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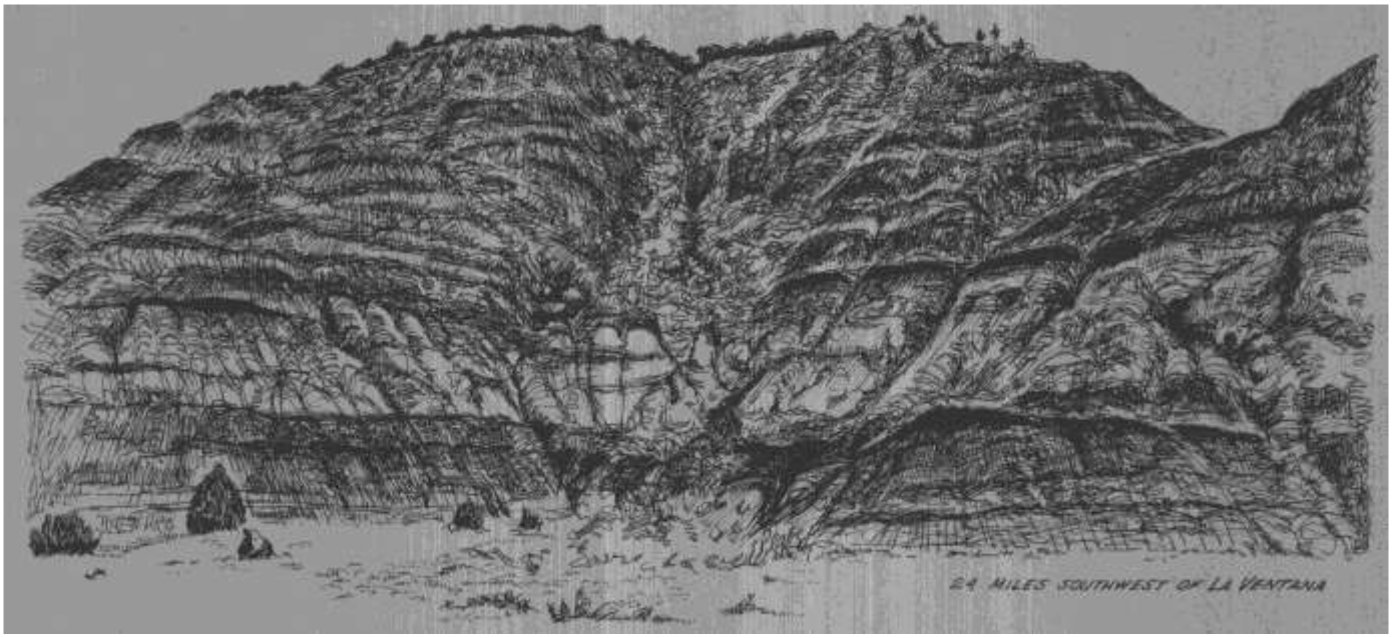


# *Geologic appraisal of deep coals, San Juan Basin, New Mexico*

*by John W. Shomaker and*

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**New Mexico Bureau of Mines & Mineral Resources**

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# Geologic appraisal of deep coals, San Juan Basin, New Mexico

*by JOHN W. SHOMAKER and MICHAEL R. WHYTE*

*This report is the result of a cooperative project funded in part by the U.S. Bureau of Mines under grant G0122108 and by the New Mexico Energy Resources Board under grant BEF 124.*

SOCORRO 1977

*First printing, 1977*

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63-1-4 Printed by University of New Mexico Printing Plant, November 1977

Available from New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801 Price $4.00

# Contents



## TABLES



## FIGURES

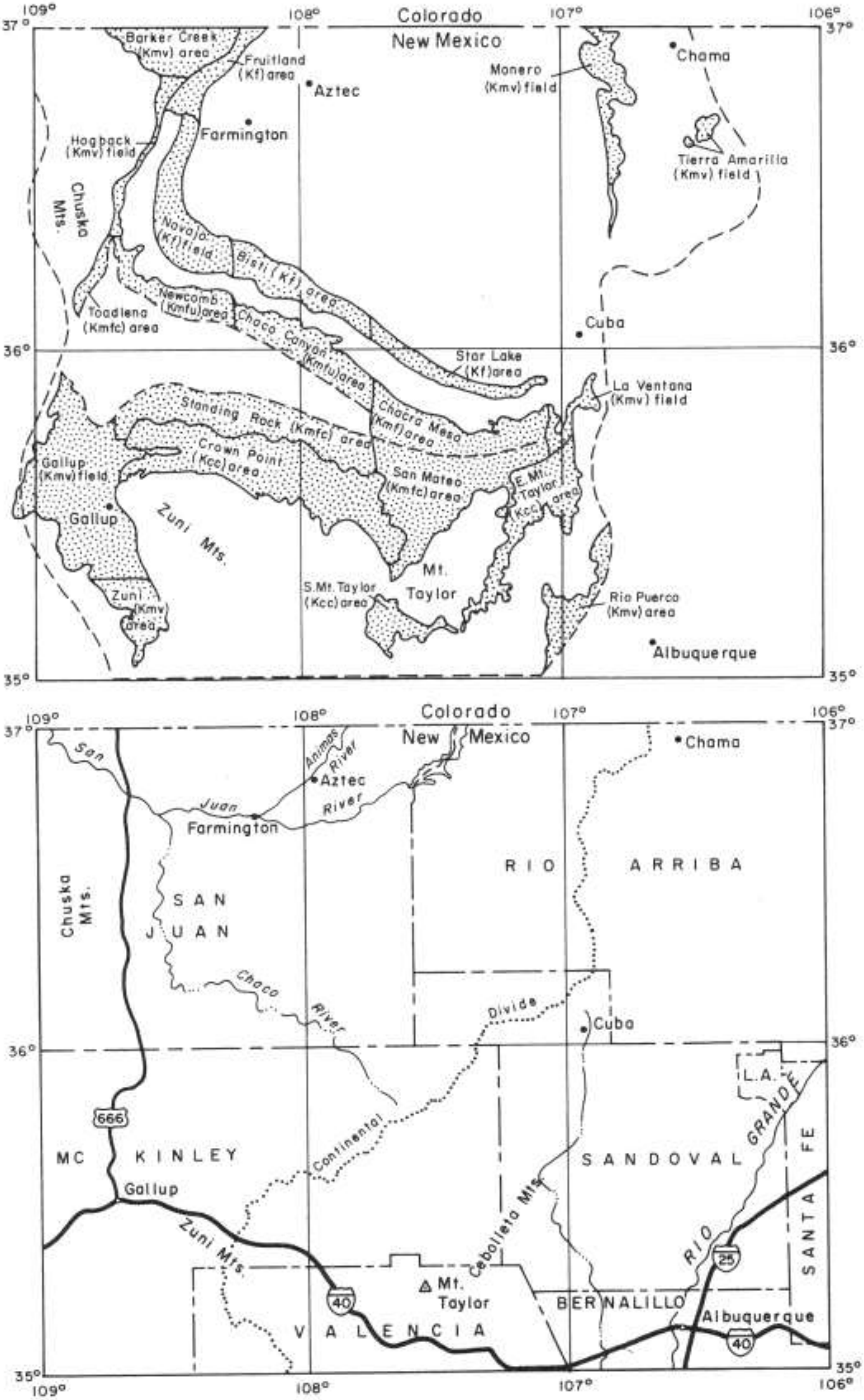


FIGURE 1—Coal fields and coal areas in New Mexico part of San Juan Basin.

Kcc—Crevasse Canyon Formation
Kd—Dakota Formation
Kf—Fruitland Formation
Kmf—Menefee Formation
Kmfc—Cleary Coal Member of Menefee Formation
Kmfv—Upper member of Menefee Formation
Kmv—Mesaverde Formation

ABSTRACT

The deep coals of the San Juan Basin are the result of numerous transgressive and regressive sequences of the Cretaceous epeiric sea. These Cretaceous coals originated from related landward coal swamps with a general N. 50-60° W. trend. Each landward coal swamp contains a few million to a few tens of millions of tons of high volatile subbituminous to bituminous coal.

The Fruitland Formation represents the last regressive sequence of the Cretaceous epeiric sea and contains some 200 billion tons of coal in beds more than 2 ft thick at depths to 4,500 ft. As received, Btu values are from 9,000 to 13,000, with a low moisture content ranging from 2 to 6 percent. The ash content of the coal is high (10 percent to more than 30 percent).

A total resource of 12 billion tons of coal is established for the Menefee Formation, in beds more than 2 ft thick with depths of as much as 6,000 ft. The average heating value is 9,860 Btu per pound, with an average ash content of 12 percent.

Under present economic conditions underground mining of the deep coals of the San Juan Basin is not practical. Some form of in situ gasification or liquefaction appears to be the most promising method of economic development.

# Introduction

## PURPOSE AND SCOPE

This report is the result of a cooperative study of the reserves of deep (250 ft or more below the surface) Cretaceous coals in the San Juan Basin of New Mexico made by the New Mexico Bureau of Mines and Mineral Resources and the U.S. Bureau of Mines under grant G-0122108, with additional funding by the New Mexico Energy Resources Board under grant 124. The objectives of the study were to outline areas of Cretaceous coals and to determine the resources available township by township. The project also sought to determine coal quality as definitely as possible and to evaluate the economic position of the coals.

The project expanded from a brief study of coal in the subsurface in the Hogback Mountain tongue of the Menefee Formation begun by Robin C. Lease (then with the New Mexico Bureau of Mines and Mineral Resources) and from a surface mapping program covering the coal-bearing part of the Menefee along the western rim of the San Juan Basin made by Robin C. Lease and Edward C. Beaumont (Consulting Geologist, Albuquerque, New Mexico). The scope of the project was expanded until it covered the entire New Mexico part of the San Juan Basin (fig. 1), with emphasis on the subsurface data.

The project consisted of four phases. The first phase was to verify the outcrop data and to selectively check subsurface information to see if deep coal beds could be identified with reasonable certainty. The second phase was to examine all available subsurface data, mainly the geophysical logs from petroleum test borings. The third phase was to drill two deep core tests to about 1,500 ft for verifying the interpretations of the geophysical data. The drilling results were somewhat unexpected and indicated that some of the geophysical interpretations should be used with caution. The final phase was a reexamination of all of the data and a compilation of the revised estimates of the coal resources.

The Fruitland Formation contains the largest resources of deep coal (250 to 3,000 ft deep) in the San Juan Basin; most of these had been calculated by Fassett and Hinds (1971), and more recent drilling has not changed their estimates significantly. This study of the deep coals beneath the Fruitland Formation is a natural extension of the program by Shomaker and others (1971) who described reserves of strippable low-sulfur coal in the San Juan Basin.

Robin Lease and John Shomaker began this deep coal study in 1971, with John Shomaker as the principal investigator. The latest phase, reexamination of the data and much of the compilation of the final report, was by Michael Whyte, with assistance from Frank Kottlowski, Edward Beaumont, Robert Bieberman, Arthur Meyerhoff, and others.

Records of the more than 14,000 wells drilled in the San Juan Basin were examined, and all other applicable materials such as cuttings, a few core tests, and drillers' logs were utilized. The main basis for our estimates of the coal resources was 294 key wells in which the Menefee Formation was examined in detail. Partial sections from other oil and gas test holes were also studied.

## PREVIOUS STUDIES

Gardner (1909 a-c, 1910) mapped the "Laramie Formation" in parts of the northern and southern San Juan Basin; however, the Fruitland Formation was defined and named by Bauer (1916) in a paper on the stratigraphy of the western San Juan Basin. Bauer and Reeside (1921) described the occurrence of coals in the Fruitland Formation in the western and southwestern parts of the basin, and Reeside (1924) summarized earlier data in his paper on the western part of the basin; Dane (1936) mapped the southeastern part of the basin and noted that Fruitland rocks are not present on the east side of the basin.

The following geologists mapped outcrops of Fruitland Formation in other parts of the basin: Dane (1946, 1948), Wood, Kelley, and MacAlpin (1948), Zapp (1949), Barnes (1953), Barnes, Baltz, and Hayes (1954), Hayes and Zapp (1955), Beaumont and O'Sullivan (1955), O'Sullivan and Beaumont (1957), Baltz, Ash, and Anderson (1966), Fassett (1966), Hinds (1966), and Baltz (1967).

The following geologists have discussed and illustrated the subsurface occurrence of Fruitland Formation: Silver (1950, 1951), Bozanic (1955), Kilgore (1955), Baltz (1962, 1967), and Fassett (1964). Hinds (1964) discussed quality coals of the Fruitland Formation. The most comprehensive study to date was done by Fassett and Hinds (1971).

In what is now termed the Menefee Formation, coal has been studied in the outcrops around the San Juan Basin for many years. The first treatment of the entire basin was that of F. C. Schrader (1906), but earlier mention of the coals was made by Storrs (1902) in the Twenty-second Annual Report of the Geological Survey and in the still earlier reports of the Wheeler and Hayden surveys.

Early reports were by Taff(1907) on the Durango coal district, Shaler (1907) on the western part of the Durango-Gallup coal field, Gardner (1909a) on the coal field between Gallina and Raton Spring in the eastern San Juan Basin, Gardner (1909b) on the coal field between Durango and Monero, Gardner (1909c) on the coal field between Gallup and San Mateo, Gardner (1910) on the coal field between San Mateo and Cuba, and Collier (1919) on the coal south of Mancos in Montezuma County, Colorado.

Relatively detailed work on the coals in the southern part of the San Juan Basin was done by Sears (1925) for the Gallup-Zuni Basin, Sears (1934) for the area eastward from Gallup to Mount Taylor, Dane (1936) for the La Ventana-Chacra Mesa coal field, and Hunt (1936) for the Mount Taylor coal field.

Beginning in the late 1940's and early 1950's, mapping of the coal geology, principally on a quadrangle basis, led to the reports by Zapp (1949) of the Durango area, Beaumont (1954) of the Beautiful Mountain area, Allen and Balk (1954) of the Fort Defiance and Tohatchi quadrangles, Beaumont (1955) of the Ship Rock and Hogback quadrangles, O'Sullivan (1955) of the Naschitti quadrangle, Beaumont and O'Sullivan (1955) of the Kirtland quadrangle area, Zieglar (1955) of the Toadlena quadrangle, and O'Sullivan and Beaumont (1957) of the western San Juan Basin.

The first attempt to deal quantitatively with the coal resources in the Menefee Formation was the compilation by Read and others (1950). The basis of this work was extensive mapping by U.S. Geological Survey workers. Although they gave an estimate for the total resource in the entire formation regardless of depth, the estimate is based almost entirely upon outcrop data. Resources and reserves of Menefee coal within stripping depth, but not deeper, were summarized for the entire basin by Shomaker, Beaumont, and Kottlowski (1971).

The Menefee occurring in Colorado was studied both as to strippable and deep reserves and resources by Shomaker and Holt (1973). The scope of that study was generally the same as the present study of the Menefee in New Mexico.

The revision of New Mexico Bureau of Mines and Mineral Resources Open-file Report 34 (Shomaker, 1973) is incorporated in the present report.

Coal associated with the Dakota Sandstone has been mentioned by many authors, but a systematic study has never been undertaken to determine deep resources in the New Mexico part of the San Juan Basin. Shomaker, Beaumont, and Kottlowski (1971) discussed potentially strippable areas in New Mexico and Colorado, and Shomaker and Holt (1973) considered the Dakota at depth in the Colorado part of the San Juan Basin.

## GEOGRAPHY

The north-south-trending continental divide lies along the eastern side of the San Juan Basin. The main streams of the San Juan Basin are the San Juan River and the Animas River. The San Juan River flows southwestward through the Colorado part of the basin and into northern New Mexico to the town of Blanco; from Blanco it flows westward across the basin and joins the Colorado River in Utah. The Animas River flows south through Durango, Colorado, into New Mexico and joins the San Juan River at Farmington, New Mexico. The La Plata River flows south near the west rim of the basin and joins the San Juan River in Farmington about 2 mi below the Animas-San Juan junction. There are many intermediate streams; the largest are the Chaco River and Canyon Largo. The Chaco River drains the southern and western part of the basin, while Canyon Largo drains the south-central part of the basin and joins the San Juan at the town of Blanco.

The San Juan Basin lies in the Navajo physiographic section of the Colorado Plateau province. The San Juan Basin has a topographic relief of nearly 3,000 ft with altitudes ranging from slightly more than 8,000 ft in the northern part of the basin to about 5,100 ft on the west side where the San Juan River crosses the basin rim.

The Hogback monocline, which rims the basin on the northwest, north, and east sides, rises as much as 700 ft above the adjoining country on the west side of the basin (fig. 2). This is the most prominent physiographic feature of the San Juan Basin. For the most part, the San Juan Basin is a country of sandstone ribs and shale flats with sand sheets and local sand dunes near the dry washes. The sedimentary beds dip gently and have been subjected to arid climate ruled by spring and autumn winds and sparse summer thunderstorms. The other distinctive physiographic landscape forms are: the table end mesa, rock terrace, dry arroyo, cuesta, canyon and

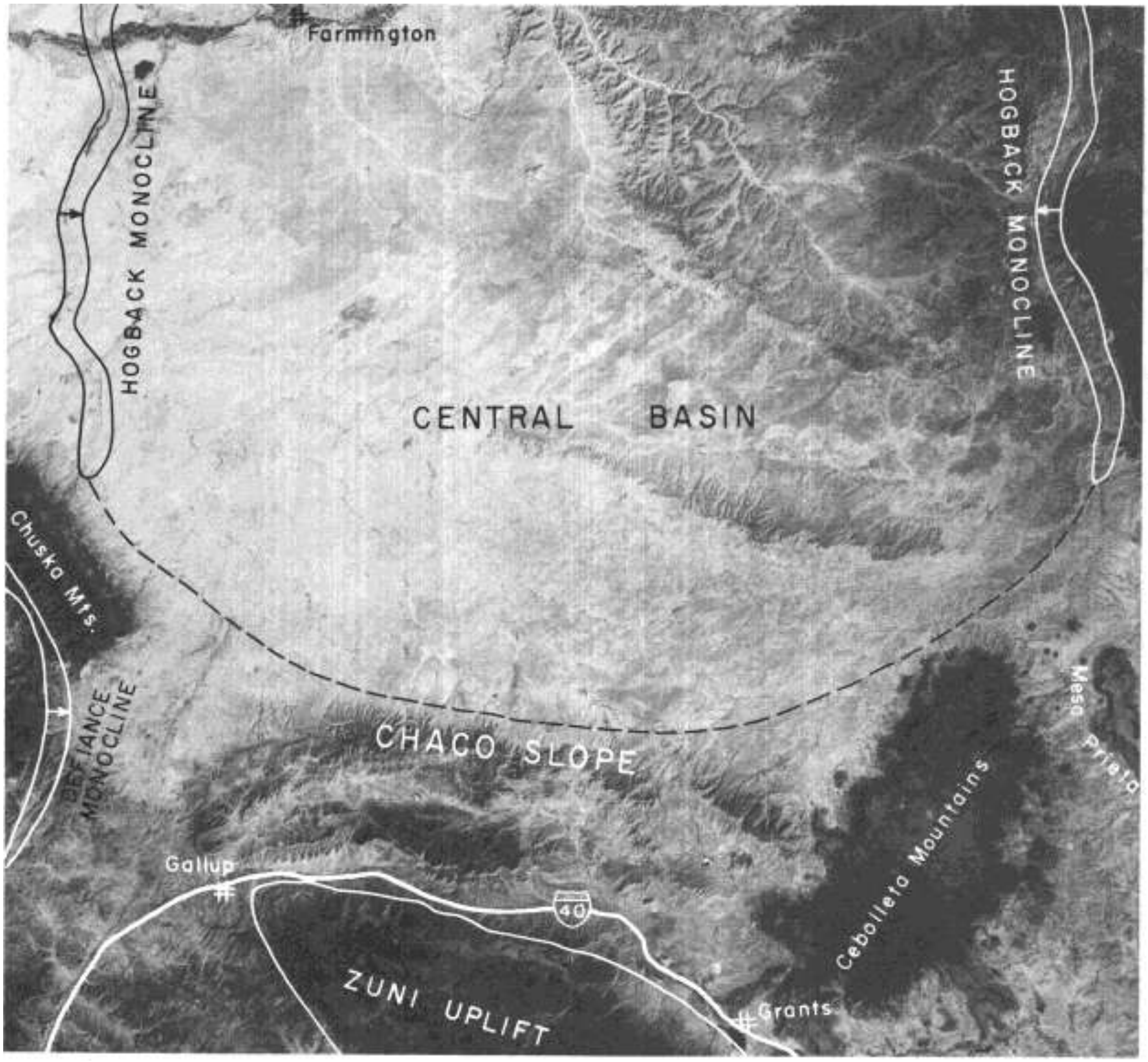


FIGURE 2—GEOLOGIC STRUCTURES OF SAN JUAN BASIN; SCALE: 1 INCH = 18.86 MILES.

erosional escarpment. The climate of the San Juan Basin is arid to semiarid, with rainfall averaging from a low of 3 to 4 inches a year at the lower altitudes to a high of nearly 20 inches a year in the higher altitudes. Rainfall generally occurs in the late summer and spring; temperatures range from below zero in the winter to above 100° F in the summer.

At the lower altitudes in the San Juan Basin short grass, sagebrush, and many varieties of cactus are common. A growth of piñon and juniper, scattered sagebrush, and sparse scrub oak is common on the mesas of the basin. Around the north and east rims of the basin ponderosa pines are common; cottonwood trees grow in the valleys of many streams.

Although a myriad of access roads to oil and gas wells permit entry to almost every part of the San Juan Basin, only three paved highways cross the area: NM-44, NM- 17, and US-550.

# Structure of San Juan Basin

The San Juan Basin (fig. 2) is the southeastern part of the Colorado Plateau physiographic province and makes up the eastern half of the Navajo section, mainly in northwestern New Mexico, but extending into southwestern Colorado. The central-plains part of the basin is underlain by almost horizontal strata and is dissected by sandy arroyos. This central part begins at about 36° N. latitude and reaches northward to Durango, with its eastern boundary the monoclines and anticlines, extending northward from the Nacimiento uplift, and with the western boundary at the Hogback monocline and its southward extensions.

The Nacimiento uplift, a thrust block that has moved westward at steep angles over basinal strata, abruptly borders the basin on the east.

The southern margin of the San Juan Basin is the most complex; the almost horizontal strata of the Central Basin dip at slightly higher angles (and thus, locally dip too steeply to allow extensive strip mining) southward along the Chaco slope, which encompasses the area from 36° N. latitude southward beyond Grants.

East of Grants is the junction of the Chaco slope from the west, the Acoma embayment from the south, and the Rio Grande fault belt from the east. In this area, on the southeast flank of the San Juan Basin, are the faults and folds of the uranium-producing Ambrosia Lake district, the Mount Taylor syncline overlain by the Cenozoic lavas of Mount Taylor and Cebolleta Mesa, and the Rio Puerco fault belts.

The most striking structural features of the San Juan Basin are hogback ridges, called monoclines by Kelley (1951). These hogbacks are caused by steep dips of the strata on the outer, basinward limb of an anticline and the accompanying inner synclinal bend. The Hogback monocline is essentially continuous from the northwest side of the central basin, around the north rim, and then southward to the west edge of the Nacimiento uplift. The most spectacular exposures are where the San Juan River cuts the hogback between Shiprock and Farmington.

The entire Hogback monocline, a horseshoe-shaped figure opening southward, does bring the coal-bearing strata into a belt, 1 mi to 5 mi wide, in which the beds dip too steeply for any appreciable amount of coal to be strip-mined. Outside of this belt, the strata dip relatively gently into the central basin, with the dips becoming more and more steep outward, especially on the Chaco slope. The center of the central basin is actually in the geographically northeastern part of the San Juan Basin, near Archuleta, New Mexico.

# Stratigraphy

The Dakota Sandstone is highly variable in structure, texture, and composition (fig. 2). It is characterized more by a persistent combination of features than by the persistence of any given bed. The base is commonly, but by no means universally, marked by a conglomerate; the top is in many places a coarse, brown or gray sandstone bed, but it may be a group of interbedded sandstones and shale or wholly yellow or gray sandy shale. Coal lenses prevail in the middle of the Dakota but are found in all positions from top to bottom. The formation is everywhere lenticular; lenses and wedges of sandstone, conglomerate, shale, and coal a few inches to tens of feet thick overlap, appear, and disappear. The thickness of the Dakota is variable and ranges from 54 ft to a little over 200 ft.

The Mancos Shale consists of gray to dark-gray carbonaceous marine shales that overlie the Dakota Sandstone and elsewhere rest upon the pre-Dakota rocks. The Mancos splits southwestward into three main units on the north flank of the Zuni uplift. The highest unit is the Satan Tongue that thins westward and becomes indistinguishable from the Mesaverde. The middle unit, called the Mulatto Tongue, extends southwest to the vicinity of Gallup and becomes inseparable from the Mesaverde. The lowest unit extends far west and also is recognizable as far south as Silver City, New Mexico. The thickness of the Mancos Shale ranges from 400 ft to 2,000 ft.

The first persistent regressive sandstone that intertongues with the lower part of the Mancos Shale is called the Gallup Sandstone. The Gallup Sandstone consists of three persistent massive sandstones and interbedded shale and coal that ranges from 180 to 250 ft thick. The base of the Gallup Sandstone is often transitional into the Mancos Shale.

The Dilco Coal Member of the Crevasse Canyon Formation contains many of the valuable coal beds in the western part of the San Juan Basin. This member is between 240 and 300 ft thick in the Gallup-Zuni Basin and is gradually replaced northeastward by sandstone and shale. Over a large area in the San Juan Basin the Dilco is directly overlain by the Mulatto Tongue of the Mancos Shale.

The Dalton Sandstone Member of the Crevasse Canyon Formation is the littoral sandstone enclosing the Mulatto Tongue of the Mancos Shale. The Dalton Sandstone Member splits into two tongues northeastward, the lower tongue intervening between the Mulatto Tongue of the Mancos Shale and the Dilco Coal Member for a few miles before lensing out. The main body of the Dalton, an upper sandstone tongue, is the regressive sandstone lying above the Mulatto Sandstone Member and ranges from 70 to 180 ft.

The Gibson Coal Member of the Crevasse Canyon Formation consists of 150 to 175 ft of clay, irregular sandstone, and coal.

In the southern part of the San Juan Basin, the Point Lookout Sandstone is split into two members by the

Satan Tongue of the Mancos Shale. The lower member is called the Hosta Tongue of the Point Lookout Sandstone. The Hosta Tongue consists of a massive bed of medium-grained sandstone 200 ft thick. The upper member is the Point Lookout Sandstone and consists of a massive bed of medium-grained sandstone ranging from 100 to 300 ft thick.

The Point Lookout Sandstone is overlain by the Cleary Coal Member of the Menefee Formation. The Cleary Coal Member consists of coal, shale, and sandstone and is 400 ft thick. The upper member of the Menefee Formation wedges out to the north and the east and consists of shale and sandstone to 800 ft thick. The Hogback Mountain tongue of the Menefee Formation is equivalent to and in part enclosed by the La Ventana sandstone. The tongue is a sequence of lenticular sandstones, shales, and coals. Another coal-bearing sequence analogous to the Hogback Mountain tongue was deposited landward from the Chacra sandstone; however, erosion has removed all but the northwestern end of this coal-bearing tongue.

The Cliff House Sandstone, Chacra sandstone, and La Ventana sandstone are deposits of the transgressive transition zone between the marine Lewis Shale and the largely nonmarine Menefee Formation. These deposits differ from the regressive sandstones in that they are not continuous sand bodies but rather a continuous zone of sand lenses which intertongue deeply into both the Lewis Shale and the Menefee Formation.

The Pictured Cliffs Sandstone is the uppermost marine unit in the San Juan Basin and records the final withdrawal of the Cretaceous sea. The Pictured Cliffs Sandstone is medium to fine grained and grades northeastward into the Lewis Shale. Thickness ranges from 50 to 400 ft. Outcrops occur on the north, west, and south sides of the San Juan Basin.

Behind and above the nearshore sands of the Pictured Cliffs Sandstone is 200 to 300 ft of the coal-bearing Fruitland Formation. The Fruitland is composed of interbedded sandstone, siltstone, shale, carbonaceous shale, carbonaceous sandstone, coal, and (at places in the lower part) thin limestone beds composed almost entirely of shells of brackish-water pelecypods; most individual beds pinch out laterally usually within a few hundred feet. The thick coal beds are confined to the lower third of the formation.

## SEDIMENTARY SEQUENCES

The general relationships of the coal-bearing units with other rocks of Cretaceous age are shown in fig. 3. The oldest rocks in the sequence belong to the Dakota Sandstone, a complex assemblage of nearshore marine sands; barrier island, delta, and beach deposits; and marsh and swamp sediments (including coal), along with sandy coastal plain and floodplain deposits. The Dakota represents an encroachment of the sea from north to south and thus rises slightly in the stratigraphic section from north to south across the San Juan Basin.

The transgression continued, moving the shoreline south and southwestward until it stood in southwestern New Mexico. During that time, the area which would later become the San Juan Basin was occupied by a shallow sea, and marine shales of the lowermost Mancos Shale were deposited upon the Dakota. The north

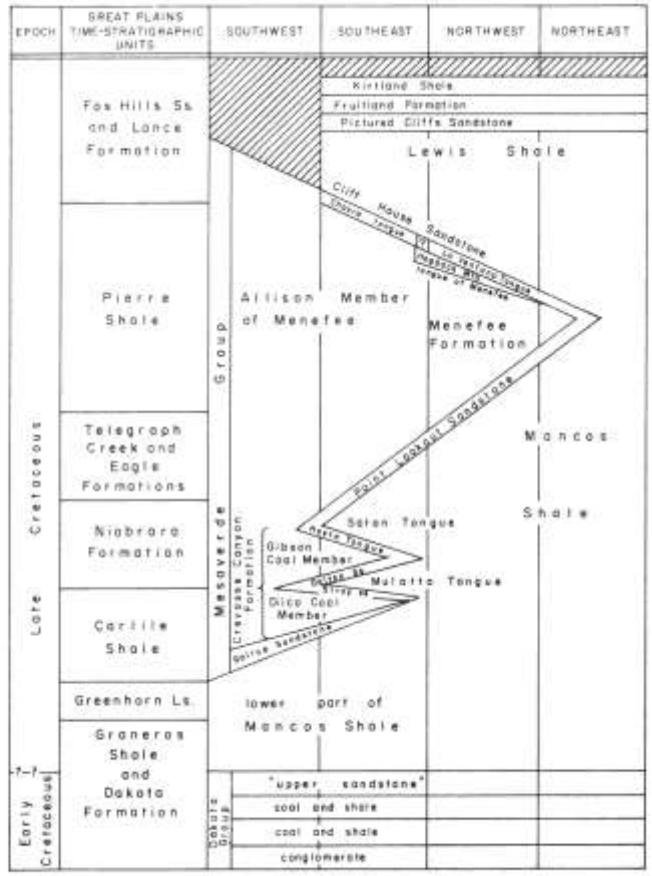


FIGURE 3—STRATIGRAPHIC UNITS OF SAN JUAN BASIN AND GREAT PLAINS.

ward regression of the sea resulted in deposition of the Gallup Sandstone in several tongues, each representing a short-distance regression-transgression cycle. The youngest of these still preserved resulted from a retreat of somewhat greater distance such that coal-swamp deposits followed the position of the shoreline well northward into what is now the San Juan Basin. These coals are assigned to the Dilco Coal Member of the Crevasse Canyon Formation. Above them is a transgressive sandstone (known as the "stray") representing the southward encroachment of the sea after deposition of the Dilco.

About the time the shoreline advanced beyond the basin, uplift took place in the northern part of the area, interrupting the succession of advances and retreats for a short period and resulting in some erosion of the Gallup-Dilco-"stray" sequence. After the effect of uplift had subsided, the entire area was left covered by marine waters in which the Mulatto Tongue of the Mancos Shale (and its lateral equivalents further seaward) were deposited.

The next retreat of the sea resulted in deposition of beach sands of the Dalton Sandstone Member of the Crevasse Canyon and their landward equivalents, the coal swamp and floodplain deposits of the Gibson Coal Member. As the retreat came to a halt and advance began again, the Hosta Tongue of the Point Lookout Sandstone was laid down, again associated with the landward equivalents assigned to the Gibson Coal Member.

Near the southern rim of the present basin, the advance again slowed and stopped, and the beach environment again moved seaward, creating the Point Lookout Sandstone. The continental deposits laid down behind the retreating beach included the coal-swamp materials of the Cleary Coal Member of the Menefee Formation. This regression proceeded relatively smoothly to still another turnaround near the northeasterly limits of the basin in Colorado.

On the way south again, the products of the new transgression by the beach environment are termed the Cliff House Sandstone. This transgression was less orderly than earlier ones, and the Cliff House is thus composed of several benches (each the result of a period of slower overall movement) separated by thin zones that record periods of more rapid southwestward movement of the shore. Near the middle of the present basin, there was an interruption in the pattern: the shoreline moved rapidly southwestward, then returned to near its former position and remained near there for a long period. The result is a thin tongue of marine Mancos Shale which overlies a very thin Cliff House Sandstone (representing the rapid shift of shoreline and consequent rapid deepening of water), all overlain by a thick beach and bar sandstone body (representing the long stillstand of the shore).

The thick sandstone is referred to as the La Ventana Tongue of the Cliff House. It is a long narrow sandstone body which lies on a straight depositional strike line across the basin. To the southwest, the landward equivalent of the La Ventana is a coal-rich section of the Menefee Formation; the seaward equivalent is a part of the Lewis Shale. This part of the Lewis is progressively less sandy to the northeast until indistinguishable from the remainder of the formation above and below.

After the La Ventana stillstand ended, the shoreline again moved southwestward. There was a rapid transgression, represented by a thin transgressive sandstone, then another period of stillstand and slow transgression, which produced the Chacra tongue of the Cliff House. The Chacra is thus analogous to the La Ventana but thinner. Coal is associated with the Chacra because the equivalent Menefee Formation floodplain and coastal plain environments included coal swamps.

After the culminating transgression, represented by the highest sandstones of the Chacra, the shoreline retreated northeastward once more. The final regressive sandstone is the Pictured Cliffs Sandstone (the southwestern and lowest extremity of which merges with the Chacra). The landward equivalents of the Pictured Cliffs beach deposits belong to the Fruitland Formation and are coal bearing.

Throughout the Cretaceous the direction of transgression and regression and the trend of the shoreline, and hence the depositional strike of the beds, remained remarkably constant. Though there is much variation in detail, the general trend through most of the cycles averaged N. 50° W. to N. 60° W. The foregoing outline of the history of the Cretaceous rocks of the basin is intended only to furnish a framework to aid in understanding the nomenclature of the geologic units. A more detailed treatment can be found in a paper by Beaumont in Shomaker, Beaumont, and Kottlowski (1971, p. 15-30).

## PALEOENVIRONMENTS

The southwestern land mass, onto which the Cretaceous sea repeatedly encroached and then retreated, provided rather uniform materials to sedimentation. Further, the climate seems to have remained generally the same throughout the period so that the depositional environments were similar throughout, and the orderly progression from one environment to the next (land to sea) was fairly predictable.

These environments and their characteristic sediments include: 1) floodplains, including fluviatile sands, silts, and muds; 2) coastal swamps, with carbonaceous shales, silts, thin sands, and peat; 3) deltas, beaches, and offshore bars, all characterized by clean sands and minor silts and muds, and 4) the bottom of the shallow sea, with muds, very fine sands and silts, and calcareous material.

In general, the floodplain deposits, which include most of the Menefee Formation and the noncoalbearing parts of the Dilco Coal Member, the Gibson Coal Member, and the Fruitland Formation. The deposits consist of drab-gray, greenish-gray and brownish-gray shales, soft-white and light-tan poorly sorted sandstones, and brown and gray-brown carbonaceous shales. These beds are interpreted to have been deposited on a very broad, gently sloping coastal plain with little relief. Most of the beds are riverborne sediments, with considerable carbonaceous material derived from vegetative cover. A substantial quantity of lake-bottom sediment is present along with innumerable thin, lenticular sandstone bodies, which may represent channel sediments in wide, slow-moving rivers. There are coaly beds among the floodplain deposits, and these are doubtless the products of freshwater swamp and lake-margin swamp environments that occurred sporadically on the floodplain.

The coastal swamp environment, resulting in commercial coal accumulations, consisted primarily of freshwater swamps. These swamps were very near the marine shore and were supported by heavy precipitation and a climate conducive to rapid growth of vegetation. The low sulfur content of these coals is the fundamental criterion by which the coals are interpreted to be principally freshwater swamp deposits, rather than the products of marshes connected with (and sometimes inundated by) marine waters.

The coal swamps may be considered analogous in many ways to the present-day Okefenokee Swamp in southeastern Georgia. The general environment may have been very similar, but the swamp environment was probably much more extensive and more persistent in the San Juan Basin area of the Late Cretaceous than in the Atlantic Coastal Plain of the present. The cause of this may be the rapidity with which the sea advanced and retreated during the Late Cretaceous; the repeated advances and accompanying strong nearshore erosion kept the coastal plain adjusted to a uniform seaward slope. Time intervals between retreat and succeeding advance were insufficient for dissection of the coastal plain.

The swamp environment included great expanses of shallow water in which vegetation grew profusely; beneath the surface, peat accumulated as dead vegetal matter. The high ash content of the San Juan Basin coals may indicate that rainfall was very high and that a great volume of surface drainage entered the swamps from the landward (southwest) margins, depositing much silt-size and clay-size material and discharging to the sea through shallow, low-gradient streams that drained the seaward (northwest) margins of the swamps. The streams probably carried considerable volumes of coarse, sand-size material at various times, resulting in lens-shaped sandstone bodies within the coal-bearing section.

Differential compaction played an important part in the early development of the peat, accounting for some of the irregularity of the present-day coal beds. Highly concentrated vegetal material was compressed to volume much smaller than that of the original clay-rich sediment; sand bodies lost far less volume. In this way, the bedding of sediments, particularly near the margins of the swamps and near the courses of through-flowing streams, became more and more distorted.

Just seaward of the coal swamps lay accumulations of sand associated with beach, lagoon, barrier bar, and nearshore marine environments. A band of windblown, intermittently stabilized sand was behind the beach. These sands are represented in the Upper Cretaceous rocks of the San Juan Basin by the Gallup Sandstone, the Dalton Sandstone Member, the Hosta Tongue and the main body of the Point Lookout Sandstone, the Cliff House Sandstone with its associated La Ventana and Chacra tongues, and the Pictured Cliffs Sandstone. As mentioned, all of these from the Dalton upward are homogenetic equivalents, simply recording the back-and-forth passage of the shore environment with changing shore position. Probably the freshwater swamps occupied the sites of former lagoons (between the beaches and barrier bars) which remained as topographic lows when the marine waters retreated.

Given a very gently sloping, uniform surface with sediments of the floodplain variety, transgression of the sea would result in progressive covering of preexisting materials with sand; the sand to supply the process must be furnished by streams carrying copious quantities of water and draining source areas with abundant sediment.

# Uniform classification of coal resources

The uniform classification for energy resource commodities as adopted by the U.S. Geological Survey and the U.S. Bureau of Mines is followed in the present report. According to this classification, coal *reserves* include only coal that has been: 1) measured within an error of 20 percent by closely-spaced drilling and sample analysis, or 2) indicated partly by sample analysis and partly by reasonable geologic projection, or 3) inferred in unexplored extensions and geologic projections of measured and indicated reserves and is economically minable at the time of determination. All other estimates of tonnage in place are classified as *resources* consisting of: 1) hypothetical coal (in known districts) or, 2) speculative coal (in as yet undiscovered districts), or 3) subeconomic (not economically minable).

Aside from certain strippable reserves along the southern margin of the Menefee Formation and strippable reserves of the Fruitland Formation, all the coal discussed in this report is classified either as submarginal indicated reserves or resources. Nowhere else is drilling sufficiently dense to establish reserves; given current economic limitations, virtually none of the coal can be profitably mined with the present technology and market conditions.

After the total thickness of coal was determined from geophysical logs, isopach maps were prepared, and contour lines showing approximate depths to the top of the first coal were drawn. Areas of equal coal thickness in each depth category were measured with a planimeter and the area in acres was multiplied by a factor of 1,770 tons per ac-ft.

# Basic geologic data

## CORE TESTS

As part of the project, two deep core test holes were drilled. The purposes of this drilling were to verify the thicknesses of coal as determined by the geophysical logs and to collect samples for analysis. The locations and descriptions of the two holes are:

| Number | Location | Elevation (ft) | Depth (ft) | Cored intervals (ft) |
|---|---|---|---|---|
| DC-2 | 50 ft FNL-50 ft FEL, sec. 11, T. 18 N., R. 5 W. | 6,740 | 1,407 | 30.0- 40.0<br>356.0- 366.0<br>580.0- 599.6<br>655.0- 670.0<br>685.0- 705.0<br>730.0- 740.0 |
| DC-3 | 2,400 ft FNL-2,310 ft FEL, sec. 7, T. 21 N., R. 8 W. | 6,625 | 1,591 | 980.0-1,000.4<br>1,265.0-1,282.0<br>1,435.0-1,445.0<br>1,540.0-1,560.0 |

A comparison of geophysical log response with core description for a typical coal-bearing section is shown in fig. 4. Graphic logs of the cored intervals are shown in figs. 5 and 6; coal analyses are included in tables 1 and 2.

## WELL LOG ANALYSES

The high electrical resistivity of coal beds causes positive anomalous deflections on resistivity curves. A sharp symmetrical peak on the short normal and the lateral curve occurs when the electrodes pass a coal seam. The long normal curve shows a sharp reversal reading (fig. 4). The method used in this study to determine thickness was to measure the width of the peaks at half the peak height above background. These three measurements from the electric logs were then averaged and the average was used as the thickness of the coal seam.

The low density and apparent high porosity of coal make the density logs the most useful tool for interpreting well logs. Coal densities range from 1.4 to 1.8 whereas the density of most sedimentary rocks ranges from about 2.0 to 2.5. The most important factor in interpretation of density logs from coal is the amount of travel time; that is, a normal run of 25 ft per minute means that the equipment has approximately 7 seconds to react to a 3-ft coal seam. At this travel time the equipment will not fully react to a coal seam less than 2.5 ft thick (fig. 4). The coal seam thickness is determined directly from the density logs by measuring the width of the peak on the density scale where the peak crosses the 1.8 line.

Sonic logs may also be used to determine coal thicknesses. The interval transit time, known as At values must be determined for each formation. For this study the At values used ranged from 124 to 140 microseconds per ft and peak widths were read at one-half the peak height for this range.

The majority of the well logs used in this study were from oil and gas tests and the machine settings for these tests are not the same as those necessary for the precise interpretation of coal seams. Thus coal seams reported here as 3 ft thick will have an error factor of plus or minus 1 ft.

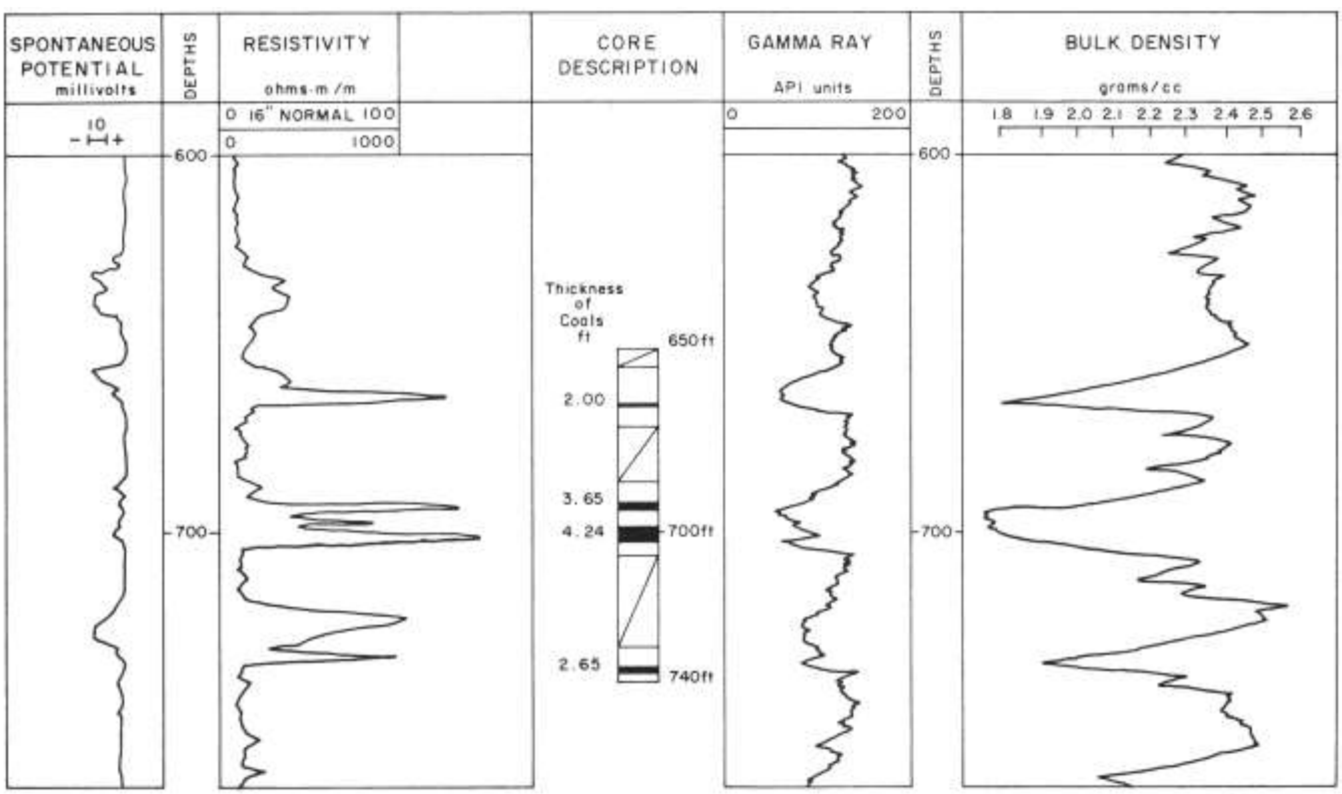


FIGURE 4—Comparison of geophysical log traces with core descriptions (interval 650 ft to 740 ft in test hole DC-2).

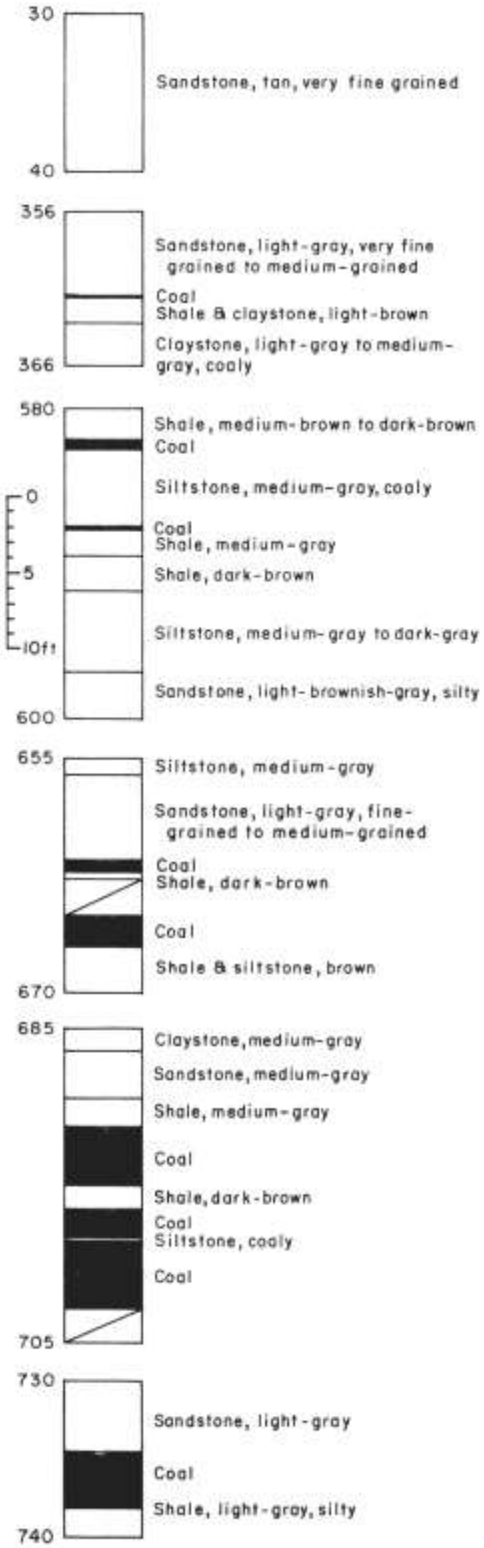


FIGURE 5—Graphic log of cored intervals in test hole DC-2 (50 ft from north line to 50 ft from east line sec. 11, T. 18 N., R. 5 W.).

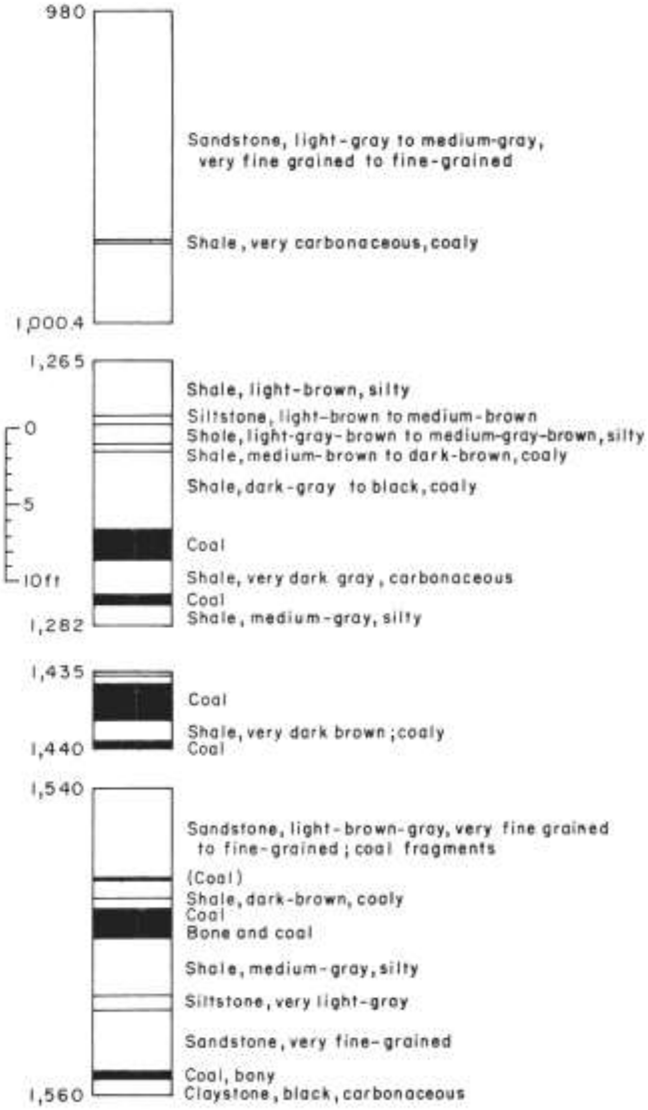


FIGURE 6—Graphic log of cored intervals in test hole DC-3 (2,400 ft from north line to 2,310 ft from east line sec. 7, T. 21 N., R. 8 W.).

# Quality of coals

## FRUITLAND FORMATION

The coal of the Fruitland Formation is hard, brittle, and black; it decomposes, or slacks, on exposure to weather and cannot be stored for long periods. Many woody charcoal fragments and small lumps of fossil resin may be found. Iron sulfide can be observed in the form of small grains and veinlets of pyrite and marcasite.

Table 1 (after Fassett and Hinds, 1971) shows analysis of 67 samples of Fruitland coals taken from 65 locations in the San Juan Basin.

The fresh unweathered coals from the Fruitland Formation have a moisture content generally in the range of 2-5 percent (Fassett and Hinds, 1971). Sulfur content is consistently somewhat less than 1 percent.

There are three general zones of ash distribution across the San Juan Basin. An irregular area in the west-central part of the basin contains coal with an ash content of 8 percent to 15 percent. An intermediate zone in a strip running north-south near the central part of the basin has an ash content of 15-20 percent; an eastern zone has ash in amounts exceeding 20 percent. This distribution shows only that, in general, the east half of the basin area received a greater amount of detrital matter, but the zones do not follow depositional trends and are seemingly unrelated to bed thickness, fixed-carbon to volatile ratios, absolute (moisture and ash free) Btu values, or the relative ages of the coal beds.

The absolute Btu values vary between 9,000 in the southwestern part of the basin to 15,720 in the northwest. The values can be plotted and contoured to produce a map containing zones of Btu values. These zones parallel almost exactly the zones of deposition and the structural axis of the present basin.

Fruitland coal of the San Juan Basin is considered subbituminous in New Mexico and low-grade bituminous in Colorado. Based solely on percentage of fixed carbon and heating value on a mineral-matter-free basis, most coal in the northern half of the basin would range from high-volatile to medium-volatile bituminous in rank. Because of the known slacking tendency of the coal in the western part of the basin and the very high ash content in the east half of the basin, all the Fruitland coal is considered subbituminous in this report.

## MENEFEE FORMATION

In general, the quality of coal in the Menefee Formation improves northward from the southern edge of the basin. In the vicinity of Standing Rock (fig. 1), the coal is subbituminous A with average heating value of about 9,860 Btu per lb and an ash content of about 12 percent. Near La Ventana the coal is either subbituminous A or high-volatile C bituminous. Coal from the two drillholes DC-2 and DC-3 (figs. 5 and 6) is high-volatile C bituminous rank, whereas in a core from a well further northwest in sec. 9, T. 29 N., R. 15 W., the coal is high-volatile B bituminous. As received at the laboratory, the heating value was 12,740 Btu per lb and ash content was 6.3 percent. At the north end of the basin, at Hesperus and at Monero, almost all of the analyses indicate high-volatile A bituminous.

Sulfur content is lowest in the southern part of the basin, generally less than 1 percent, and higher and more erratic in the northern part. Individual sulfur analyses reach 3.5 percent in both the Hesperus and Monero area, but the average sulfur content is probably less than 1.5 percent.

Typical analyses from various areas are shown in table 2. Only active mines and core samples are included because samples taken at prospect pits and small intermittently worked wagon mines are generally somewhat weathered and not representative of actual commercial coal production.

# Estimates of reserves and resources

### FRUITLAND FORMATION

About 200 billion tons (Fassett and Hinds, 1971) of coal is contained in the Fruitland Formation between its outcrop and its deepest point of slightly more than 4,000 ft below the surface (fig. 6). Estimates of these coal resources are based on the assumption that all the coal in the formation is subbituminous and has an average weight of 1,132,560 tons per mi-ft (1,770 tons per ac-ft).

The coal is reported in three categories of bed thickness and six categories of overburden (table 3). The bed-thickness categories are the standard categories used by the U.S. Geological Survey in estimating subbituminous resources, except that the lower limit of thickness is 2 ft in this report instead of the 2 1/2 ft of the standard categories. As can be seen in table 3, there are approximately 14 billion short tons of coal that may be strippable, about 14 billion tons of coal at depths from 500 to 1,000 ft below the surface, and approximately 28 billion tons of coal at depths from 1,000 to 2,000 ft (figs. 7, 8, and 9).

### MENEFEE FORMATION

Coal in the Menefee is in the upper and lower few hundred feet, with the exception of the Hogback Mountain tongue. Because of the thinness, lenticularity, and lack of closely spaced drilling, correlation of the individual coals is difficult.

The coals formed in small landward basins are roughly parallel to the ancient shorelines, with each basin containing a few million to a few tens of millions of tons of coal.

Drill-hole density was considered sufficient for estimation of resources for 42 townships (tables 4 and 5). There is an estimated 1001.7 million tons of coal of which 660.9 million tons are at depths greater than 2,000 ft. There are 282.8 million tons of coal at depths less than 500 ft. In T. 17 N., R. 9 W. and T. 17 N., R. 10 W., 54.1 million tons are present at depths of 200-300 ft, and in T. 20 N., R. 10 W., there are an estimated 39.4 million tons at depths of less than 500 ft (figs. 10 and 11).

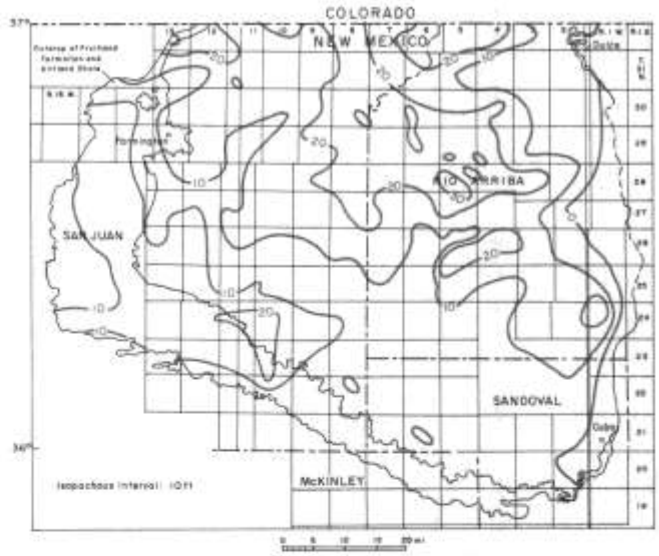


FIGURE 8—Isopachous contours of individual coal seams in Fruitland Formation (after Fassett and Hinds, 1971).

## Hogback Mountain tongue

The term Hogback Mountain tongue is used to refer to one or more Menefee tongues that are laterally equivalent to the La Ventana Tongue of the Cliff House Sandstone and occupy a geographic position between the southern extent of La Ventana sandstone and the extent of Menefee lithology in the La Ventana stratigraphic interval. The relationships are illustrated by the cross sections (figs. 12 and 13). The Hogback Mountain tongue crops out on the east slopes of the Hogback Mountains in T. 27 N., R. 16 W. and T. 28 N., R. 16 W.

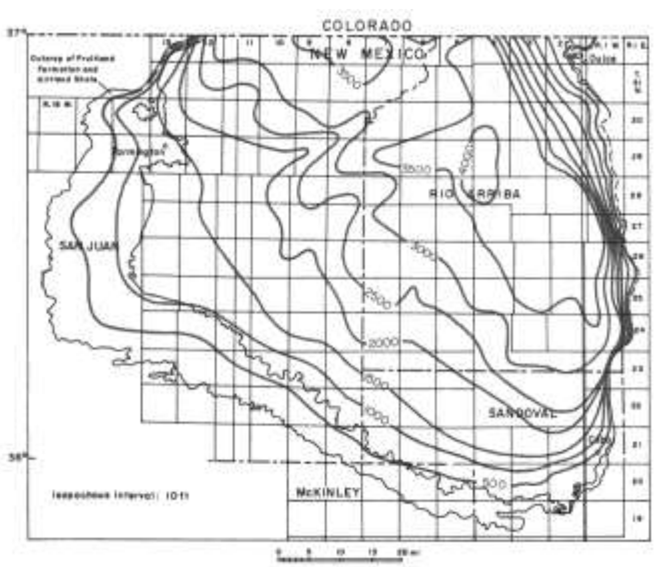


FIGURE 7—Isopachous contours of overburden on Fruitland coals (after Fassett and Hinds, 1971).

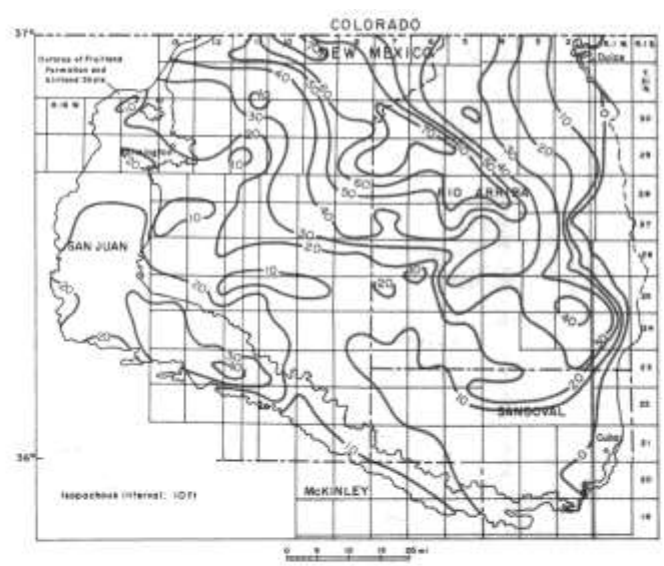


FIGURE 9—Isopachous contours of coal in Fruitland Formation (after Fassett and Hinds, 1971).

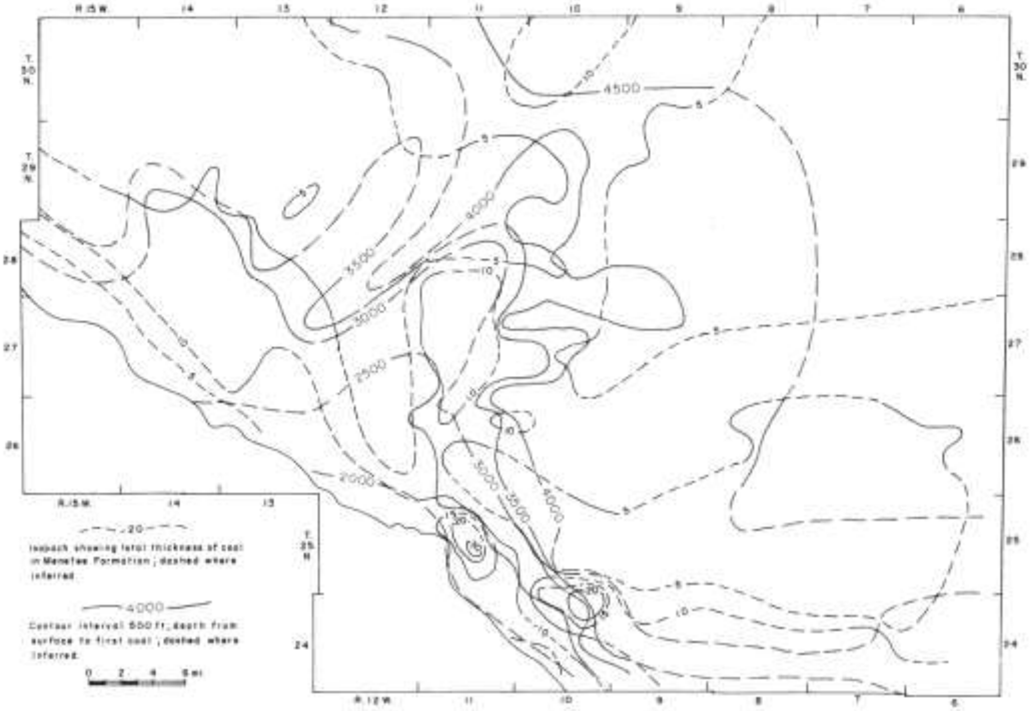


FIGURE 10—Isopachous contours of coal in Menefee Formation in northern San Juan Basin (in New Mexico).

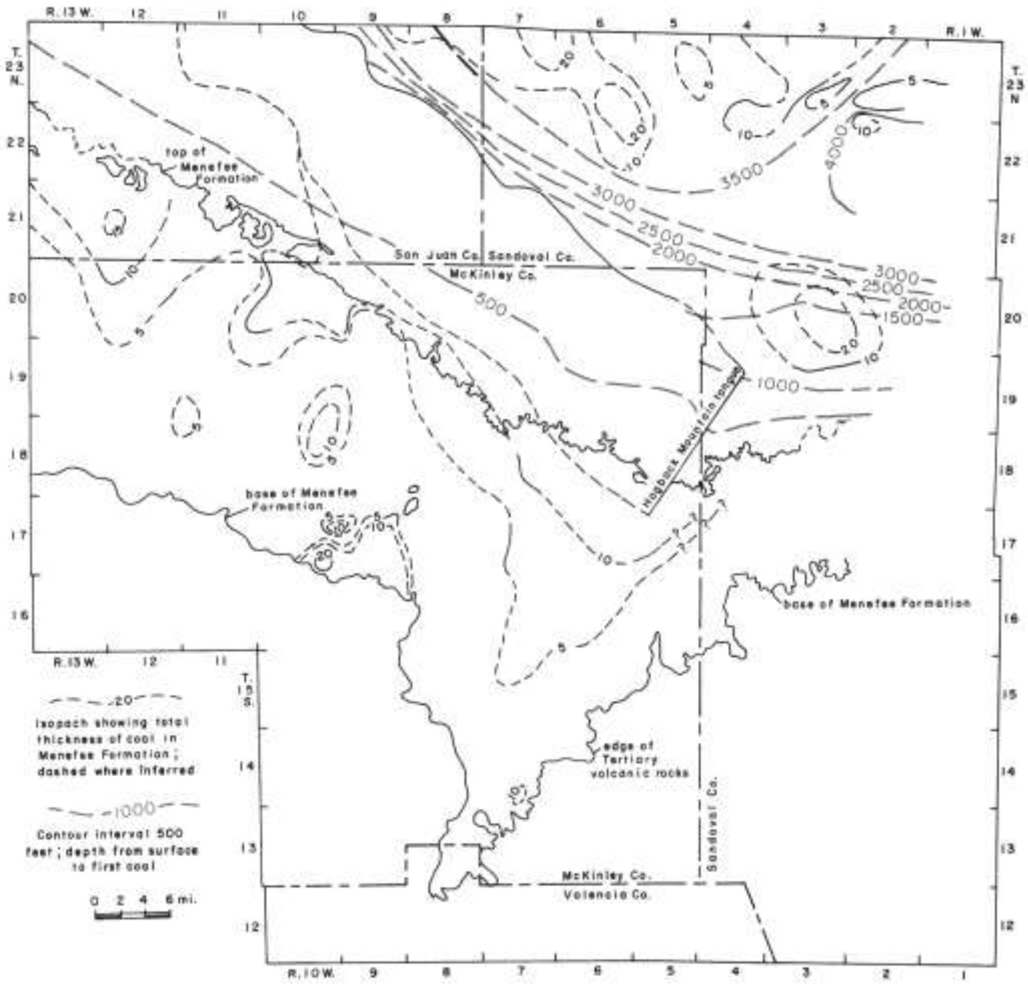


FIGURE 11—Isopachous contours of coal in Menefee Formation in southern San Juan Basin.

and is present in the subsurface in a straight band 3 mi to 12 mi wide and 92 mi long, trending S. 53° E. from Hogback Mountain to the vicinity of Torreon.

Resources were calculated for 42 townships and a total resource of 11,280 million tons was estimated, of which 1,680 million tons lie more than 2,000 ft below the surface. The township-by-township estimates are shown in table 6.

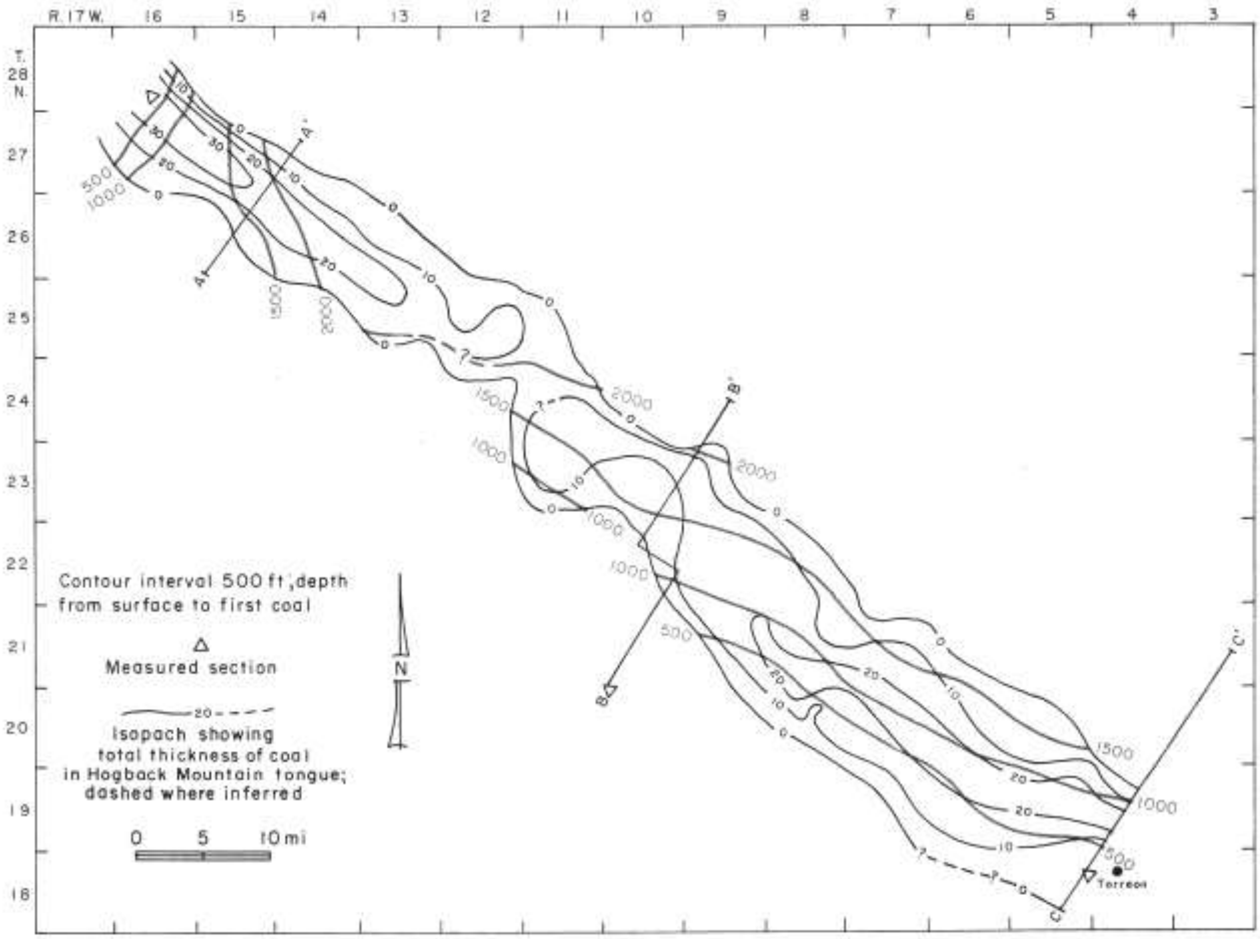


FIGURE 12—Isopachous contours of coal in Hogback Mountain tongue (fig. 13 and appendix 2B).

*Figure 13 follows*

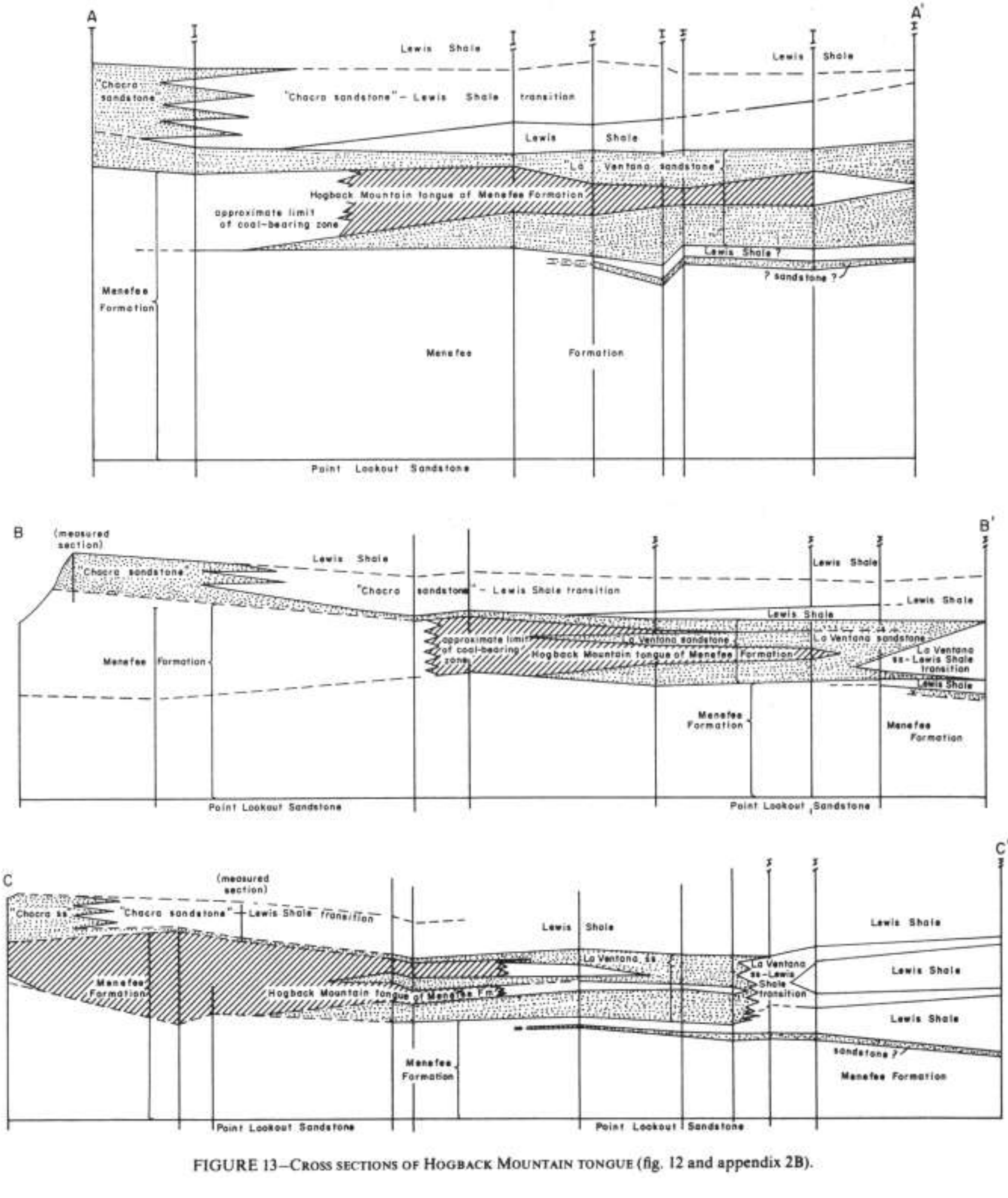


FIGURE 13—Cross sections of Hogback Mountain tongue (fig. 12 and appendix 2B).

# Economics of future prospects

To meet the expanding energy requirements of the nation, the demand for and selling price of coal has risen steadily since 1970. The cost of coal varies with the mining method and with each operation. In 1974 the national average cost of strip-mined coal was $11.11 per ton. Underground coal in 1974 cost $19.86 per ton (U.S. Bureau of Mines, 1974). With ongoing inflation in coal mining costs, the contract price of strip-mined coal per ton in 1985 may well be $20 (Arnold and others, 1977).

The coals in the southern and southeastern part of the San Juan Basin, as near Star Lake and Bisti, will have additional costs for washing and transportation. These coals will probably require washing to cut down on the high ash content. This will cost $1.50 to $3.00 per ton depending mainly on costs for obtaining the water from deep wells (Paul Weir Company, 1975). Also, to develop these coal deposits a 70-mi railroad costing $50 million is planned from Prewitt to Star Lake, New Mexico.

The depth of the Menefee coals will probably require new exotic methods of production-for example, in situ gasification or solution mining. While these methods are not economically feasible now, research into new process technology is in various stages.

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# Tables and Appendices

TABLE 1—ANALYSES OF COAL SAMPLES FROM FRUITLAND FORMATION (form of analysis: A, as received; B, moisture free; C, moisture and ash free. Analyses by U.S. Bureau of Mines and by U.S. Geological Survey).

| Location Sec. | T.N. | R.W. | Well or source | Approx. depth interval of sample (ft) | Form of analysis | Proximate analysis (%) Moisture | Volatile matter | Fixed carbon | Ash | Sulfur | Heating value (Btu) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 32 | 6 | La Plata Gathering | 2,811-2,830 | A | 1.1 | 20.6 | 50.6 | 27.7 | 0.6 | 11,020 | |
| | | | San Juan Unit 32-50 | | B | --- | 20.8 | 51.2 | 28.0 | .6 | 11,130 | |
| | | | No. 2-27 | | C | --- | 28.9 | 71.1 | --- | .9 | 15,470 | |
| 24 | 32 | 10 | Delhi-Taylor | 3,370-3,400 | A | 1.5 | 24.4 | 44.9 | 29.2 | .7 | 10,690 | |
| | | | Wickens No. 1 | | B | --- | 24.8 | 45.5 | 29.7 | .7 | 10,860 | |
| | | | | | C | --- | 35.3 | 64.7 | --- | 1.0 | 15,440 | |
| 5 | 31 | 5 | El Paso Nat. Gas | 3,124-3,136 | A | 1.6 | 23.5 | 50.0 | 24.9 | .7 | 11,550 | |
| | | | Rosa Unit No. 41 | | B | --- | 23.8 | 50.9 | 25.3 | .7 | 11,740 | |
| | | | | | C | --- | 31.9 | 68.1 | --- | 1.0 | 15,720 | |
| 20 | 31 | 9 | Delhi-Taylor | 3,230-3,255 | A | 1.3 | 33.7 | 49.2 | 15.8 | .7 | 12,830 | |
| | | | Barrett No. 1 | | B | --- | 34.1 | 49.9 | 16.0 | .7 | 13,000 | |
| | | | | | C | --- | 40.6 | 59.4 | --- | .9 | 15,470 | |
| 8 | 31 | 11 | El Paso Nat. Gas | 2,710-2,740 | A | 1.7 | 40.3 | 47.0 | 11.0 | .7 | 13,350 | |
| | | | Case No. 9 | | B | --- | 41.0 | 47.9 | 11.1 | .7 | 13,580 | |
| | | | | | C | --- | 46.1 | 53.9 | --- | .8 | 15,280 | |
| 5 | 31 | 12 | Consolidated Oil | 2,215-3,000 | A | 2.4 | 39.4 | 47.3 | 10.9 | .5 | 13,000 | |
| | | | & Gas, Mitchell 1-5 | | B | --- | 40.4 | 48.5 | 11.1 | .5 | 13,410 | |
| | | | | | C | --- | 45.5 | 54.5 | --- | .6 | 15,100 | |
| 11 | 31 | 13 | Consolidated Oil | 1,776-1,782 | A | 2.3 | 37.9 | 43.6 | 16.2 | 1.3 | 12,040 | |
| | | | & Gas, Freeman 1-11 | | B | --- | 38.8 | 44.7 | 16.5 | 1.3 | 12,320 | |
| | | | | | C | --- | 46.5 | 53.5 | --- | 1.6 | 14,760 | |
| 10 | 30 | 6 | El Paso Nat. Gas | 3,100-3,105 | A | 1.5 | 24.1 | 49.4 | 25.0 | .7 | 11,310 | |
| | | | S.J.U. 30-6 No. 37 | | B | --- | 24.5 | 50.1 | 25.4 | .7 | 11,480 | |
| | | | | | C | --- | 32.8 | 67.2 | --- | .9 | 15,380 | |
| 5 | 30 | 8 | Delhi-Taylor | 2,800-3,028 | A | 1.7 | 32.6 | 41.4 | 24.3 | 1.8 | 11,250 | |
| | | | Moore No. 6 | | B | --- | 33.2 | 42.1 | 24.7 | 1.8 | 11,440 | |
| | | | | | C | --- | 44.0 | 56.0 | --- | 2.4 | 15,100 | |
| 28 | 30 | 9 | El Paso Nat. Gas | 2,385-2,390 | A | 1.5 | 39.9 | 45.5 | 13.1 | 2.2 | 12,960 | |
| | | | Turner No. 3 | | B | --- | 40.5 | 46.2 | 13.3 | 2.2 | 13,150 | |
| | | | | | C | --- | 46.7 | 53.3 | --- | 2.5 | 15,170 | |
| 29 | 30 | 10 | El Paso Nat. Gas | 2,340-2,360 | A | 2.3 | 33.1 | 39.9 | 24.7 | .7 | 10,800 | Uppermost of two samples from |
| | | | Ludwick No. 20 | | B | --- | 33.9 | 40.9 | 25.2 | .7 | 11,060 | this location |
| | | | | | C | --- | 45.3 | 54.7 | --- | .9 | 14,790 | |
| 29 | 30 | 10 | El Paso Nat. Gas | 2,505-2,515 | A | 2.6 | 41.7 | 44.5 | 11.2 | .6 | 13,080 | Lowermost of two samples from |
| | | | Ludwick No. 20 | | B | --- | 42.9 | 45.6 | 11.5 | .6 | 13,420 | this location |
| | | | | | C | --- | 48.4 | 51.6 | --- | .7 | 15,160 | |
| 7 | 30 | 11 | Aztec Oil & Gas | 2,020-2,030 | A | 1.4 | 37.2 | 44.1 | 17.3 | .6 | 12,010 | |
| | | | Ruby Jones No. 1 | | B | --- | 37.7 | 44.8 | 17.5 | .6 | 12,180 | |
| | | | | | C | --- | 45.7 | 54.3 | --- | .7 | 14,770 | |
| 22 | 30 | 12 | Southwest Production | 1,713-1,742 | A | 2.2 | 38.8 | 45.3 | 13.7 | .6 | 12,370 | |
| | | | Sullivan No. 1 | | B | --- | 39.7 | 48.3 | 14.0 | .6 | 12,640 | |
| | | | | | C | --- | 46.1 | 53.9 | --- | .7 | 14,700 | |
| 18 | 30 | 13 | R & G Drilling | 1,425-1,440 | A | 2.8 | 40.4 | 44.7 | 12.1 | .6 | 12,390 | |
| | | | Lunt No. 62 | | B | --- | 41.6 | 45.9 | 12.5 | .6 | 12,750 | |
| | | | | | C | --- | 47.5 | 52.5 | --- | .7 | 14,570 | |
| 31 | 30 | 13 | Compass Exploration | 1,070-1,080 | A | 5.7 | 38.8 | 43.0 | 12.5 | .6 | 11,840 | |
| | | | Federal No. 1-31A | | B | --- | 41.2 | 45.5 | 13.3 | .6 | 12,540 | |
| | | | | | C | --- | 47.4 | 52.6 | --- | .7 | 14,460 | |
| 21 | 30 | 15 | N.M.P.S.C.C. | 69-70 | A | 5.6 | 39.7 | 43.3 | 11.4 | .7 | 11,850 | Sample from coal core—not floated |
| | | | Core Hole No. 7 | | B | --- | 42.0 | 46.0 | 12.0 | .7 | 12,540 | in $CCl_4$. A is air-dried analysis |
| | | | | | C | --- | 47.8 | 52.2 | --- | .8 | 14,260 | |
| 5 | 29 | 5 | El Paso Nat. Gas | 3,175-3,200 | A | 2.2 | 29.3 | 44.8 | 23.7 | .8 | 11,460 | |
| | | | S.J.U. 29-5 No. 17 | | B | --- | 30.0 | 45.8 | 24.2 | .8 | 11,720 | |
| | | | | | C | --- | 39.5 | 60.5 | --- | 1.1 | 15,470 | |
| 9 | 29 | 6 | El Paso Nat. Gas | 3,575-3,580 | A | 1.2 | 27.7 | 42.6 | 28.5 | .6 | 10,780 | |
| | | | S.J.U. 29-6 No. 66 | | B | --- | 28.0 | 43.1 | 28.9 | .6 | 10,910 | |
| | | | | | C | --- | 39.4 | 60.6 | --- | .8 | 15,330 | |
| 30 | 29 | 9 | Aztec Oil & Gas | 1,985-2,005 | A | 1.6 | 41.1 | 46.6 | 10.7 | .7 | 13,310 | |
| | | | Cain No. 16-D | | B | --- | 41.7 | 47.5 | 10.8 | .7 | 13,520 | |
| | | | | | C | --- | 46.8 | 53.2 | --- | .7 | 15,160 | |
| 5 | 29 | 10 | Aztec Oil & Gas | 2,065-2,080 | A | 2.3 | 39.1 | 42.1 | 16.5 | 1.9 | 12,020 | Uppermost of two samples from |
| | | | Grenier "B" No. 3 | | B | --- | 40.0 | 43.1 | 16.9 | 2.0 | 12,300 | this location |
| | | | | | C | --- | 48.1 | 51.9 | --- | 2.4 | 14,800 | |
| 5 | 29 | 10 | Aztec Oil & Gas | 2,150-2,160 | A | 2.0 | 40.6 | 47.6 | 9.8 | .5 | 13,300 | Lowermost of two samples from |
| | | | Grenier "B" No. 3 | | B | --- | 41.4 | 48.6 | 10.0 | .5 | 13,560 | this location |
| | | | | | C | --- | 46.0 | 54.0 | --- | .6 | 15,070 | |
| 12 | 29 | 11 | Tidewater | 2,065-2,070 | A | 2.1 | 38.7 | 47.9 | 11.3 | .6 | 12,830 | |
| | | | N.M.-Fed. No. 12-E | | B | --- | 39.5 | 48.9 | 11.6 | .6 | 13,100 | |
| | | | | | C | --- | 44.7 | 55.3 | --- | .7 | 14,820 | |
| 9 | 29 | 11 | International Oil | 1,905-1,910 | A | 1.8 | 39.9 | 43.9 | 14.4 | .7 | 12,360 | |
| | | | Fogelson No. 1-9 | | B | --- | 40.6 | 44.8 | 14.6 | .7 | 12,590 | |
| | | | | | C | --- | 47.6 | 52.4 | --- | .8 | 14,750 | |
| 10 | 29 | 12 | Tennessee Oil & Gas | 1,740-1,750 | A | 2.1 | 40.0 | 44.8 | 13.1 | .5 | 12,340 | |
| | | | Cornell Gas Unit A | | B | --- | 40.9 | 45.7 | 13.4 | .5 | 12,600 | |
| | | | No. 1 | | C | --- | 47.2 | 52.8 | --- | .6 | 14,560 | |
| 20 | 29 | 13 | Aztec Oil & Gas | 1,125-1,140 | A | 5.6 | 39.0 | 41.3 | 14.1 | .6 | 11,580 | |
| | | | Hagood No. 21-G | | B | --- | 41.3 | 43.8 | 14.9 | .6 | 12,260 | |
| | | | | | C | --- | 48.5 | 51.5 | --- | .7 | 14,420 | |

TABLE 1–Fruitland Formation (cont.).

| Location Sec. | T.N. | R.W. | Well or source | Approx. depth interval of sample (ft) | Form of analysis | Proximate analysis (%) Moisture | Volatile matter | Fixed carbon | Ash | Sulfur | Heating value (Btu) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 29 | 13 | Aztec Oil & Gas | 1,635-1,640 | A | 3.5 | 39.6 | 43.2 | 13.7 | .5 | 11,910 | |
| | | | Hagood No. 13-G | | B | --- | 41.0 | 44.8 | 14.2 | .6 | 12,330 | |
| | | | | | C | --- | 47.8 | 52.2 | --- | .6 | 14,370 | |
| 36 | 29 | 14 | Humble Oil & Gas | 1,490-1,495 | A | 4.1 | 40.0 | 40.6 | 15.3 | .7 | 11,600 | |
| | | | Humble No. L-9 | | B | --- | 41.7 | 42.3 | 16.0 | .7 | 12,100 | |
| | | | | | C | --- | 49.7 | 50.3 | --- | .9 | 14,400 | |
| 19 | 28 | 4 | El Paso Nat. Gas | 4,115-4,120 | A | 1.6 | 31.1 | 43.7 | 23.6 | .7 | 11,580 | |
| | | | S.J.U. 28-4 No. 28 | | B | --- | 31.6 | 44.4 | 24.0 | .7 | 11,770 | |
| | | | | | C | --- | 41.6 | 58.4 | --- | .9 | 15,480 | |
| 28 | 28 | 5 | El Paso Nat. Gas | 3,323-3,345 | A | 2.6 | 31.6 | 39.0 | 26.8 | .6 | 10,640 | |
| | | | S.J.U. 28-5 No. 50 | | B | --- | 32.5 | 40.0 | 27.5 | .6 | 10,920 | |
| | | | | | C | --- | 44.8 | 55.2 | --- | .9 | 15,070 | |
| 30 | 28 | 8 | El Paso Nat. Gas | 2,185-2,195 | A | 1.9 | 33.7 | 35.1 | 29.3 | .6 | 10,270 | |
| | | | Florence No. 10-C | | B | --- | 34.3 | 35.8 | 29.9 | .7 | 10,460 | |
| | | | | | C | --- | 48.9 | 51.1 | --- | .9 | 14,920 | |
| 17 | 28 | 9 | Aztec Oil & Gas | 1,985-1,990 | A | 1.4 | 36.1 | 42.1 | 20.4 | .8 | 11,670 | |
| | | | Reid No. 23-D | | B | --- | 36.6 | 42.7 | 20.7 | .8 | 11,830 | |
| | | | | | C | --- | 46.2 | 53.8 | --- | 1.0 | 14,920 | |
| 16 | 28 | 10 | Aztec Oil & Gas | 1,842-1,853 | A | 1.6 | 38.4 | 40.7 | 19.3 | .6 | 11,760 | |
| | | | Caine No. 13 | | B | --- | 39.0 | 41.4 | 19.6 | .6 | 11,950 | |
| | | | | | C | --- | 48.5 | 51.5 | --- | .8 | 14,870 | |
| 10 | 28 | 11 | Redfern & Herd | 1,490-1,500 | A | 2.1 | 39.8 | 43.4 | 14.7 | .6 | 12,190 | |
| | | | Redfern & Herd No. 5 | | B | --- | 40.7 | 44.3 | 15.0 | .6 | 12,460 | |
| | | | | | C | --- | 47.9 | 52.1 | --- | .7 | 14,670 | |
| 18 | 28 | 12 | Sunray Mid-Continent | 1,305-1,315 | A | 3.0 | 38.9 | 44.4 | 13.7 | .6 | 12,010 | |
| | | | Gallegos No. 122 | | B | --- | 40.1 | 45.8 | 14.1 | .6 | 12,390 | |
| | | | | | C | --- | 46.8 | 53.2 | --- | .7 | 14,430 | |
| 16 | 28 | 13 | Pan American | 1,705-1,715 | A | 4.1 | 39.4 | 42.8 | 13.7 | .6 | 11,740 | |
| | | | Holder No. 7 | | B | --- | 41.1 | 44.6 | 14.3 | .6 | 12,240 | |
| | | | | | C | --- | 47.9 | 52.1 | --- | .7 | 14,290 | |
| 32 | 27 | 4 | El Paso Nat. Gas | 3,935-3,945 | A | 2.2 | 33.9 | 37.9 | 26.0 | .7 | 10,780 | |
| | | | S.J.U. 27-4 No. 30 | | B | --- | 34.6 | 38.8 | 26.6 | .7 | 11,010 | |
| | | | | | C | --- | 47.2 | 52.8 | --- | .9 | 15,020 | |
| 23 | 27 | 5 | El Paso Nat. Gas | 3,250-3,260 | A | 3.1 | 34.4 | 39.5 | 23.0 | .8 | 11,080 | |
| | | | S.J.U. 27-5 No. 74 | | B | --- | 35.6 | 40.7 | 23.7 | .9 | 11,440 | |
| | | | | | C | --- | 46.6 | 53.4 | --- | 1.1 | 15,010 | |
| 21 | 27 | 6 | El Paso Nat. Gas | 3,165-3,180 | A | 1.4 | 39.3 | 44.5 | 14.8 | .9 | 12,690 | |
| | | | Rincon Unit No. 171 | | B | --- | 39.8 | 45.2 | 15.0 | .9 | 12,870 | |
| | | | | | C | --- | 46.9 | 53.1 | --- | 1.1 | 15,150 | |
| 13 | 27 | 7 | El Paso Nat. Gas | 3,130-3,140 | A | 2.3 | 32.9 | 34.3 | 30.5 | .8 | 9,900 | |
| | | | Rincon Unit No. 177 | | B | --- | 33.7 | 35.1 | 31.2 | .8 | 10,130 | |
| | | | | | C | --- | 48.9 | 51.1 | --- | 1.2 | 14,720 | |
| 8 | 27 | 8 | El Paso Nat. Gas | 2,800-2,820 | A | 1.9 | 29.5 | 32.9 | 35.7 | .6 | 9,170 | |
| | | | Schwerdtfeger No. 20-A | | B | --- | 30.0 | 33.6 | 36.4 | .6 | 9,350 | |
| | | | | | C | --- | 47.2 | 52.8 | --- | 1.0 | 14,700 | |
| 8 | 27 | 9 | Aztec Oil & Gas | 2,215-2,230 | A | 2.2 | 36.7 | 41.2 | 19.9 | .8 | 11,440 | |
| | | | Whitley No. 6-D | | B | --- | 37.5 | 42.1 | 20.4 | .8 | 11,700 | |
| | | | | | C | --- | 47.1 | 52.9 | --- | 1.1 | 14,700 | |
| 29 | 27 | 9 | Aztec Oil & Gas | 2,135-2,145 | A | 2.7 | 38.3 | 40.4 | 18.6 | .8 | 11,650 | |
| | | | Hudson No. 5-D | | B | --- | 39.3 | 41.6 | 19.1 | .8 | 11,970 | |
| | | | | | C | --- | 48.6 | 51.4 | --- | 1.0 | 14,800 | |
| 12 | 27 | 10 | Aztec Oil & Gas | 1,900-1,905 | A | 2.2 | 40.4 | 44.0 | 13.4 | .6 | 12,520 | |
| | | | Hanks No. 14-D | | B | --- | 41.3 | 45.1 | 13.6 | .6 | 12,790 | |
| | | | | | C | --- | 47.9 | 52.1 | --- | .7 | 14,820 | |
| 14 | 27 | 11 | British-American Oil | 1,920-1,930 | A | 3.3 | 40.8 | 43.9 | 12.0 | .6 | 12,370 | |
| | | | Fullerton No. 8 | | B | --- | 42.2 | 45.4 | 12.4 | .6 | 12,790 | |
| | | | | | C | --- | 48.1 | 51.9 | --- | .7 | 14,600 | |
| 26 | 27 | 12 | Southwest Production | 1,900-1,910 | A | 2.6 | 41.2 | 40.5 | 15.7 | .6 | 11,810 | |
| | | | Campbell No. 2 | | B | --- | 42.3 | 41.6 | 16.1 | .6 | 12,120 | |
| | | | | | C | --- | 50.4 | 49.6 | --- | .7 | 14,440 | |
| 6 | 27 | 13 | Royal Development | 1,214-1,245 | A | 4.3 | 39.7 | 44.6 | 11.4 | .7 | 11,970 | |
| | | | Ojo Amarillo No. 2 | | B | --- | 41.4 | 46.7 | 11.9 | .7 | 12,500 | |
| | | | | | C | --- | 47.0 | 53.0 | --- | .8 | 14,190 | |
| 2 | 26 | 6 | Caulkins Oil | 3,184-3,200 | A | 1.3 | 38.9 | 41.4 | 18.4 | .7 | 12,130 | |
| | | | State "A" MD No. 62 | | B | --- | 39.4 | 41.9 | 18.7 | .7 | 12,290 | |
| | | | | | C | --- | 48.4 | 51.6 | --- | .9 | 15,120 | |
| 19 | 26 | 7 | Kay Kimbell | 2,105-2,150 | A | 2.5 | 38.1 | 41.2 | 18.2 | .6 | 11,760 | |
| | | | Leiberman No. 5 | | B | --- | 39.1 | 42.2 | 18.7 | .6 | 12,060 | |
| | | | | | C | --- | 48.1 | 51.9 | --- | .8 | 14,830 | |
| 5 | 26 | 11 | Southwest Production | 1,700-1,705 | A | 3.6 | 40.6 | 39.3 | 16.5 | .7 | 11,540 | |
| | | | Ted Henderson No. 1 | | B | --- | 42.1 | 40.8 | 17.1 | .7 | 11,970 | |
| | | | | | C | --- | 50.8 | 49.2 | --- | .8 | 14,430 | |
| 35 | 25 | 6 | Merrion & Associates | 2,455-2,465 | A | 3.6 | 36.3 | 35.6 | 24.5 | .8 | 10,440 | |
| | | | Federal 3-35 | | B | --- | 37.7 | 36.9 | 25.4 | .8 | 10,830 | |
| | | | | | C | --- | 50.5 | 49.5 | --- | 1.1 | 14,510 | |
| 21 | 25 | 9 | Century Exploration | 1,620-1,625 | A | 4.2 | 31.5 | 33.3 | 31.0 | .9 | 9,280 | |
| | | | Mobil-Rudman No. 2 | | B | --- | 32.8 | 34.8 | 32.4 | .9 | 9,680 | |
| | | | | | C | --- | 48.6 | 51.4 | --- | 1.4 | 14,310 | |

TABLE 1—Fruitland Formation (cont.).

| Location | | | Well or source | Approx. depth interval of sample (ft) | Form of analysis | Proximate analysis (%) | | | | | Heating value (Btu) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sec. | T.N. | R.W. | | | | Moisture | Volatile matter | Fixed carbon | Ash | Sulfur | | |
| 16 | 25 | 13 | Standard of Texas State No. 1 | 1,156-1,208 | A | 9.5 | 30.9 | 43.3 | 16.3 | 1.8 | 10,270 | Abnormal moisture content may be due to inadequate drying of sample during preparation process |
| | | | | | B | — | 34.1 | 47.9 | 18.0 | 2.0 | 11,340 | |
| | | | | | C | — | 41.6 | 58.4 | — | 2.5 | 13,820 | |
| 22 | 24 | 3 | El Paso Nat. Gas Lindrith No. 42 | 3,194-3,205 | A | 2.1 | 38.7 | 36.7 | 22.5 | .7 | 10,990 | |
| | | | | | B | — | 39.5 | 37.5 | 23.0 | .7 | 11,230 | |
| | | | | | C | — | 51.3 | 48.7 | — | 1.0 | 14,580 | |
| 31 | 24 | 6 | Val Reese & Assoc. Bobby "B" No. 2-31 | 2,070-2,090 | A | 3.6 | 41.1 | 40.6 | 14.7 | .7 | 11,840 | |
| | | | | | B | — | 42.6 | 42.2 | 15.2 | .7 | 12,280 | |
| | | | | | C | — | 50.2 | 49.8 | — | .9 | 14,480 | |
| 27 | 24 | 7 | Val Reese & Assoc. Lybrook No. 7-27 | 2,140-2,150 | A | 4.4 | 40.9 | 41.2 | 13.5 | .6 | 11,790 | |
| | | | | | B | — | 42.8 | 43.1 | 14.1 | .6 | 12,340 | |
| | | | | | C | — | 49.9 | 50.1 | — | .7 | 14,370 | |
| 12 | 24 | 8 | Dorfman Production Nancy Fed. No. 1 | 2,525-2,535 | A | 3.9 | 35.4 | 33.7 | 27.0 | 1.1 | 9,960 | |
| | | | | | B | — | 36.8 | 35.1 | 28.1 | 1.1 | 10,370 | |
| | | | | | C | — | 51.2 | 48.8 | — | 1.5 | 14,410 | |
| 32 | 24 | 13 | N.M.P.S.C.C. DH-32-1 | 100-112 | A | 12.0 | 32.5 | 39.3 | 16.2 | .5 | 9,670 | Coal core crushed and floated in $CCl_4$ |
| | | | | | B | — | 36.9 | 44.7 | 18.4 | .6 | 10,990 | |
| | | | | | C | — | 45.2 | 54.8 | — | .7 | 13,460 | |
| 15 | 23 | 7 | Val Reese & Assoc. Betty "B" No. 1-15 | 2,180-2,195 | A | 5.7 | 39.3 | 40.8 | 14.2 | .6 | 11,410 | |
| | | | | | B | — | 41.7 | 43.3 | 15.0 | .7 | 12,100 | |
| | | | | | C | — | 49.1 | 50.9 | — | .8 | 14,240 | |
| 3 | 23 | 13 | N.M.P.S.C.C. DH-3-2 | 42-44 | A | 6.7 | 35.9 | 46.9 | 10.5 | .6 | 11,320 | Coal core not floated in $CCl_4$ |
| | | | | | B | — | 38.5 | 50.3 | 11.2 | .6 | 12,140 | |
| | | | | | C | — | 43.4 | 56.6 | — | .7 | 13,680 | |
| 3 | 19 | 2 | Fruitland outcrop | Surface | A | 5.9 | 33.6 | 29.8 | 30.7 | .6 | 7,370 | Weathered coal from surface exposure. Not floated in $CCl_4$ |
| | | | | | B | — | 35.7 | 31.7 | 32.6 | .7 | 7,830 | |
| | | | | | C | — | 53.0 | 47.0 | — | 1.0 | 11,620 | |
| 7 | 19 | 2 | Fruitland outcrop | Surface | A | 6.5 | 37.0 | 35.0 | 21.5 | .7 | 8,350 | do |
| | | | | | B | — | 39.6 | 37.4 | 23.0 | .7 | 8,930 | |
| | | | | | C | — | 51.4 | 48.6 | — | .9 | 11,590 | |
| 11 | 19 | 4 | Fruitland outcrop | Surface | A | 6.2 | 36.2 | 37.1 | 20.5 | .5 | 8,610 | do |
| | | | | | B | — | 38.6 | 39.6 | 21.8 | .5 | 9,170 | |
| | | | | | C | — | 49.3 | 50.7 | — | .6 | 11,730 | |
| 9 | 19 | 5 | Pit sample | ----- | A | 5.8 | 35.8 | 31.0 | 27.4 | .6 | 9,450 | Sample from small prospect pit in Fruitland outcrop |
| | | | | | B | — | 38.1 | 32.8 | 29.1 | .6 | 10,040 | |
| | | | | | C | — | 53.7 | 46.3 | — | .9 | 14,160 | |

TABLE 2—Analyses of coal samples from Menefee Formation (analyses by U.S. Bureau of Mines and by U.S. Geological Survey).

| Location | | | Kind of sample | Geologic unit | Laboratory no. 1 | Condition | Proximate analysis (%) | | | | Ultimate analysis (%) | | | | | | Heating value, British thermal units per pound | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sec. | T.N. | R.W. | | | | | Moisture | Volatile matter | Fixed carbon | Ash | Hydrogen | Carbon | Nitrogen | Oxygen | Sulfur | Ash | | |
| 8 & 26 | 18 | 14 | core | Menefee Formation near base | J-61752 through J-61756 | 1 | 16.1 | 33.5 | 38.7 | 11.7 | 5.9 | 56.4 | 0.9 | 24.5 | 0.7 | 11.7 | 9,860 | Standing Rock area, average of 5 analyses (original analyses in Shomaker, Beaumont, Kottlowski 1971, p. 74) |
| | | | | | | 2 | • | 39.8 | 46.3 | 13.9 | 4.8 | 67.1 | 1.1 | 12.3 | 0.8 | 13.9 | 11,750 | |
| | | | | | | 3 | • | 46.4 | 53.6 | • | 5.6 | 77.9 | 1.3 | 14.2 | 0.9 | • | 13,640 | |
| 36 | 17 | 10 | core | | J-63534 | 1 | 16.5 | 33.4 | 40.4 | 9.7 | 6.0 | 57.4 | 0.9 | 25.4 | 0.6 | 9.7 | 10,070 | |
| | | | | | | 2 | • | 40.0 | 48.3 | 11.7 | 5.0 | 68.8 | 1.1 | 12.7 | 0.7 | 11.7 | 12,060 | |
| | | | | | | 3 | • | 45.3 | 54.7 | • | 5.7 | 77.8 | 1.2 | 14.5 | 0.8 | • | 13,650 | |
| 19<br>31<br>35 | 19<br>19<br>19 | 1<br>1<br>2 | mine | Menefee Formation Allison & Cleary Members | A-47085<br>A-46366<br>A-60026<br>A-64268 | 1 | 15.9 | 33.7 | 44.0 | 6.4 | 6.3 | 60.4 | 1.1 | 24.3 | 1.2 | 6.4 | 10,720 | La Ventana area, average of 4 analyses (Shomaker, Beaumont, Kottlowski, 1971, p. 97) |
| | | | | | | 2 | • | 40.1 | 52.3 | 7.6 | 6.4 | 71.9 | 1.4 | 12.0 | 1.4 | 7.6 | 12,750 | |
| | | | | | | 3 | • | 43.1 | 56.9 | • | 5.8 | 77.9 | 1.5 | 13.0 | 1.7 | • | 13,750 | |
| 11 | 18 | 5 | core | Menefee Formation upper part | K-57022 | 1 | 12.0 | 34.1 | 39.9 | 14.0 | 5.6 | 59.3 | 1.2 | 19.6 | 0.3 | 14.0 | 10,410 | core test DC-2 691.1 ft to 694.75 ft |
| | | | | | | 2 | • | 38.7 | 45.4 | 15.9 | 4.8 | 67.4 | 1.4 | 10.1 | 0.4 | 15.9 | 11,830 | |
| | | | | | | 3 | • | 46.1 | 53.9 | • | 5.7 | 80.2 | 1.6 | 12.0 | 0.5 | • | 14,070 | |
| 11 | 18 | 5 | core | Menefee Formation upper part | K-57023 | 1 | 13.0 | 34.7 | 33.8 | 18.5 | 5.3 | 55.8 | 1.1 | 19.0 | 0.3 | 18.5 | 9,550 | core test DC-2 696.29 ft to 702.85 ft |
| | | | | | | 2 | • | 39.8 | 39.0 | 21.2 | 4.5 | 64.1 | 1.3 | 8.5 | 0.4 | 21.2 | 10,980 | |
| | | | | | | 3 | • | 50.6 | 49.4 | • | 5.7 | 81.4 | 1.6 | 10.8 | 0.5 | • | 13,940 | |
| 11 | 18 | 5 | core | Menefee Formation upper part | K-57024 | 1 | 11.0 | 34.4 | 35.1 | 19.5 | 5.2 | 55.5 | 1.2 | 18.2 | 0.4 | 19.5 | 9,800 | core test DC-2 734.45 ft to 737.65 ft |
| | | | | | | 2 | • | 38.7 | 39.4 | 21.9 | 4.4 | 62.4 | 1.3 | 9.5 | 0.5 | 21.9 | 11,020 | |
| | | | | | | 3 | • | 49.5 | 50.5 | • | 5.7 | 79.9 | 1.7 | 12.1 | 0.6 | • | 14,100 | |
| 7 | 21 | 8 | core | Menefee Formation upper part | K-57025 | 1 | 12.0 | 33.6 | 44.9 | 9.5 | 5.7 | 62.0 | 1.3 | 20.5 | 1.0 | 9.5 | 10,950 | core test DC-3 1,275.80 ft to 1,277.70 ft |
| | | | | | | 2 | • | 38.2 | 51.0 | 10.8 | 5.0 | 70.5 | 1.5 | 11.1 | 1.1 | 10.8 | 12,450 | |
| | | | | | | 3 | • | 42.8 | 57.2 | • | 5.6 | 79.0 | 1.7 | 12.5 | 1.2 | • | 13,950 | |
| 9 | 29 | 15 | core | Menefee Formation upper part | J-58561 | 1 | 5.6 | 40.4 | 47.7 | 6.3 | • | • | • | • | 0.8 | 6.3 | 12,740 | Merrion & Bayless #1 Union 2,494 ft to 2,500 ft. Free-swelling index=2½ |
| | | | | | | 2 | • | 42.7 | 50.7 | 6.6 | • | • | • | • | 0.9 | 6.6 | 13,490 | |
| | | | | | | 3 | • | 45.8 | 54.2 | • | • | • | • | • | 1.0 | • | 14,450 | |
| 28, 29, 32 | 15 Colorado | 11 | mine | Menefee Formation upper part | | 1 | 4.1 | 38.8 | 51.1 | 6.1 | • | • | • | • | 1.3 | 6.1 | 13,270 | Hay Gulch area, near Hesperus, average of 14 analyses |
| | | | | | | 3 | • | 43.2 | 56.8 | • | • | • | • | • | 1.4 | • | 14,760 | |
| 7, 6, 20<br>8, 10 | 31<br>31 | 1<br>1 | mine | Menefee Formation upper part | 29,279<br>5,761<br>A-37774<br>A-37934 | 1 | 4.0 | 37.3 | 51.0 | 7.7 | 5.4 | 71.7 | 1.5 | 10.7 | 1.4 | 7.7 | 12,900 | Monero area, average of 5 analyses (Shomaker, Beaumont, Kottlowski, 1971, p. 99) |
| | | | | | | 2 | • | 38.9 | 53.1 | 8.0 | 5.2 | 73.9 | 1.6 | 8.2 | 1.4 | 8.0 | 13,430 | |
| | | | | | | 3 | • | 41.8 | 58.2 | • | 5.7 | 81.5 | 1.7 | 9.1 | 1.9 | • | 14,940 | |

TABLE 3—Coal resources of Fruitland Formation.

| Overburden (ft) | Total coal in beds of indicated thickness (millions of short tons) 2-5 ft | 5-10 ft | 10 ft | Total |
|---|---|---|---|---|
| 0-500 | 4,021.1 | 4,888.3 | 5,728.9 | 14,638.3 |
| 500-1,000 | 3,583.2 | 4,780.0 | 5,505.0 | 13,868.2 |
| 1,000-2,000 | 8,468.3 | 9,809.1 | 9,660.0 | 27,937.4 |
| 2,000-3,000 | 11,736.5 | 14,759.7 | 32,312.0 | 58,808.2 |
| 3,000-4,000 | 14,032.1 | 17,291.8 | 51,500.2 | 82,824.1 |
| 4,000+ | 501.4 | 594.5 | 1,964.9 | 3,060.8 |
| Total | 42,342.6 | 52,123.4 | 106,671.0 | 201,137.0 |

TABLE 4—Estimated coal resources of Menefee Formation in northern San Juan Basin (New Mexico).

| Location T.N. | R.W. | Depth of minable coal beds (millions of short tons) 1,500-2,000 | 2,000-2,500 | 2,500-3,000 | 3,000-3,500 | 3,500-4,000 | Township totals |
|---|---|---|---|---|---|---|---|
| 24 | 10 | 4.5 | 10.8 | 14.6 | 4.5 | 5.3 | 39.7 |
| 25 | 11 | 13.6 | 17.6 | 7.5 | • | • | 38.7 |
| 26 | 11 | • | 2.5 | 7.8 | 6.8 | 6.2 | 23.3 |
| 26 | 12 | 1.3 | 29.8 | • | • | • | 31.1 |
| 27 | 10 | • | • | • | 2.8 | 18.8 | 21.6 |
| 27 | 11 | • | 2.0 | 25.8 | 11.5 | 3.3 | 42.6 |
| 27 | 12 | • | 2.1 | 5.3 | 2.1 | 1.5 | 11.0 |
| 27 | 13 | • | • | 26.7 | 3.6 | 1.0 | 31.3 |
| 28 | 11 | • | 18.0 | • | • | • | 18.0 |
| 28 | 12 | • | • | • | 13.5 | • | 13.5 |
| 28 | 13 | • | • | 3.0 | 9.2 | 4.0 | 16.2 |
| 28 | 15 | • | • | 7.6 | 18.2 | 3.7 | 29.5 |
| 29 | 14 | • | • | 1.5 | 5.2 | • | 6.7 |
| 29 | 15 | • | • | • | 1.4 | 16.2 | 17.6 |
| Totals | | 19.4 | 82.8 | 99.8 | 78.8 | 60.0 | 340.8 |

TABLE 5—Estimated coal resources of Menefee Formation in southern San Juan Basin.

| Location T.N. | R.W. | Depth of minable coal beds (millions of short tons) 0-500 ft | 500-1,000 ft | 3,000-3,500 ft | 3,500-4,000 ft | Township totals |
|---|---|---|---|---|---|---|
| 17 | 5 | 1.3 | • | • | • | 1.3 |
| 17 | 7 | 19.8 | • | • | • | 19.8 |
| 17 | 8 | 1.3 | • | • | • | 1.3 |
| 17 | 9 | 46.2 | • | • | • | 46.2 |
| 17 | 10 | 7.9 | • | • | • | 7.9 |
| 18 | 7 | 39.7 | • | • | • | 39.7 |
| 18 | 8 | 18.0 | • | • | • | 18.0 |
| 18 | 10 | 10.4 | • | • | • | 10.4 |
| 18 | 11 | 1.0 | • | • | • | 1.0 |
| 19 | 3 | • | 15.1 | • | • | 15.1 |
| 19 | 9 | 1.8 | • | • | • | 1.8 |
| 19 | 10 | 2.3 | • | • | • | 2.3 |
| 20 | 3 | • | 48.3 | • | • | 48.3 |
| 20 | 9 | 8.6 | • | • | • | 8.6 |
| 20 | 10 | 39.4 | • | • | • | 39.4 |
| 20 | 11 | 18.0 | • | • | • | 18.0 |
| 20 | 12 | 18.0 | • | • | • | 18.0 |
| 20 | 13 | 10.8 | • | • | • | 10.8 |
| 21 | 10 | 21.6 | • | • | • | 21.6 |
| 21 | 12 | 16.6 | • | • | • | 16.6 |
| 22 | 3 | • | • | • | 6.0 | 6.0 |
| 22 | 5 | • | • | • | 25.1 | 25.1 |
| 22 | 6 | • | • | • | 34.6 | 34.6 |
| 23 | 2 | • | • | • | 21.4 | 21.4 |
| 23 | 3 | • | • | • | 36.0 | 36.0 |
| 23 | 4 | • | • | • | 28.9 | 28.9 |
| 23 | 5 | • | • | • | 32.5 | 32.5 |
| 23 | 6 | • | • | • | 50.5 | 50.5 |
| 23 | 7 | • | • | 1.5 | 43.6 | 45.1 |
| 23 | 8 | • | • | 22.5 | 12.1 | 34.6 |
| Totals | | 282.8 | 63.4 | 24.0 | 290.7 | 660.9 |

TABLE 6—ESTIMATED COAL RESOURCES OF HOGBACK MOUNTAIN TONGUE OF MENEFEE FORMATION.

| Location | | Depth to first minable coal bed, ft (millions of short tons) | | | | | |
|---|---|---|---|---|---|---|---|
| T.N. | R.W. | 0-500 ft | 500-1,000 ft | 1,000-1,500 ft | 1,500-2,000 ft | Deeper than 2,000 ft | Township totals |
| 18 | 4 | | | | | | ? |
| 18 | 5 | 81.0 | • | • | • | • | 81.0 |
| 18 | 6 | 47.0 | • | • | • | • | 47.0 |
| 18 | 7 | • | • | • | • | • | ? |
| 19 | 4 | • | 125.4 | 61.6 | • | • | 187.0 |
| 19 | 5 | 121.2 | 351.7 | 68.8 | • | • | 541.7 |
| 19 | 6 | 297.5 | 387.0 | • | • | • | 684.5 |
| 19 | 7 | 241.8 | 25.8 | • | • | • | 267.6 |
| 20 | 4 | • | 6.7 | • | • | • | 6.7 |
| 20 | 5 | • | • | 100.8 | • | • | 100.8 |
| 20 | 6 | • | 274.3 | 227.5 | 27.2 | • | 529.0 |
| 20 | 7 | 169.7 | 454.9 | 169.4 | • | • | 794.0 |
| 20 | 8 | 264.7 | 214.5 | • | • | • | 479.2 |
| 20 | 9 | 63.0 | • | • | • | • | 63.0 |
| 21 | 6 | • | • | • | 91.6 | • | 91.6 |
| 21 | 7 | • | • | 215.0 | 254.2 | • | 469.2 |
| 21 | 8 | • | 382.6 | 193.5 | • | • | 576.1 |
| 21 | 9 | 45.4 | 404.3 | 28.7 | • | • | 478.4 |
| 22 | 7 | • | • | • | 6.7 | • | 6.7 |
| 22 | 8 | • | • | 90.8 | 133.8 | • | 224.6 |
| 22 | 9 | • | 43.0 | 344.0 | 95.6 | • | 482.6 |
| 22 | 10 | • | 71.1 | 87.9 | • | • | 159.0 |
| 23 | 8 | • | • | • | 3.6 | • | 3.6 |
| 23 | 9 | • | • | • | 186.4 | 31.5 | 217.9 |
| 23 | 10 | • | • | 29.4 | 199.0 | • | 228.4 |
| 23 | 11 | • | 65.4 | 206.9 | 76.5 | • | 348.8 |
| 24 | 10 | • | • | • | 27.0 | • | 27.0 |
| 24 | 11 | • | • | 33.5 | 17.1 | 28.7 | 79.3 |
| 24 | 12 | • | • | • | • | • | ? |
| 25 | 11 | • | • | • | • | 25.2 | 25.2 |
| 25 | 12 | • | • | • | • | 285.2 | 285.2 |
| 25 | 13 | • | • | • | • | 533.9 | 533.9 |
| 25 | 14 | • | • | • | 35.5 | 153.5 | 189.0 |
| 26 | 13 | • | • | • | • | 124.4 | 124.4 |
| 26 | 14 | • | • | • | 289.9 | 432.0 | 721.9 |
| 26 | 15 | • | • | 116.6 | 258.0 | • | 374.6 |
| 27 | 14 | • | • | • | • | 43.0 | 43.0 |
| 27 | 15 | • | • | 152.9 | 498.0 | 21.0 | 671.9 |
| 27 | 16 | 94.6 | 164.4 | 673.3 | • | • | 932.3 |
| 27 | 17 | 9.6 | • | • | • | • | 9.6 |
| 28 | 15 | • | • | 1.6 | • | • | 1.6 |
| 28 | 16 | 50.4 | 113.7 | 23.9 | • | • | 188.0 |
| Totals | | 1,485.9 | 3,084.8 | 2,826.1 | 2,200.1 | 1,678.4 | 11,275.3 |

APPENDIX I—SUMMARY OF MEASURED SECTIONS AND DRILL-HOLE DATA FOR FRUITLAND FORMATION (*see table 3 in Fassett and Hinds, 1971).

| * Number on pl. 3 | Published reference or company | Measured section or well name | Location Sec. | T. N. | R. |
|---|---|---|---|---|---|
| 38 | Hayes and Zapp (1955) | 44 | 21 | 32 | 13 W. |
| 39 | do | 53 | 18 | 32 | 12 W. |
| 40 | Pan American Petroleum Corp | Fed. Gas Unit No. 1 | 20 | 32 | 12 W. |
| 41 | El Paso Natural Gas Co | Moore No. 6 | 25 | 32 | 12 W. |
| 42 | Great Western Drilling Co | Decker No. 3 | 17 | 32 | 11 W. |
| 43 | El Paso Natural Gas Co | S.J.U. 32-9 No. 48 | 14 | 32 | 10 W. |
| 44 | Pacific NW Pipeline Corp | S.J.U. 32-9 | 9 | 32 | 9 W. |
| 45 | El Paso Natural Gas Co | S.J.U. 32-9 No. 63 | 36 | 32 | 9 W. |
| 46 | Pacific NW Pipeline Corp | S.J.U. 32-8 Mesa 9-20 | 20 | 32 | 8 W. |
| 47 | El Paso Natural Gas Co | Allison No. 16 (MD) | 15 | 32 | 7 W. |
| 48 | do | Allison No. 13 | 12 | 32 | 7 W. |
| 49 | do | Allison No. 17 | 24 | 32 | 7 W. |
| 50 | Pacific NW Pipeline Corp | S.J.U. 32-5 No. 6-10 | 10 | 32 | 6 W. |
| 51 | El Paso Natural Gas Co | S.J.U. 32-5 No. 14 | 26 | 32 | 6 W. |
| 52 | LaPlata Gathering System, Inc | S.J.U. 32-5 No. 1-31 | 31 | 32 | 5 W. |
| 53 | Belco Petroleum Corp | Carracas Mesa Unit No. 1-26 | 26 | 32 | 5 W. |
| 54 | Phillips Petroleum Co | Mesa Unit No. 32-4 No. 1-29 | 29 | 32 | 4 W. |
| 55 | do | Mesa Unit No. 32-4 No. 2-16 | 16 | 32 | 4 W. |
| 56 | Pan American Petroleum Corp | Pagosa Jicarilla No. 1 | 23 | 32 | 3 W. |
| 57 | Hayes and Zapp (1955) | 22 | 26, 35 | 31 | 15 W. |
| 58 | do | 26 | 29 | 31 | 14 W. |
| 59 | do | 34 | 23 | 31 | [1] 14 W. |
| 60 | do | 37 | 7, 18 | 31 | 13 W. |
| 61 | Southern Union Production Co | Fed. Lea No. 1 | 34 | 31 | 13 W. |
| 62 | Ohio Oil Co | Ohio Govt. No. 1-20 | 20 | 31 | 12 W. |
| 63 | El Paso Natural Gas Co | Case No. 7 | 19 | 31 | 11 W. |
| 64 | do | Heaton No. 9 | 32 | 31 | 11 W. |
| 65 | Delhi-Taylor Oil Corp | Mudge No. 1 | 10 | 31 | 11 W. |
| 66 | Wood River Oil and Refining Co., Inc | Lamb No. 3 | 21 | 31 | 10 W. |
| 67 | El Paso Natural Gas Co | S.J.U. 32-9 No. 64 | 2 | 31 | 9 W. |
| 68 | Pacific NW Pipeline Corp | S.J.U. 32-8 Mesa 8-22 | 22 | 31 | 8 W. |
| 69 | do | S.J.U. 31-6 No. 5-31 | 31 | 31 | 6 W. |
| 70 | do | Rosa Unit No. 10-13 | 13 | 31 | 6 W. |
| 71 | do | Rosa Unit No. 15-29 | 29 | 31 | 5 W. |
| 72 | Shar-Alan Oil Co | Carson No. 1 | 10 | 31 | 5 W. |
| 73 | Humble Oil and Refining Co | Jic. Tr. 29-1 | 32 | 31 | 2 W. |
| 74 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | | 31 | 1 W. |
| 75 | Hayes and Zapp (1955) | 8 | 28 | 30 | 15 W. |
| 76 | A. C. Bruce, Jr | Fed. Pipkin No. 1 | 5 | 30 | 14 W. |
| 77 | Stone Drilling, Inc | Kirtland No. 1-20 | 20 | 30 | 14 W. |
| 78 | Compass Exploration, Inc | Aztec No. 2-35 | 35 | 30 | 14 W. |
| 79 | Texas National Petroleum Co | Govt. No. 1 | 29 | 30 | 13 W. |
| 80 | Southern Union Production Co | Fed. No. 2-25 | 25 | 30 | 13 W. |
| 81 | Northwest Production Corp | Blanco 30-12 No. 1-4 | 4 | 30 | 12 W. |
| 82 | Pubco Petroleum Corp | State No. 30 | 36 | 30 | 12 W. |
| 83 | Tennessee Gas Transmission Co | Blanco State No. 1 | 2 | 30 | 11 W. |
| 84 | International Oil Co | E. E. Fogelson No. 1-25 | 25 | 30 | 11 W. |
| 85 | El Paso Natural Gas Co | Sunray No. 1-J (PM) | 7 | 30 | 10 W. |
| 86 | LaPlata Gathering System, Inc | Riddle No. 2 | 23 | 30 | 10 W. |
| 87 | Delhi Oil Corp | Florence-Fed 2-10 | 30 | 30 | 9 W. |
| 88 | El Paso Natural Gas Co | Howell No. 4-C | 18 | 30 | 8 W. |
| 89 | do | Gartner No. 8 | 26 | 30 | 8 W. |
| 90 | do | Manning No. 1-A | 20 | 30 | 6 W. |
| 91 | do | S.J.U. 30-5 No. 29-14 | 14 | 30 | 5 W. |
| 92 | do | S.J.U. 30-5 No. 32-26 | 26 | 30 | 5 W. |
| 93 | do | S.J.U. 30-4 No. 31 | 14 | 30 | 4 W. |
| 94 | do | S.J.U. 30-4 No. 32 | 33 | 30 | 4 W. |
| 95 | Sunray DX Oil Co | Jicarilla Tr. No. 1 | 34 | 30 | 3 W. |
| 96 | Hayes and Zapp (1955) | Composite of 4 and 6 | 3 | 29 | 15 W. |
| 97 | El Paso Natural Gas Co | Foutz No. 1 | 12 | 29 | 15 W. |
| 98 | Sunray Mid-Continent Petroleum Co | N. M. Fed No. 1-6 | 15 | 29 | 14 W. |
| 99 | Humble Oil and Refining Co | Navajo L No. 3 | 26 | 29 | 14 W. |
| 100 | Tennessee Gas Transmission Co | USA Glenn Callow | 33 | 29 | 13 W. |
| 101 | Pan American Petroleum Corp | Gallegos Can. No. 144 Unit No. 1. | 16 | 29 | 12 W. |
| 102 | El Paso Natural Gas Co | Bloomfield No. 1 | 17 | 29 | 11 W. |
| 103 | Redfern and Herd, Inc | Nye No. 1 | 32 | 29 | 11 W. |
| 104 | International Oil Co | Fogelson No. 1-11 | 11 | 29 | 11 W. |
| 105 | Congress Oil Co | Congress No. 4 | 35 | 29 | 11 W. |
| 106 | LaPlata Gathering System, Inc | Houck No. 2-12 | 12 | 29 | 10 W. |
| 107 | H.D.H. Drilling Co | San Juan No. 2 | 33 | 29 | 9 W. |

See footnote at end of table.

APPENDIX 1—Fruitland Formation (cont.).

| Number on pl. 3 | Published reference or company | Measured section or well name | Location Sec. | T. N. | R. |
|---|---|---|---|---|---|
| 108 | El Paso Natural Gas Co | MV Strat test No. 3 | 21 | 29 | 8 W. |
| 109 | do | S.J.U. 29-7 No. 65 | 22 | 29 | 7 W. |
| 110 | Pacific NW Pipeline Corp | S.J.U. 29-6 Mesa 20-8 | 8 | 29 | 6 W. |
| 111 | El Paso Natural Gas Co | S.J.U. 29-5 No. 13-30 | 30 | 29 | 5 W. |
| 112 | do | S.J.U. 29-5 No. 32-29 (MD) | 29 | 29 | 5 W. |
| 113 | do | S.J.U. 29-5 No. 48-15 | 15 | 29 | 5 W. |
| 114 | do | S.J.U. 29-4 No. 14-31 | 31 | 29 | 4 W. |
| 115 | do | S.J.U. 29-4 No. 16-36 | 36 | 29 | 4 W. |
| 116 | Pacific NW Pipeline Corp | Jic. Ind. A-2 | 30 | 29 | 3 W. |
| 117 | Phillips Petroleum Co | Indian D No. 1 | 21 | 29 | 3 W. |
| 118 | Smith Drilling Co | Jic. S-1 | 19 | 29 | 2 W. |
| 119 | Aztec Oil and Gas Co | Stinking Lake No. 1 | 35 | 29 | 1 W. |
| 120 | Bauer and Reeside (1921) | Composite of 161-163 (Ojo Alamo Arroyo). | 30 | 28 | [1] 15 W. |
| 121 | Floyd J. Ray | Cole No. 1 | 22 | 28 | 15 W. |
| 122 | Sunray DX Oil Co | Gulf-Navajo No. 1 | 21 | 28 | 14 W. |
| 123 | British-American Oil Producing Co | Scott D No. 1 | 20 | 28 | 13 W. |
| 124 | Pan American Petroleum Corp | Gallegos Cany. No. 116 | 24 | 28 | 13 W. |
| 125 | Sunray DX Oil Co | Gallegos Cany. No. 127 | 21 | 28 | 12 W. |
| 126 | Pan American Petroleum Corp | Gallegos Cany. No. 125 | 24 | 28 | 12 W. |
| 127 | Redfern and Herd, Inc | Lucerne "C" No. 1 | 21 | 28 | 11 W. |
| 128 | Angel Peak Oil Co | Angel Peak No. 20-B | 24 | 28 | 11 W. |
| 129 | Pan American Petroleum Corp | J. C. Davidson No. G-1 | 21 | 28 | 10 W. |
| 130 | El Paso Natural Gas Co | Michener No. 4-A (PM) | 28 | 28 | 9 W. |
| 131 | do | Bolack No. 3-B (PM) | 33 | 28 | 8 W. |
| 132 | do | S.J.U. 28-7 No. 73 (PM) | 28 | 28 | 7 W. |
| 133 | do | S.J.U. 28-6 No. 76 | 23 | 28 | 6 W. |
| 134 | do | S.J.U. 28-5 No. 32 | 20 | 28 | 5 W. |
| 135 | do | S.J.U. 28-5 No. 13 | 9 | 28 | 5 W. |
| 136 | do | S.J.U. 28-5 No. 25 | 13 | 28 | 5 W. |
| 137 | do | S.J.U. 28-4 No. 14-29 | 29 | 28 | 4 W. |
| 138 | Pacific NW Pipeline Corp | Jicarilla L No. 2 | 16 | 28 | 3 W. |
| 139 | Skelly Oil Co | Jicarilla No. 1-A | 3 | 28 | 2 W. |
| 140 | Gulf Oil Corp | Jicarilla 298 No. 1 | 10 | 28 | 1 W. |
| 141 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | | 28 | 1 W. |
| 142 | Bauer and Reeside (1921) | Composite of 183-186 | 2 | 27 | [1] 16 W. |
| 143 | do | Composite of 201-205 | 22 | 27 | [1] 16 W. |
| 144 | Davis Oil Co | Budd-Navajo No. 1 | 17 | 27 | 15 W. |
| 145 | William Callaway | Navajo No. 1 | 14 | 27 | 15 W. |
| 146 | Miami Oil Producers, Inc | Ojo Alamo No. 1 | 14 | 27 | 14 W. |
| 147 | Royal Development Co | Ojo Amarilla No. 2 | 6 | 27 | 13 W. |
| 148 | Sunray DX Oil Co | Hoska-ne-nos-wot No. 1 | 22 | 27 | 13 W. |
| 149 | Stanolind Oil and Gas Co | USA E. H. Newman No. 1 | 31 | 27 | 13 W. |
| 150 | Sunray Mid Continent Co | Fed. J. No. 1 | 35 | 27 | 13 W. |
| 151 | Southwest Production Co | Thompson Fed No. 2 | 10 | 27 | 12 W. |
| 152 | Tenneco Oil Co | Watson Unit No. 1 "A" | 21 | 27 | 12 W. |
| 153 | Texaco Inc | Navajo "AA" No. 1 | 19 | 27 | 11 W. |
| 154 | British-American Oil Producing Co | Scott No. 8 | 22 | 27 | 11 W. |
| 155 | Tennessee Gas Transmission Co | Bolack Gas Unit A No. 1 | 2 | 27 | 11 W. |
| 156 | Stanolind Oil and Gas Co | Huerfano No. 6 | 31 | 27 | 10 W. |
| 157 | Pan American Petroleum Corp | J. C. Gordon No. 2 | 22 | 27 | 10 W. |
| 158 | El Paso Natural Gas Co | Lodewick No. 8 | 19 | 27 | 9 W. |
| 159 | J. Glenn Turner (for Turner-Webb) | Huerfanito No. 43-22 | 22 | 27 | 9 W. |
| 160 | Southern Union Gas Co | Navajo No. 3-B | 19 | 27 | 8 W. |
| 161 | El Paso Natural Gas Co | Bolack No. 9 (PM) | 31 | 27 | 8 W. |
| 162 | do | S.J.U. 28-7 No. 98 (MD) | 29 | 27 | 7 W. |
| 163 | do | S.J.U. 28-7 No. 93 (PM) | 9 | 27 | 7 W. |
| 164 | do | S.J.U. 28-7 No. 64 | 22 | 27 | 7 W. |
| 165 | do | Rincon No. 97 (PM) | 18 | 27 | 6 W. |
| 166 | do | S.J.U. 28-6 No. 23 | 9 | 27 | 6 W. |
| 167 | do | S.J.U. 27-5 No. 19 | 20 | 27 | 5 W. |
| 168 | do | S.J.U. 27-5 No. 21 | 3 | 27 | 5 W. |
| 169 | do | S.J.U. 27-5 No. 33 | 26 | 27 | 5 W. |
| 170 | do | S.J.U. 27-4 No. 16 (MD) | 17 | 27 | 4 W. |
| 171 | do | S.J.U. 27-4 No. 17 (PM) | 29 | 27 | 4 W. |
| 172 | Phillips Petroleum Co | Indian "C" No. 1 | 20 | 27 | 3 W. |
| 173 | Magnolia Petroleum Co | Jicarilla "G" No. 2 | 25 | 27 | 3 W. |
| 174 | Northwest Production Corp | NE No. 1-16 | 16 | 27 | 2 W. |
| 175 | Magnolia Petroleum Co | Jicarilla No. 1 | 20 | 27 | 2 W. |
| 176 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | | 27 | 1 W. |
| 177 | Bauer and Reeside (1921) | Composite of 239-242 and 250 (Pina Veta China Arroyo). | | 26 | [1] 16 W. |

See footnote at end of table.

APPENDIX 1—Fruitland Formation (cont.).

| Number on pl. 3 | Published reference or company | Measured section or well name | Location Sec. | T. N. | R. |
|---|---|---|---|---|---|
| 178 | ----do---- | Composite of 277, 279, 281, 282, 289, 301 (Klaychin Arroyo). | ---- | 26 | 16 W. |
| 179 | Shell Oil Co | Burnham No. 1 | 14 | 26 | 15 W. |
| 180 | British-American Oil Producing Co | Navajo No. 1 | 15 | 28 | 14 W. |
| 181 | Skelly Oil Co | A. L. Duff No. 13 | 18 | 26 | 13 W. |
| 182 | Benson-Montin-Greer Drilling Corp | Foster No. 4 | 15 | 26 | 13 W. |
| 183 | El Paso Natural Gas Co | Sullivan No. 1-C | 17 | 26 | 12 W. |
| 184 | ----do---- | Nelson No. 1-A | 9 | 26 | 12 W. |
| 185 | Skelly Oil Co | Navajo D No. 1 | 13 | 26 | 12 W. |
| 186 | Pan American Petroleum Corp | O. H. Randel No. 4 | 15 | 26 | 11 W. |
| 187 | El Paso Natural Gas Co | Huerfano No. 104 | 17 | 26 | 10 W. |
| 188 | ----do---- | Huerfano No. 92 | 7 | 26 | 9 W. |
| 189 | Turner-Webb | Ballard 11-15 | 15 | 26 | 9 W. |
| 190 | Southern Union Gas Co | Newsome No. 1-A | 15 | 26 | 8 W. |
| 191 | El Paso Natural Gas Co | Hamilton State No. 7 | 32 | 26 | 7 W. |
| 192 | Caulkins Oil Co | Breech No. 307 (MD) | 13 | 26 | 7 W. |
| 193 | El Paso Natural Gas Co | Johnson State No. 1 | 32 | 26 | 6 W. |
| 194 | Northwest Production Corp | West No. 1-7 | 7 | 26 | 5 W. |
| 195 | ----do---- | Indian W No. 2-5 | 5 | 26 | 5 W. |
| 196 | Tenneco Oil Co | Jicarilla B No. 5 | 21 | 26 | 5 W. |
| 197 | Southern Union Gas Co | Jicarilla No. 2-H | 17 | 26 | 4 W. |
| 198 | ----do---- | Jicarilla No. 2-A | 14 | 26 | 4 W. |
| 199 | Magnolia Petroleum Co | Jicarilla D No. 2 | 14 | 26 | 3 W. |
| 200 | Northwest Production Corp | Jicarilla E No. 3-34 | 34 | 26 | 3 W. |
| 201 | Cabot Carbon Co | Humble Fed. B No. 1 | 16 | 26 | 2 W. |
| 202 | Bolack, Greer, et al | Bolack No. 1 | 9 | 26 | 1 W. |
| 203 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | ---- | 26 | 1 E. |
| 204 | Bauer and Reeside (1921) | Composite of 338-340, 349, 350 (Brimhall Wash). | ---- | 25 | 16 W. |
| 205 | Amerada Petroleum Corp | Navajo T. R. No. 19-1 | 21 | 25 | 14 W. |
| 206 | Gulf Oil Corp | Pinabete Navajo No. 1 | 3 | 25 | 14 W. |
| 207 | F. R. Anderson | Federal No. 11-18 | 18 | 25 | 13 W. |
| 208 | British-American Oil Producing Co | Ross No. 2 | 24 | 25 | 13 W. |
| 209 | Shell Oil Co | Govt. No. 41-21 | 21 | 25 | 12 W. |
| 210 | ----do---- | Bisti Wtr. Well W No. 1 | 24 | 25 | 12 W. |
| 211 | ----do---- | Carson No. 3 | 7 | 25 | 11 W. |
| 212 | ----do---- | Govt. A No. 21-22 | 22 | 25 | 11 W. |
| 213 | El Paso Natural Gas Co | McKee No. 1 | 1 | 25 | 11 W. |
| 214 | Wellshire Development Co | Ma-Ga-El No. 2 | 19 | 25 | 10 W. |
| 215 | El Paso Natural Gas Co | Brookhaven No. 3-A | 29 | 25 | 10 W. |
| 216 | Consolidated Oil and Gas, Inc | Sunshine No. 1-13 | 13 | 25 | 10 W. |
| 217 | M. B. Rudman | Federal No. 21-1 | 21 | 25 | 9 W. |
| 218 | Texas National Petroleum Co | Govt. No. 1-25-9 | 1 | 25 | 9 W. |
| 219 | Davis Oil Co | Govt.-Mead No. 1 | 24 | 25 | 9 W. |
| 220 | El Paso Natural Gas Co | Quitzau No. 13 | 15 | 25 | 8 W. |
| 221 | ----do---- | Harvey State No. 2 | 16 | 25 | 7 W. |
| 222 | Superior Oil Co | Hightower-Govt. No. 1-24 | 24 | 25 | 7 W. |
| 223 | El Paso Natural Gas Co | Harvey State No. 11 | 16 | 25 | 6 W. |
| 224 | Kay Kimbell | Salazar-Federal No. 1-22 | 22 | 25 | 6 W. |
| 225 | Humble Oil and Refining Co | Jicarilla J-4 | 6 | 25 | 5 W. |
| 226 | Amerada Petroleum Corp | Jicarilla Apache No. F-10 | 16 | 25 | 5 W. |
| 227 | El Paso Natural Gas Co | Jicarilla No. 67-5 | 29 | 25 | 5 W. |
| 228 | Amerada Petroleum Corp | Jic-Apache A No. 5 | 25 | 25 | 5 W. |
| 229 | El Paso Natural Gas Co | Jicarilla No. 2-C | 15 | 25 | 4 W. |
| 230 | Skelly Oil Co | C. W. Roberts No. 3 | 18 | 25 | 3 W. |
| 231 | Southern Union Gas Co | Lebow No. 1 | 14 | 25 | 3 W. |
| 232 | El Paso Natural Gas Co | Federal No. 15 | 3 | 25 | 2 W. |
| 233 | San Juan Gas Corp | Federal 27-IC | 27 | 25 | 2 W. |
| 234 | Skelly Oil Co | N. M. Fed. "E" No. 1 | 18 | 25 | 1 W. |
| 235 | Bolack-Greer, Inc | Canada Ojitos No. 1-16 | 16 | 25 | 1 W. |
| 236 | Mtn. States Petroleum Corp | Gavilan No. 31-1-C | 31 | 25 | 1 W. |
| 237 | Bolack-Greer, et al | Bolack No. 1-14 | 14 | 25 | 1 W. |
| 238 | Bolack-Greer Inc | Canada Ojitos No. 1-23 | 23 | 25 | 1 W. |
| 239 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | ---- | 25 | 1 E. |
| 240 | Bauer and Reeside (1921) | Composite of 360-363, 370, 375 (Medio Arroyo). | ---- | 24 | 16 W. |
| 241 | Davis Oil Co | Perry Navajo No. 1 | 6 | 24 | 14 W. |
| 242 | Monsanto Chemical Co | Chaco No. 1 | 20 | 24 | 13 W. |
| 243 | Humble Oil and Refining Co | Tanner Unit No. 1 | 21 | 24 | 12 W. |
| 244 | H. I. Fanning | Vanderslice No. 1 | 13 | 24 | 12 W. |
| 245 | Magnolia Petroleum Co | Beamon-Fed. No. 1 | 29 | 24 | 11 W. |

See footnote at end of table.

APPENDIX 1—Fruitland Formation (cont.).

| Number on pl. 3 | Published reference or company | Measured section or well name | Location Sec. | T. N. | R. |
|---|---|---|---|---|---|
| 246 | Phillips Petroleum Co. | Gallegos No. 1 | 14 | 24 | 11 W. |
| 247 | Forest Oil Corp. | Huerfano Fed. No. 1 | 13 | 24 | 10 W. |
| 248 | Gulf Oil Corp. | S. Huerfano Fed. No. 1-X | 15 | 24 | 9 W. |
| 249 | Exeter Drilling Co. | Escrito Fed. No. 1 | 20 | 24 | 8 W. |
| 250 | Lemm and Maitatico | Govt. No. 1 | 34 | 24 | 8 W. |
| 251 | Ray Smith, Trustee | Federal No. 2 | 13 | 24 | 8 W. |
| 252 | Standard Oil Co. of Texas | Federal No. 1 | 27 | 24 | 7 W. |
| 253 | Pan American Petroleum Corp. | John S. Dashko No. 1 | 15 | 24 | 7 W. |
| 254 | Val R. Reese and Associates, Inc. | Lybrook No. 1-19 | 19 | 24 | 6 W. |
| 255 | El Paso Natural Gas Co. | Bolack No. 1E | 35 | 24 | 6 W. |
| 256 | do. | Bolack No. 1-D | 13 | 24 | 6 W. |
| 257 | do. | Jicarilla No. 4-A | 15 | 24 | 5 W. |
| 258 | Amerada Petroleum Corp. | Jicarilla Apache No. El | 30 | 24 | 4 W. |
| 259 | Magnolia Petroleum Co. | Jillson-Fed. No. 1 | 7 | 24 | 3 W. |
| 260 | El Paso Natural Gas Co. | Lindrith No. 35 | 15 | 24 | 3 W. |
| 261 | do. | Lindrith No. 30 | 18 | 24 | 2 W. |
| 262 | San Juan Gas Corp. | Federal A No. 13 | 13 | 24 | 2 W. |
| 263 | Shar-Alan Oil Co. | E. A. Down-Fed. No. 1 | 16 | 24 | 1 W. |
| 264 | Magnolia Petroleum Co. | Duff-Fed. No. 1 | 27 | 24 | 1 W. |
| 265 | Reading and Bates, Inc. | Duff No. 1 | 24 | 24 | 1 W. |
| 266 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | ---- | 24 | 1 E. |
| 267 | Bauer and Reeside (1921) | Composite of 388–390 (Hunters Wash). | 1 | 23 | 15 W. |
| 268 | do. | Composite of 419, 420, 443, 432, 434, 433, 430. | 23 | 13 | 14 W. |
| 269 | Humble Oil and Refining Co. | Tanner Unit No. 3 | 5 | 23 | 12 W. |
| 270 | Bauer and Reeside (1921) | Composite of 520, 521, 524, 526, 528. | ------ | 23 | 12 W. |
| 271 | Shell Oil Co. | Meyer Govt. No. 3 | 20 | 23 | 11 W. |
| 272 | do. | Meyer Govt. No. 1 | 14 | 23 | 11 W. |
| 273 | E. B. LaRue, Jr. | Kinebeto No. 2 | 17 | 23 | 10 W. |
| 274 | Great Western Drilling Co. | Lucy English No. 1 | 25 | 23 | 10 W. |
| 275 | do. | Chaco Unit No. 1 | 14 | 23 | 9 W. |
| 276 | do. | Chaco Unit No. 3 | 21 | 23 | 8 W. |
| 277 | El Paso Natural Gas Co. | Sapp No. 1-A | 18 | 23 | 7 W. |
| 278 | Rhodes Drilling Co. | Elkins Fed. No. 1 | 13 | 23 | 7 W. |
| 279 | S. D. Johnson | Chapman No. 1 | 20 | 23 | 6 W. |
| 280 | Sinclair Oil and Gas Co. | Tex. Nat'l Fed. No. 1 | 25 | 23 | 6 W. |
| 281 | Sunray DX Oil Co. | N. M. Apache No. 1 | 21 | 23 | 5 W. |
| 282 | Pubco Petroleum Corp. | Jic. 23-5 No. 23-11 | 23 | 23 | 5 W. |
| 283 | San Juan Drilling Co. | Vanderslice No. 1 | 21 | 23 | 4 W. |
| 284 | Caswell Silver | Jicarilla No. 2-S | 19 | 23 | 3 W. |
| 285 | U.S. Smelting, Refining and Mining Co. | Jicarilla No. 1 | 7 | 23 | 3 W. |
| 286 | El Paso Natural Gas Co. | Jicarilla 183-2 | 27 | 23 | 3 W. |
| 287 | Wagenseller and August | Mobile-Apache No. 9-P | 12 | 23 | 3 W. |
| 288 | Shar-Alan Oil Co. | Jicarilla "L" No. 3 | 15 | 23 | 2 W. |
| 289 | Magnolia Petroleum Co. | Evans Fed. No. 1 | 18 | 23 | 1 W. |
| 290 | Shar-Alan Oil Co. | Northcut No. 1 | 2 | 23 | 1 W. |
| 291 | Bauer and Reeside (1921) | Composite of 537, 538, 546, 541. | 10, 11 | 22 | 11 W. |
| 292 | E. B. LaRue, Jr. | Kinebeto No. 4 | 9 | 22 | 10 W. |
| 293 | Bauer and Reeside (1921) | Composite of 560, 559 (Escavada Wash). | 25, 26 | 22 | 10 W. |
| 294 | Great Western Drilling Co. | So. Chaco No. 1 | 9 | 22 | 9 W. |
| 295 | Humble Oil and Refining Co. | So. Chaco No. 3 | 23 | 22 | 9 W. |
| 296 | do. | So. Chaco No. 4 | 10 | 23 | 8 W. |
| 297 | Northwest Production Corp. | 22-7 No. 1-23 | 23 | 22 | 7 W. |
| 298 | Plymouth Oil Co. | Tomas No. 1 | 22 | 22 | 6 W. |
| 299 | Humble Oil and Refining Co. | Jic. "B" No. 1 | 1 | 22 | 5 W. |
| 300 | Skelly Oil Co. | Jic. "E" No. 1 | 8 | 22 | 4 W. |
| 301 | Exeter Drilling Co. | Jicarilla Apache No. 1 | 28 | 22 | 4 W. |
| 302 | Bonanza Oil Co. | Jicarilla No. 1 | 2 | 22 | 3 W. |
| 303 | Lloyd H. Smith | Jicarilla No. 32-1 | 32 | 22 | 2 W. |
| 304 | Shar-Alan Oil Co. | Humble Dakota No. 1 | 21 | 22 | 2 W. |
| 305 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | ---- | 22 | 1 W. |
| 306 | Ray McGlothlin | Federal No. 1 | 22 | 21 | 8 W. |
| 307 | Davis Oil Co. | Govt. Co-op No. 1 | 20 | 21 | 7 W. |
| 308 | Kingsley-Locke Oil Co. | Miles KL No. 1 | 21 | 21 | 6 W. |
| 309 | Shell Oil Co. | Pool Four No. 1 | 22 | 21 | 5 W. |
| 310 | Roy Furr | Sun-Fed. No. 1 | 14 | 21 | 4 W. |
| 311 | Sun Oil Co. | McElvain Govt. No. 1 | 23 | 21 | 2 W. |
| 312 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | ---- | 21 | 1 W. |
| 313 | Dane (1936) | Measured coal sec. | 8 | 20 | 7 W. |

See footnote at end of table.

APPENDIX 1 – Fruitland Formation (cont.).

| Number on pl. 3 | Published reference or company | Measured section or well name | Location Sec. | T. N. | R. |
|---|---|---|---|---|---|
| 314 | do | do | 23 | 20 | 7 W. |
| 315 | Davis Oil Co | McCollum Govt. No. 1 | 12 | 20 | 6 W. |
| 316 | Austral Oil Co., Inc | Salvador Toledo Heirs No. 1 | 23 | 20 | 5 W. |
| 317 | Atlantic Refining Co | Torreon No. 3 | 15 | 20 | 3 W. |
| 318 | A. N. Brown | Magnolia Fed. No. 1 | 8 | 20 | 2 W |
| 319 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | | 20 | 1 W[1] |
| 320 | Dane (1936) | Measured coal sec | 12 | 19 | 6 W. |
| 321 | do | Composite of 2, 7, 9 | | 19 | 5 W. |
| 322 | J. S. Hinds and J. E. Fassett | Unpub. outcrop data | 11 | 19 | 4 W. |
| 323 | do | do | 7 | 19 | 3 W. |
| 324 | do | do | 8 | 19 | 2 W. |

[1] Projected.

APPENDIX 2A—SUMMARY OF DRILL-HOLE DATA FOR MENEFEE FORMATION.

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 10 Fernandez | 33-14N-7W | 3 | 10 | 700 |
| 2 Horacek | 11-14N-8W | 1 | 3 | 68 |
| 1 San Miguel Creek | 5-15N-6W | 0 | - | - |
| 1 Divide | 13-15N-10W | 0 | 0 | - |
| 1 Navajo | 14-15N-10W | 0 | 0 | - |
| Mutual Help WSW | 17-15N-12W | 4 | 23 | 489 |
| 1 Mariano Dome | 8-15N-13W | 0 | 0 | - |
| 340 Water Well | 30-15N-13W | 0 | 0 | - |
| 1 WW Wingate Plant | 16-15N-17W | 3 | 10 | 830 |
| 1 Federal Tract 16 | 8-16N-5W | 0 | - | - |
| 2 Federal Tract 15 | 16-16N-5W | 0 | - | - |
| 1 Santa Fe | 28-16N-6W | 2 | 6 | 310 |
| 1 Grace Hoxsey State | 32-16N-6W | 2 | 6 | 120 |
| 1 Fernandez | 17-16N-8W | 3 | 9 | 76 |
| 1 Butcher Federal | 18-16N-8W | 0 | - | - |
| 3 Fernandez | 33-16N-8W | 1 | 4 | 266 |
| 1 SFP-RR | 1-16N-9W | 0 | 0 | - |
| 1 Bullseye | 17-16N-9W | 0 | 0 | - |
| 1 El Nariz | 17-16N-10W | 1 | 6 | 192 |
| 1 E. L. Naric | 19-16N-10W | 0 | 0 | - |
| 1 Borrego Pass | 7-16N-11W | 1 | 5 | 286 |
| 1 Federal Dignco "N" | 34-16N-11W | 0 | 0 | - |
| 1 NMA-Satan | 15-16N-12W | 0 | 0 | - |
| 1 Santa Fe 160 Chico | 20-17N-5W | 4 | 12 | 275 |
| 1 Santa Fe Sand Springs | 18-17N-7W | 0 | - | - |
| 1 Wolfenden | 28-17N-7W | 1 | 3 | 622 |
| 1 Bobcat Pass Santa Fe | 29-17N-7W | 1 | 3 | 416 |
| 35 Santa Fe "B" | 5-17N-8W | 1 | 3 | 474 |
| 1 Hansen X | 6-17N-8W | 1 | 3 | 214 |
| 2 Hansen | 6-17N-8W | 2 | 6 | 200 |
| 3 Hansen | 6-17N-8W | 1 | 3 | 62 |
| 4 Santa Fe | 7-17N-8W | 1 | 4 | 282 |
| 1 Sand Springs | 10-17N-8W | 1 | 3 | 640 |
| 1 Don Ne Pah | 18-17N-8W | 1 | 3 | 340 |
| 1 B Santa Fe | 6-17N-9W | 3 | 12 | 74 |
| 1 D Santa Fe | 7-17N-9W | 1 | 3 | 442 |
| 3 Whigham | 11-17N-9W | 1 | 4 | 648 |
| 25 Hospah | 12-17N-9W | 2 | 6 | 218 |
| 1 Whigham "A" | 14-17N-9W | 2 | 10 | 600 |
| 1 Hospah West | 18-17N-9W | 5 | 17 | 240 |
| 1 Hospah Southwest | 31-17N-9W | 5 | 17 | 220 |
| 2 S.F.P.R.R. A | 32-17N-9W | 4 | 17 | 118 |
| 1 NB New Mexico | 36-17N-9W | 5 | 18 | 240 |
| 1 Long Shot | 28-17N-13W | 0 | 0 | - |
| 1 Goodner | 3-18N-3W | 0 | - | - |
| 1-X Navajo | 22-18N-4W | 0 | - | - |
| 1 Torreon Unit | 12-18N-5W | 2 | 8 | 500 |
| 1 N. Garcia | 28-18N-7W | 0 | - | - |
| 1-C Santa Fe | 28-18N-8W | 1 | 3 | 664 |

APPENDIX 2A–Menefee Formation (cont.)

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 1 Santa Fe Tract C | 31-18N-8W | 0 | - | - |
| 31 Santa Fe RR | 31-18N-8W | 2 | 6 | 390 |
| 1 White Horse | 15-18N-9W | 0 | - | - |
| 86 State "B" | 36-18N-9W | 0 | - | - |
| 1 Brown Horse | 6-18N-10W | 0 | - | - |
| Dark Horse | 14-18N-10W | 4 | 13 | 50 |
| 1 Santa Fe RR | 27-18N-11W | 0 | - | - |
| 1 Martin | 6-18N-12W | 3 | 9 | 250 |
| 1 Hutchinson Federal | 14-19N-3W | 3 | 9 | 1,160 |
| 2 Hutchinson Federal | 15-19N-3W | 3 | 9 | 1,120 |
| 1 Gonzales "C" | 16-19N-3W | 3 | 9 | 1,300 |
| 1 Encino Wash | 7-19N-4W | 6 | 20 | 1,000 |
| 1 Renkoff | 17-19N-4W | 3 | 10 | 1,000 |
| 1 Renkoff "D" | 17-19N-4W | 4 | 12 | 950 |
| 1 Federal | 8-19N-5W | 4 | 18 | 800 |
| 2-17 Navajo | 17-19N-5W | 4 | 18 | 750 |
| 1 Paper Thin | 30-19N-5W | 3 | 10 | <500 |
| 1 Santa Fe | 31-19N-5W | 3 | 9 | <500 |
| 1 Santa Fe Pacific | 1-19N-10W | 0 | - | - |
| 1 "D" S.F.P.R.R. | 25-19N-10W | 2 | 7 | 1,000 |
| 1-18 State | 32-19N-12W | 0 | - | - |
| 1 Tohatchi School | 16-19N-18W | 2 | 6 | 320 |
| 1 Navajo Tribe Tract 9 | 29-19N-17W | 3 | 9 | 680 |
| 1 USA "C" | 17-20N-3W | 7 | 22 | 1,480 |
| 1 New Mexico State "W" | 16-20N-3W | 8 | 27 | 1,670 |
| 1 Castillo | 35-20N-3W | 7 | 23 | 1,460 |
| 1 Castillo | 35-20N-7W | 6 | 22 | <500 |
| 1 La Coy Federal | 1-20N-8W | 4 | 18 | 860 |
| 1 Linda | 14-20N-8W | 3 | 10 | 500 |
| 1 Pint Add Canyon | 23-20N-8W | 2 | 6 | 500 |
| 1 Pueblo Pintado | 23-20N-8W | 4 | 12 | <500 |
| 1 Wild Card | 19-20N-11W | 1 | 3 | 1,100 |
| 2 Pueblo Bonito | 25-20N-11W | 6 | 18 | 76 |
| 1 Bonito | 25-20N-11W | 3 | 10 | 70 |
| 1 N.M. - Ariz. | 19-20N-12W | 3 | 9 | 120 |
| 1 Stoney Butte | 9-20N-13W | 1 | 3 | 1,100 |
| 1 White Government | 6-21N-4W | 0 | - | - |
| 1 Federal Duff | 3-21N-7W | 0 | - | - |
| 1 Federal-Andele | 13-21N-8W | 4 | 12 | 1,420 |
| 1 El Norte | 17-21N-8W | 2 | 6 | 974 |
| 2 Scham Hanson Federal | 18-21N-8W | 3 | 12 | 1,140 |
| 1 Chace Federal | 27-21N-8W | 8 | 26 | 980 |
| 1 El Sur | 32-21N-8W | 5 | 19 | 580 |
| 1 Black Jack | 1-21N-9W | 5 | 15 | 1,100 |
| 1 Santa Fe, 55 Alamo | 20-21N-9W | 2 | 7 | <500 |
| Chaco Canyon Project | 21-21N-10W | 1 | 3 | <500 |
| 2 N.M. & Ariz. Land & Cattle Co. | 19-21N-12W | 5 | 15 | 140 |
| 1 Navajo | 1-21N-14W | 2 | 6 | 1,640 |
| 1 State | 16-19N-6W | 8 | 25 | 600 |

APPENDIX 2A–Menefee Formation (cont.)

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 1 Chop Up | 31-19N-6W | 2 | 7 | <500 |
| 1 Chacra Mesa | 14-19N-7W | 6 | 20 | <500 |
| 1 Villiard Reynolds | 26-19N-7W | 2 | 7 | <500 |
| 1 Lucky "B" | 35-19N-7W | 1 | 3 | <500 |
| 1 USA "C" | 17-20N-3W | - | 0 | - |
| 1 Castillo | 34-20N-7W | 7 | 23 | 500 |
| 1 N.M. State "W" | 16-20N-6W | 6 | 18 | 900 |
| 1-A Gulf Navajo | 4-21N-16W | 5 | 15 | 440 |
| 1 Cuba Pan-Am | 24-22N-3W | 2 | 8 | 4,110 |
| 2 Cuba Union | 26-22N-3W | 2 | 6 | 4,100 |
| 1 Jicarilla "B" | 1-22N-5W | 3 | 9 | 1,820 |
| 1 Littleton | 8-22N-5W | 0 | - | - |
| 11-1 Jicarilla | 11-22N-5W | 1 | 7 | 3,250 |
| 1 Lanmon | 16-22N-5W | 2 | 6 | 3,810 |
| 1-O-32 Jicarilla | 32-22N-5W | 0 | - | - |
| 1-E Federal | 17-22N-9W | 4 | 13 | 2,660 |
| 1 Roulette | 26-22N-10W | 5 | 16 | 900 |
| 1 Kinebeto Unit | 26-22N-10W | 2 | 6 | 840 |
| 2 Santa Fe-Pacific | 31-22N-13W | 4 | 12 | 460 |
| 1 Continental Navajo | 14-22N-16W | 5 | 15 | 1,000 |
| 3-X-G Jicarilla | 14-23N-2W | 2 | 6 | Partial |
| 1 L Jicarilla | 15-23N-2W | 2 | 6 | 560 |
| 1-A Jicarilla | 18-23N-2W | 2 | 6 | 600 |
| 4-163 Jicarilla I | 23-23N-2W | 1 | 3 | 580 |
| 1 Jicarilla R | 29-23N-2W | 0 | - | - |
| 2 Jicarilla R | 30-23N-2W | 0 | - | - |
| 1 Crosswise | 31-23N-2W | 3 | 10 | 4,380 |
| 1 Jicarilla Apache "S" | 20-23N-3W | 6 | 18 | 1,500 |
| 1 Jicarilla Apache "55" | 26-23N-3W | 2 | 6 | 850 |
| 1 Jicarilla | 29-23N-3W | 0 | - | - |
| 1-D Jicarilla | 33-23N-3W | 2 | 6 | 4,460 |
| 11 Jicarilla "E" | 8-23N-4W | 3 | 9 | 3,420 |
| 1 Vanderslice | 21-23N-4W | 0 | - | - |
| 1 Jicarilla Tribe | 26-23N-4W | 2 | 6 | Partial |
| 1 Jicarilla Tract "25" | 33-23N-4W | 4 | 12 | 3,510 |
| 1 Jicarilla "C" | 4-23N-5W | 2 | 6 | 3,550 |
| 5 Axl Apache "F" | 14-23N-5W | 1 | 5 | 2,182 |
| 1 Jicarilla "C" | 36-23N-5W | 2 | 6 | Partial |
| 1 Yarborough-Federal | 3-23N-6W | 2 | 6 | 4,210 |
| 1 Chapman | 20-23N-6W | 4 | 12 | 3,770 |
| 1 Quinella | 31-23N-6W | 2 | 6 | 3,660 |
| 1 Maddox FA | 34-23N-6W | 6 | 24 | 2,900 |
| 1 Dunn | 10-23N-7W | 8 | 20 | 3,380 |
| 1 Federal-Elkins | 13-23N-7W | 7 | 22 | 3,500 |
| 2-C Federal | 31-23N-7W | 2 | 6 | 3,726 |
| 1 Federal "F" | 8-23N-8W | 2 | 7 | 3,780 |
| 1 Riddel Federal | 12-23N-8W | 4 | 14 | 3,400 |
| 2 Kinebeto Unit | 17-23N-10W | 2 | 6 | 1,632 |
| 1 Lucy English | 25-23N-10W | 3 | 9 | 1,670 |
| 3 Kinebeto | 27-23N-10W | 2 | 6 | 1,598 |
| 1 M.S.E. | 13-23N-11W | 3 | 9 | 1,620 |

APPENDIX 2A—Menefee Formation (cont.)

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 2 Meyer Government | 26-23N-11W | 3 | 9 | 1,414 |
| 2 John Dashko B | 11-24N-7W | 1 | 4 | 3,960 |
| 1 John Dashko | 15-24N-7W | 6 | 18 | 4,010 |
| 1-24 Brown Federal | 24-24N-7W | 3 | 9 | 3,780 |
| 2 Hairston | 6-24N-9W | 0 | - | - |
| 1 State of NM AW | 2-24N-10W | 8 | 26 | 3,000 |
| 1 Ye-Na-Pah-White | 4-24N-10W | 6 | 19 | 2,900 |
| 2-9 Federal | 9-24N-10W | 4 | 12 | 2,500 |
| 1 A.W. Butter | 10-24N-10W | 7 | 21 | 2,550 |
| 1 Huerfano Fed. | 13-24N-10W | 4 | 12 | 3,500 |
| 1 Tom Corr | 23-24N-10W | 2 | 7 | 3,100 |
| 1 Case | 20-24N-10W | 5 | 15 | 2,050 |
| 1 Edgar | 25-24N-10W | 3 | 9 | 2,700 |
| 1 Gallegos | 14-24N-11W | 3 | 9 | 2,100 |
| 1 Jen Na Pia | 2-25N-10W | 2 | 6 | 4,412 |
| 5 L. E. Lockhart | 28-25N-10W | 1 | 3 | 4,100 |
| 3 Canyon | 5-25N-11W | 3 | 11 | 2,750 |
| 3 Carson | 7-25N-11W | 4 | 12 | 1,795 |
| 12-16 A Covernment | 16-25N-11W | 8 | 26 | 2,350 |
| 14-17 Carson Unit | 17-25N-11W | 5 | 16 | 2,000 |
| 4 Carson | 20-25N-11W | 10 | 30 | 1,690 |
| 21-22 Government "A" | 22-25N-11W | 11 | 34 | 1,600 |
| 1 Dect-So-Sa | 24-25N-11W | 3 | 12 | 2,790 |
| 1 Harold Bengay | 25-25N-11W | 4 | 12 | 2,490 |
| 5 Carson | 27-25N-11W | 6 | 19 | 2,620 |
| 1 Yazzie | 28-25N-11W | 4 | 13 | 2,290 |
| 11-30 Carson | 30-25N-11W | 8 | 25 | 2,600 |
| 15 Federal C | 8-25N-12W | 2 | 7 | 2,408 |
| 22-11 Carson Unit | 11-25N-12W | 2 | 6 | 2,414 |
| 1 Bisti Water Well "W" | 24-25N-12W | 4 | 12 | 2,396 |
| Carson | 25-25N-12W | 3 | 10 | 2,374 |
| 21-29 Federal | 29-25N-12W | 3 | 9 | 2,140 |
| 5 Marye | 1-25N-13W | 2 | 6 | 2,420 |
| 10 Kelly State | 2-25N-13W | 3 | 11 | 2,400 |
| 11-52-85 Federal | 4-26N-6W | 2 | 6 | 4,610 |
| T-Loy Breech E | 5-26N-6W | 2 | 6 | 4,670 |
| 11 Rincon | 6-26N-6W | 2 | 6 | 4,590 |
| 25-51-127 Federal Doswell | 8-26N-6W | 2 | 6 | 4,690 |
| 132 Breech "A" | 9-26N-6W | 3 | 9 | 4,710 |
| 23-49-129 Federal | 9-26N-6W | 3 | 9 | 4,840 |
| 19-34-157 Federal | 10-26N-6W | 2 | 6 | 4,980 |
| 1-268 State | 16-26N-6W | 1 | 3 | 4,690 |
| 341 Breech D | 21-26N-6W | 2 | 7 | 4,674 |
| 57 Rincon Ut. | 1-26N-7W | 2 | 6 | 4,620 |
| 224 Breech PMO | 13-26N-7W | 0 | - | - |
| 307 Breech | 13-26N-7W | 0 | - | - |
| 11-B Newsom | 5-26N-8W | 2 | 7 | 4,282 |
| 10-B Newsom | 8-26N-8W | 1 | 3 | 3,714 |
| 16 Newsom | 17-26N-8W | 1 | 6 | 3,672 |

APPENDIX 2A—Menefee Formation (cont.)

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 17 Newsom | 20-26N-SW | 1 | 6 | 3,750 |
| 7 Hodges | 22-26N-SW | 1 | 3 | 4,940 |
| 1 State 572 | 2-26N-11W | 1 | 4 | 4,244 |
| 1 Western | 7-26N-11W | 2 | 6 | 3,400 |
| 1-A Western | 8-26N-11W | 3 | 10 | 3,060 |
| 1-B O. H. Randell | 10-26N-11W | 2 | 6 | 2,570 |
| 1 South Kutz | 11-26N-11W | 2 | 11 | 3,472 |
| 2 Delhi-Taylor | 17-26N-11W | 2 | 6 | 2,340 |
| 1 Uskayahewood | 18-26N-11W | 2 | 6 | 2,340 |
| 1 Navajo | 15-26N-14W | 6 | 18 | 2,256 |
| 2 Navajo | 1-26N-15W | 4 | 23 | 1,960 |
| 1 Dunham | 14-26N-15W | 4 | 23 | 1,620 |
| 3 Jernigan | 24-27N-9W | 2 | 6 | 4,108 |
| 1 N. M. Galt "H" | 1-27N-10W | 2 | 6 | 3,808 |
| 1 USA Hargrave "J" | 3-27N-10W | 0 | - | - |
| 1 N. M. Galt "J" | 6-27N-10W | 1 | 3 | 3,750 |
| 1 USA Hargrave "H" | 9-27N-10W | 0 | - | - |
| 2 Morris | 10-27N-10W | 1 | 3 | 4,030 |
| 1 Angels Peak | 15-27N-10W | 1 | 3 | 3,920 |
| 1 USA Hargrave "K" | 16-27N-10W | 0 | - | - |
| 1 E. J. Johnson | 21-27N-10W | 2 | 6 | 3,620 |
| 2 Angel Peak Unit | 22-27N-10W | 2 | 6 | 4,320 |
| 1 Jack Frost "B" | 27-27N-10W | 1 | 3 | 4,250 |
| 1 C. A. McAdams "B" | 28-27N-10W | 3 | 9 | 3,630 |
| 11 Pipkin | 12-27N-11W | 1 | 3 | 4,214 |
| 1-B Warren | 18-27N-12W | 3 | 10 | 2,695 |
| 3 Government-Morgan | 31-27N-12W | 1 | 6 | 2,420 |
| 1 Charley Hosh | 12-27N-13W | 2 | 6 | 3,680 |
| 1 Shultz | 15-27N-13W | 3 | 9 | 2,765 |
| 1 USA E. H. Newman | 31-27N-13W | 3 | 10 | 2,860 |
| 1-A Navajo 2084 | 35-27N-15W | 4 | 28 | 1,600 |
| 1 Day Eas | 7-28N-10W | 3 | 9 | 3,620 |
| 1 J. F. Day "E" | 17-28N-10W | 1 | 3 | 3,870 |
| 1 J. F. Day "D" | 20-28N-10W | 2 | 6 | 3,750 |
| 1-G Davidson | 21-28N-10W | 1 | 3 | 4,190 |
| 1-H Davidson | 22-28N-10W | 1 | 3 | 4,230 |
| 1 USA Kutz Deep | 27-28N-10W | 1 | 3 | 4,200 |
| 1-F Davidson | 28-28N-10W | 2 | 6 | 3,740 |
| 1 Fred Feasel "L" | 32-28N-10W | 1 | 3 | 3,930 |
| 1 Fred Feasel "H" | 33-28N-10W | 0 | - | - |
| 1 Fred Feasel "J" | 34-28N-10W | 1 | 3 | 3,716 |
| 88 Gallegos Canyon | 31-28N-11W | 4 | 12 | 3,226 |
| 7 Pipkin | 35-28N-11W | 4 | 12 | 3,390 |
| 9 Pipkin | 35-28N-11W | 5 | 15 | 3,226 |
| 5 Pipkin | 36-28N-11W | 0 | - | - |
| 8 Gallegos Canyon | 22-28N-12W | 0 | - | - |
| 83 Gallegos Canyon | 26-28N-12W | 1 | 3 | 4,070 |
| 3 C. J. Holder | 8-28N-13W | 2 | 6 | 3,160 |
| 6 C. J. Holder | 9-28N-13W | 1 | 3 | 4,070 |
| 4 C. J. Holder | 16-28N-13W | 3 | 9 | 3,500 |
| 1 C. J. Holder | 21-28N-13W | 2 | 6 | 3,955 |

APPENDIX 2A–Menefee Formation (cont.)

| Name of well | Location (sec.-T.-R.) | No. of units | Total thickness of coal (ft) | Depth to first coal (ft) |
|---|---|---|---|---|
| 1 G. L. Davis "B" | 27-28N-13W | 2 | 6 | 3,750 |
| 1 Valencia GU "B" | 18-29N-9W | 1 | 4 | 3,900 |
| 1 Rock Island | 22-29N-9W | 2 | 8 | 4,006 |
| 8 Albright | 15-29N-10W | 1 | 3 | 4,003 |
| 6 Albright | 22-29N-10W | 0 | - | - |
| 1 Martinez GU "G" | 24-29N-10W | 2 | 9 | 3,800 |
| 1 Davis GU "F" | 27-29N-11W | 0 | - | - |
| 1 Johnson GU "C" | 7-29N-12W | 1 | 3 | 3,925 |
| 96 Gallegos Canyon | 18-29N-12W | 1 | 3 | 3,794 |
| 202 Gallegos Canyon | 33-29N-12W | 1 | 3 | 3,390 |
| 1 Calloway "B" | 31-29N-13W | 0 | - | - |
| 1 State Oil Unit | 32-29N-13W | 1 | 3 | 3,940 |
| 10-G Hagood | 34-29N-13W | 2 | 6 | 3,965 |
| 86 Gallegos Canyon | 35-29N-13W | 1 | 3 | 4,010 |
| 3 "H" Navajo Tribal | 13-29N-14W | 0 | - | - |
| 4 "G" Navajo Tribal | 17-29N-14W | 0 | - | - |
| 1 "G" Navajo Tribal | 20-29N-14W | 1 | 3 | 3,040 |
| 3-E Navajo Tribal | 21-29N-14W | 1 | 3 | 3,495 |
| 1 "E" Navajo Tribal | 22-29N-14W | 1 | 3 | 3,614 |
| 1 "H" Navajo Tribal | 23-29N-14W | 2 | 6 | 3,560 |
| 2 "H" Navajo Tribal | 24-29N-14W | 1 | 3 | 3,526 |
| 47-X Florance | 5-30N-9W | 0 | - | - |
| 2 Florance | 20-30N-9W | 1 | 3 | 4,588 |
| 8 "B" Elliott | 27-30N-9W | 0 | - | - |
| 3 "B" Heath | 31-30N-9W | 1 | 3 | 4,150 |
| 1 State | 32-30N-9W | 2 | 6 | 4,130 |
| 5 Stewart | 20-30N-10W | 4 | 12 | 4,730 |
| 1 Lee | 30-30N-11W | 2 | 9 | 3,772 |

APPENDIX 2B—MEASURED SECTION OF HOGBACK MOUNTAIN TONGUE OF MENEFEE FORMATION (Location: SE¼SW¼ sec. 25, T. 27 N., R. 17 W. as shown in fig. 12. Measured by R. Lease and J. Shomaker. Color code in accordance with rock-color chart distributed by Geological Society of America).

| Description | Thickness (ft) |
|---|---|
| Sandstone, 5 Y 7/2, very fine grained, clear-grained, very well cemented, weathers blocky | 2.5 |
| Sandstone, interbeds, shale, selenite | 35.0 |
| Sandstone, 10 YR 7/4, very fine grained, platy, fissile, soft | 2.0 |
| Shale, 10 YR 6/2, very sandy | 3.0 |
| Sandstone, 10 YR 7/4, very fine grained, platy, faint laminations | 2.0 |
| Shale, 10 YR 6/4, sandy, fissile | 5.0 |
| Sandstone, 10 YR 7/4, very fine grained, scarce black minerals, platy | 8.7 |
| Shale, 5 Y 3/2, coaly, silty | 2.5 |
| Sandstone, 10 YR 8/2, fine-grained, well-sorted, scarce black minerals, obscure bedding, scarce limonite concretions | 14.5 |
| Siltstone, 5 YR 5/2, carbonaceous, poorly exposed | 29.0 |
| Sandstone, 6 YR 5/6, fine-grained to very fine grained, well-sorted, weathers with heavy limonite stain | 2.5 |
| Shale, 5 YR 5/2, weathers white, fissile indistinct | 8.0 |
| Sandstone, 10 YR 8/2, fine-grained, subangular, well-sorted, abundant dark minerals, indistinct bedding | 15.0 |
| Siltstone, 5 YR 5/2, carbonaceous, very poorly exposed | 60.0 |
| Coal, black, attrital | 21.0 |
| Siltstone, 5 YR 5/2, carbonaceous, very poorly exposed | 35.0 |
| Sandstone, 5 YR 8/4, fine-grained, subangular, well-sorted, possibly clay cement, platy, limonite stained | 17.0 |
| Shale, 5 YR 5/2, fissile | 6.0 |
| Siltstone, 5 YR 5/2, carbonaceous, fissile | 4.0 |
| Shale, 5 GY 6/4, fissile, streaks of sandstone | 13.7 |
| Sandstone, N 9, very fine grained, silty, very thin bedded, weathers with limonite stain | 4.9 |
| Siltstone, 5 YR 5/2, carbonaceous, fissile | 13.0 |
| Coal, black, attrital, weathered | 5.5 |
| Shale, 5 YR 3/2, coaly, fissile | 3.0 |
| Sandstone, 10 YR 8/2, fine-grained, rounded grains, well-sorted, well-cemented, abundant black minerals | 3.8 |
| Siltstone, 5 YR 5/2, carbonaceous, fissile | 8.5 |
| Coal, black, attrital, weathered, no parting | 11.0 |
| Shale, 5 YR 5/2, very carbonaceous, fissile, thin streaks of coal | 1.2 |
| Siltstone, 5 YR 5/2, carbonaceous, fissile | 2.0 |
| Sandstone, 10 YR 8/2, fine-grained, subrounded to rounded grains, well-sorted abundant fine-sized black, nonmagnetic minerals, weathers into 1 inch balls, no visible bedding | 14.6 |
| Siltstone, 5 YR 5/2, carbonaceous fissile, carbonaceous fragments | 25.4 |
| Sandstone, 5 Y 8/1, fine-grained, well-sorted, subangular, scarce black minerals, well-cemented, poor to fine porosity | 0.75 |
| Siltstone, 5 YR 5/2, carbonaceous, fissile, carbonaceous fragments | 7.0 |
| Sandstone, 10 YR 8/4, fine-grained to very fine grained, subrounded to subangular, well-sorted, weathered in ¾ inch to 1½ balls, good porosity | 9.7 |
| Note: 32° E. dip all through section | |

| | |
|---|---|
| *Type faces:* | Text in 10 pt. Times Roman, leaded one point<br>References in 8 pt. Press Roman, leaded one point<br>Display heads in 24 pt. Times Roman, letterspaced |
| *Appendices:* | Camera-ready copy furnished by NM Bureau of<br>Mines & Mineral Resources |
| *Presswork:* | Miehle Single Color Offset |
| *Binding:* | Saddlestitched with softbound cover |
| *Paper:* | Cover on 651b. Talisman Cover<br>Text on 60 lb. White Offset |