground bentonite is also a good substitute for seismic holes for which conventional gravel has been used in the past. Although conventional stream gravels usually prevent blowouts, the permeability of the gravel cannot prevent the mixing of aquifers. Coarse bentonite, on the other hand, swells up and provides an impermeable barrier to the movement of ground water intercepted by the shot holes.

Trona is Wyoming's most valuable nonfuel mineral. Currently, the trona industry is slowly recovering from the 1982 depression. Production in 1983 increased four percent over 1982, due primarily to increased exports. Although domestic consumption of soda ash (refined trona) has increased in 1984, exports have decreased. As a result, 1984 trona production is close to 1983 levels, and may even be running slightly behind last year.

Domestic consumption is expected to increase. But unless exports increase, the trona industry is expected to show only slight growth.

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1984)

Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	13.6 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	21.2 billion barrels

Remaining Reserve Base (January 1, 1984)

Measured reserves (Proved reserves)	0.8 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[3]
Total	3.6 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1984)

Discovered	20.4 trillion cubic feet
Undiscovered (there is another 35 trillion cubic feet of noncombustible CO_2 gas)	58.0 trillion cubic feet
Total	78.4 trillion cubic feet

Remaining Reserve Base (January 1, 1984)

Measured reserves (Proved reserves)	9.6 trillion cubic feet

COAL

Remaining Resources (January 1, 1984)

Identified (Discovered)	136.5 billion tons[4]
Undiscovered	800.0 billion tons[5]
Total	936.5 billion tons

Remaining Reserve Base (January 1, 1984)

Demonstrated strippable (Measured and indicated reserve base)	27.6 billion tons[4]
Demonstrated underground-minable (Measured and indicated reserve base)	38.4 billion tons[4]
Total	66.0 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

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 Modified from 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, June, 1984. (Modified from Berryhill, H.L., Jr. and others, 1950, *Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.*

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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.

New rules on taxable value proposed by the Attorney General's Office may substantially increase taxes paid on trona. Traditionally, taxes have been based on the value of trona ore (about $10.00 per ton). The new rules may assess the tax on the soda ash value after processing. Soda ash is currently valued at $69 per ton.

Production of other industrial minerals (gypsum, limestone, sand and gravel, etc.) continues to increase as the local economy improves and construction increases. 1984 production of these industrial minerals should be about five percent greater than 1983.

As mentioned earlier this year, Rocky Mountain Energy Company is testing a zeolite-bearing horizon in southwestern Wyoming. A few hundred tons of ore have been shipped to a laboratory in Indiana. Zeolites are natural ion exchangers with properties similar to water softener beads and may be useful in water softeners, kitty litter, and feedlot deodorizers. They may also have uses in the cleanup of natural and industrial pollutants.

Wyoming has two perlite processing operations: a packaging operation, Western Perlite, in Green River, and a processing plant operated by Harborlite, Inc., west of Green River, which supplies perlite to the trona industry for use as a filter aid during the trona refining process.

Perlite is a glassy volcanic rock containing 2 to 5 percent water. When heated, this rock will expand rapidly. The expanded material, also called perlite, has low density, high silica content, and a large surface area. These properties make it useful in a variety of industrial applications.

Perlite processed in Wyoming is mined in Arizona and Idaho as there are no known occurrences of perlite in Wyoming. Glassy volcanic rocks exist in Wyoming in a few places outside of Yellowstone Park, but these have not been tested for their water content and expansion properties.

Recent publications by the Uranium and Industrial Minerals Section of the Wyoming Geological Survey include:

Harris, R.E., and Hausel, W.D., 1984, Mineral resources of Permian and Pennsylvanian rocks in Wyoming: Wyoming Geological ASsociation 35th Annual Field Conference Guidebook, p. 369-381.

Harris, R.E., 1984, An overview of the geology and production of Wyoming trona: Society of Mining and Metallurgical Engineers preprint 84-326, 11 p.

COAL UPDATE

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

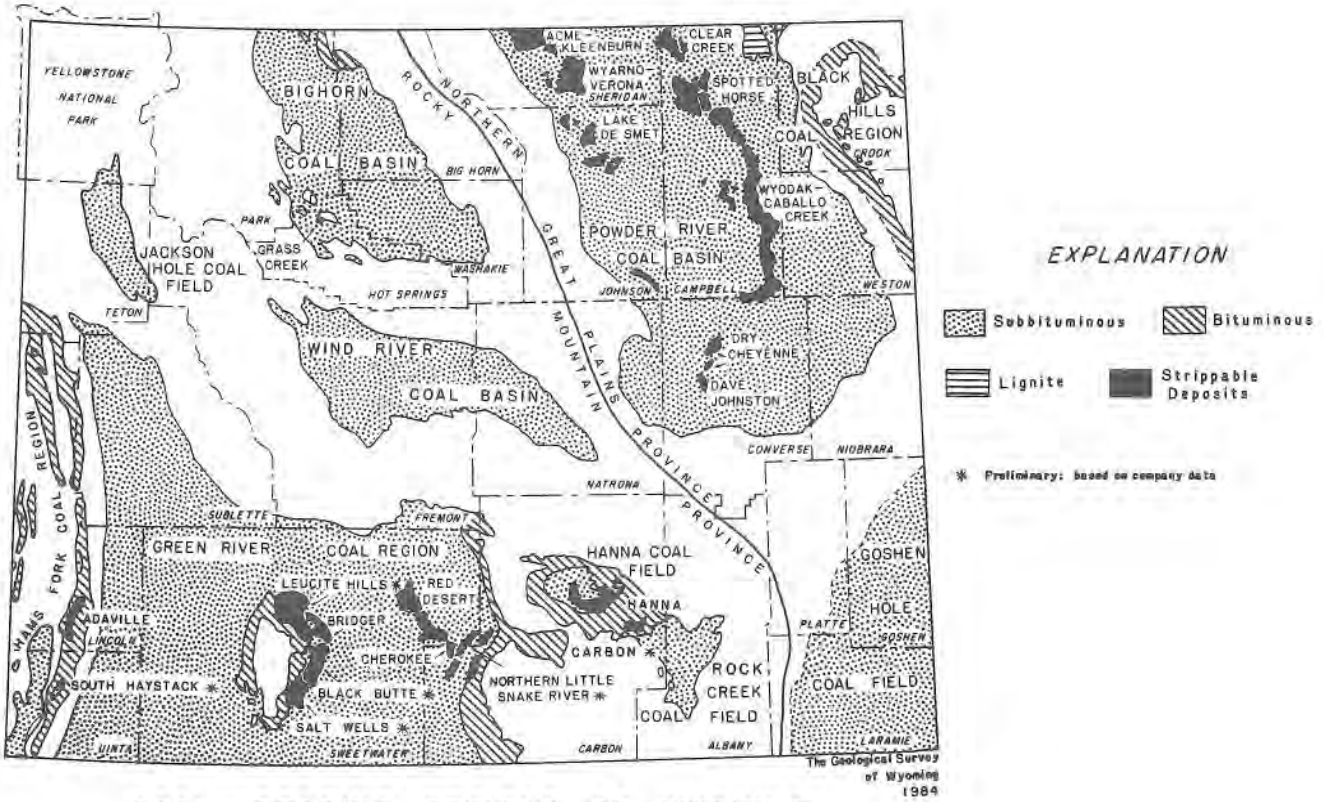
It now appears that Wyoming coal production for 1984 will exceed the 120 million tons predicted in September (Geo-notes No. 4, Table 2, p. 3). Based on coal deliveries filed with the Federal Energy Regulatory Commission for the first eight months of 1984, production is nearly nine million tons ahead of production for the same period in 1983 (Table 1). If these production rates continue for the last four months of the year and if unreported tonnages remain at about five million tons (as

Table 1. Reported coal deliveries from Wyoming mines (in short tons x 10^3)[1].

	1983 MONTHLY	1983 CUMULATIVE	1984 MONTHLY	1984 CUMULATIVE
JANUARY	10,313.0	10,313.0	9,540.2	9,540.2
FEBRUARY	8,719.7	19,032.7	9,654.6	19,194.8
MARCH	9,051.2	28,083.9	10,875.0	30,069.8
APRIL	8,195.0	36,278.9	8,721.4	38,791.2
MAY	8,364.6	44,643.5	9,481.5	48,272.7
JUNE	8,330.2	52,973.7	9,464.5	57,737.2
JULY	8,734.7	61,708.4	11,019.6	68,756.8
AUGUST	9,669.3	71,337.7	11,433.0	80,189.8
SEPTEMBER	9,189.7	80,567.4		
OCTOBER	9,406.3	89,973.7		
NOVEMBER	9,013.6	98,987.3		
DECEMBER	7,680.6	106,667.9		
TOTAL REPORTED DELIVERED TONNAGE	106,667.9			
TOTAL TONNAGE NOT REPORTED	5,520.0			
TOTAL TONNAGE PRODUCED [2]	112,187.9			

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

[2] *Source: Wyoming State Mine Inspector's Annual Reports for 1982 and 1983.*



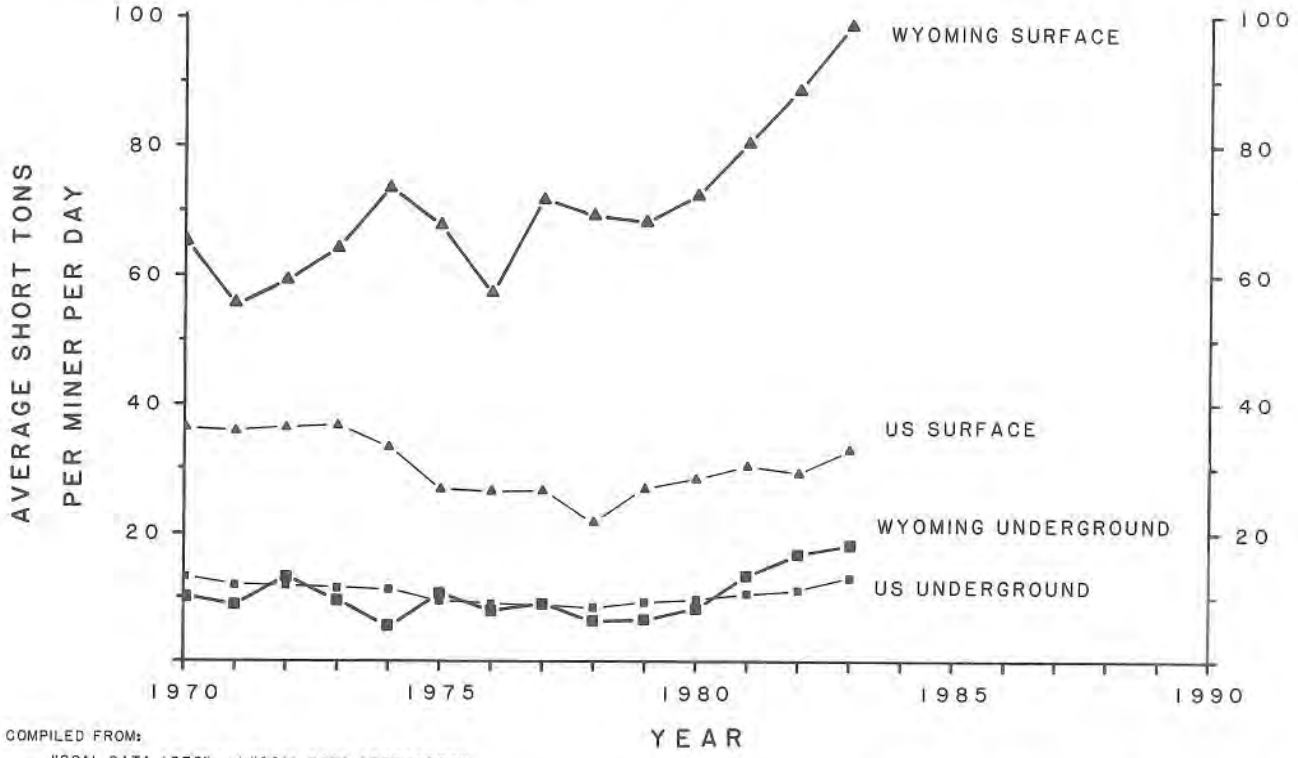
COAL– BEARING REGIONS OF WYOMING

they have the last two years), Wyoming's production may exceed 129 million tons in 1984.

The production increase seen in the State in 1984 has also occurred nationwide: the U.S. Department of Energy's Energy Information Administration (EIA) reports that a record 447.9 million tons of coal were produced in the first half of 1984, an increase of 18.5 percent over the first half of 1983. The increase was attributed to a rise in electric utility consumption and a buildup of coal stocks in anticipation of a possible strike by the United Mine Workers. The National Coal Association predicted in July that the total U.S. production in 1984 would be 853 million tons (an all-time record) and that total U.S. coal consumption would be 849 millions tons, also a record. The EIA predicts (November 1984) that national coal production in 1984 will be 871.5 million tons and national coal consumption will be 795.8 million tons.

National coal production figures for 1983 are now available in a recently published report entitled, *Coal Production-1983*, by the Energy Information Administration (EIA, 1984). This publication confirms that Wyoming was the third largest coal-producing state in the nation in 1983 with 112.2 million tons of production, behind only Kentucky (128.7 million tons) and West Virginia (114.3 million tons). Wyoming has ranked third in total coal production and first in production from surface mines since 1980. In 1983, Wyoming produced about 14 percent of the nation's total coal production of 782.1 million tons, about 23 percent of the nation's total surface production of 478.3 million tons, about 69 percent of the nation's

WYOMING AND U.S. COAL MINE PRODUCTIVITY



COMPILED FROM:

"COAL DATA 1975" and "COAL DATA 1979/1980" by National Coal Association

"COAL PRODUCTION 1981, 1982 & 1983" by DOE/EIA

Wyoming Geological Survey, 1984

subbituminous coal, and about half the coal produced in the Western Coal Production Region. The total U.S. production was down 6.7 percent from the record high 838.1 million tons produced in 1982.

Coal mine productivity in Wyoming has increased each year since 1979, and 1983 was no exception (Figure 1). Coal mine productivity, expressed by short tons of coal produced per miner per hour (or per day), was eight percent higher in 1983 than the previous year for underground mining, five percent higher for surface mining, and nearly six percent higher overall. Productivity from Wyoming's only underground mine (Carbon County No.1) is slightly higher than the national average and about the same as the Western Region average. Surface mine productivity is about three times the national average and about 1.3 times the average for the Western Region. Overall productivity for the State's mines in 1983 was 94 short tons per miner per day, compared to about 61 short tons per miner per day for Western Region mines and about 21 short tons per miner per day for all mines in the United States. Montana is the only state with a productivity rate higher than Wyoming's and that is because less productive mines in southern Wyoming (including an underground mine) are included in Wyoming's overall productivity. The differences in productivity between southern Wyoming mines and Powder River Basin mines reflect inherent geologic differences between the two areas. The mined coals in the Powder River Basin are not only much thicker than the coals mined in southern Wyoming, but they are nearly flat-lying. Consequently, mining methods in the two areas are quite different.

The EIA report also summarizes recovery rates (percent of a mine's reserves that can be recovered) and utilization rates (a measure of a mine's production rate to a mine's productive capacity) for each state and the nation. Wyoming mines that were active in 1983 contain nearly six billion tons of recoverable coal reserves, about one-half of the 12 billion tons in the western region and about one-fourth of the nation's 24.5 billion tons. It is estimated that Wyoming's overall recovery rate is nearly ninety percent, slightly less than Montana and North Dakota's rate (because of the influence of an underground mine and southern Wyoming mines), but well above the national average of about 73 percent. The recovery rate for underground mining in Wyoming is about the same as that for the Western Region (55.63 percent), but less than the overall rate for the nation. This is mainly because coal beds in the Western Region are much thicker than coal beds in the Eastern and Interior Regions and often part of the coal remains in place on either the roof or the floor of the mine for safety reasons or for better operating efficiency.

The daily productive capacity for the United States coal industry was 3.8 million short tons at the end of 1983, and the average daily production of coal in 1983 was 3.4 million tons; the utilization rate (the percentage of total capacity represented by production) for the United States was 89.0 percent. This is a decrease from the 89.5 percent reported in 1982 and probably reflects a weakened coal market in 1983. The daily productive capacity for Wyoming was 479,000 short tons in 1983, up slightly from the 441,000 short tons in 1982. Wyoming mines operated at about 85 per-

PRODUCTION FROM FEDERAL, STATE, AND PRIVATE LANDS IN WYOMING

LANDS	1981	1982	1983
Federal[1]	59,576,163 (59%)	63,612,335 (59.9%)	67,975,848 (60.6%)
State[2]	26,485,275 (25.8%)	19,872,591 (18.4%)	18,189,147 (26.2%)
Private[3]	16,721,996 (16.2%)	24,469,657 (22.7%)	26,022,908 (23.2%)
TOTAL[4]	102,783,434	107,954,58	112,187,903

Reference Sources

1 *Minerals Management Service Annual Reports: Royalties, 1981; Mineral Revenues, 1982 and 1983.*

2 *Wyoming Department of Public Lands Annual Reports.*

3 *Derived by subtracting Federal and State production from total production.*

4 *Wyoming State Mine Inspector Annual Reports.*

PRODUCTION FROM STATE COAL LEASES BY COUNTY[1]

County	1980	1981	1982	1983
Campbell	21,417,481	26,274,778	19,815,682	17,297,231
Carbon	160,584	186,430	384,578	353,974
Converse	--	17,953	472,330	537,941
Lincoln	14,107	6,114		
TOTAL	21,592,172	26,485,275	19,872,590	18,189,146

[1] Wyoming Department of Public Lands Annual Reports.

cent of total capacity in 1983, a slight decrease from the 85.7 percent recorded in 1982.

The State's annual production would be about 133 million tons if all the mines in the State operated at full productive capacity. Bear in mind that productive capacity is only what could be produced under current market conditions -- if Wyoming coal mines were able to sell all the coal they could possibly produce today and could operate at maximum announced mine capacity, the annual production might be as high as 243 million tons (Wyoming Geological Survey, 1984).

In 1983, average mine prices for Wyoming coal dropped slightly from 1982, according to the EIA. The average mine price for all coal in the State in 1983 was $12.63/ton, compared with $12.75/ton in 1982. Coal from Carbon County, including the State's only underground-mined coal was priced at an average of $29.81/ton in 1983, up 6.5 percent from the $27.99/ton in 1982. However, the price

for surface-mined coal from Campbell County, which represents the bulk of Wyoming's production, dropped 2.4 percent from $9.88/ton in 1982 to $9.64/ton in 1983.

Another indication that the price of coal has declined slightly is the assessed value of the coal as determined by the State's Ad Valorem Tax Division, Department of Revenue and Taxation: the average value of Wyoming coal produced in 1982 and assessed in 1983 was $10.71/ton (Ad Valorem Tax Division, 1983); for coal produced in 1983 (assessed in 1984) the average value was $10.67/ton (Ad Valorem Tax Division, 1984). This is the first time since 1967 that the assessed value per ton has not increased each year.

According to the U.S. Department of the Interior's Minerals Management Service (1984), the average value of Federal coal produced in the State has also decreased. The total value of Federal coal from Wyoming in 1982 was $788.4 million for 63.6 million tons of coal. In 1983, the total value was $787.2 million for 68.0 million tons of coal. The average value per ton has declined from $12.39/ton in 1982 to $11.58/ton in 1983, a decrease of 6.5 percent. The decreased value of the coal has caused a drop of over $6 million in revenues collected from Federal coal leases in Wyoming. Wyoming production accounted for 64 percent of all Federal coal produced in the nation in 1983.

Other developments in the State since the last update are related to increased use of coal in smaller industrial and commercial installations. In Sheridan County, Perkins Power Company has

announced their plans to reactivate the 12-Megawatt Acme power plant north of Sheridan. Nine million dollars of industrial revenue bonds have been issued to finance the project, and the company is looking for about 85,000 tons of coal per year to burn in the plant, which has not operated since 1976. The company plans to employ about 55 people in the power plant and in an associated hydroponic greenhouse which will be heated by excess steam produced by the plant. The power would be sold to Montana Power Company and will require a 62-mile long transmission line to Hardin, Montana.

It now appears that Fremont County will have the State's newest coal mine, the Muddy Creek mine, located about 40 miles northwest of Riverton. The mine is a small strip mine that will produce high quality lump and stoker coal for local consumption. The mine, which will employ several people to mine the coal as well as a contract trucker, expects to begin retail sales this winter.

Another industrial fuel user, Holly Sugar Company's sugar beet processing plant in Torrington, recently completed a $3.5 million conversion project from natural gas to coal. The company could use up to 33,000 tons of stoker coal this winter and expects to cut their fuel expenses in half by using coal. In the 1984-1985 season, Holly has purchased coal from NERCO's Spring Creek Mine in Montana, the Rosebud Mine at Hanna, Wyoming, and from an unidentified mine at Walden, Colorado. They apparently have a contract with NERCO's Antelope Mine in the southern Powder River Basin for their 1985-1986 season.

In other coal market news, it now appears that Big Horn Coal Company's three million ton per year contract with Commonwealth Edison, which has deferred about one million tons per year from Big Horn already, will not be renewed when it expires in 1988. Commonwealth Edison evidently has an oversupply of coal at the present time and expects even more oversupply by the late 1980's when its four new nuclear reactors come on line. A coal industry analyst has estimated that when Commonwealth's nuclear plants begin operations, Peter Kiewit Sons', Inc. annual shipments of 13.6 million tons of low-sulfur western coal (mined in Wyoming and Montana) could be cut in half.

A controversy, however, is now raging as to the future of these plants. On one hand, Commonwealth claims the new plants will save consumers' money because uranium is cheaper than coal as a fuel. This claim is substantiated by data from the Atomic Industrial Forum trade group: uranium fuel costs are estimated at 0.6¢/kwh compared to coal fuel costs of 2¢/kwh. On the other hand, a study funded by the United Mine Workers and several Illinois consumer groups claims that by canceling the proposed nuclear plants, four coal-fired plants could be built instead, saving consumers $1.86 billion, boosting Illinois coal production by five million tons per year and creating 1,500 new coal mining jobs by the year 2006. A study by the Electric Power Research Institute also concluded that power from nuclear reactors coming on line from 1983 to the early 1990's would cost 50 percent more than coal-generated power.

In Federal coal leasing news, China Butte Coal Company, the holder of a 5,975-acre Federal coal

lease in southern Wyoming recently filed for bankruptcy. The company acquired the China Butte lease in October 1981 in one of the first lease sales held in the State since Federal coal leasing resumed after the leasing moratorium in the early 1970's. Evidently, the company has been in default on a $358,000 payment (one of five payments on the bonus bid) to the U.S. Department of the Interior since March of this year and had asked Interior to defer the last three payments. Before China Butte declared bankruptcy, the Department of the Interior was moving to terminate the lease for default on the bonus payment. By filing a Chapter 11 bankruptcy, China Butte is granted protection and can prevent Interior from canceling the lease or demanding immediate payment of bonus and rental payments. China Butte Coal Company lists its principal asset as the China Butte lease and its debts as the outstanding lease bonus and rental payments ($1 million) due BLM as well as $4 million due the First National Bank of Chicago.

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EARTHQUAKES IN WYOMING

The historic record of earthquakes in Wyoming begins in 1871, numbers nearly 1,000, and continues to the present day. The first significant earthquake in the State, however, occurred north of Casper on June 25, 1895. It was an Intensity V quake which knocked dishes to the floor, threw people from their beds, and caused the Platte River to run thick with mud (*Earthquake history of the United States*, U.S. Geological Survey and National Oceanic and Atmospheric Administration Publication 41-1, 1982).

An even larger earthquake, with Intensity VI-VII, occurred at approximately the same location on November 14, 1897. In that quake, the Grand Central Hotel in Casper was damaged considerably and frightened citizens ran into the streets.

The most significant recorded earthquake to affect Wyoming actually had its epicenter outside the State. That 1959 quake had an epicenter near Hegben Lake, Montana, near the northwestern boundary of Yellowstone National Park. It had a

recorded magnitude of 7.1 and a reported maximum intensity of X although the highest intensities reported in the park were VIII. Twenty-eight people were killed as a result of that earthquake. Dams were cracked, homes were destroyed, and features within Yellowstone, including Old Faithful, were altered. One hundred and fifty-six aftershocks were felt in the park within 21 hours of the main shock. Incidently, about 85 percent of all the earthquakes in Wyoming have occurred in Yellowstone National Park.

There have been other earthquakes which caused structural damage to buildings and other structures. Some of these are listed below:

July 25, 1910, Rock Springs, Wyoming. Intensity V - houses were shaken and mine shafts disturbed.

July 15, 1936, Yellowstone National Park. Intensity VI - several chimneys were cracked.

December 25, 1959, Foxpark, Wyoming. Intensity V - a concrete block building was cracked.

April 18, 1963, Yellowstone National Park. Intensity V - minor damage to facilities with some geysers thrown off schedule.

October 18, 1984, Northern Albany County. Magnitude 5.5. - cracks in walls and ceilings of homes. Boulders rolling down hills near epicenter. County courthouse in Douglas was cracked.

November 3, 1984, West of Atlantic City. Magnitude 5.0 - some minor cracks in win-

dows, walls and foundations in Lander. A year-old police department building in Lander suffered some cracked walls.

Updating information on this year's more significant earthquakes in Wyoming, on May 29th and again on September 8th, earthquakes occurred west of Gillette around the Johnson - Campbell County line. They were both Magnitude 5.1, making them the largest quakes in the Wyoming portion of the Powder River Basin in recent history. The faults that were responsible for the quakes were not exposed at the surface, and only further study will delineate them.

Three other earthquakes have occurred within 35 miles of these two recent quakes. Approximately 20 miles to the south, there was a Magnitude 4.8, Intensity V, quake in 1976. Thirty-five miles to the west, there was an Intensity II quake in 1922, and an Intensity IV quake in 1948.

The October 18, 1984, earthquake in the northern portion of Albany County near Mule Creek Mountain was Magnitude 5.5. It was not only the largest quake felt in the State since 1975 when a 5.6 magnitude earthquake occurred in Yellowstone National Park, but is was also the largest quake to occur in Wyoming outside the park area. An aftershock of Magnitude 4.0 occurred shortly after the main shock, and as many as 20 smaller aftershocks had been recorded by the next day.

The U.S. Geological Survey sent a seismic crew to the area in an attempt to accurately locate the hypocenter (actual point of rupture on fault), epicenter (point on Earth's surface above

hypocenter), and fault trace. The hypocenter was estimated to be at a depth of 12-15.5 miles (10-25 kilometers).

Two other earthquakes have occurred within ten miles of Mule Creek Mountain. In 1938, an Intensity III quake occurred to the northwest, and in 1983, a Magnitude 4.0 quake occurred to the south. Six earthquakes with intensities from III-IV occurred about twenty-five miles northeast of Mule Creek Mountain between 1952-1978.

The November 3rd earthquake near Lake Christina, west of Atlantic City, has been assigned a magnitude of 5.0. As with the earthquakes around Gillette, more study is required to locate the fault that was responsible for this quake.

Other earthquakes have occurred within fifteen miles of Christina Lake. In 1923, there was an Intensity IV quake to the northeast; in 1925, an Intensity III quake to the east; and in 1959, another Intensity IV quake to the east. In 1963, an Intensity V, Magnitude 4.3 earthquake occurred to the northwest of the Christina Lake area.

James C. Case
Environmental Geologist

SURVEY RECEIVES MAPPING GRANT

In October, the U.S. Geological Survey awarded an $18,315 grant to the Wyoming Geological Survey in support of geologic mapping in two regions of

the State: the eastern Bighorn Mountains and the South Pass area. A portion of these funds will support 1:24,000 scale mapping on the southeastern flank of the Bighorn Mountains. The project area includes twenty-four, 7½-minute quadrangles (an area of approximately 2,125 square miles), which were last mapped by N.H. Darton in 1906 at a scale of 1:250,000. The Survey's Stratigrapher, Rodney H. De Bruin, will be the Project Chief. Current plans call for the mapping of two quadrangles in the first year of the project. The grant only supports the 1985 field season.

The South Pass area, which is at the southern tip of the Wind River Mountains, is well known for its iron resources and numerous, historic gold mines. More than 90 million tons of iron ore and 325,000 ounces of gold have been produced from this region.

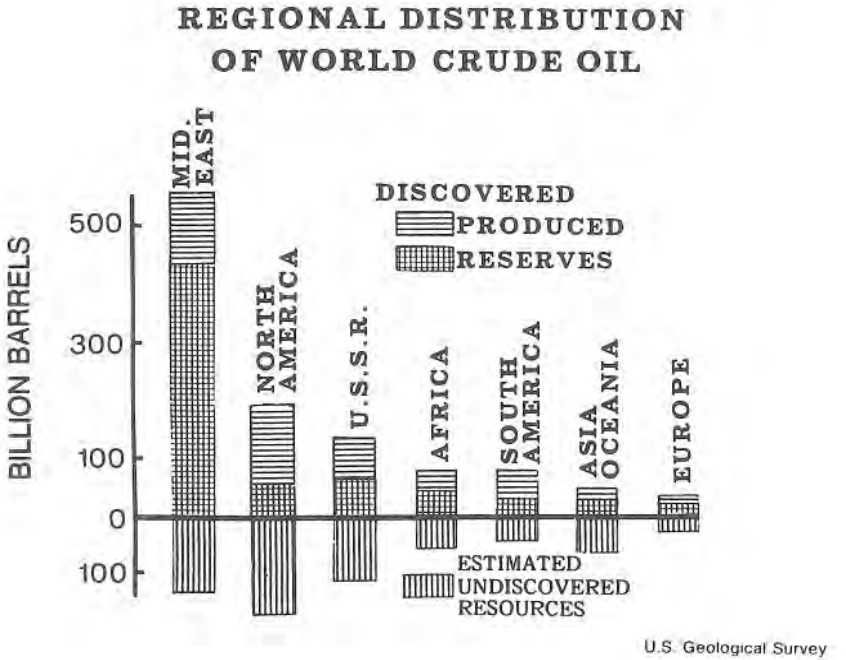
The Survey's Deputy Director, W. Dan Hausel, will map portions of the area at 1:24,000 scale. These maps will later be compiled into a regional map of the entire South Pass region. In addition, maps of all accessible underground mines will be prepared. Again the U.S. Geological Survey grant only supports the first year of this three year project.

WORLD CRUDE OIL

According to a chart prepared by the U.S. Geological Survey, most of the world's oil reserves -- more than 442 billion barrels still known to be in the ground -- are in the Middle East, which has more reserves than those of all the rest

of the world combined. The next largest reserves are in the USSR, followed by North America and Africa.

The chart below was part of a presentation of the U.S. Geological Survey's Petroleum Research Symposium held October 10-11, 1984, on the campus of the Colorado School of Mines in Golden, Colorado. Hundreds of oil and gas experts from government, industry, and academic communities attended the symposium at which more than 50 presentations were made by U.S. Geological Survey scientists.



In ranking estimates of undiscovered oil resources, North America is first with about 163 billion barrels, followed by the Middle East (125 billion barrels), and the USSR (107 billion barrels).

RECENT AND NEW PUBLICATIONS

Bibliography of Wyoming geology, 1960-1969, by Charlotte Tancin, Bulletin 64, 1984 ($8.00).

Index to selected U.S. Geological Survey Bulletins that contain geologic maps for Wyoming, compiled by Rodney H. DeBruin, Map Series MS-9G, 1984 ($2.50).

Index to selected U.S. Geological Survey Professional Papers that contain geologic maps for Wyoming, compiled by Rodney H. DeBruin, Map Series MS-9H, 1984 ($2.50).

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).

Tour guide to the geology and mining history of the South Pass gold district, Fremont County, Wyoming, by W. Dan Hausel, Public Information Circular No. 23, 1984, ($4.50).

Alteration and mineralization associated with sandstone uranium occurrences, Morton Ranch area, Wyoming, by Ray E. Harris, Report of Investigations No. 25, 1984 ($7.00).

Geothermal resources of the Laramie, Hanna, and Shirley Basins, Wyoming, by Bern S. Hinckley and Henry P. Heasler, Report of Investigations No. 26, 1984 ($7.00).

Analyses and measured sections of 25 coal samples from the Hanna Coal Field of southcentral Wyoming, by Gary B. Glass and Jay T. Roberts, Report of Investigations No. 27, 1984 ($8.00).

Summary of coal contracts with Wyoming mines, compiled by Gary B. Glass, available in xerox format only, 1984 ($15.00).

Coal mining in Wyoming, compiled by the Wyoming Highway Department, 30-page map atlas with short text, 1984 ($10.00).

**Oil and gas map of Wyoming*, compiled by Thomas R. Stephenson, Alan J. VerPloeg, and Lori S. Chamberlain, Map Series No. MS-12, 1984 ($10.00).

**Paleontology of the Green River Formation with a review of the fish fauna*, Lance Grande, Bulletin 63, 1984 (2nd edition, revised) ($12.50).

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