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STRIPPABLE RESERVES OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES

Superceded by IC 8531 see sections on Alaska

By Staff, Bureau of Mines

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UNITED STATES DEPARTMENT OF THE INTERIOR
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cc:
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STRIPPABLE RESERVES OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES

by

Staff

ABSTRACT

The economically strippable reserves of coal and lignite in the U.S. were calculated in accordance with the prevailing conditions of seam thickness and depth of overburden in each of the several coal-producing areas of the Nation. Within defined limited of seam thickness and depth of overburden, it is estimated that there is a remaining strippable resource of 119 billion tons of raw bituminous coal and lignite as of January 1, 1968. Because of topography, natural and man-made features, and other limitations, only 45 billion tons of the resource is economically recoverable. Of this, 32 billion tons is considered low-sulfur (less than 1 percent), 4 billion tons is medium-sulfur (1 to 2 percent), and 9 billion tons is high-sulfur (over 2 percent) coal.

Due to a cleaning loss to that portion of strip coal that is mechanically cleaned, the 45 billion tons or strippable reserves are reduced to 39.6 billion tons of marketable coal.

Without regard to rank, Wyoming has the largest reserve of strip-minable coal in the Nation--almost 14 billion tons, followed by: Montana, 7 billion tons; Alaska, 4 billion tons; and Illinois with

3 billion tons. According to rank, the largest reserve of economically strippable bituminous coal is in Illinois, followed by West Virginia and Missouri; the largest reserve of subbituminous coal is in Wyoming, followed by Alaska, Montana, and New Mexico. The largest reserves of economically strippable lignite are in Montana, North Dakota, and Texas.

The location of major low-sulfur reserves depends on the rank of coal. West Virginia with 1.1 billion tons has the largest available reserve of bituminous coal, followed by: Kentucky, 532 million tons; Alaska, 480 million tons; and Colorado, 476 million tons. The largest reserve of subbituminous low-sulfur coal is in Wyoming with 13.4 billion tons; Alaska has 3.9 billion tons, followed by Montana with 3.2 billion tons and New Mexico with 2.5 billion tons. Large reserves of low-sulfur lignite are in Montana with 3.0 billion tons, North Dakota with 1.7 billion tons, and Texas with 625 million tons.

A brief discussion is given for each coal-producing State, summarizing past and present production, historical background, and outlook. Appendix I contains reserve data by State, county, seam, and sulfur content. Appendix II contains in tabular form, the general information and requirements necessary to comply with the current strip mining laws covering 21 States.

INTRODUCTION

During 1969, one-third of the bituminous coal and lignite produced in the United States was from strip mining operations. By 1980, the demand for coal is expected to be 53 percent greater than it was in

1967 and by the year 2000, the projected demand will be 78 percent greater---probably resulting in more and larger strip mines. Of particular significance is the increasing demand for coal of low-sulfur content to comply with present or proposed air quality standards.

This study was undertaken to establish the location and extent of coal of varying sulfur content available for strip mining. The project was a joint undertaking of several Bureau of Mines offices. In each of these offices, coal and lignite reserves were estimated in accordance with the locally prevailing criteria and mining techniques.

For each of the States except Alaska the strippable coal reserves were identified by county and by seam. Reserves have been compiled by State and coal province. Resources and reserves have been determined by rank---bituminous, subbituminous, and lignite. Additionally, the reserves were compiled by seam, by sulfur content, and the coal presently in-place within specified limits of overburden thickness.

The U.S. Geological Survey has published reports on strippable coal resources of the United States and for selected areas of Montana, North Dakota, and Pennsylvania. A joint study was made of the strippable coal in Indiana by the U.S. Geological Survey and the Indiana Geological Survey. The strippable resources of Kansas were estimated by the Kansas Geological Survey. The Illinois Survey has calculated the resources in five counties in that State.

This report differs from previous reports in that it is primarily concerned with strippable reserves, that portion of the resource which is recoverable with present prices, technology and other conditions; it is also concerned with the amount and location of coal reserves by sulfur content.

ACKNOWLEDGMENTS

The manuscript was compiled with the assistance and cooperation of many people concerned with coal resources and coal mining by stripping methods. The authors gratefully acknowledge advice and criticism on all aspects of strip mining, from representatives of the coal and utility companies. The list of agencies and individuals that contributed coal data includes many State Geological Surveys, State Mining Departments, and authors of U.S. Geological Survey and Bureau of Mines publications; to them, a special note of appreciation. Thanks are extended to those Bureau of Mines engineers whose review and criticism contributed to the accuracy of this report.

HISTORICAL BACKGROUND

Strip mining is thought to have started in 1877 in the area of Pittsburg, Kansas (160). The fully revolving steam shovel made its appearance at Pittsburg in 1910; the capacity of the bucket was 1-1/2 cubic yards. The early shovels were mounted on rails and moved in the coal pits on portable track. They were used primarily to remove overburden. The uncovered coal was drilled and blasted and hand loaded into wooden mine cars.

In the Appalachian area, contour stripping on hillsides began about 1917. Because of the steep slopes, the work was difficult and progress was slow until the advent of crawler-track-mounted equipment.

During World War II when road construction was reduced, much earth-moving equipment was diverted to strip mining. Many road contractors continued to strip mine coal after the war, and never returned to highway construction. Over the ensuing years, the number of mines increased, and equipment became larger and more efficient.

During the 30 years preceding 1969, coal production in the U.S. from underground mines declined about 3 percent from 357 million tons to 347 million tons per year. Meanwhile strip mining increased 413 percent, from 38 million tons to 195 million tons. Auger mining, which was virtually unknown in 1939, produced 16 million tons of coal in 1969. During 1969, 30 percent of the coal mines were strip operations---acounting for 35 percent of total production. There were 87 strip mines with annual production of more than one-half million tons each.

Constraints on the Industry

The Nation is experiencing an increasing demand for energy. From the 53.8 quadrillion Btu of energy consumed in 1966, it is estimated that 159 quadrillion Btu will be required annually by the year 2000 (118). Coal in general as well as the portion of production that is strip mined, is expected to share in this increased market. The extent of expansion by strip mining will depend on various constraints; these include safety legislation, regulations on stri-mine reclamation, competition from other fuels, and pollution controls.

The Air Quality Act of 1967 enables the Federal Government to establish controls for industries that contribute to air pollution. While no such regulation has been established nationally, various local regulations have been applied which limit the sulfur content of fuel or stack gas emission of sulfur oxides. Since as yet no acceptable system has been developed to remove sulfur either from coal or stack gas, there has been a trend towards the consumption of low-sulfur fuels. In some areas this has resulted in a switch by the major consumer of coal, electric utilities, to low-sulfur residual fuel oil; it has also given some impetus to the development of nuclear power.

The first law requiring reclamation of strip-mined land was enacted in West Virginia in 1939. Since then, 20 more States have enacted similar regulations. Certain provisions are common to these laws: Need for a permit, posting of bonds, land descriptions and progress reports, restoration standards, time limits, water pollution controls, and penalties for violations. While the impact of current regulations has been considered in this report, more stringent regulations are being considered. The effect of future regulations along with recently implemented safety legislation has not been fully assessed.

In most cases, these regulations will result in additional costs to the consumer. This will affect the competitive position of strip-mined coal as well as the amount of strip coal available.

DEFINITIONS

The words "resource" and "reserve" have occasionally been used interchangeably in other publications. To eliminate possible confusion, these and other terms used in this report are defined as follows:

COAL. - When used alone, includes bituminous coal, subbituminous coal and lignite.

MINABLE COAL. - A coalbed equal to or greater than a specified minimum thickness. Grade or quality of the coal is not considered.

STRIPPABLE RESOURCE. - The quantity of coal in-place under a specified maximum depth of overburden and minable by surface methods.

REMAINING STRIPPABLE RESOURCE. - The total orginal coal resource reduced by depletion computed from past strip and auger mining production.

RECOVERABLE STRIP RESOURCE. - The resource that is recoverable with technology and equipment presently available or available in the foreseeable future. The remaining strippable resource multiplied by a mining recovery factor.

STRIPPABLE RESERVES. - The recoverable resource adjusted to conform to the current economic conditions, and further reduced by the amount of coal that for various other reasons cannot be mined.

RECOVERY FACTOR. - The proportion of the resource that is technically capable of being produced, usually expressed as a percent.

DEPLETION. - The tonnage mined plus the coal lost as a result of the mining operation.

STRIPPING RATIO. - The ratio of overburden to coal, expressed generally in two ways:

1. As cubic yards of overburden per ton of coal either mined or marketable (cubic yards to ton).
2. As average feet of overburden thickness per foot of coalbed thickness (feet to feet).

OVERBURDEN. - Soil and rock material overlying the coalbed.

CUT. - Width of coal uncovered in one position of the stripping equipment.

HIGHWALL. - The final face of the overburden at the last cut.

AREA STRIPPING. - Mining of large areas of flat-lying beds under relatively shallow overburden. Overburden is removed in many successive cuts.

CONTOUR STRIPPING. - Mining of coal on hillsides in hilly or mountainous areas. Overburden is removed in ore or several cuts by equipment following the coal outcrop along the natural contour of the surface of the ground.

LOW SULFUR COAL. - Coal containing less than 1 percent sulfur, by weight.

MEDIUM SULFUR COAL. - Coal containing 1 to 2 percent sulfur, by weight.

HIGH SULFUR COAL. - Coal containing over 2 percent sulfur, by weight.

MARKETABLE COAL. - Coal in a condition ready for sale to consumers; includes both raw and cleaned coal.

RAW COAL. - Coal shipped to the consumer as mined, without prior preparation other than crushing to a desired maximum size, but which causes no appreciable additional loss.

CLEANED COAL. - Coal recovered after processing by cleaning and sizing. A loss averaging more than 20 percent of the raw coal entering the preparation plant results from cleaning.

COALFIELDS OF THE UNITED STATES

The bituminous coal and lignite fields of the United States are subdivided geographically by the U.S. Geological Survey, as follows: (1) The Eastern province, (2) the Interior province, (3) the Gulf province, (4) the Northern Great Plains province, (5) the Rocky Mountain province, (6) the Pacific Coast province, and (7) Alaska (figs. 1 and 2). Within these provinces the bituminous coal and lignite deposits

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FIGURE 1. - Bituminous and subbitumious coal and lignite fields of the conterminous United States.

FIGURE 2. - Coalfields of Alaska.

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are further subdivided into regions, basins, and fields.

The Eastern Province

In the Eastern province, bituminous coal occurs throughout the Appalachian Region, an area of about 70,000 square miles. This region encompasses parts of Pennsylvania, Ohio, Maryland, West Virginia, Virginia, eastern Kentucky, Tennessee, Alabama, and Georgia. The coal occurs in formations of Pennsylvanian and Permian ages. There has been some structural deformation of the coal-bearing formations into broad, open folds. Attitudes of the seams vary from flat to gently dipping, with local steepening in some fields.

There are approximately 90 minable coal seams throughout the Appalachian Region. Sixty of the seams can be strip-mined to varying extents, depending on location and depth of overburden. West Virginia

The Pacific Coast Province

The Pacific Coast province covers parts of California, Oregon, and Washington; minor deposits occur in the first two. The largest strippable reserves of importance occur in Washington. All the coals of this province are in Tertiary formations. There is only one major strippable deposit. It is located in the Tono Basin, Centralia region of the State of Washington. Strippable coal occurs in two seams, the Big seam and Smith seam. The Centralia region contains many other coal seams for which no strippable reserves have been estimated. The coal seams range from 5 to 50 feet in thickness. Over 90 percent of the estimated reserve is in the Big seam. The coal is subbituminous in rank and is mined to supply an electric generating plant. Washington is the only State in the province with a sizable deposit of coking coal, none of which is considered strippable.

Alaska

Alaska has six coalfields for which strippable reserves have been estimated. Figure 2 shows the known coalfields of Alaska. The coals are of Cretaceous and Tertiary ages, and rank from lignite to anthracite. The seams vary from nearly flat to steeply dipping, and from relatively continuous to lenticular. Seam thicknesses range up to 50 feet; strippable reserves are estimated for a minimum thickness of 14 inches. The coal is low in sulfur, with generally less than 1 percent, and much of it less than one-half percent sulfur.

Nearly all the coal currently produced is consumed within 150 miles of the mine. Transportation is by rail or truck. The markets are electric utilities and space heating. However, natural gas is becoming more competitive for heating purposes.

METHODOLOGY

The procedure in ascertaining strippable coal resources was dependent upon the type, quantity, and quality of information that was available. The criteria for evaluating these resources were based on economic consideration for each area under study.

The original in-place resource was obtained mainly as follows:

a. Where outcrop maps were available, the length of each minable coalbed outcrop was measured by map meter or the area was measured by planimeter. An average coalbed thickness was determined for each seam. An average bench width from outcrop to maximum overburden thickness was estimated. From these data acres of strippable coal were calculated, and when multiplied by a tonnage factor, gave total original in-place resource. It was generally assumed that one acre-foot of coal in the ground was equivalent to 1,800 tons of bituminous coal. A lesser figure of 1,760 tons per acre-foot was used for subbituminous coal and lignite.

b. In other areas, original resource was based on latest estimates of the U.S. Geological Survey, State geological surveys, coal mining companies, and railroad companies.

In areas where coal demand was great and the supply rather limited, the minable seam thickness was generally less and the maximum overburden greater than for the country as a whole. For example, in the Appalachian area, only that coal greater than 28 inches in thickness under a 15 to 1 ratio of overburden thickness (at the final highwall) to seam thickness was considered strippable. In parts of the Rocky Mountain area, only coal in seams five feet or more in thickness are considered minable by stripping. Meanwhile, in Alaska, very large tonnages of coal, particularly on the North Slope, are considered more as a resource than a reserve because of the high cost of mining created by severe weather conditions and the lack of an export market. All coal that was considered uneconomic or unminable was excluded from the available reserve estimates. Minimum coalbed thickness, maximum overburden thickness, and economic stripping ratio used to estimate the strippable reserves in the various States are summarized in table 1.

Sulfur content was generally derived from coal analyses published by either the Bureau of Mines or State agencies. Over 11,000 analyses were recorded and used. In the absence of sufficient information on sulfur analyses of coal from strip mines, published analyses of sulfur content from underground mines was applied to the stripping portion of the same coalbed.

Procedures used to evaluate the strippable coal resources are as follow:

1. Original in-place resources were either estimated or obtained from other sources.

TABLE 2. - Estimated remaining strippable resources and strippable reserves of coal and lignite in the United States, January 1, 1968 by rank of coal, sulfur category, and coal province

(Millions of short tons)

Rank	Remaining strippable resources	Strippable reserves	Strippable reserves: Low sulfur	Strippable reserves: Medium sulfur	Strippable reserves: High sulfur
BITUMINOUS COAL					
Eastern Province - Appalachian Region					
Alabama	667	134	33	74	27
Kentucky--east	4,609	781	532	189	60
Maryland	150	21	0	8	13
Ohio	5,566	1,033	0	126	907
Pennsylvania	2,272	752	0	225	527
Tennessee	483	74	5	43	26
Virginia	2,741	258	154	99	5
West Virginia	11,230	2,118	1,138	669	311
Subtotal	27,718	5,171	1,862	1,433	1,876
Interior and Gulf Provinces 1/					
Arkansas	200	149	3	118	28
Illinois	18,845	3,247	0	80	3,167
Indiana	2,741	1,096	0	293	803
Iowa	1,000	180	0	0	180
Kansas	1,388	375	0	0	375
Kentucky--west	4,746	977	0	0	977
Michigan	6	1	0	0	2/ 1
Missouri	3,425	1,160	0	0	1,160
Oklahoma	434	111	10	44	57
Subtotal	32,785	7,296	13	535	6,748
Rocky Mountain and Northern Great Plains Provinces 3/					
Colorado	870	500	476	24	0
Utah	252	150	6	136	8
Subtotal	1,122	650	482	160	8
Alaska					
Alaska	1,201	480	4/ 480	0	0
Total Bituminous	62,826	13,597	2,837	2,128	8,632

TABLE 2. - Estimated remaining strippable resources and strippable reserves of coal and lignite in the United States, January 1, 1968 by rank of coal, sulfur category, and coal province--Continued

(Millions of short tons)

Rank	Remaining strippable resources	strippable reserves	Strippable reserves: Low sulfur	Medium sulfur	High sulfur
SUBBITUMINOUS COAL					
Rocky Mountain and Northern Great Plains Provinces 5/					
Arizona	400	387	387	0	0
Montana	7,813	3,400	3,176	224	0
New Mexico	3,307	2,474	2,474	0	0
Wyoming	22,028	13,971	13,377	65	529
Subtotal	33,548	20,232	19,414	289	529
Pacific Coast Province 6/					
California	100	25	25	0	0
Washington	500	135	135	0	0
Subtotal	600	160	160	0	0
Alaska					
Alaska	6,190	4/7/3,926	4/7/3,926	0	0
Total Subbituminous	40,338	24,318	23,500	289	529
LIGNITE					
Interior and Gulf Provinces 8/					
Arkansas	32	25	25	0	0
Texas	3,272	1,309	625	684	0
Subtotal	3,304	1,334	650	684	0

TABLE 2. - Estimated remaining strippable resources and strippable reserves of coal and lignite in the United States, January 1, 1968 by rank of coal, sulfur category, and coal province--Continued

(Millions of short tons)

Rank	Remaining strippable resources	Strippable reserves	Strippable reserves: Low sulfur	Strippable reserves: Medium sulfur	Strippable reserves: High sulfur
LIGNITE					
Rocky Mountain and Northern Great Plains Provinces					
Montana	7,058	3,497	2,957	540	0
North Dakota	5,239	2,075	1,678	397	0
South Dakota	399	160	160	0	0
Subtotal	12,696	5,732	4,795	937	0
Alaska					
Alaska	8	5	5	0	0
Total Lignite	16,008	7,071	5,450	1,621	0
Grand Total United States	119,172	44,986	31,787	4,038	9,161

1/ Bituminous coal resource and reserve not estimated for Texas and Nebraska.
2/ There may be isolated areas of some seams which might be classed in the medium-sulfur category.
3/ Bituminous coal resource and reserve not estimated for Montana, New Mexico, Idaho, and Wyoming.
4/ 478 million tons of bituminous and 3,387 million tons of subbituminous coal reserves in the Northern Alaska Fields (North Slope) are included in the estimates even though an economic export market, which is essential for exploitation, does not currently exist.
5/ Subbituminous coal resource and reserve not estimated for Colorado.
6/ Bituminous coal resource and reserve not estimated for Washington, and subbituminous coal resource and reserve not estimated for Oregon.
7/ Includes 179 million tons of undifferentiated subbituminous coal and lignite.
8/ Lignite resource and reserve not estimated for Kansas, Mississippi, Louisiana, and Alabama.

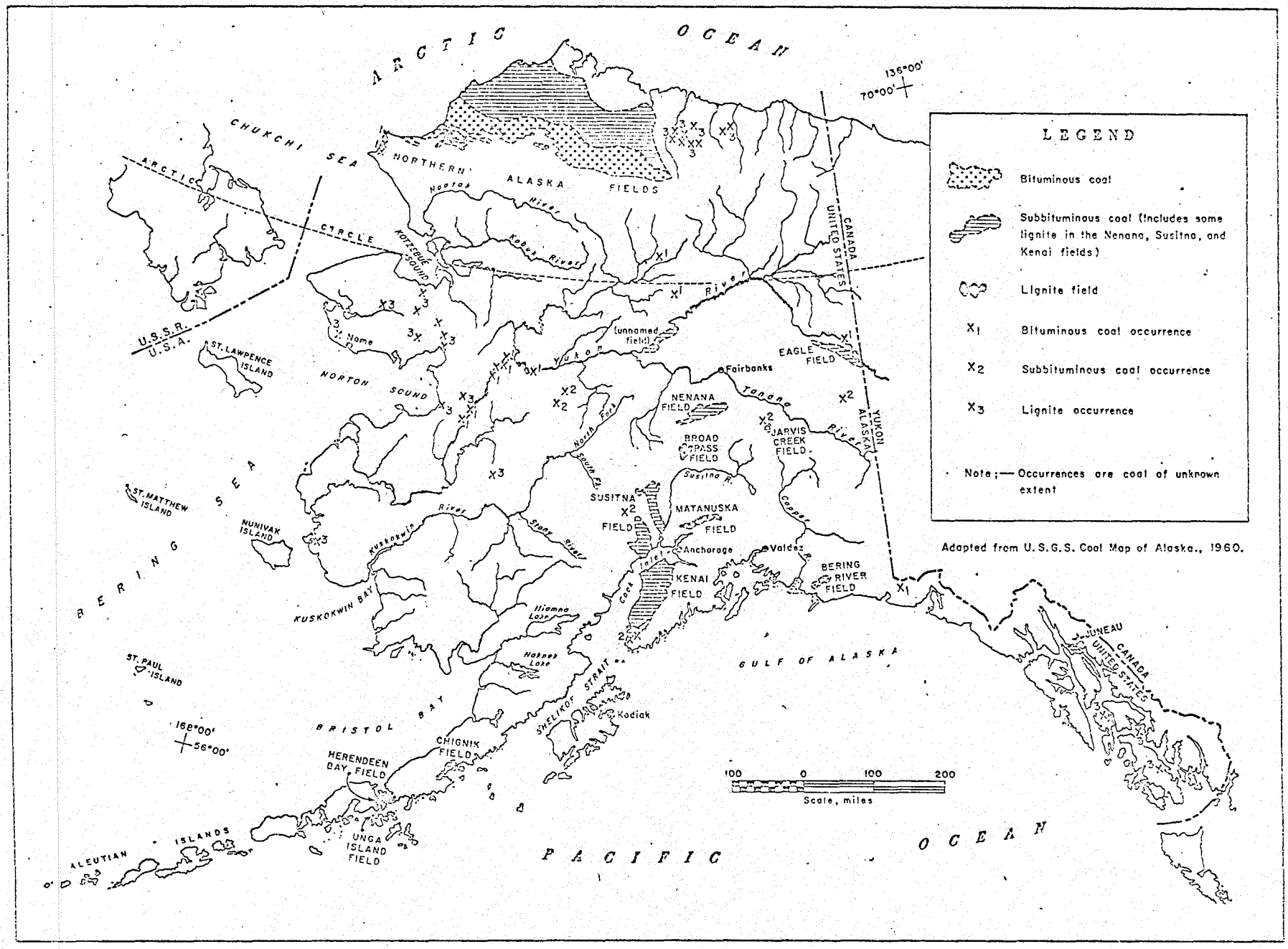

FIGURE 2. - Coalfields of Alaska

Alaska

Strip coal reserve estimates totaling 4.4 billion tons under less than 120 feet of overburden were made for six Alaskan coalfields: the Northern, Nenana, Broad Pass, Susitna, Matanuska, and Kenai fields. The Northern field, where coal is believed to underlie continuously about 30,000 square miles, contains 92 percent of Alaska's estimated total original resource of 130 billion tons. These coals are Cretaceous in geologic age, whereas coal of the other fields are Tertiary. The Nenana and Matanuska fields, located near Fairbanks and Anchorage, respectively, and served by rail, are the only fields from which sustained production has been made. Total recorded Alaskan production through 1969 is about 20.6 million tons. Production, except for a single one or two-man stripping operation, ceased during 1967 in the Matanuska field. Strip production from the Nenana field continues at the rate of about 670,000 tons per year. Analyses of Alaskan coals indicate that they nearly all fall into the low-sulfur category.

The first coal mine in Alaska was opened in 1855 by the Russians at Port Graham, but the mine was abandoned after only about 10 years of operation. Sustained coal production did not come about until completion of the Alaska Railroad to the Matanuska coalfield in 1916 and to the Nenana field in 1918.

All Alaskan coal production is by strip mining. The Nenana field coals are all subbituminous in rank. The greater proportion of Nenana field coal is burned for power generation in and near Fairbanks, but a considerable amount is still used directly for space heating and for space heat steam raising in central plants.

The small amount of coal still being produced from the Matanuska field is truck-hauled to market and is consumed in entirety for space heating purposes. Electric utilities in the Anchorage area which formerly burned Matanuska field coal have been converted to natural gas use.

An export market for metallurgical quality coking coals, and possibly some steam coal, exists in Japan and possibly elsewhere, but no such exports have taken place. The various reasons for nonexport can be summed into the apparent inability to make Alaskan coals economically competitive f.o.b. an Alaskan all-weather port. A factor which may enhance export possibilities is the apparent low-sulfur content of all Alaskan coals.

Some of the bituminous coking coals of Arctic Northwestern Alaska (North Slope), where exposed, exhibit simple geologic structure that they should be amenable to modern large-scale mechanized mining, either surface or underground, and perhaps their permanently frozen condition can be used advantageously in the mining system. The greatest problem of exploitation is transport of the coal to an ice-free harbor for export. The Arctic Ocean near the coal deposits has about 90 ice-free days per year.

All Alaskan coals that are or have been mined in quantity are Tertiary in geologic age. The Tertiary coals range in rank from lignite to anthracite; the Cretaceous coals from subbituminous to bituminous. Strip mining usually, but with the possible exception of some lignite beds and some Northern field subbituminous beds, is confronted with dipping beds and some faulting.

The Tertiary coalfields are much less in areal extent than the Northern Cretaceous field, and individual Tertiary beds are characteristically lenticular. Coalbeds of the Northern field are believed less lenticular, but this premise is based on the observable persistence of more resistant beds rather than actual knowledge of coalbed continuity.

Coalbed thicknesses vary from a few inches to 50 feet. Nenana field subbituminous beds currently being strip mined are 25 feet and 50 feet thick and dip about 55°. A group of eight formerly-mined Matanuska field bituminous beds vary in individual thickness from 3 feet to 16 feet, comprising a total coal thickness of about 50 feet within a total strata thickness of about 200 feet dipping approximately 40°. Coal burning ceased during the 1960's when Barrow was granted permission by Congress to use natural gas from a field just outside Barrow in Naval Petroleum Reserve No. 4.

Alaska has not enacted strip mining laws. Probably, when large-scale strip mining becomes imminent, regulations will be issued to control surface damage and to enforce reasonable reclamation practices.

There are no privately owned coal lands in Alaska; they all are either Federal Government or State held lands to which the leasing laws apply. A brief summary of the Federal leasing laws follow:

Coal Prospecting Permits are granted by the Department of the Interior for a 2-year period to qualified applicants to prospect unclaimed, undeveloped lands where prospecting or exploratory work is necessary to determine the existence or workability of coal deposits. An application for a permit must be filed, in duplicate, in the appropriate land office. Each application must be accompanied by a filing fee of $10 which is not returnable, and by full payment of the first year's rental at the rate of 25 cents per acre. In addition, the applicant must furnish a corporate surety bond or a personal bond conditional upon compliance with all the terms of the prospecting permit.

Each permit covers a maximum of 2,560 acres, and no permit holder may have more than four permits (16 square miles). The recipients of a permit may remove only as much coal as is necessary to determine the commercial value of the deposit. If coal is mined commercially, a Coal Lease must be obtained. Leases are subject to the 25 cents per acre rental fee and to a royalty payment on a minimum annual production, the payments beginning with the sixth year of the lease.

A summary of the strippable coal resources and reserves are shown in tables 4 and 5, appendix I.

State leasing laws are similar to the Federal laws.

BIBLIOGRAPHY

1. Abernathy, G. E., J. M. Jewett, and W. M. Shoewe. Coal Reserves in Kansas, State Geol. Survey of Kansas Bull. 70, pt. 1, 1947, pp. 5-20.

2. Andrews, D. A., Geology and Coal Resources of the Minot Region, North Dakota Geol. Survey Bull. 906-B, 1939, pp. 43-84.

3. Andrews, D. A., T. A. Hendricks, and J. W. Huddle, Analyses of Arizona, California, Idaho, Nevada and Oregon Coals. BuMines Tech. Paper 696, 1947.

4. Andrews, D. A., and J. W. Huddle. Analyses of Michigan, North Dakota, South Dakota, and Texas Coals. BuMines Tech. Paper 700, 1948, 106 pp.

5. Aresco, S. J., et. al., Analyses of Tipple and Delivered Samples of Coal, BuMines Rept. of Inv. (Annual Reports from 1940 to 1970).

6. Ashley, George H., Bituminous Coal Fields of Pennsylvania. Pennsylvania Topog. and Geol. Survey Bull. M 6, 1928.

7. _____, The Coal Deposits of Indiana, Twenty-Third Annual Report of the Indiana Department of Geology and Natural Resources, 1898.

8. Averitt, Paul. Stripping-Coal Resources of the United States. U.S. Geol. Survey Bull. 1252-C, 1968, pp. 12 and 14.

9. _____. Coal Resources of the United States, Jan. 1, 1967. U.S. Geol. Survey Bull. 1275, 1969, 116 pp.

10. Ayler, M. F., J. B. Smith, and G. M. Deutman. Strippable Coal Reserves of Montana - Location, Tonnage, and Characteristics of Coal and Overburden. BuMines Prelim. Report 172, March 1969, 68 pp.

11. Baker, A. A. The Northward Extension of the Sheridan Coal Field. U.S. Geol. Survey Bull. 806-B, 1929, pp. 1-67.

12. Ball, Clayton G. An Economic Appraisal of Lignite Reserves in North Dakota, in Technology and Use of Lignite. Proceedings, Bureau of Mines and University of North Dakota, Symposium, Bismark, North Dakota, April 29-30, 1965, BuMines Inf. Circ. 8304, 124 pp.

13. Barnes, F. F., and Payne, T. G., The Wishbone Hill District, Matanuska Coalfield, Alaska: U.S. Geol. Survey Bull. 1016, 1956, 88 pp.

14. Barnes, F. F., and Cobb, E. H., Geology and Coal Resources of the Homer District, Kenai Coalfield, Alaska: U.S. Geol. Survey Bull. 1058-F, 1959, pp. 217-260.

15. Barnes, F. F., Coal Resources of Alaska: U.S. Geol. Survey Bull. 1242-B, 1967, 36 pp.

16. _____, Geology and Coal Resources of the Beluga-Yentna Region, Alaska: U.S. Geol. Survey Bull. 1202-C, 1966, 54 pp.

17. Bass, N. W., J. B. Eby, and M. R. Campbell, Geology and Mineral Fuels of Parts of Routt and Moffat Counties, Colorado. U.S. Geol. Survey Bull. 1027-D, 1956, pp. 142-250.

18. Bauer, C. M. and F. A. Herald. Lignite in the Western Part of the Fort Berthold Indian Reservation South of the Missouri River, N. Dak. Geol. Survey Bull. 726-D, 1921, pp. 109-172.

19. Beaumont, E. C. Coal-bearing formations in the western part of the San Juan Basin of New Mexico. New Mexico Geological Society - Nineteenth Field Conference, 1968.

20. Beekly, A. L. Culbertson Lignite Field, Valley County, Montana. U.S. Geol. Survey Bull. 471, Part II Mineral Fuels, 1910, pp. 319-358.

21. _____. Geology and Coal Resources of North Park, Colorado. U.S. Geol. Survey Bull. 596, 1915, pp. 93-116.

22. Bement, A. Illinois Coal. Illinois State Geol. Survey Bull. No. 56, 1929.

23. Berryhill, Henry L., Jr., Donald M. Brown, Andrew Brown and Dorothy A. Taylor. Coal Resources of Wyoming. U.S. Geol. Survey Circ. 81, 1950, 78 pp.

24. Bowsher, Arthur L., and John M. Jewett. Coal Resources of the Douglas Group in East-Central Kansas. Kansas Geol. Survey Bull. 46, 1943, 94 pp.

25. Boyd, John T., and Associates. A reserve Study of the Decker Coal Field, Big Horn County, Montana, 1965, Unpubl. Rept.

26. Brant, Russell A. and Richard M. DeLong. Coal Resources of Ohio, Ohio Division of Geol. Survey Bull. 58, 1960.

27. Brant, R. A. Lignite Resources of North Dakota, U.S. Geol. Survey Circ. 226, 1953, 78 pp.

28. Brown, Andrew, W. C. Culbertson, R. J. Dunham, R. C. Kepferle, and P. R. May. Strippable Coal in Custer and Powder River Counties, Montana. U.S. Geol. Survey Bull. 995-E, 1954, pp. 151-196.

29. Brown, Calvin S. Lignite of Mississippi. Mississippi State Geol. Survey Bull. No. 3, 1907.

30. Brown, D. M. Lignite Resources of South Dakota. U.S. Geol. Survey Circ. 159, 1952, 18 pp.

31. Bryson, R. P., and N. W. Bass. Geologic Map and Coal Sections of the Moorhead Coal Field, Montana. U.S. Geol. Survey Open File Report.

32. Bryson, R. P. The Coalwood Coal Field, Powder River County, Montana. U.S. Geol. Survey Bull. 973-B, 1952, pp. 23-106.

33. Butts, Charles. Montevallo - Columbiana, Ala. Part of Geologic Atlas of the United States, U.S. Geol. Survey Folio 226, 1940, 22 pp.

34. Cady, Gilbert H., Analyses of Illinois Coals, Illinois Geological Survey Bulletin, Supplement to Bulletin 62, 1948.

35. Campbell, M. R., The Twentymile Park District of the Yampa Coal Field, Routt County, Colo. U.S. Geol. Survey Bull. 748, 1923, 82 pp.

36. Cashion, W. B., Goelogy and Fuel Resources of the Orderville-Glendale Area, Kane County, Utah. U.S. Geol. Survey Coal Inv. Map C-49, 1961.

37. Cohee, George V., Ruth N. Bairns, Andrew Brown, Russell A. Brant, and Dorothy Wright. Coal Resources of Michigan. Geological Survey Circular 77, June 1952, 56 pp.

38. Collier, A. J., and M. M. Knechtel. The Coal Resources of McCone County, Montana. U.S. Geol. Survey Bull. 905, 1939, pp. 1-80.

39. Colton, Roger B. Geology of the Otter Creek Quadrangle, Montana. U.S. Geol. Survey Bull. 1111-G, 1963, pp. 237-285.

40. Crane, W. R. Special Report on Coal: Kansas Univ. Geol. Survey, v. 3, pt. 2, 1898, p. 188.

41. Culbertson, W. C. Geology and Coal Resources of the Coal-Bearing Rocks, of Alabama. U.S. Geol. Survey Bull. 1182-B, 1964, 79 pp.

42. _____. Strippable Coal Reserves in the Fort Union Region of Montana and North Dakota (abs). Econ. Geol. v. 50, No. 1, 1955, p. 102.

43. _____. Three Deposits of Strippable Lignite West of the Yellowstone River, Montana. U.S. Geol. Survey Bull. 995-H, 1954, pp. 293-329.

44. Dane, C. H., H. E. Rothrock, and James Steele Williams. Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field. U.S. Geol. Survey Bull. 874-C, pt. 3, The Quinton-Scipio District--Pittsburg, Haskell, and Latimer Counties, 1938, pp. 151-208.

45. Davis, John A., The Little Powder River Coal Field, Campbell County, Wyoming. U.S. Geol. Survey Bull. 471, 1910, pp. 423-440.

46. Denson, N. M., The Lignite Deposits of the Cheyenne River and Standing Rock Indian Reservations, Corson, Dewey, and Ziebach Counties, South Dakota, and Sioux County, North Dakota. U.S. Geol. Survey Circ. 78, 1950, 22 pp.

47. Dobbin, C. E., and V. H. Barnett. The Gillette Coalfield, Northeastern Wyoming. U.S. Geol. Survey Bull. 796, 1927, pp. 1-64.

48. Dobbin, C. E., C. F. Bowen, and H. H. Hoots. Geology and Coal and Oil Resources of the Hanna and Carbon Basins, Carbon County, Wyoming. U.S. Geol. Survey Bull. 804, 1929, p. 88.

49. Dobbin, C. E., E. H. Denny, F. G. Tryon, et al. Analyses of Wyoming Coals. BuMines Tech. Paper 484, 1931, 159 pp.

50. Dobbin, C. E. The Forsyth Coal Field, Rosebud, Treasure, and Big Horn Counties, Montana. U.S. Geol. Survey Bull. 812-A, 1929, pp. 1-55.

51. Dunham, R. J. and J. V. A. Trumbull. Geology and Coal Resources of the Henryetta Mining District, Okmulgee County, Okla. U.S. Geol. Survey Bull. 1015-F, 1955, pp. 183-225.

52. England, K. J., H. L. Smith, L. D. Harris, and J. G. Stevens. Geology of the Ewing Quadrangle, Kentucky, U.S. Geol. Survey Map GQ-172, 1961.

53. Fieldner, A. C., H. M. Cooper, and F. D. Osgood. Analyses of Oklahoma Coals. U.S. BuMines Tech. Paper 411, 1928, pp. 11-30.

54. Fieldner, A. C., H. M. Cooper, and R. F. Abernathy. Analyses of Colorado Coals. BuMines Tech. Paper. 574, 1937, pp. 46-315.

55. Fieldner, A. C., W. A. Selvig, and J. W. Paul, Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1916 to 1919, 1922, Bull. 193, 391 pp.

56. Fieldner, A. C., W. E. Rice, and H. E. Moran, Typical Analyses of Coals of the United States, 1942, Bull. 446, 45 pp.

57. Fisher, W. L. Lignites of the Texas Gulf Coastal Plain. Bur. Econ. Geol., Rept. of Inv. No. 50, 1963.

58. Gaskill, D. L., and G. H. Horn. Northeast Rangley Coal Area, Rio Blanco and Moffat Counties, Colorado. U.S. Geol. Survey Open File Rept. No. 627, 1961, 49 pp.

59. Gibson, A. M. Report Upon the Coosa Coalfield. Alabama Geol. Survey Spec. Rept. 7, 1895, 143 pp.

60. Gilmour, Ernest H. and Loren A. Williams. Geology and Coal Resources of the Foster Creek Coal Deposit, Eastern Montana. Mont. BuMines and Geol. Bull. 73, 1969, 9 pp.

61. Glenn, L. C. The Northern Tennessee Coalfield. Tennessee Division of Geology, Bull. 33 B, 1925, 478 pp.

62. Green, Frank C. The Lexington Coal in Northwestern Missouri, 62nd Biennial Rept., 1943, pp. 3-12.

63. Gregory, Herbert E. and Raymond C. Moore. The Kaiparowits Region. A Geographic and Geologic Reconnaissance of Parts of Utah and Arizona. U.S. Geol. Survey Prof. Paper 164, 1931, 161 pp.

64. Groff, S. L. and Robert E. Matson. Montana's Coal Resource Situation. Mont. BuMines and Geol. Summary Report to the 1969 Legislature, 1969, 27 pp.

65. Grose, L. T., D. H. Hileman, and A. E. Ward. Coal Resources of Southwestern Utah. Potential for Utilization in Steam-Electric Power-Generation Plants. BuMines Inf. Circ. 8326. 1967, 78 pp.

66. Hahn, A. D., and R. B. Stroud. Mineral Resources of Southwest Missouri Coal District, BuMines Prel. Rept. 118, 1958, pp. 5-70.

67. Hail, W. J., Jr., Geology of southwestern North Park and vicinity, Colorado. U.S. Geol. Survey Bull. 1257, 1968, p. 119.

68. Haley, B. R. Coal Resources of Arkansas. U.S. Geol. Survey Bull. 1072-P, 1960, pp. 795-831.

69. Hancock, E. T. The New Salem Lignite Field, Morton County, North Dakota. U.S. Geol. Survey Bull. 726-A, 1921, pp. 1-39.

70. Hares, C. J. Geology and Lignite Resources of the Marmarth Field, Southwestern North Dakota. U.S. Geol. Survey Bull. 775, 1928, 110 pp.

71. Headlee, A. J. W. Characteristics of Minable Coals of West Virginia. West Virginia Geological Survey, 1955.

72. Heidenreich, W. Lee. Mineral Resources of Northern Missouri Coal District, BuMines Prel. Rept. 104, 1955, pp. 14-144.

73. Hendricks, Thomas A. Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field. U.S. Geol. Survey Bull. 874-A, 1937, pt. 1. The McAlester District--- Pittsburg, Atoka, and Latimer Counties, pp. 1-82.

74. _____. Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field. U.S. Geol. Survey Bull. 874-D, 1939, pt. 4. The Howe-Wilburton District, Latimer and LeFlore Counties, pp. 255-284.

75. Hershey, Robert E., Lloyd Williams, and B. W. Gandrud. Estimate of Known Recoverable Reserves of Coking Coal in Grundy County, Tenn. BuMines, Rept. of Inv. 5148, 1955, 16 pp.

76. Hershey, Robert E., Lloyd Williams, W. L. Grentz, and J. W. Miller. Estimate of Known Recoverable Reserves and Preparation Characteristics of Coking Coal in Van Buren County, Tenn. BuMines R.I. 5208, 1956, 25 pp.

77. _____. Estimate of Known Recoverable Reserves and the Preparation Characteristics of Coking Coal in Hamilton County, Tenn. BuMines R.I. 5263, 1956, 27 pp.

78. Hinds, Henry. The Coal Deposits of Missouri. Missouri Bur. of Geol. and Mines, v. 11, 2nd Series, 1912.

79. Hose, R. K. Geology of the Crazy Woman Area, Johnson County, Wyoming. U.S. Geol. Survey Bull. 1027-B, 1956, pp. 33-118.

80. Huddle, J. W., E. J. Lyons, H. L. Smith, and J. C. Ferm. Coal Reserves of Eastern Kentucky. U.S. Geol. Survey Bull. 1120, 1963, 247 pp.

81. Hunter, William S., Jr. The Kemmerer Coal Field. Wyo. Geol. Assoc. 5th Annual Field Conference Guidebook, Southwest Wyoming, August 1950, pp. 123-132.

82. Illinois Department of Mines and Minerals, Annual Coal Reports, 1920-1967. Department of Mines and Minerals.

83. Johnson, Robert C. Coal Reserves of Greenup County, Ky. BuMines Open File Report 2-69, 1969, 33 pp.; pub: Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. PB 184 707.

84. Johnson, Robert C. and Edward T. Luther. Strippable Coal in the Northern Cumberland Plateau Area of Tennessee. Tenn. Div. Geol., report in progress.

85. Johnson, W. D., Jr., and R. P. Kunkel. The Square Buttes Coal Field, Oliver and Mercer Counties, N. Dak. U.S. Geol. Survey Bull. 1076, 1959, 91 pp.

86. Kansas Dept. of Labor. General Statutes of Kansas, 1949, or supplements thereto, Secs. 49-401, through 49-423, September 1, 1968.

87. Kepferle, R. C. Selected Deposits of Strippable Coal in Central Rosebud County, Montana. U.S. Geol. Survey Bull. 995-I, 1954, pp. 333-381.

88. Kepferle, R. C., and W. C. Culbertson. Strippable Lignite Deposits, Slope and Bowman Counties, North Dakota. U.S. Geol. Survey Bull. 1015E, 1955, pp. 123-182.

89. Kiersch, G. A., Mineral Resources, Navajo-Hopi Indian Reservations, Arizona - Utah. Arizona University Metalliferous Minerals and Mineral Fuels, v. 1, 1955.

90. Knechtel, M. M. Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field. U.S. Geol. Survey Bull. 874-B, 1937, pt. 2, The Lehigh District--Coal, Atoka, and Pittsburg Counties, pp. 92-144.

91. _____. Geology and Coal and Natural Gas Resources of Northern LeFlore County, Okla. Oklahoma Geol. Survey Bull. 68, 1949, 76 p.

92. Kottlowski, F. E. The Economic Geology of Coal in New Mexico. N. Mex. BuMines and Min. Res. Circ. 71, 1964.

93. Landis, E. R. Coal Resources of Colorado. U.S. Geol. Survey Bull. 1072-C, 1959, 232 pp.

94. Landis, E. R. and Orville J. Van Eck. Coal Resources of Iowa, Iowa Geol. Survey, Tech. Paper No. 4, 1965.

95. Leonard, A. G. The North Dakota - Montana Lignite Area. U.S. Geol. Survey Bull. 285, 1906, pp. 316-330.

96. Leonard, A. G., E. J. Babcock, and L. P. Dove. The Lignite Deposits of North Dakota. N. Dak. Geol. Survey Bull. 4, 1925, 240 pp.

97. Lloyd, E. R. The Cannonball River Lignite Field, Morton, Adams, and Hettinger Counties, North Dakota. U.S. Geol. Survey Bull. 541, 1914, pp. 243-291.

98. Lord, N.W. Analyses of coals in the United States, BuMines Bull. 22, Part I, 1913, pp. 321.

99. Lowe, R. W., W. L. Crentz, and J. W. Miller, Estimate of Known Recoverable Reserves and the Preparation Characteristics of Coking Coal in Fentress County, Tenn. BuMines Rept. of Inv. 5235, 1956, 34 pp.

100. Lupton, Charles T. Geology and Coal Resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah. U.S. Geol. Survey Bull. 628, 1916, pp. 88.

101. Luther, Edward T. The Coal Reserves of Tennessee. Tennessee Div. of Geol. Bull. 63, 1959, 294 pp.

102. Mapel, W. J. Bituminous Coal Resources of Texas. U.S. Geol. Survey Bull. 1242-D, 1967, pp. 1-28.

103. _____. Coal in the Powder River Basin. Wyo. Geol. Assoc. Thirteenth Annual Field Conference Guidebook, Powder River Basin, 1958, pp. 218-224.

104. _____. Geology and Coal Resources of the Buffalo-Lake DeSmet Area, Johnson and Sheridan Counties, Wyoming. U.S. Geol. Survey Bull. 1078, 1959, 152 pp.

105. Mapel, W. J., James M. Schopf, and James R. Gill. A Thick Coal Bed Near Lake DeSmet, Johnson County, Wyoming. U.S. Geol. Survey Circ. 228, 1953, 47 pp.

106. Maryland Bureau of Mines, Annual Reports of the State of Maryland (for years 1943 to 1962).

107. Masursky, Harold. Uranium-Bearing Coal in the Eastern Part of the Red Desert Area, Wyoming. U.S. Geol. Survey Bull. 1099-B, 1962, 152 pp.

108. Matson, Robert E., Montana's Strippable Coal Resources. in Proceeding of the Montana Coal Symposium, Billings, Montana, Nov. 6, 7, 1969, pp. 80-88.

109. Matson, Robert E., Gardar G. Dahl, Jr., and John W. Blumer. Strippable Coal Deposits on State Land, Powder River County, Montana. Montana Bureau of Mines and Geol. Bull. 69, 1968, 81 pp.

110. May, P. R. Strippable Lignite Deposits, Wibaux Area, Montana and North Dakota. U.S. Geol. Survey Bull. 995-G, 1954, pp. 255-292.

111. McFarlan, Arthur C. Geology of Kentucky. Kentucky Univ., 1943, 531 pp.

112. Meagher, D. Pope, and L. C. Aycock. Louisiana Lignite, Geol. Pamphlet No. 3, Louisiana Geol. Survey, 1942.

113. Missouri, State of. Annual Rept. of the Div. of Mines Inspection of the Dept. of Labor and Industrial Relations, 1946 and 1963.

114. Montana Bureau of Mines and Geology. Open File Drill Logs, Powder River Co., Mont., dated July 1968. Available for inspection at Butte, Montana.

115. _____. Open File Drill Logs, McCone Co., Montana, Sept. - Oct. 1968. Available for inspection at Butte, Montana.

116. Moore, G. W., R. E. Melin, and R. C. Kepferle. Uranium-bearing Lignite in Southwestern North Dakota. U.S. Geol. Survey Bull. 1055 E, 1959, pp. 147-166.

117. Moore, S. L. Geology of the Austin Quadrangle, Kentucky, U.S. Geol. Survey Map GQ-173, 1961.

118. Morrison, Warren E. and Charles L. Readling. An Energy Model for the United States, Featuring Energy Balances for the years 1947 to 1965 and Projections and Forecasts to the years 1980 and 2000 BuMines Inf. Circ. 8384, 1968, 127 pp.

119. National Coal Association. Bituminous Coal Facts 1968, Washington, D.C. 107 pp.

120. _____. Summary of the Basic Provisions of State Strip Mining Laws With Special Emphasis On Reclamation Requirements, Laws effective December, 1968. April, 1969.

121. Nelson, W. A. The Southern Tennessee Coalfield. Tennessee Div. of Geology Bull. 33 A, 1925, 237 pp.

122. Northern Pacific Railroad Co. Coalstrip Coalfield. Rosebud, Treasure and Big Horn Counties, Montana, 1964.

123. _____, Geology Division. Preliminary Evaluation of Dickinson Lignite Field, Billings, Dunn, and Stack Counties, North Dakota, May 1963, 6 pp.

124. Oakes, Malcolm C. Broken Arrow Coal and Associated Strata, Western Rogers, Wagoner, and Southeastern Tulsa Counties, Okla. Okla. Geol. Survey Cir. 24, 1944, 40 pp.

125. Oakes, Malcom C. and M. M. Knechtel, Geology and Mineral Resources of Haskell County, Okla. Geol. Survey Bull. 67, 1948, 134 pp.

126. _____, Geology and Mineral Resources of Tulsa County, Okla. (includes parts of adjacent counties). Okla. Geol. Survey Bull. 69, 1952, pp. 1-128.

127. _____, Geology and Petroleum of McIntosh County, Okla. Okla. Geol. Survey Bull. III, pt. I, Geology and Mineral Resources of McIntosh County, 1967, pp. 1-49, app. pp. 68-85.

128. O'Connor, H. G., W. H. Schoewe, E. D. Goebel, and Norman Plummer. Geology, Mineral Resources, and Ground-Water Resources of Osage County, Kansas State Geol. Survey of Kansas, v. 13, pt. 2, 1955, p. 24, and Map in Appendix.

129. Ohio, Geological Survey, Bulletin 43, The Coal Beds of Western Carroll County and the Coal Beds in Southeastern Mahoning County, 1942.

130. Ohio, State of, Annual Coal Report and Non-Metallic Mineral Report with Directories of Reporting Firms, (for years 1914 to 1967).

131. Oklahoma, State of. Annual Report of Department of Mines, 1945-1967.

132. Olive, W. W. The Spotted Horse Coalfield, Sheridan and Campbell Counties, Wyoming. U.S. Geol. Survey Bull. 1050, 1957, 82 pp.

133. O'Sullivan, R. B. Summary of Coal Resources of the Black Mesa Coal Field, Arizona, New Mexico Geological Society Guidebook, 9th Field Conference, 1958.

134. Padgett, Ward. Mining Laws of the State of Oklahoma, Oklahoma Department of Mines, Title 45. Mines and Mining, Chapter 8. Open-cut Land Reclamation Act, 1968, pp. 123-137.

135. Parker, Frank S. The Richey-Lambert Coal Field, Richland and Dawson Counties, Montana. U.S. Geol. Survey Bull. 847-C, 1936, pp. 121-174.

136. Parr, S. W. Composition and Character of Illinois Coals, Illinois State Geological Survey, Bulletin No. 3, 1906.

137. Pierce, W. G. and W. H. Courtier. Geology and Coal Resources of the Southeastern Kansas Coal Field in Crawford, Cherokee, and Labette Counties. State Geol. Survey of Kansas Bull. 24, 1938, pp. 61-79.

138. Pierce, W. G. The Rosebud Coal Field, Rosebud and Custer Counties, Montana. U.S. Geol. Survey Bull. 847-B, 1936, pp. 43-120.

139. Pipiringos, George N. Uranium-Bearing Coal in the Central Part of the Great Divide Basin. U.S. Geol. Survey Bull. 1099-A, 1961, 104 pp.

140. Pishel, M. A. Lignite in the Fort Berthold Indian Reservation, N. Dak., North of Missouri River. U.S. Geol. Survey Bull. 471, 1912, pp. 170-186.

141. Pope, George S. Analyses of Coals Purchased by the Government During the Fiscal Years 1908-1915. BuMines, Bull. 119, 1916, 118 pp.

142. Price, Paul H., Rietz C. Tucker, and Oscar L. Haught. Geology and Natural Resources of West Virginia. West Virginia Geol. Survey, 1938.

143. Read, C. B., R. T. Duffner, G. H. Wood, and A. D. Zapp. Coal resources of New Mexico, U.S. Geol. Survey Circ. 89, 1950, 24 pp.

144. Regulations Pertaining to Coal Leases, Permits, and Licenses on the Public Land (as contained in Title 43 of the Code of Federal Regulations): Bur. of Land Management Circ. 2154, 1964, 11 pp.

145. Roberts, A. E. Geology and Coal Resources of the Toledo-Castle Rock District, Cowlitz and Lewis Counties, Washington. U.S. Geol. Survey Bull. 1062, 1958, 71 pp.

146. Robison, Richard A. A Reconnaissance Survey of the Coal Resources of Southwestern Utah. Utah Geol. and Min. Survey Special Studies 3, 1963, 34 pp.

147. _____. Progress Report on the Coal Resources of Southern Utah. Utah Geol. and Min. Survey Special Studies 7, 1964, 27 pp.

148. Rothrock, E. P. Geology of Cimarron County, Okla., Oklahoma Geol. Survey Bull. 34, 1925, pp. 86-88.

149. Russell, Dearl T. Geology of Northern Latimer County, Okla. Okla. Geol. Survey Cir. 50, 1960, 56 pp.

150. Sanford, Robert S. and Pierce, Harold C. Exploration of Coal Deposits of the Point Barrow and Wainright Areas, Northern Alaska: BuMines Rept. of Inv. 3934, 1946, 17 pp.

151. Schoewe, Walter H. Coal Resources of the Kansas City Group, Thayer Bed, in Eastern Kansas. Kansas Geol. Survey Bull. 52, pt. 3, 1944, 55 pp.

152. _____. Coal Resources of the Wabaunsee Group in Eastern Kansas. Kansas Geol. Survey Bull. 63, 1946, 144 pp.

153. _____. Coal Resources of the Cretaceous System (Dakota Formation) in Central Kansas. Kansas Geol. Survey Bull. 96, pt. 2 1952, pp. 74-153.

154. _____. Coal Resources of the Marmaton Group in Eastern Kansas. Kansas Geol. Survey Bull. 114, pt. 2, 1955, 62 pp.

155. _____. Coal Resources of the Cherokee Group in Eastern Kansas. Kansas Geol. Survey Bull. 134, pt. 5, 1959, 141 pp.

156. School of Mines and Metallurgy. Mining and Mineral Resources of Missouri, Bull. 73, 1948, pp. 24-28.

157. Searight, Walter V. A Preliminary Report of the Coal Resources of South Dakota. South Dakota Geol. and Nat. History Survey, Rept. of Inv. No. 3, 1930, 46 pp.

158. Searight, Walter V. and Wallace B. Howe. The Stratigraphic Succession in Missouri, Pennsylvanian System. State of Missouri, Dept. of Business and Administration, Div. of Geol. Survey and Water Resources, 1961, pp. 78-122.

159. Shannon, C. W. and others. Coal in Oklahoma. Okla. Geol. Survey Bull. 4, 1926, 110 pp.

160. Shaw, Wesley E. The Glenrock Coal Field, Wyoming. U.S. Geol. Survey Bull. 341, 1909, pp. 151-164.

161. Sherwood, R. H. The Development of Strip Mining, Mining Congress Journal, Nov. 1945, p. 31.

162. Shotts, Reynold Q. Some Significant Recent Changes in the Pattern of Coal Production and Markets in Alabama. J. Ala. Acad. Sci., 33, No. 2, 1962, pp. 67-82. Reprinted as Ala. State Mine Exp. Sta. Contribution No. 10, Feb. 1964 and as Reprint Series No. 15, Geol. Survey of Ala., 1965.

163. Shotts, Reynold Q. and H. L. Riley. Coal Resources of the Fabius-Flat Rock Area, Jackson County, Ala. BuMines Inf. Circ. 3295, 1966, 36 pp.

164. Shultz, A. R. Geology and Geography of a Portion of Lincoln County, Wyoming. U.S. Geol. Survey Bull. 543, 1914, pp. 1-115.

165. Smith, A. E. Report of Progress for 1875. Alabama Geol. Survey, 1876, pp. 28-82.

166. Smith, C. D. The Fort Berthold Indian Reservation Lignite Field, North Dakota. U.S. Geol. Survey Bull. 381, 1908, pp. 30-39.

167. _____. The Washburn Lignite Field, North Dakota. U.S. Geol. Survey Bull. 381-A, 1910, pp. 19-29.

168. Smith, Joseph Blake. Strippable Coal Reserves of Montana, North Dakota, and Wyoming, abs., Am. 7 Assoc. of Petroleum Geologists Bull., v. 53, No. 1, 1969, p. 214.

169. Snyder, N. H. and L. N. Plein. Analyses of Delivered Coal. U.S. BuMines Tech. Paper 455, 1929, pp. 20-29.

170. Snyder, N. H. and S. J. Aresco. Analyses of Tipple and Delivered Samples of Coal, BuMines Bull. 516, 1950, pp. 41-42.

171. Sondreal, Everett A., Wayne R. Kube, and James L. Elder. Analysis of Northern Great Plains Province Lignites and Their Ash: A Study of Variability. BuMines Rept. of Inv. 7158, August 1968, 94 pp.

172. Spencer, Frank D. Coal Resources of Indiana. U.S. Geol. Survey Circ. 266, 1953, 42 pp.

173. Stone, R. W. and C. T. Lupton. The Powder River Coal Field, Wyoming, Adjacent to the Burlington Railroad. U.S. Geol. Survey Bull. 381, 1908, pp. 115-136.

174. Stroup, Robert K., and Arthur E. Falvey. Coal Reserves for Steam-electric Generation in Kansas and Missouri Areas of Missouri River Basin, U.S. Dept. of the Interior, BuMines Prel. Rept. 174, 1969, pp. 1-37.

175. Taft, J. A. The Sheridan Coal Field, Wyoming. Geol. Survey Bull. 341, pt. 2, 1907, p. 136.

176. Tennessee Valley Authority, Office of Power Fuels Planning Staff. Coal Reserves of Western Kentucky. Chattanooga, Tenn., 1969, 4 maps.

177. Department of Conservation, Division of Geology, State of Tennessee. Geologic Map and Mineral Resources Summary Series.

178. Thom, W. T. Jr., G. M. Hall, C. H. Wegeman, and G. F. Moulton. Geology of Big Horn County and the Crow Indian Reservation, Montana. U.S. Geol. Survey Bull. 856, 1935, pp. 1-200.

179. Toenges, Albert L., J. D. Davis, Louis A. Turnbull, and J. M. Schopf. Reserves, Bed Characteristics, and Coking Properties of the Willow Creek Coal Bed, Kemmerer District, Lincoln County, Wyo. BuMines Tech. Paper 673, 1945, p. 48.

180. Toenges, Albert L., Turnbull, L. A., and Cole, W. A. Exploration, Reserves, Bed Characteristics, and Strip-Mining Possibilities of a Lignite Deposit Near Toledo, Lewis County, Washington. BuMines Tech. Paper 699, 1947, 55 pp.

181. Toenges, Albert L., Louis A. Turnbull, Lloyd Williams, H. L. Smith, H. J. O'Donnell, H. M. Cooper, R. F. Abernathy, and Karl M. Waage. Investigation of Lower Coal Beds in Georges Creek and North Part of Upper Potomac Basins, Allegany and Garret Counties, Md. BuMines Tech. Paper 725, 1949, 142 pp.

182. Townsend, Don H. Economic Report on the Kemmerer Coal Field. Wyo. Geol. Assoc. 15th Annual Field Conference Guidebook, Overthrust Belt of Southwestern Wyoming and Adjacent Areas, 1960, pp. 251-255.

183. Travis, Raymond G. A Study of Coal Mining Operations and Coal Resources in Northern Kansas. BuMines Missouri River Basin Preliminary Rept. No. 34, 1949, 40 pp.

184. _____. A Study of Coal Mines, Resources, and Power Requirements in the Big Horn River Basin, Wyo., and Carbon County, Mont. BuMines Missouri River Basin Preliminary Report No. 56, August 1951, 73 pp.

185. Trumbull, James V. A. Coal Resources of Oklahoma. U.S. Geol. Survey Bull. 1042-J, 1957, pp. 307-382.

186. U.S. Dept. of Agriculture, Soil Conservation Service and Agriculture Stabilization and Conservation Service. Aerial photographs, Craig and Nowata Counties, Okla. 1964.

187. _____. Restoring Surface - Mined Land. Misc. Pub. No. 1082, April 1968.

188. U.S. Dept. of the Interior, Surface Mining and Our Environment. Washington, D.C., U.S. Govt. Printing Office, 1967, 124 pp.

189. Vanderpool, Robert E. Geology of the Featherson Area, Pittsburg County, Okla. Okla. Geol. Survey Circ. 53, 1960, 36 pp.

190. Van Sant, J. N., and R. C. Ellman. Methods and Costs of Mining Lignite in North Dakota. BuMines Inf. Circ. 7891, 1959, 82 pp.

191. Virginia, State of, Department of Labor and Industry Annual Reports, 1946-1955.

192. Virginia Geological Survey. The Coal Resources of the Clintwood and Bucu Quadrangles, Virginia, Bull. 12, 1916.

193. _____. The Geology and Coal Resources of Buchanan County, Virginia, Bull. 18, 1918.

194. Virginia Geological Survey. The Geology and Coal Resources of the Coal-bearing Portion of Tazewell County, Virginia. Bull. 19, 1919.

195. _____. The Geology and Coal Resources of Dickenson County, Virginia. Bull. 21, 1921.

196. _____. The Geology and Coal Resources of Russell County, Virginia. Bull. 22, 1922.

197. _____. The Geology and Mineral Resources of Wise County and the Coal-bearing Portion of Scott County, Virginia. Bull. 24, 1923.

198. _____. The Geology and Coal Resources of the Coal-bearing Portion of Lee County, Virginia. Bull. 26, 1925.

199. Walker, F. E., and F. E. Hartner. Forms of Sulfur in U.S. Coals, BuMines Inf. Circ. 8301, 1966, 51 pp.

200. Wallace, Joseph J., James J. Dowd, Lloyd Williams, R. F. Abernathy, and D. A. Reynolds. Estimate of Known Recoverable Reserves of Coking Coal in Allegany County, Md. BuMines Rept. of Inv. 4970, 1953, 18 pp.

201. Warfield, R. S. Bituminous Coal Deposits of the Matanuska Coalfield, Alaska: Central and Western Parts, Wishbone District: BuMines Rept. of Inv. 5950, 1962, 190 pp.

202. _____. Investigation of a Subbituminous Coal Deposit Suitable for Opencut Mining, Beluga River Coalfield, Alaska: BuMines Rept. of Inv. 6238, 1963, 100 pp.

203. Warfield, R. S., and Boley, Charles C. Sampling and Coking Studies of Several Coalbeds in the Kokolik River, Kukpowruk River, and Cape Beaufort Areas of Arctic Northwestern Alaska: BuMines Rept. of Inv. 7321, 1969, 58 pp.

204. Warren, W. C. Reconnaissance Geology of the Birney-Broadus Coal Field, Rosebud and Powder River Counties, Montana. U.S. Geol. Survey Bull. 1072-J, 1959, pp. 561-585.

205. Webb, Philip K. Geology of the Cavanal Syncline. Okla. Geol. Survey Circ. 51, 1960, 65 pp.

206. Wegemann, Carroll H. The Sussex Coal Field, Johnson, Natrona, and Converse Counties, Wyoming. U.S. Geol. Survey Bull. 471, 1910, pp. 441-471.

207. _____. The Barber Coal Field, Johnson County, Wyoming. U.S. Geol. Survey Bull. 531-I, 1913, pp. 263-284.

208. Wegemann, Carroll H., R. W. Howell, and C. E. Dobbin. The Pumpkin Buttes Coal Field, Wyoming. U.S. Geol. Survey Bull. 806-A, 1928.

209. West Virginia, State of. Annual Reports of the Department of Mines, years 1942 to 1967.

210. Whitla, R. E. Coal Resources of Kansas: Post Cherokee Deposits. Kansas Geol. Survey Bull. 32, 1940, 64 pp.

211. Williams, Lloyd, R. E. Hershey, and B. W. Gandrud. Estimate of Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Marion County, Tenn. BuMines Rept. of Inv. 5159, 1955, 30 pp.

212. Williams, Lloyd, R. F. Abernathy, B. W. Gandrud, D. A. Reynolds, and D. E. Wolfson. Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Overton County, Tenn. BuMines, Rept. of Inv. 5131, 1955, 27 pp.

213. Williams, Lloyd, R. E. Hershey, R. F. Abernathy, B. W. Gandrud, and D. A. Reynolds. Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Sequatchie County, Tenn. BuMines Rept. of Inv. 5136, 1955, 28 pp.

214. Williams, Lloyd, Robert Lowe, L. A. Turnbull, E. P. Carman, W. L. Crentz, D. A. Reynolds, and R. F. Abernathy. Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Putnam County, Tenn. BuMines Rept. of Inv. 5029, 1954, 21 pp.

215. Winchester, Dean E. The Lost Spring Coal Field, Converse County, Wyoming. U.S. Geol. Survey Bull. 471, 1910, pp. 472-515.

216. Witkind, Irving J. Quaternary Geology of the Smoke Creek-Medicine Lake-Glenora Area, Montana and North Dakota. U.S. Geol. Survey Bull. 1073, 1959, 80 pp.

217. Woodruff, E. G., Coalfields of the Southwest Side of the Bighorn Basin, Wyoming, U.S. Geol. Survey Bull. 341, 1909, pp. 200-219.

218. Woodruff, E. G., and Dean E. Winchester. Coal Fields of the Wind River Region, Fremont and Natrona Counties, Wyoming. U.S. Geol. Survey Bull. 471, 1910, pp. 516-564.