A

New Mexico
BUSINESS

Reprint

February 1964

CIRCULAR 71

THE ECONOMIC GEOLOGY OF COAL IN NEW MEXICO

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25 Cents

The Economic Geology of Coal in New Mexico

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In New Mexico, 126,519,000 tons of coal, valued at $322,019,000, have been mined since 1882. Although the State's coal industry was severely affected by dieselization of the railroads and by the upsurge in the use of natural gas, the current small coal boom in San Juan, McKinley, and Colfax counties has once again focused attention upon coal mining.

Reserves of coal in New Mexico are huge; at the present rate of mining, the coal beds could last for 40,000 years, if the deeper and thinner seams could be mined economically. The ups and downs experienced by coal mining in New Mexico are suggested by the accompanying production chart (Figure 1). These booms and depressions have been due to the changing economy, the changing technology of coal users, the changing methods of mining, and competition from other mineral fuels.

Coal Mining

INDIAN AND SPANISH ACTIVITIES

Coal mining became an important industrial activity in New Mexico about eight decades ago; but the Paleo-Indians wore "jet" ornaments, fragments of shiny coal, more than 12,000 years ago. Coal ash, dated at about 1300 A. D., has been found in long-cooled firepits of the Hopi Indians and of the abandoned pueblos in the region of the San Juan river. The extensive outcrops of thick coal beds from Zuni northward into Colorado to Mesa Verde were mined for some use in small open fires by the Zunis and the Navajos, as well as by the former's Puebloan ancestors; but they all preferred wood, because it was more easily obtained, was more fragrant, and gave off less smoke. A few thin lenses of coal along Aztec creek almost within the city of Santa Fe were used in a small way by the Spanish several centuries ago. Anthracite from the White Ash seam near Madrid was mined for local use as early as 1835.

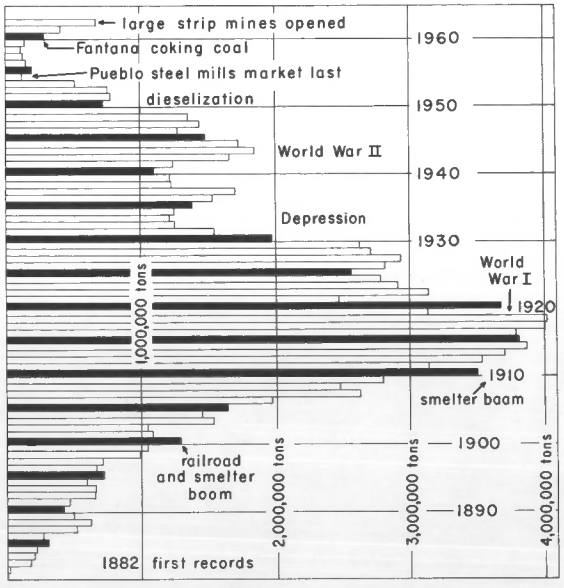
SINCE 1861

Actual mining of more than a few tons a year began in 1861, when government troops stationed at Fort Craig south of Socorro opened a mine in the Carthage coal field. Statewide production remained as mere tens of tons until 1878-1882, when railroads were built into and through New Mexico, providing both transportation to out-of-state markets and a need for coal with which to run the steam locomotives. Thus in 1882, the first year in which accurate records were kept, 164,000 tons of coal were mined in the Territory, and coal became an important New Mexico product.

Old Coal Towns

Some of the old major coal towns were significant population and trade centers, contributing greatly to the State's economy. Two of New Mexi-

Figure 1



Annual Coal Production in New Mexico
1882-1962

[The opinions expressed in this article, which is published with the approval of Alvin J. Thompson, Director of the State Bureau of Mines and Mineral Resources, do not necessarily reflect the thinking of the Bureau of Business Research or The University of New Mexico.]

co's present cities Gallup and Raton owe their original growth to coal mining and the attendant development of railroads. Dawson, in Vermejo canyon on the southwest edge of the Raton coal field, was one of the main coal-mining centers until the mines in that canyon shut down in 1950. When the Dawson mines, owned by Phelps Dodge Corporation, were in full production in the 1940s, the population was about 3,500. Today the few remaining buildings--caretakers' homes, the old coal washer, and crumbling coke ovens and smokestacks--are not even spotted on highway road maps. This city rivaled Raton in importance during the early 1900s, with Dawson's 3,500 inhabitants accounting for more than 1 per cent of the Territory's total population and with a labor force at the mines, the coke ovens, and in associated construction and railroad activities totaling about 1,500.

Madrid, once famous for its spectacular Christmas-lighting displays, is another old major coal town that grew swiftly during the 1890s and early 1900s. During peak years when its high-carbon anthracite was being shipped to the West Coast and as far east as Chicago, the population exceeded several thousand. At the height of the coal, gold, lead, and zinc boom of the 1880s in the Cerrillos hills and San Pedro mountains, both Cerrillos and Madrid vied in size and importance with Albuquerque. Madrid still had more than a thousand people in 1940, but the large coal mines closed down in the early 1950s; today it is almost a ghost town with only about 20 inhabitants.

Major Uses and Users

From the time of the first large-scale mining of coal its main commercial users were railroads and smelters. As the railroads spread over the Southwest, they ran from New Mexico to California and from New Mexico eastward on power generated by the State's coal. During the late 1890s and the early 1900s, the Gallup coal field led the State in output, mainly because of the use of its coal by railroads and smelters. The smelters not only required large tonnages of coking and powdered bituminous coal, but also used subbituminous coal and much slack coal. The old lead blast furnaces, such as the one at Park City near Socorro, used the coke, whereas the copper smelters utilized powdered bituminous coal. High-grade slack coal, the fine-grained coal fragments under one-quarter inch in size without much included clay, was shipped to make powdered coal feed for the copper smelters, with the low-grade slack being used for ordinary heating purposes such as boilers to heat water. Whereas bituminous coal with its greater heat value was preferred for the smelters, the subbituminous coal near Gallup was utilized, because of lower shipping charges, by smelters at Clarksdale, Hayden, Inspiration, Clifton, and Douglas in Arizona, and El Paso in Texas.

Early warnings of the switch by railroads to oil came in 1911, with the use of oil in California; but major dieselization arrived just after World War II during the 1947-to-1954 period, when almost all steam locomotives were retired and became relics of the past. Smelters also switched to oil in the 1910s and 1920s, and later to natural gas.

Coke

Coke was first produced by the San Pedro Coal and Coke Company from the Carthage field, where considerable tonnages occur--production which supplied lead smelters in southwestern New Mexico and later in northern Mexico and El Paso. But most of our coking coal is in the Raton field, where the most extensive mining of coal for coke has also occurred. Lesser amounts of coking coal are to be found in the Cerrillos field. Most of the Raton production has been shipped from the mines of the Stag Canon Fuel Company and the St. Louis, Rocky Mountain, and Pacific Fuel Company. Early use was by smelters here and in Arizona, Colorado, and northern Mexico. Several decades after the Colorado Fuel and Iron Corporation's first production of pig iron and steel in 1881 at Pueblo, Colorado, the Raton field began supplying much coke to the steel mills, an important market until 1954, when coking coals near Trinidad, Colorado, were developed to feed the Pueblo mills.

Trinidad Field

The Trinidad coal field is a northward extension of New Mexico's Raton field; both occur in similar geologic conditions as part of the Raton Mesa coal mining area which extends as far north as Walsenburg, Colorado. Coal has been mined from the Trinidad field since 1873; annual production reached 1 million tons in 1889 and has never fallen below that amount, with 1910 being the year of peak production, nearly 8 million tons. Coal reserves of the field are estimated at about 3 billion tons (Harbour and Dixon, 1959). Most of the coal is of bituminous coking rank; some has been transformed into natural coke near igneous intrusive rocks.

Space-Heating

Space-heating users of coal were supplied in California and Arizona to the west and Texas, Oklahoma, and Kansas to the east. The western markets vanished when oil and gas replaced coal for such purposes in the early 1900s. The eastern space-heating demand for coal dropped drastically after World War II; and, even in New Mexico in the coal-mining regions, fuel oil and natural gas have now largely replaced coal for heating purposes.

TABLE I

VOLUME AND VALUE OF COAL PRODUCTION IN NEW MEXICO
1882-1962
(in thousands)

Year	Tons	Value	Year	Tons	Value
1882	164	$ 267	1924	2,786	$ 9,774
1883	211	344	1925	2,557	8,611
1884	221	360	1926	2,818	8,916
1885	306	499	1927	2,936	9,179
1886	271	442	1928	2,712	8,636
1887	508	828	1929	2,623	8,314
1888	627	1,022	1930	1,969	6,017
1889	487	873	1931	1,553	4,597
1890	420	600	1932	1,264	3,321
1891	462	779	1933	1,226	3,071
1892	661	1,075	1934	1,259	3,402
1893	665	979	1935	1,389	3,681
1894	597	936	1936	1,547	2,924
1895	721	1,073	1937	1,715	3,337
1896	663	930	1938	1,239	2,422
1897	717	992	1939	1,230	3,506
1898	992	1,345	1940	1,111	3,300
1899	1,051	1,462	1941	1,251	3,791
1900	1,299	1,776	1942	1,669	5,256
1901	1,087	1,547	1943	1,851	6,533
1902	1,049	1,500	1944	1,744	6,609
1903	1,542	2,106	1945	1,484	5,638
1904	1,452	1,904	1946	1,280	5,300
1905	1,650	2,190	1947	1,443	6,523
1906	1,965	2,639	1948	1,364	6,942
1907	2,629	3,832	1949	1,004	5,231
1908	2,468	3,369	1950	727	3,918
1909	2,801	3,620	1951	783	4,501
1910	3,508	4,877	1952	759	4,382
1911	3,148	4,526	1953	514	3,081
1912	3,537	5,037	1954	123	728
1913	3,709	5,401	1955	202	1,236
1914	3,878	6,231	1956	158	922
1915	3,818	5,481	1957	137	830
1916	3,793	5,580	1958	117	719
1917	4,001	7,455	1959	149	838
1918	4,023	10,787	1960	295	1,748
1919	3,139	9,751	1961	412	2,477
1920	3,683	13,568	1962	677	2,594
1921	2,457	9,585			
1922	3,147	10,977	TOTAL	126,519	$322,018
1923	2,915	10,668			

Source: U. S. Bureau of Mines and Annual Reports of the New Mexico State Inspector of Mines

Cerrillos Anthracite

Some of the anthracite coal of the Cerrillos field ranks as high in quality as the best Pennsylvania anthracite. Significant tonnages up to 45,000 tons annually were produced during the period from 1888 to 1957 and shipped to suppliers throughout the central and western parts of the nation. However, freight costs, competition from natural gas and fuel oil, and difficulties in mining combined to close the anthracite mines near Madrid.

PRODUCTION SUMMARY

Our peak coal year was 1918 (see Table I), when World War I stimulated coal mining generally. The 4,023,239 tons mined that year were used mainly by smelters, steel plants, other factories, and the railroads. Even during the Great Depression, this state's average annual production was close to 1.3 million tons per year. Dieselization and use of natural gas caused a reduction in output below the million-ton mark in 1950; and, with the opening of new coking-coal mines in southern Colorado to serve the Pueblo steel mills, production fell to only 123,099 tons in 1954. The following year, however, the Kaiser Steel Corporation bought the coking mines of the St. Louis, Rocky Mountain, and Pacific Fuel Company near Koehler in the Raton area. Although a fire in the Koehler mine in 1958 dropped the State's production to an all-time low of 116,656 tons, by 1960 Kaiser Steel's development program was completed; and since then 190,000 to 350,000 tons yearly have been shipped to Kaiser's coking ovens and steel mills at Fontana, California.

National and State Data

Comparison of our coal industry with the nation's aids in placing this vital part of our economy in proper perspective. The mining and distribution of coal is the second largest mineral industry in the United States in respect to dollar value of production. It is topped only by petroleum and outranks all metallic minerals combined. During 1962, for example, 439 million tons of coal valued at $2,026 million were produced in the nation. Consumers of this coal were electric utilities, 40 per cent; coke producers (chiefly the steel industry), 29 per cent; industrial plants, 24 per cent; and retail deliveries, 7 per cent. The major change in consumption has come since World War II, when electric utilities began to replace railroads as the largest single users of coal.

Production of coal increased rapidly in the early 1800s in the Eastern States. Nationwide, it doubled almost every decade until about World War I; similarly, New Mexico's coal production doubled every decade from the beginning of mining in 1882 (when railroads were built in the State) to World War I. The nation's early peak in production was 1918, the same year as our coal-mining peak. Nationally, coal production and consumption declined thereafter, because of the large expansion in the use of petroleum and natural gas and the Depression of the 1930s. The impetus afforded by World War II, however, boomed coal mining, so that shortly after the war it reached its U. S. all-time high of 688 million tons in 1947, a coal-mining boom shared only in part by New Mexico. Since then, coal production has tapered off to a national average of 484 million tons during the 1950s; our present state increase is not reflected nationwide.

NEW MEXICO MINING METHODS

Most of New Mexico's coal has been mined underground either along nearly horizontal drifts or through gently inclined slopes. Because many of the coal beds are thin (less than four feet thick), especially the lenticular (lens-shaped) coal beds of the northwestern part of the State, underground mining in many localities is not commercial with the present types of equipment. Strip-mining, whereby thin, near-surface coal seams can be economically recovered, has been introduced on a large scale only in recent years. Now, how-

TABLE II

FUEL COSTS FOR STEAM-ELECTRICAL POWER
(in cents per million Btu)

	1956	1957	1958	1959	1960	1961
Coal	22.0	22.0	21.9	21.3	20.2	19.6
Oil	26.0	25.1	25.2	24.3	25.0	25.6
Gas	22.0	22.2	22.2	25.7	27.8	28.5

Source: U.S. Bureau of Mines

ever, that technique produces all of our major coal output except that at the Kaiser mines. Until 1963, strip-mining had been confined to McKinley county's Gallup coal field, where small stripping operations were begun in 1945. Until 1962, tons mined there averaged about 20,000 annually.

STEAM-ELECTRICAL POWER

The combination of inexpensive strippable coal in McKinley and San Juan counties and the demand for electric power in Arizona and New Mexico have boomed the State's production of coal. In 1960 the Pittsburg and Midway Coal Company began stripping overburden from near-surface coal beds about 15 miles northwest of Gallup. They mined coal at their McKinley strip pit in early 1962. This subbituminous coal is shipped westward to supply the Cholla 110-megawatt thermal-electric generating plant of the Arizona Public Service Company at Joseph City, Arizona; requirements are for 380,000 tons each year. In 1961 ground was broken for a 350-megawatt thermal-electric generating plant of the Arizona Public Service Company near Fruitland, and subbituminous coal is being stripped by the Utah Construction and Mining Company at the Navajo mine to supply this Four-Corners power plant. About 800,000 tons were scheduled to be mined there in 1963, and exploitation is to be increased to 2.5 million tons by 1975. Also, the Public Service Company of New Mexico has acquired areas adjacent to Navajo lands underlain by strippable coal northwest of Pueblo Bonita and north of Fruitland and plans to use this coal to make electric power by 1966. In addition, El Paso Natural Gas Company has a large block of strippable coal under lease from the Navajos, southeast of the Navajo mine, which may be used in a coal conversion plant.

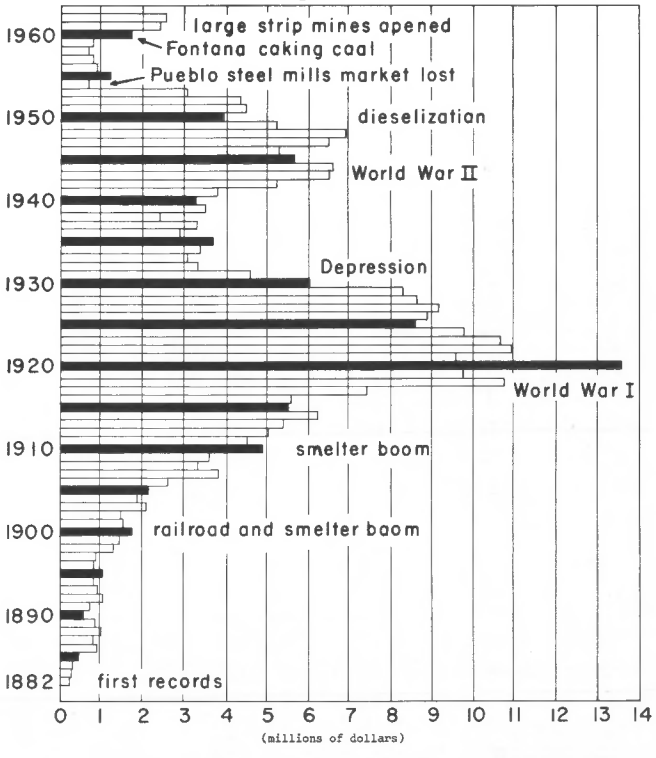
Until the recent opening of these thermal-electric generating plants fed by coal, much of the electric power used in New Mexico was from steam-generating plants fueled by natural gas. A ton of subbituminous coal will produce about 19 million Btu. Since a thousand cubic feet (Mcf) of natural gas will generate 1.04 million Btu, the energy from 18.27 Mcf of natural gas is needed to equal that of a ton of subbituminous coal. Natural gas, if available, can be sold to local industrial consumers at 16 cents to 20 cents per Mcf; thus the price of the volume of gas energy equivalent to the volume of energy produced by a ton of subbituminous coal ranges from $2.92 to $3.65. Costs of strip-mining the coal in northwestern New Mexico, under favorable conditions of thin overburden and reasonably thick coal, may be less than $2.00 a ton. With the McKinley strip mine just coming into production, the U.S. Bureau of Mines reported the average cost of strip-mined coal in New Mexico was $2.86 a ton during 1962; this cost should drop as both the McKinley mine and the Navajo mine come into full production.

Comparative costs of fuels used in steam-electrical power generation, as reported by the Federal Bureau of Mines, are given in Table II in cents per million Btu for the Mountain States (New Mexico, Arizona, Colorado, Utah, Wyoming, Idaho, and Montana).

In comparison, even at the 1962 cost of strip mining ($2.86 per ton), a million Btu could be produced from New Mexico's subbituminous coal at a cost of only 15.1 cents.

The State's strippable subbituminous coal may not be usable except for on-the-site thermal-electric generation plants or gas and chemical conversion plants. Freight costs prohibit shipping this relatively low-grade coal any appreciable distance, either inside or outside the State. Our natural gas, on the other hand, can be trans-

Figure 2



Annual Value of New Mexico Coal Production

1882 - 1962

ported by pipelines comparatively inexpensively to California and other states, where its price during 1962 in California, for example, was 99 cents to residential users, 70 cents to commercial operators, and 39 cents to industrial plants per Mcf (U.S. Bureau of Mines, 1962). Obviously, much of this increased price from New Mexico to California is absorbed in transportation, handling, and other charges; but the natural gas can be sold as a source of energy outside the State, whereas because of freight costs the subbituminous coal could not be shipped.

From the overall viewpoint of conservation and utilization of our natural resources, New Mexico should use its subbituminous coal mainly at on-the-site generating or conversion plants; by contrast, our natural gas would be worth more when sold to local and out-of-state domestic, commercial, and industrial markets other than thermal-electric generating plants.

More than a million tons of coal will be strip-mined each year, to produce electricity in the mid-1960s. About 400,000 tons annually should be obtained from the underground mines, chiefly of coking coal. By the mid-1970s, with increases in the capacity of the present power-generating facilities and the addition of two other large coal-consuming plants, strip-mining production may reach 4 million tons annually.

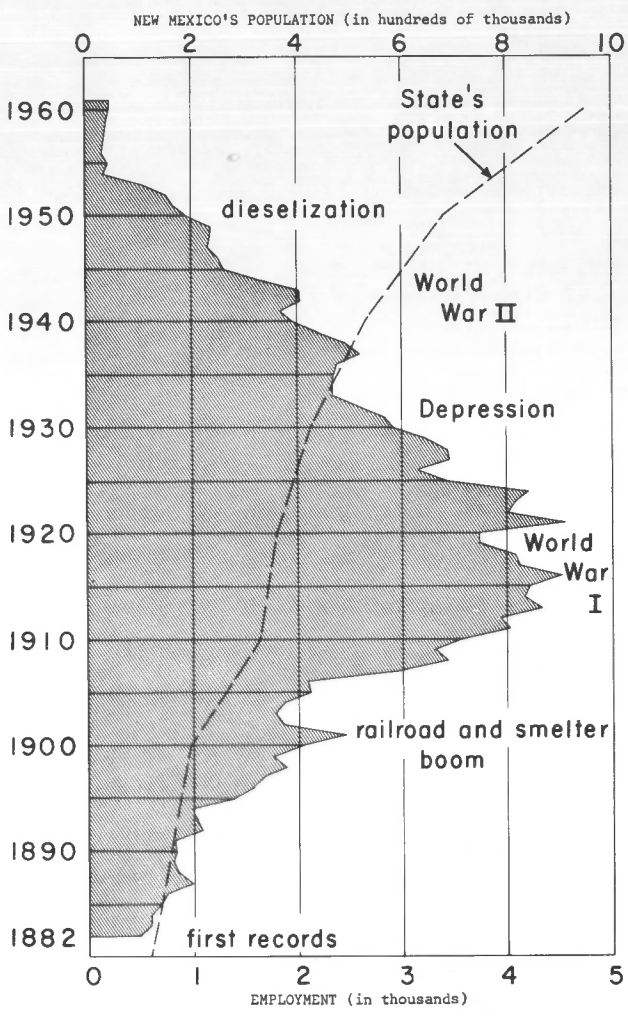
Value of Coal Production

The value of coal mined (Figure 2, Table I) climbed above $2 million a year in 1903 and averaged $5.6 million annually, until the State's coal-market "crash" of 1954, when the value dropped below a million dollars. The peak was the boom year of 1920, when 3.6 million tons of coal sold for $13.57 million. Present production is worth more than $4 million annually, even with the low value of strip-mined coal. The average price per ton remained under $2 until 1918, went to a high of $3.90 in 1921, sank drastically to $1.82 in 1936, and then climbed steadily to average more than $5.75 during the 1951-61 decade. Ironically, the highest average value ($6.16) came during 1958, when the State's coal output was the lowest on record. With the large-scale introduction of strip-mining at captive mines in 1962, the value per ton dropped from $6.01 in 1961 to $3.83.

Employment

Most of the gross income from coal mining in New Mexico goes for (1) purchases of capital equipment, (2) labor, (3) mining supplies, (4) royalties, and (5) profits. Part of the costs of mining supplies and royalties remains in the State, but much of the spending for large equipment and most of the profits go elsewhere. The

Figure 3



New Mexico Coal-Mine Employment
1882 - 1962

major direct benefit to New Mexico, aside from taxes, is the employment of miners and associated workers. The number employed (Figure 3; Table III) exceeded 1,000 by 1892 and averaged 2,708 until 1943, when employment dropped under 2,000 and then declined steadily to 520 in 1953. During this period of 60 years the production of a thousand tons of coal per year required an average of about 1.3 employees. By 1962, because of increased mechanization (particularly in strip-mining), the mining of a thousand tons required less than one employee (0.5). As a result of such mechanization and of greatly curtailed production in the 1951-1961 years, since 1954 only 175 to 325 men have been employed in New Mexico's coal mines. And as strip-mining expands, employment per thousand tons will continue to decline. From 1900 to 1924, coal miners made up more than 1 per cent of the State's population, but by 1960 they accounted for only 0.023 per cent of all residents.

TABLE III

COAL-MINE EMPLOYMENT IN NEW MEXICO
1882-1962

Year	Employees	Year	Employees
1882	485	1923	4,095
1883	600*	1924	4,206
1884	600	1925	3,444
1885	700	1926	3,167
1886	750	1927	3,456
1887	995	1928	3,441
1888	850	1929	3,233
1889	800	1930	2,902
1890	827	1931	2,830
1891	806	1932	2,602
1892	1,083	1933	2,340
1893	1,011	1934	2,342
1894	985	1935	2,355
1895	1,383	1936	2,392
1896	1,559	1937	2,608
1897	1,659	1938	2,474
1898	1,873	1939	2,199
1899	1,750	1940	1,958
1900	2,037	1941	1,823
1901	2,478	1942	2,023
1902	1,849	1943	2,003
1903	1,789	1944	1,741
1904	1,849	1945	1,311
1905	2,108	1946	1,269
1906	2,070	1947	1,164
1907	2,970	1948	1,192
1908	3,448	1949	1,193
1909	3,317	1950	956
1910	3,585	1951	825
1911	4,007	1952	756
1912	3,928	1953	520
1913	4,329	1954	185
1914	4,178	1955	222
1915	4,205	1956	175
1916	4,522	1957	188
1917	4,126	1958	191
1918	4,095	1959	202
1919	3,745	1960	223
1920	3,738	1961	225
1921	4,577	1962	325
1922	4,001		

*Estimated.
Source: U. S. Bureau of Mines and Annual Reports of the New Mexico State Inspector of Mines

During recent decades New Mexico coal mines have been relatively safe. Since World War II only 18 fatalities have occurred in those mines, representing a very small 0. 2 per cent of the total employees. In contrast, from 1910 to 1932, fatalities numbered 777, representing almost 1 per cent of the labor force. Two large-scale disasters have occurred: a coal-dust explosion in 1913 in the mine operated by the Stag Canon Fuel Company at Dawson (Raton coal field) killed 261 miners, and in 1923 another coal-dust explosion in the same Dawson mine killed 120 miners.

Coal Reserves

Coal reserves in New Mexico, as calculated by the U. S. Geological Survey, come close to 62 billion tons, of which 50. 8 billion are subbituminous, 10. 9 billion are bituminous, and almost 6 million are anthracite. The Raton coal field contains 4. 7 billion tons of bituminous coal. San Juan county has 4. 1 billion tons of bituminous, but many of these reserves are deeply buried. Much of the subbituminous coal is also more than 1, 000 feet below the surface; the largest reserves are in San Juan county (32. 5 billion tons) and McKinley county (13. 2 billion tons). All anthracite reserves are in the Cerrillos field of Santa Fe county. In contrast to these huge reserves, the total coal production reported in New Mexico through 1962 was a mere 127 million tons.

A note of caution should be sounded here. Although the State's remaining 62 billion tons of coal are available by means of present mining methods, competitive costs of mining and of transportation and the low grade of the coal greatly reduce the possibility that much will be mined in the near future, if ever. If demand becomes strong enough, the coal can be obtained; but the overriding concern is the overall cost of production. To meet competition, the industry will mine New Mexico coal at only a few favorable localities. The remainder may never be recovered, unless new extractive methods make such recovery economically feasible. Underground gasification experiments may lead to the development of techniques that will allow commercial recovery of our thin or deeply buried coal beds, although natural gas should be less expensive to extract from the underground as long as it is available.

At present, as pointed out by many economists, the United States is geared to a gaseous- and liquid-fuel economy. In the long run, when reserves of oil and of natural gas are depleted, coal may become more valuable for synthesis of these fuels, in addition to being used as solid fuels. If this conversion of coal to gas and gasoline becomes widespread, we will be in a favorable location for such development, as the State has huge reserves of coal and also will have facilities for transporting gas and liquid-petroleum products.

Various hydrogenerating processes have been used to make petroleum products and chemicals from coal. These processes are most economical when utilized at a mine. Many of New Mexico's coal deposits could be mined for these purposes at on-the-site mines and used directly in coal conversion plants.

Coal Fields

The State's largest coal field is located in the San Juan basin in McKinley, San Juan, Rio Arriba, and Sandoval counties, although for present practical mining purposes the recoverable coal crops out mainly around the rim of the Basin. Coal mining districts are actually separate coal fields, their areas being determined mainly by access to railroads; but the various coal-bearing formations are essentially continuous throughout the Basin. The Gallup coal field on the southwest has been by far the most exploited in the San Juan and is the present site of several underground mines as well as the large McKinley strip pit of the Pittsburg and Midway Coal Company. The Monero

coal field on the northeast edge of the Basin has been a steady producer from small underground mines, and coal for local use has been mined from the La Ventana field on the east side and from the Fruitland coal field on the northwest edge. Small amounts have been produced from the Mount Taylor field on the southeast margin. The large Navajo strip pit of the Utah Construction and Mining Company near Fruitland makes the Fruitland field currently the largest New Mexico producer.

These commercial coal beds in the San Juan are Late Cretaceous; and, in general, they dip inward toward the center of the Basin--at relatively low angles along the southern and western sides, except near local anticlines, but at steep inclines in most areas along the northern and eastern margins. Even on the western edge the outcrop pattern is essentially linear, the strip-mining pits being long, narrow openings limited on the east by excessive amounts of overburden. The mineable coals occur in the Mesaverde Group and the Fruitland Formation; coal beds in the latter formation are thicker than the Mesaverde coals, but contain interlaminated shale beds and have a higher percentage of ash.

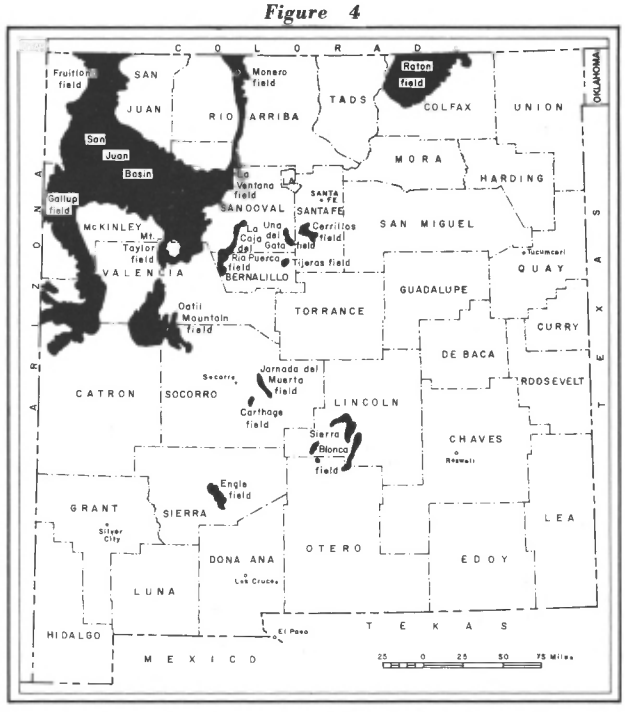
The Raton coal field in northeastern New Mexico's Colfax county lies on the western edge of the Great Plains in rugged, dissected plateau country, bordering the Sangre de Cristo mountains. Many west- to northwest-trending canyons reach into this plateau and provide easy access to the coal beds, which either are almost horizontal or dip gently eastward throughout the eastern and central parts of the field. Mineable coal beds are located in the Late Cretaceous Vermejo Formation and the Late Cretaceous-Early Tertiary Raton Formation. The Raton coal bed in the Vermejo Formation is mined by the Kaiser Steel Corporation at Koehler, to provide coking coal. This seam, along with closely equivalent beds, has provided much of the output from the field. Of the many beds in the Raton Formation, the most mined and prospected are the Sugarite, Yankee, Tinpan, and Potato Canyon seams. Reserves lie near the surface in this group of beds in the central part of the field; in the northwestern region, near Vermejo Park, Vermejo Formation reserves are promising.

Coal beds of the Sierra Blanca field of Lincoln and Otero counties occur in the Mesaverde Formation and have been mined near Capitan, White Oaks, and Carrizozo. Reserves appear to be large; but the structure is relatively complex, and the coal-bearing rocks have been broken by many faults and intruded by numerous igneous dikes and sills. Mining there is inactive at present. Coals in the Cerrillos field of Santa Fe county are also in the Mesaverde. Intrusion by many igneous dikes and sills makes mining difficult, but has provided the only known reserves of semianthracite and anthracite in the State. Considerable tonnages, particularly of anthracite, have been mined from the major seams--the Miller Gulch, the Cook and White, and the White Ash beds--and to some extent the beds are of coking coal. Present production is used only for local heating.

The Carthage coal field in Socorro county is another occurring in the Mesaverde Formation. Mining has been conducted in only one seam--the Carthage, which is excellent quality coking coal of bituminous rank. This field is cut into numerous small blocks by many faults, which make mining difficult and costly. It once supplied coking coal to smelters in southwestern New Mexico and northern Mexico; but today only a single small operation is conducted, providing coal for local heating. To the east and northeast of the Carthage area, five to 20 miles away, Mesaverde coals underlie the northwest edge of Jornada del Muerto. Wind-blown sand conceals much of the bedrock, and there has been no mining in this remote area of northeastern Socorro county. To the south in eastern Sierra county near Engle similar beds of the Mesaverde crop out. Except for a prospect mine in the eastern Caballo mountains, the Engle coals have not been explored, but appear to be of limited extent.

In Bernalillo county on the eastern edge of the Sandia mountains lies the Tijeras coal field. Several thin beds of bituminous coal occur in the Mesaverde Formation, but only a few tons have been mined for blacksmithing and minor local use. To the north in southeastern Sandoval county is

Figure 4



Outcrops of Coal-Bearing Rocks in New Mexico

the Una del Gato field. The coal beds there are approximately equivalent to those of the Cerrillos coal field, are of mineable thickness, and are of bituminous rank. Several small mines were operated near Hagen in years past, but the field's remoteness and the numerous faults cutting its coal beds caused the closing of the mining operations.

The most remote and the least-known coal field is the Datil Mountain field, covering more than 1,000 square miles near the junction of Socorro, Catron, and Valencia counties. The known beds are thin, are mostly of subbituminous rank, occur in the Mesaverde Formation, are broken by many faults, and locally are complexly folded as well as intruded by igneous rock bodies. To the northeast in western Bernalillo and southwestern Sandoval is found an isolated extension of the San Juan coal field, called the eastern part of the Mount Taylor field or La Ceja del Rio Puerco coal field. The beds are in the Mesaverde Formation and are broken by many faults, and there is extensive cover of the bedrock by wind-blown sand and slope wash. Formerly, small mines were worked near the Canoncito Navajo Day School in the southern part of the field and southwest of Zia Pueblo on the northeastern edge.

Other isolated occurrences of coal, none commercial, include Cretaceous coals in the southwestern San Andres mountains near Love Ranch, once mined briefly for use at Fort Selden, and a thin coal lens northeast of Silver City. Thin lenticular coals of Pennsylvanian age crop out near Las Vegas, along Pecos canyon, and near Santa Fe.

Future Production

Coal production in areas of large population is related mainly to heavy industries such as iron, steel, and cement plants; but mining of coal to produce electric power has increased to the point at which such use takes almost 50 per cent of the nation's supply. But even the use of coal to produce electric power requires a large market within a reasonable distance from the power plant. Heavy industries are much more closely bound to markets, because of the high cost of transporting heavy manufactured items on railroads.

People create markets, and normally a rapid increase in population--like New Mexico's 40-per cent increase from 1950 to 1960--is related to industrial growth. Job seekers migrate to areas of expanded employment and better environments. Manufacturing in the State has almost doubled since 1950, but very little of the manufacturing is of heavy industrial products that require large amounts of coal. The manufacturing industry uses about 6 per cent of the employees working in New Mexico; thus, while it has contributed to the economic expansion of the State, that industry is only one of many factors influencing our growth. Development of the numerous military and defense installations has been the principal contributor to New Mexico's population boom; except for electric power, these installations use little else that demands a local coal production.

Coal output, therefore, will depend upon mining of coal to make electric power, shipping of coking coal to steel plants such as Kaiser's Fontana plant, and the possible installation of coal conversion plants which could make gasoline, gas, and numerous coal derivatives and chemicals. Under present conditions of transportation, present mining processes, and today's concentration of population, probably only the Raton and the San Juan basin coal fields will be utilized to any large extent. But who can say what new needs and new techniques may be just around the corner?

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Volume 17, Number 2

New Mexico Business Is Published Monthly by The Bureau of Business Research

The University of New Mexico, Albuquerque

Subscription Price: Four Dollars Per Year
MEMBER: ASSOCIATED UNIVERSITY BUREAUS OF BUSINESS AND ECONOMIC RESEARCH

Entered as second-class matter January 31, 1949, at the post office at Albuquerque, New Mexico, under the act of August 24, 1912.